IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

Compiled by:
Barry Dalal-Clayton
Miles Scott-Brown

July 2024
Updated October 2024

Version 1

IAIA
International Association for Impact Assessment

International Association for Impact Assessment (IAIA)

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FOREWORD

We live in an era of accelerating climate challenges and an urgent need to decarbonize energy systems. Decision-makers across the globe face the daunting task of delivering a complex, rapid, and just energy transition with potentially significant consequences across economies and societies. It is against this backdrop that the International Association for Impact Assessment (IAIA) is launching “Improving Decision-Making for the Energy Transition: Guidance for Using Strategic Environmental Assessment.” We hope it will serve as an essential and timely reference for policymakers, planners, industry leaders, civil society, and other important stakeholders involved in the energy sector.

This guidance comes at a critical time. The past five years have witnessed remarkable growth in renewable energy generation, a trend set to increase. The International Energy Agency forecasts that more renewable energy will be added in the next five years than has been installed since the first commercial renewable energy power plant was built more than 100 years ago. Despite this progress, we are still not on a path to reach the agreed COP28 target of tripling global renewable energy generation by 2030. Reaching net zero by 2050 will remain out of reach if we continue on our current trajectory.

Rapid advancements in green technologies, greater efficiencies driving down cost, and a desire for greater energy security are set to deliver further exponential growth in renewable energy projects. But this will cause people to face a fundamental truth: the energy transition, while vital, is not benign; it is instead messy and challenging and can cause many unintended consequences in a world of complex, interrelated systems.

Strategic environmental assessment (SEA) is a powerful and effective process to address this challenge. It provides a comprehensive framework to see the big picture, to harmonize renewable energy development with the interests of other sectors, address the perspectives of stakeholders, communities, and marginalized groups; and ensure that sustainability considerations are paramount in protecting the future of life on our planet.

SEA is a proactive approach that examines the interconnected systems of people, our economies, and our environments. It considers alternatives to proposed policies, plans, and programs for the energy transition and addresses the potential cumulative impacts that might arise from their implementation. SEA identifies ways to reduce or avoid potential negative environmental and socioeconomic impacts, as well as how to find win-win outcomes and enhance the socioeconomic benefits of energy projects. It improves the planning process by providing a clearer understanding of the consequences for future decisions.

For policymakers, SEAs can also provide a structure for progress on international commitments made under the Sustainable Development Goals, Nationally Determined Contributions under the Paris Agreement, the Global Biodiversity Framework, and other international commitments.

This report is a practical guide for undertaking SEA to support strategic-level policymaking, planning, and program development for the energy transition. It describes best practices for conducting SEA across the energy sector and offers detailed methods and case studies across various energy types that illustrate its application in different contexts.

As we collectively strive to meet global climate goals and ambitions, this guidance will be a valuable resource. It will equip leaders to make informed, sustainable, and wise decisions and will help the public and industry to contribute to these decisions. Such decisions will shape the future of our energy systems to best fit the natural and human environments where the projects will be developed, enabling a just and sustainable energy transition.

Alan Ehrlich

President
International Association for Impact Assessment

ABOUT IAIA

The International Association for Impact Assessment (IAIA) is the leading global network on best practice in the use of impact assessment for informed decision-making regarding policies, programs, plans, and projects (www.iaia.org). It was established in 1980 with a voluntary membership comprising professionals involved with impact assessment, including environmental, social, and health impact assessment and strategic environmental assessment. The association promotes the application of integrated and participatory approaches to impact assessment, conducted to the highest professional standards.

IAIA has members from over 100 countries, and membership is open to anyone. It has affiliate organizations in over 20 countries, including Cameroon, Canada (multiple affiliates: Ontario, Quebec, Western and Northern Canada), Germany, Ghana, Iran, Italy, South Korea, Mozambique, New Zealand, Nepal, Nigeria, Portugal, South Africa, Spain, and Zambia.

IAIA publishes *Impact Assessment and Project Appraisal,* a quarterly journal comprising peer-reviewed research articles, professional practice articles, and book reviews of recently published titles. IAIA also publishes a newsletter and other downloadable documents. IAIA's primary activities are its annual conference, which is hosted by different countries and regularly attracts over 700 participants, and regional symposia.

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The materials in this guidance build on and draw from many sources, including existing SEA guidelines from many countries and organizations. A starting point for the discussion of key issues for particular energy sub-sectors (in Chapters 5-12) were narratives developed for a regional scoping report for a SESA of the Energy Transmission Mechanism in SE Asia (ADB 2022).

BACKGROUND TO THE IAIA SEA GUIDANCE FOR THE ENERGY TRANSITION

Global challenges and why the SEA guidance is needed for the energy transition

The world is facing two man-made and intricately linked environmental crises that threaten the functioning of the earth as a system: climate change and the biodiversity crisis. Both crises are linked to energy (Box 1).

Box 1: Links between climate, biodiversity, energy and associated global agreements

The causes of climate change (global warming) have been clearly shown to be linked to the emissions of greenhouse gases from burning fossil fuels. The biodiversity crisis (loss of habitats and species) is linked to the energy sector through biomass. In many poor regions, people depend directly on biomass for energy (fuelwood, peat, charcoal) while, in the energy transition, bio-based fuels (such as wood pellets or biodiesel) play an important role. Both are biodiversity dependent and may be drivers of ecosystem degradation due to overexploitation.

Three leading global agreements stress the need to address the climate and biodiversity crises in a coordinated manner, with human well-being as the overarching goal:

- ***The Sustainable Development Goals*** (UN, 2015), described as a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are 17 Goals, which are an urgent call for action by all countries, developed and developing, in a global partnership. SDG 7 is concerned with "affordable, reliable, sustainable, and modern energy for all." The SDGs recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth, all while tackling climate change and working to preserve our oceans and forests. They are integrated and indivisible and balance the three dimensions of sustainable development: economic, social, and environmental.

- ***The Paris Agreement*** (UNFCCC, 2015) under the UN Framework Convention on Climate Change with its overarching goal to hold "*the increase in the global average temperature to well below 2°C above pre-industrial levels*" and pursue efforts "*to limit the temperature increase to 1.5°C above pre-industrial levels*." For the first time, a binding agreement brings all nations together to combat climate change and adapt to its effects. In their Nationally Determined Contributions (NDCs), countries communicate actions they will take to reduce their greenhouse gas emissions and actions they will take to build resilience to adapt to the impacts of climate change.

- ***The Global Biodiversity Framework*** (GBF, 2022) contains global goals and targets aiming to protect and restore nature for current and future generations, ensure its sustainable use, as well as spur investments for a green global economy. Together with the Paris Agreement, the GBF paves the way towards a climate-neutral, nature-positive, and resilient world by 2050. It has clear, measurable goals and targets, with complete monitoring, reporting, and review arrangements to track progress. Target 14 of the GBF is to "integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral PPPs."

The consequence of these global agreements is that all sectors must contribute and collaborate to achieve a sustainable energy transition. Sectors must not only mitigate the negative environmental and socioeconomic risks and impacts of implementing their policies, plans, and programs (PPPs), but must also align their PPPs to environmental (in particular climate) and socioeconomic objectives and actively contribute to solutions. This will require a substantial change away from the business-as-usual approach. For the energy sector, it means a shift towards a sustainable economy that is not based on fossil fuels and overconsumption of natural resources, but which relies on low-carbon solutions, simultaneously promoting a circular economy and, where possible, creating positive outcomes for biodiversity (restoration of degraded or destroyed ecosystems).

Potentially, there are numerous further linkages between energy sector activities and the above three global agreements, but they will depend on specific country and energy sector characteristics. This is why it may be difficult for sector authorities to address these cross-linkages with other sectors in an integrated manner when developing their sector PPPs. But this is a challenge that SEA can help to address by assessing the consequences of the initiatives (particularly PPPs) of an individual sector on domains beyond the horizon of that sector and identifying opportunities for the sector to create win-win opportunities beyond its specific sector boundaries.

Climate is one of the key physical factors defining the type of ecosystems present in a region (including the type of crops that can be grown). Climate change will cause agro-ecological zones to shift (or even disappear), affecting the ability of a region to maintain its original ecosystems or types of cultivable crops. On the other hand, ecosystems act as climate stabilizers, governing patterns of evaporation and rainfall and providing system resilience to bounce back to normal after unexpected disastrous events.

Climate change is arguably the most critical existential challenge faced by the world today. The evidence for the need to take urgent steps to address this issue has been presented in reports by the Intergovernmental Panel on Climate Change (IPCC). The most recent report, the Sixth Assessment Report, was finalized on 4 April 2022. It states that "in 2010-2019, average annual global greenhouse gas emissions were at their highest levels in human history, but the rate of growth has slowed; and that without immediate and deep emissions reductions across all sectors, limiting global warming to 1.5°C is beyond reach."

Through various UN agreements reached at Conferences of the Parties to the UN Framework Convention on Climate Change (UNFCCC), countries have committed to address climate change by reducing emissions of greenhouse gases and to promote Energy Transition (ET), which requires the retirement of coal and other fossil fuel power facilities and movement towards renewable energy (RE) supplies (wind, hydropower, solar, tidal, bioenergy, geothermal, green ammonia, and others).

According to REN21[1], "The world is witnessing a remarkable boom in solar photovoltaics (PV) and a significant surge in energy investments. Global additions to renewable power capacity increased an estimated 36% in 2023 to reach around 473 gigawatts (GW), a new record for the 22nd consecutive year. Solar PV drove the increase and accounted for three-quarters of all the renewable power capacity additions in 2023."

In many countries, concerns about energy security have accelerated the transition to renewables and energy efficiency. However, some other countries have opted to embrace fossil fuels for energy supply assurance.[2] Global investment in both fossil gas and coal infrastructure remains substantial.[3] Many developing countries have prioritized short-term economic growth over long-term energy transition.

To support the energy transition, some countries are developing national energy plans and sector-specific plans (see Chapter 4), while multilateral development banks and others are providing financial support for energy transition activities.

But such energy PPPs and implementing the energy transition (through PPPs and subsequent projects) will not be benign. They may also give rise to environmental and socioeconomic impacts (some positive, many potentially negative if not well managed and mitigated). The opportunities can be enhanced and the risks minimized by applying impact assessment processes, particularly environmental and social impact assessment at the individual project level (e.g., for the retirement of a coal-fired power station, the closure of a coal mine, or the development of individual renewable energy generation facilities, including their associated infrastructure). At the higher planning and program levels, to move energy generation away from fossil fuels to renewable sources, strategic

[1] REN21 (2024)
[2] REN21 (2024), see Target 13
[3] REN21 (2024), see Target 14

environmental assessment (SEA) is the most appropriate process to support ET planning and decision-making to respond to environmental and socioeconomic concerns.

There has been very limited application to date of SEA for PPPs that focus on the energy transition and renewable energy development in general (although there are examples of SEAs for the energy sector in general, referenced in this guidance, that may include renewable energy components). Guidance for its application in this context does not exist but is critically required by practitioners and decision-makers. Furthermore, there is an urgent need for capacity strengthening and outreach, beyond the development of guidance, to explain to planners and decision-makers and decision-takers in the energy sector and others how SEA can help: what is its role and key steps, how it can benefit energy transition, the decisions that need to be made, and how to engage in the planning process.

Traditional environmental impact assessment (EIA) conducted at the individual project level has proven to be insufficient to deal with the bigger picture beyond project-level impacts, to address cumulative impacts from multiple projects/developments, and to protect the public interest. A more strategic approach is required to support policy-making and long-term planning by public and private actors in the energy sector. SEA is now a well-established procedure that supports such planning by ensuring that relevant alternatives are assessed, that all environmental and social effects are evaluated, and that all stakeholder interests are taken into account in the SEA.

SEA has been adopted by about 100 countries, nearly all high-income countries, and an increasing number of low- and middle-income countries. In those countries without SEA legislation, the process is applied voluntarily and supported by IFIs and/or bilateral donors. As the global renewable energy sector is expected to expand significantly in the coming years, there is an immediate and pressing need for guidance to deal with siting issues, the overall lack of a comprehensive regulatory framework, and increasing public concerns about the over-saturation of renewable energy projects in the landscape. These concerns can only be addressed at a strategic level, not at the individual project level.

A partnership approach to developing the guidance

Recognizing the necessary shift required towards the use of more renewable energy, the International Association of Impact Assessment (IAIA) launched a three-phased initiative in February 2022 to:

- ***Develop guidance*** (building on relevant existing initiatives) for the application of SEA to policies, plans, and programs for renewable energy development, focusing initially on the hydropower, solar, wind, and bioenergy sub-sectors and subsequently expanding to include geothermal, tidal, green hydrogen, and coal-fired power plant and coal mine closures;
- ***Establish a learning platform*** to share experiences with a broad group of stakeholders using the guidance and other platforms;
- ***Promote application of the guidance*** in selected countries to strengthen capacity and raise awareness (with training and coaching of stakeholders), to implement an outreach plan, and to gather experience, supporting SEA case applications of the guideline, and
- ***Launch a help desk team*** of experienced experts in the field of SEA and energy planning facilitated by respective practice organizations in this field.

IAIA is recognized as the leading international body for environmental assessment professionals and is well positioned to take a leading technical role in developing this SEA guidance for the renewable energy sector. But preparing such guidance is only one step. Securing practical application of the guidance will be dependent on the interest and commitment of a range of actors with responsibilities for SEA application, renewable energy development, and financing the transition to renewable energy. Thus, IAIA has developed the guidance as a partnership initiative with the renewable energy sector, international and UN organizations, international finance institutions, bilateral donors, civil society representatives, and other organizations. A partnership approach will also be required to apply and test the guidance.

Initiative phases

A: Launch Phase (January – June 2022):

- Development of a draft outline of the guidance;
- Establishment of oversight through a "Partners Council" (PC) and "Technical Advisory Committee" (TAC);
- Preparation of an inventory of existing SEA guidelines and an Inception Report on how to proceed in Phases B and C.

B: Development Phase (January 2023 – June 2024):

- Preparation of preliminary draft and full draft of the guidance (available on the IAIA website);
- Establishment of a Reference Group (RG);
- Inputs by RE experts, TAC, RG, and IAIA members;
- Open review of preliminary and full drafts;
- Peer review of the "full draft" chapters;
- Revision and finalization of Version 1 of the guidance;
- Professional copy editing of Version 1 and presenting it in a user-friendly and readable format;
- Securing financial support for follow-up to the project (implementation of the guidance, lessons learned, training, etc.), and

C: Implementation/roll-out Phase (2024 – 2027 onwards):

- Conversion of the guidance to an accessible, searchable, web-based format;
- Dissemination of the guidance;
- Development of training materials regarding SEA and its nature, role, and modalities; its applicability to the energy transition; use of the guidance; and conducting a trainer orientation event;
- Regional and other workshops (piggybacking on already planned events) to build awareness and provide training on the guidance and use of SEA in the renewable energy sector, including a pilot training course to test the training materials;
- Test application of the guidance to renewable energy plans and programs in various countries by governments and others on a voluntary basis;
- Development of case studies documenting applications of SEA (using the guidance) for different renewable energy facilities;
- Revision of the guidance, where needed, to incorporate lessons learned from their application.

Governance

Three bodies were established to provide for oversight, technical review, and engagement in the process of developing the guidance:

Partners Council *– to:*
- Review project documents (e.g., the Concept Note, Inception Report, Draft Guidance);
- Monitor progress of the initiative;
- Advise and assist on securing sources of funding and support;
- Advise on opportunities to pilot/apply the guidance;
- Recommend possible additional members of the Council;
- Advocate for uptake and application of the SEA guidance for renewable energy, and
- Plan for implementation of Phases B & C.

Technical Advisory Committee *– to:*
- Provide technical support and guidance on the process of developing the guidance.

Reference Group *– a larger group of all interested individuals and organizations that are interested in the guidance initiative – to:*

- Engage in broaden debate and information/experience gathering and build support for the initiative and its outputs, and subsequent uptake of the guidance, and
- Share experiences and engage in dialogue on associated issues.

AIMS OF THE GUIDANCE

For most countries, the transition away from fossil fuels to renewable energy as part of the energy transition will not focus on a single type of energy source or technology. It will inevitably involve a balance of different renewable sources and will, at least for the foreseeable future, continue to derive energy from non-renewable sources (fossil fuels) to meet a significant proportion of energy demand and ensure energy security, especially given continued population growth, rising energy demand, and geopolitical uncertainties. Therefore, this mix is likely to be reflected in national and sub-national energy strategies, policies, and plans for some years to come.

The energy transition process will not be easy and will not be completed in the next few years, more likely over the coming decades, despite the fact that the pace of renewables development is accelerating as countries seek to meet their climate obligations in line with the Paris Agreement.

This guidance addresses the application of SEA to the energy transition, notably the early retirement of coal-fired power plants, changes to intermediary coal-based supply chains, and associated closure of coal mines, and the development of the renewable energy sector and associated energy sector restructuring. Currently, the guidance covers the following renewable energy types: hydropower, wind, solar, bioenergy, geothermal energy, tidal energy, and green hydrogen and ammonia. Other types (e.g., nuclear) may be added in the next version of the guidance along with the transition from liquid or gas fossil fuels. The guidance is, therefore, primarily concerned with the supply side of energy.

Some chapters focus on the “why and how” of SEA (aims, roles, stages, tasks), while others address coal mining and power generation and various renewable energy technologies. The latter chapters discuss the main technologies in use and the key environmental and socioeconomic issues associated with them. SEAs for the energy transition will need to address such issues and provide direction for project-level EIAs (for projects concerned with coal closure and renewable energy development) about the issues that will need to be considered.

Many of the environmental and socioeconomic issues discussed in Chapters 5-12 will appear to be at a project level. This is because most of our knowledge of these issues is derived from experience implementing energy generation activities around the world, both for fossil fuel and renewable energy developments and projects. These are the very issues likely to be identified during scoping for an SEA (see Chapter 2, Section 2.5), either because stakeholders are familiar with them or, often, because they have been directly affected by them. It is important to understand these issues because they may give rise to cumulative impacts from multiple projects when a PPP is implemented, and a critical role of SEA is to identify the potential and risk of cumulative impacts arising. Furthermore, these are the issues that may require to be addressed by changes to existing laws, regulations, or PPPs, and this is a matter on which an SEA should make recommendations.

This guidance is “high-level” and does not go into detail about the options and opportunities for mitigation measures to avoid or minimize/reduce negative impacts, or to offset and compensate for them, or to restore/rehabilitate land at the end of a project, or about how to enhance positive impacts. That is one of the functions of individual project EIAs.

There are many generalized SEA guidelines published by governments and organizations. A survey of existing guidelines undertaken during Phase A of this initiative identified 142 guidelines, available at: www.iaia.org/pdf/hot-topics/Inventory-of-SEA-guidelines.pdf. The number of such guidelines can be expected to increase in the future to meet the demands of the energy transition across the globe. Some of these address individual renewable energy sub-sectors (e.g., hydropower, wind), but none are currently available that cover the entire renewable energy field or the energy transition.

This guidance fills this critical gap and aims to promote sustainability in the energy transition to renewable sources. It particularly aims to promote a common approach and best practice based on internationally accepted principles and good practices for SEA. The key target groups for the guidance include:

- ***SEA practitioners/professionals*** tasked with preparing an SEA for either (i) a PPP process under the responsibilities of an energy department (energy sector planning) or (ii) a multi-sector

PPP process in which the energy department has to play its role (e.g., spatial planning or regional development planning);

- ***Government ministries, departments, and agencies***, particularly those responsible for energy planning and development and environment agencies responsible for national SEA systems and regulations;

- ***International organizations*** focused on renewable energy development;

- ***Financing organizations*** (including multilateral development banks and bilateral donors) that support the transition to renewable energy and which require due diligence to be carried out and environmental and social safeguards to be complied for both private and public sector investments in renewables;

- ***Sector organizations*** that advocate for a specific renewable energy technology;

- ***UN and other international organizations*** that promote the transition to renewable energy and which provide advice and support to governments;

- ***NGOs and CSOs*** with an interest or mandate covering renewable energy;

- ***Private sector energy companies and renewable energy developers*** with interest in moving to the use of renewable energy or securing their projects and minimizing planning-related risks. The guidance sets out the key environmental and socioeconomic issues likely to arise when developing various renewable energy options. These issues will need to be addressed in the development and operation of facilities in relation to overarching policies, plans, and programs for renewable energy development;

- ***Researchers and academics*** working in the field of renewable energy and to students studying impact assessment, climate change, and the energy transition in its many forms;

- ***Other stakeholders*** with an interest in or likely to be affected by the energy transition to renewable energy.

STRUCTURE OF THE GUIDANCE AND HOW TO USE IT

This guidance has been compiled in a modular format with the aim that, subsequently, it will be converted to a searchable online resource on the IAIA website and revised, updated, and expanded (e.g., new modules) as needed.

The guidance is framed in two main parts.

Part A: the why, what, and how of SEA. It provides generic information that will be common to all SEAs undertaken in the renewable energy sector:

- Chapter 1 gives a background to SEA, explaining how it differs from EIA and discussing issues such as the benefits of SEA, objectives, costs, stakeholder engagement, and institutional arrangements;
- Chapter 2 describes the key stages and tasks in the SEA process and methodologies, and
- Chapter 3 sets out the legal requirements and commitments for applying SEA.

These chapters will be particularly helpful for those practitioners with limited previous experience of SEA, enabling them to draw on international experience and good practice when designing and conducting SEA processes. There is no “blueprint” or “one size fits all” approach to SEA. But the basic stages and tasks are similar for all SEAs.

Part B: focus on specific energy sectors and associated issues. It first addresses overall energy PPPs (Chapter 4), followed by individual renewable energy sub-sectors (hydropower, wind, solar, bioenergy, geothermal, tidal, and green hydrogen/ammonia) (Chapters 5-11). It also includes a chapter addressing the retirement of coal-fired power plants and closing coal mines (Chapter 12), as this will be a key element of the transition to renewable energy for many countries. It also features a chapter on associated infrastructure (e.g., transmission lines, substations, access roads, electricity storage facilities, and terminals, ports, and harbors) and supply chains, which are critical to the energy transition (Chapter 13).

Each of Chapters 5-13 are presented in a common format:

- A short explanation of why SEA is important to the sub-sector;
- A discussion of existing guidelines/guidance for the sub-sector;
- Global installed capacity;
- A brief background to the sub-sector (e.g., types of technology in use);
- A discussion of the environmental and social issues associated with developing energy generation facilities. Each individual SEA will need to determine which are the key issues that should be focused on.

Each of the renewable energy type chapters (Chapter 5-13) contains a brief technical background to the particular type (e.g., technologies involved, installed capacity in leading generation countries) and discusses the key associated environmental and socioeconomic issues. The latter material provides a resource to support the scoping of key issues during SEAs for the energy transition.

Finally, Chapter 14 provides guidance to government institutions and other organizations likely to commission or undertake SEAs for national energy plans or PPPs as part of the energy transition.

The Part B chapters do not discuss generic SEA methodology issues (these are discussed in detail in Part A: Chapters 1 and 2); but they do address particular methodological aspects that may be specific to or particularly important for SEAs of individual types of renewable energy.

A range of annexes provide additional information and details pertinent to SEA, including Annex 19, which defines the technical terms used throughout the guidance.

It is assumed that many users will not read the entire guidance from start to finish, rather, it is more likely that individuals will look at particular chapters that interest them. For this reason, readers will find that there is some repetition of key information in different chapters. This is deliberate to ensure that important issues and context (particularly about the basics of SEA) are not missed by readers concerned only with specific chapters (e.g., those concerned with individual renewable energy sub-sectors).

The intention is that this guidance will provide the material for IAIA to develop a searchable online resource that can be regularly revised and expanded, e.g., to include case studies, additional reference material, videos, and other information relevant to the use of SEA for the energy transition.

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ALARP	As low as reasonably practicable
CBD	Convention of Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DAC	Development Assistance Committee of OECD
EC	European Commission
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
ES	Environmental Statement
ESIA	Environmental and Social Impact Assessment
ESCAP	UN Economic and Social Commission for Asia and the Pacific (ESCAP)
ESQOs	Environmental and social quality objectives
FDI	Foreign Direct Investment
GIS	Geographical information system
GLOF	Glacial Lake Outburst Flood
IAIA	International Association for Impact Assessment
I&AP	Interested and Affected Parties
IEC	Independent Expert Committee
IFC	International Finance Corporation
LAC	Limits of Acceptable Change
LPG	Liquid Petroleum Gas
MDG	Millennium Development Goal
MEA	Multilateral Environmental Agreement
NGO	Non-Governmental Organization
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
PPP	Policies, Plans, and Programs
RE	Renewable Energy
SDG	Sustainable Development Goal
SEA	Strategic Environmental Assessment
SEMP	Strategic Environmental Management Plan
SESMP	Strategic Environmental and Social Management Plan
SoE	State of the Environment Report
TOR	Terms of Reference
UNDP	United Nations Development Programme
UNECE	United National Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCC	United Nations Framework Convention on Climate Change
WB	World Bank
WTO	World Trade Organization

PREFACE

Why the energy transition needs SEA

1. A brief introduction to SEA

Across the world, environmental impact assessment (EIA) and environmental and social impact assessment (ESIA) are commonly required to be undertaken for individual development projects. Strategic environmental assessment (SEA) is a higher-level tool for assessing the environmental and socioeconomic risks and impacts of the policies, plans, and programs (PPPs) that subsequently give rise to individual development initiatives and projects. For example, a hydropower sector PPP can promote investments in cascade hydropower schemes along a river or in a basin as well as associated infrastructure, such as transmission lines and access roads. Each of these developments will give rise to environmental and socioeconomic impacts (both positive and negative), and in combination with other developments, they will also lead to cumulative impacts on valued environmental and social components.

Project-level EIA/ESIA usually only considers the impacts associated with individual developments or projects, and it may also consider cumulative impacts arising from the combination of individual projects as part of the project regulatory application. However, it doesn't consider the bigger picture at a regional level of planning for multiple developments prior to decisions being made on individual projects. This is the role of SEA. It can help with the planning and positioning of individual development projects/schemes. SEA also looks at alternatives to the policies, programs, and plans (PPP) concerned, helping decision-makers to choose the technologies to be allowed/encouraged, the best locations for facility siting, and the identification of go-no-go areas.

Chapter 1 provides a more extensive introduction to SEA, and Chapter 2 sets out details of how it is undertaken and the steps involved.

2. We need to consider the bigger picture and avoid unintended consequences

The transition away from fossil fuels to renewable energy sources aims to reduce emissions of CO_2 and other greenhouse gases, a key driver of climate change. But it is important that in considering all phases of the energy transition (including retiring coal-fired power plants, closing coal mines, and developing renewable energy sources), we do not overlook that these actions may also give rise to unforeseen environmental and socioeconomic consequences that can undermine human well-being, impede achieving sustainable development, and contribute further to breaching planetary boundaries.[4] We must plan to manage these adverse consequences while at the same time maximizing the benefits and opportunities that a transition to renewable energy brings.

There are some notable examples of major environmental and social disasters that had their causes in poor planning, a lack of foresight, and failure to take a strategic view, e.g.,

- The ***Dust Bowl*** was a period of severe dust storms that greatly damaged the ecology and agriculture of the American and Canadian prairies during the 1930s. The phenomenon was caused by a combination of natural factors (severe drought) and manmade factors (a failure to apply dryland farming methods to prevent wind erosion, most notably the destruction of the natural topsoil through deep plowing by settlers in the region and replacing native grasses that were able to trap moisture and sustain grazing). Some 400,000 km^2 of land were laid bare, affecting many thousands of families.[5]

[4] The concept of nine planetary boundaries within which humanity can continue to develop and thrive was introduced by Rockstrom *et al*. (2009). In September 2023, a team of scientists quantified, for the first time, all nine processes that regulate the stability and resilience of the Earth system: climate change*, novel entities*, stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, biogeochemical flows*, freshwater change*, land system change*, and biosphere integrity*, six of which (marked *) have now been breached (Richardson et al., 2023)

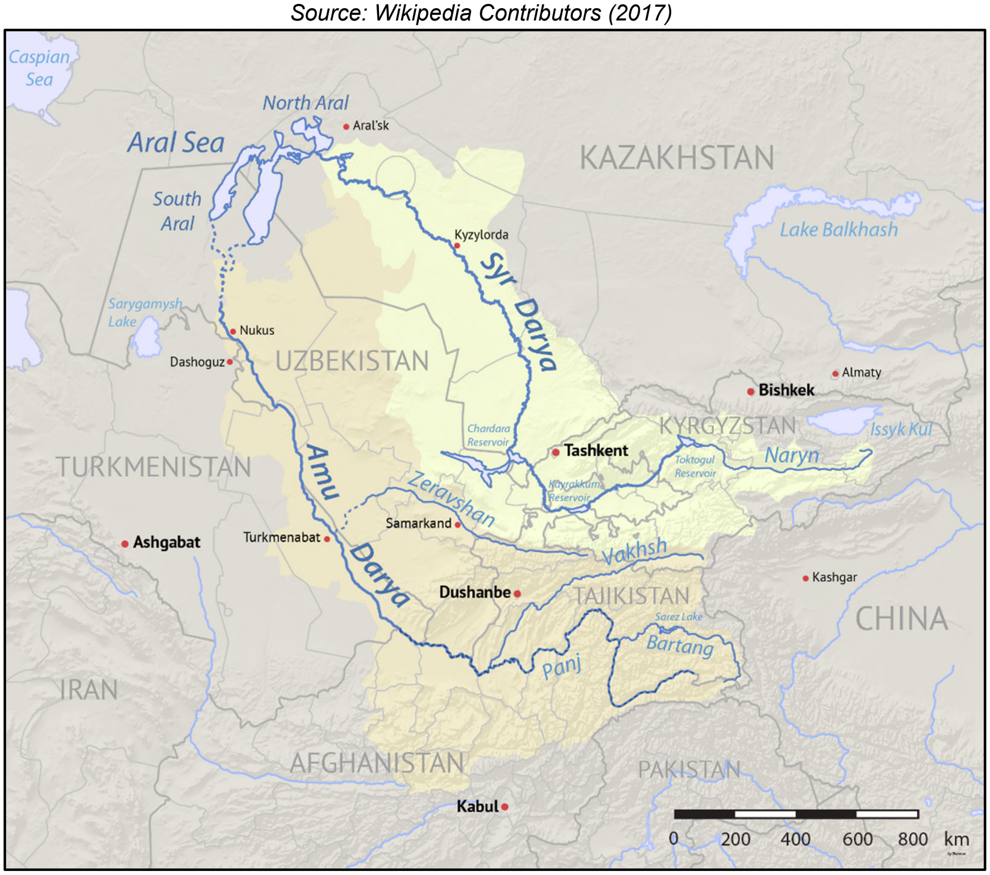
[5] History.com (2023)

- ***Land degradation/desertification***. The Sahel region once supported vast trading empires, where people were prosperous and developed extensive agricultural and livestock practices. The fragile ecosystem was unable to sustain its growing population. Increased pressure on the land and poor resource exploitation practices made droughts more ruinous, leading to a loss of grazing land, huge losses of livestock, famine, and migration/refugees. The increase of grazing and agriculture, promoted by governments to maximize economic returns (but without any strategic assessment of the likely consequences) and the farmers themselves in rainy periods, caused systematic overexploitation of the land well above its average capacity to provide water and pasture.[6]

- ***Shrinking of the Aral Sea*** – once the fourth largest inland sea in the world, with a vibrant fishing industry (e.g., high-value sturgeon and value-adding associated canning industries). In the 1950s, the Soviet Union decided to divert water from two feeder rivers of the Aral Sea lying between Kazakhstan to its north and Uzbekistan to its south (Figure 1). The water was used for irrigated and mechanized cotton, wheat, and rice production (monoculture) on low-lying plains with poor, shallow soils and low rainfall – an area traditionally used by nomadic pastoralists.

Figure 1: Major rivers diverted for irrigated agriculture schemes in Kazakhstan and Uzbekistan

Source: Wikipedia Contributors (2017)



A consequence of this ill-planning initiative has been a shrinking of the Aral Sea to a tenth of its original extent (Figure 2). This has led to: the salinity of the remining sea increasing by 300%; the fishing industry entirely collapsing by 1982 (Figure 3); changes to the local climate – the sea no longer acts as a barrier to cold wind, leading to a considerable reduction in cotton and other

[6] Schmidt, L. J. (2001)

crops; the loss of most birds and mammals; entire villages and towns abandoned; and the incidence of throat cancer amongst local inhabitants rising to nine times higher than world average. It is estimated that it would require US$300 billion to restore prior ecological functioning, which may not even be fully recoverable.[7]

Figure 2: The shrinking of the Aral Sea
Source: Wikipedia Contributors (2014)

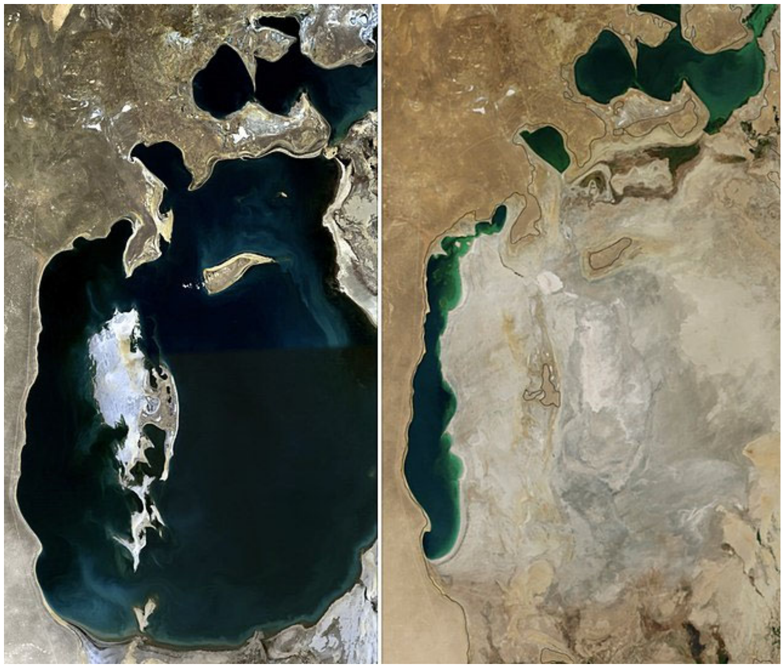


Figure 3: Dry Aral Sea bed and stranded fishing vessels
Source: Thorsten (2014)

Policies, plans, and programs to foster the energy transition are no different than any other sector development PPPs. They all usually have good intentions that aim to tackle critical issues and to increase growth, employment, and prosperity. We can no longer afford to develop and promote such

[7] U.S. Embassy in Uzbekistan (n.d.)

PPPs in ignorance of their likely environmental and socioeconomic consequences, whether positive or negative.

It is imperative that we develop a clear understanding of the potential cumulative, regional and "higher level" planning risks and impacts, their linkages, and their unintended consequences associated with the energy transition to avoid unnecessary social and environmental risks, impacts, and disasters such as those highlighted above. At the same time, we also need to identify the potential benefits and opportunities brought by the development of renewable energy sources. SEA is an internationally recognized process that can provide this understanding and identify measures to enhance benefits and mitigate against the potential negative outcomes while promoting positive ones, ideally before project-level decisions are made.

3. Benefits of SEA

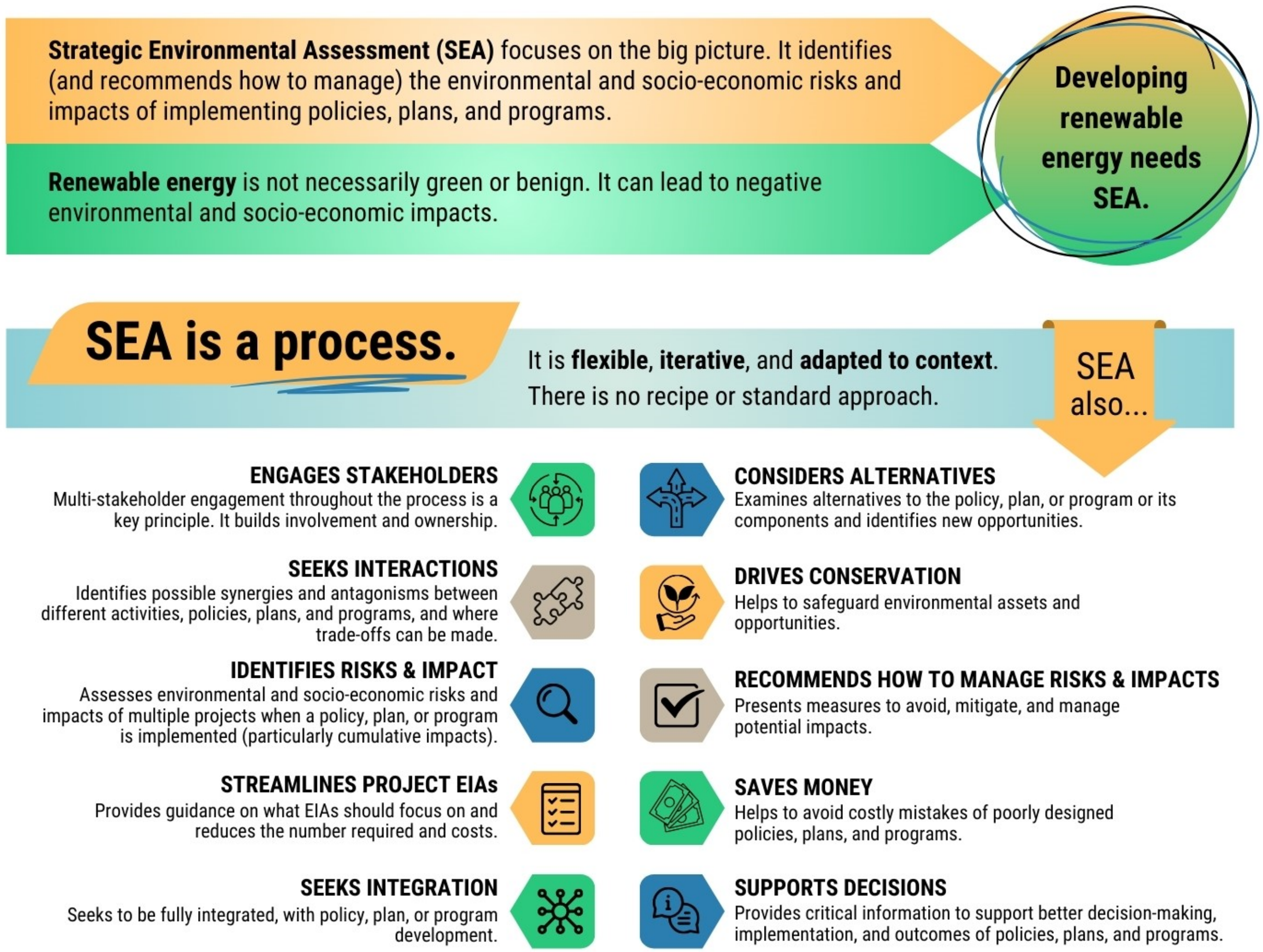
SEA has multiple benefits, not only for the environment and social settings but also in terms of the economy of a country or region. It is both a process and a mechanism to support the systematic integration of environmental, socioeconomic, and sustainability considerations in a policy, plan, or program (PPP) (Figure 4). As such, it is a key process to support countries achieve the goals of creating a green and circular economy.[8] A good SEA can yield some noteworthy benefits, including:

- safeguarding the environmental and social assets and opportunities upon which all people depend, particularly the poor and most vulnerable, thereby promoting poverty reduction;
- and supporting a gradual shift of decision-making towards genuine sustainable development, by:
  - Facilitating the identification of new opportunities for sound environmental and social management;
  - Facilitating improved consideration of environmental and socioeconomic considerations (including health) and limits in the formulation of a PPP;
  - Considering alternatives, and
  - Encouraging the search for win-win options that open opportunities for new developments (a) within the carrying capacity of ecosystems or (b) within the tolerance of social systems.

Further key benefits are listed in Box 2.

[8] A model that seeks to reduce the consumption of finite resources and the generation of waste and pollution by keeping products, components, and materials in use for as long as possible.

Figure 4: SEA supports developing more sustainable policies, plans, and programs



Box 2: Key benefits of SEA

***SEA increases efficiency of elaboration of PPPs and improves the PPP decision-making process and development outcomes by*:**

- Enabling the identification of PPP development options that perform well against environment and socioeconomic quality objectives, supporting a shift towards sustainable development;
- Warning decision-makers and the public about potentially unsustainable development options, which can help to prevent costly mistakes and conflicts, particularly over the use of natural resources;
- Providing environmentally and socially based evidence to support informed decisions;
- Providing insights into the trade-offs between such environmental and socioeconomic issues, which increases the chances to find solutions that benefit all stakeholders;
- Identifying new environmental and socioeconomic benefits and opportunities;
- Streamlining decision-making systems by reducing the complexity of environmental and social issues at the different stages of decision-making hierarchies;
- Supporting project-level decisions as these can be based on a previously optimized PPP;
- Identifying and addressing potential areas of antagonism, conflict, or inconsistency between PPPs early in the PPP formulation process and thereby preventing costly mistakes; and identifying synergies between PPPs that can deliver win-win opportunities.
- Improving governance by integrating public consultation in strategic-level decision-making;
- Identifying where changes are needed to the existing legal and regulatory framework;
- Improving inter-institutional coordination and implementation of complex decisions;
- Facilitating transboundary cooperation;
- Identifying monitoring requirements and follow-up measures to ensure effective implementation of PPPs that address SEA recommendations, and
- Improving understanding of cause-effect relationships through monitoring PPP implementation.
- Engaging governments to make early planning-level decisions and provide guidance for project proponents.

SEA improves public trust in government policymakers

- SEA allows stakeholders and the public to express their views on the proposed PPP during the consultation process, increasing the overall transparency of strategic decision-making.
- It improves public confidence in the SEA process by incorporating stakeholders' comments and opinions in a meaningful way that impacts decision-making;
- As a result, this helps policymakers and decision-makers gain public trust and credibility in the planning process.
- Furthermore, a properly executed and accountable SEA also enhances the credibility of policies, plans, and programs, and potentially helps to mobilize key stakeholders to support their enactment.
- SEA and EIA allow for the mitigation of both local as well as regional environmental and social problems. Such mitigation is more likely to be successful if proposed measures enjoy the support and agreement (mandate) of stakeholders achieved through their engagement early on in the SEA process.
- It also provides for a monitoring and follow-up process to track and ensure that SEA recommendations are implemented.

SEA strengthens and streamlines project-specific EIAs by:

- Addressing a wider range of alternatives than is normally possible in project EIA, including through the use of scenarios;
- Considering cumulative effects and relatively large-scale environmental and social changes that are difficult to address in an EIA;

- Exploring the opportunities for and constraints to development posed by the broader receiving environment, thus ensuring development is sustainable within identified limits
- Assisting in defining and maintaining a chosen level of environmental and social quality objectives;
- Identifying ways to foster inter-institutional coordination, which is often not possible at the level of project EIA, while identifying constraints to doing so.
- Supporting planning for sustainable development and rational land use planning avoiding "overcrowding" and providing a tiered approach to avoiding exceedance of thresholds and carrying capacity.
- Making mitigation and management recommendations that should be addressed by EIAs for individual projects.

Government regulators and Environment Departments in many countries are overburdened by the volume of project EIAs being submitted and requiring their review and approval. It is not uncommon to see piles of such reports in offices awaiting attention. As indicated above, SEA is closely linked to EIA. They are part of a spectrum of impact assessment approaches. They can feed information and support each other. SEA can take information and lessons learned from multiple EIAs. But they can also streamline EIAs, reduce the numbers required, and cut costs by:

- Ruling out the need for EIAs of particular activities or project types that will not be permissible under a PPP;
- Identifying the most appropriate areas/scenarios for development ("go-or-no-go"' zones), such that the priority issues for EIA have already been identified and minimized (e.g., through appropriate siting of leasing areas). This means that EIA alternatives assessment is essentially the identification of the optimal feasible solution in terms of project-level environmental and social impacts and mitigation;
- Identifying major issues at the strategic level and indicating where only additional or site-specific information may be required for the individual project;
- Identifying and assimilating a broad array of information and data that is subsequently available to project EIAs, thus reducing their costs and effort involved;
- Helping to standardize approvals and improve environmental and social performance;
- Suggesting elements for project EIA terms of reference, and
- Managing cumulative impacts of individual projects at a regional level.

SEA helps to save time and money and prevent costly mistakes

SEA provides precautionary signals that help to warn decision-makers at an early stage about environmentally and socially unsustainable development options. Ultimately, this saves time and money as problematic options are disregarded and only a few resources are spent on their development. The decision-making process also becomes less time-consuming and efficient as planners are effectively able to gather and analyze inputs from relevant stakeholders in a timely manner. It also saves the cost of remediation of future environmental disasters that would occur due to unsustainable development strategies.

SEA strengthens governance

Documenting the PPP development process through an SEA increases the overall transparency and credibility of strategic decision-making and allows the early consideration of the opinions of key stakeholders in the planning process. Properly undertaken and accountable SEA enhances the credibility of PPPs by strengthening the governance of individual government institutions and fostering cooperation and coordination between them. It may mobilize public support for implementation, as a PPP will naturally be far more effective when the values, views, opinions, and knowledge of the public have truly become part of the decision-making process. Thus, an SEA helps to build an overall "enabling environment" for sustainable options.

4. Why success is not necessarily optimal

SEA has not always been as successful in its implementation as it could be. There are many reasons for this:

- Government often does not have the internal capacity nor budgets available to undertake SEA, yet alone to do it themselves;
- Lack of baseline environmental and social data required for meaningful decision-making;
- Lack of political will or inertia to initiate SEA;
- Political and economic pressure to proceed with individual project developments prior to putting a strategic planning framework in place;
- Lack of coordination and being “out of sync” with private sector development;
- Many government departments work in silos with little opportunity given for inter-institutional cooperation and coordination;
- Lack of adequate or effective public consultation, and
- Failure to implement SEA recommendations and lasting follow-measures.

5. How government institutions and other organizations can use SEA to support the energy transition

Usually, it will be national government departments (particularly those responsible for energy) that will need to consider commissioning or undertaking an SEA to support decision-making regarding the energy transition in the country. This could be for:

- A national energy plan, policy, program, or strategy, likely to include both existing energy-generation sources, methods, and technologies, as well as promoting one or more renewable energy options;
- A PPP for particular energy/renewable energy sector (e.g., hydropower, wind, solar, geothermal, bioenergy, tidal, or other options such as green hydrogen), and
- A PPP for multiple renewable energy sectors in combination with closure of fossil-fuel power generation, mines, and supply chains.

Funding agencies, particularly multilateral development banks, may also require an SEA to be carried out to satisfy safeguard requirements linked to funding support for the energy transition.

An important factor is that achieving the energy transition will involve multiple government ministries and agencies, and this will require the involvement and “buy-in” of private sector energy companies and investors as well as the public. This makes it a complex process with a wide array of participants with different political and economic interests, each of which has their own agendas, policies, and responsibilities. Mechanisms will be needed to ensure that all such stakeholders are engaged, can contribute their perspectives, and have a role to play.

Another merging area of parallel interaction is the Just Transition, making sure that no-one is left out of the energy transition (see Section 5).

SEA should also be of interest to the private sector to help major investors weigh up their options and plan for developing renewable energy sources. By having an SEA in place, approved by stakeholders and governments, prior to the issuance of licenses for renewable energy projects, this can increase investor confidence that individual projects can proceed with minimum delay and setback due to unresolved environmental and social issues.

Box 3 summarizes the relevance of SEA for governments, energy companies and developers, and affected communities.

Box 3: Relevance of SEA for key stakeholders in the energy transition
Source: Adapted from MER/IGF/IISD (2024)

For governments

The use of SEA helps to balance multiple interests in relation to energy transition developments and the planning/construction of associated infrastructure. For example, it can:

- Lead to better preparedness and strategic governance in managing biodiversity and natural resources;
- Ensure that all interests in the energy transition are considered and protected, including vulnerable groups and those who normally do not have a voice in the planning process;
- Provide clarity on the tasks that need to be carried out, with a clear division of responsibilities between government agencies and private sector partners, and
- Offer a clear view of the concerns and aspirations of other stakeholders in society and ensure more transparent decision-making, which usually will enhance support.

For energy companies and developers

- Carrying out an SEA for the energy sector as a whole or for energy planning in a particular region in which companies are interested in investing in renewable energy development can lead to more sustainable and cost-effective projects;
- An SEA may identify the most suitable areas for investments, preventing costly mistakes (such as those caused by water scarcity);
- It can engage local stakeholders, which may build support for renewable energy projects and could prevent resistance or conflict, particularly if shared benefits can be provided, and
- Research and assessment undertaken as part of SEA baseline studies can also be used for project-specific ESIAs, saving time and money.

This all helps to secure effective investment in the renewable energy sector while maximizing the benefits for companies and society.

For affected communities

- An SEA may lead to renewable energy initiatives making a better contribution to regional and national development while minimizing the negative consequences.
- Vulnerable groups and the ecosystem services they usually depend on may receive the attention they require through their active involvement and consideration in the SEA process.

While SEA laws and regulations have been promulgated in more than 100 countries around the world, awareness of the process, its modalities, and its benefits remains limited in line agencies. There is an urgent need to raise such awareness and provide training on the role of SEA in supporting the energy transition. Energy ministries/departments should be encouraged to send relevant officials to available SEA training courses[9] or to arrange for SEA awareness-raising and training courses to be conducted, either nationally or regionally.

Chapter 14 provides detailed guidance and tips for those government institutions and other organizations likely to commission or undertake SEAs for national energy plans or PPPs, particularly as part of the energy transition away from generating power from fossil fuels to the use of renewable energy sources.

[9] IAIA offers training courses at its annual conferences (see www.iaia.org).

6. SEA and Just Transition

Uptake of the Just Transition concept

Just transition (JT) is a requirement of the energy transition. The concept was first used in the 1980s by US trade unions to protect workers affected by new water and air pollution regulations. The trade union movement developed JT as a framework to encompass a wide range of social interventions needed to secure workers' rights and livelihoods for those economies shifting to sustainable production, primarily combating climate change and protecting biodiversity. In recent years, the concept has gained traction with reference to meeting climate goals by ensuring the whole of society – all communities, all workers, all social groups – are brought along in the pivot to a net-zero future and that no one is left out of it.[10] It is highly relevant to the energy sector, as the shift from fossil fuels to renewable and low-carbon energy will entail loss of jobs in some sectors and creation of jobs in others.

The International Labour Organization (ILO) defines JT as "*greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities, and leaving no one behind*."

JT often seeks to unite social and climate justice, for example, for coal workers in coal-dependent developing regions who lack employment opportunities beyond coal when transitioning to other forms of renewable energy.

A number of organizations have used the concept of a JT with respect to environmental and/or climate justice.

With regards to climate change mitigation, the IPCC defines JT as "a set of principles, processes, and practices that aim to ensure that no people, workers, places, sectors, countries, or regions are left behind in the transition from a high-carbon to a low-carbon economy."[11]

Language regarding JT and the creation of decent work is included in the Preamble to the UN Paris Agreement agreed at the UN Climate Change Conference in 2015 (COP21). The importance of JT was subsequently highlighted in the Solidarity and Just Transition Silesia Declaration adopted at the 2018 UN Climate Change Conference in Katowice, Poland (COP24). The Declaration encourages all relevant UN agencies to proceed with its implementation and consider the issue of JT when drafting and implementing parties' nationally determined contributions, or NDCs.

At COP26 in Glasgow, the European Investment Bank announced a set of ***JT common principles*** agreed upon with multilateral development banks, aligning with the Paris Agreement. The principles refer to focusing financing on the transition to net zero carbon economies while keeping socioeconomic effects in mind, along with policy engagement and plans for inclusion and gender equality, all aiming to deliver long-term economic transformation.

A number of multilateral development banks have vowed to uphold the principles of climate change mitigation and a JT.[12]

The relationship between SEA and the Just Transition

SEA and JT can be seen as having parallel and complementary aims. They both seek to address the environmental and socioeconomic impacts and opportunities brought about by the energy transition, but with differences in focus. SEA is concerned with the environmental and socioeconomic effects of PPPs, while JT mainly emphasizes social concerns (employment, livelihoods, health, and safety) largely at the asset level.

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[10] UNDP (2022)
[11] IPCC (2022)
[12] Wikipedia contributors (2024b)

SEA is not specific to the energy transition. It is a process that supports policy-making and strategic planning across many sectors where the environmental and socioeconomic benefits, risks, and impacts of development decisions need to be assessed.

As applied to the energy transition and to individual (sometimes multiple) sectors, SEA provides a high-level assessment of government energy-related policies, plans, or programs (PPPs). It is not concerned with individual energy assets or projects. Those are the focus of project-level environmental and social impact assessment (ESIA). SEA aims to identify the potential environmental and socioeconomic benefits, negative risks, impacts of the energy transition, and the potential opportunities to promote sustainable development through the energy transition. The SEA produces a Strategic Environmental and Social Management Plan (SESMP) recommending how the opportunities, risks, and impacts of the energy transition can be managed by the responsible implementing agencies and others.

In contrast, a just energy transition can have both a strategic and asset/project-level focus. Its focus is on the process of transitioning to a low-carbon and sustainable economy in a way that is fair and equitable for all stakeholders, including workers, communities, and vulnerable populations. Special attention is paid to energy poverty. It involves ensuring that the benefits and costs of the transition are distributed fairly and that workers in industries that are being phased out are not left behind or worse off. The outputs of assessments concerned with JT identify specific social interventions required to minimize social, economic, labor, and health and safety risks of the energy transition at both a strategic and asset level. There have been calls for the JT to also include more consideration of environmental risks.[13]

While these analyses are different with regard to their outputs, the data and information derived from both JT and the SEA processes should be mutually supportive. The findings of the JT can also help inform the SEA process for the energy transition.

The relationship between JT and SEA lies in their shared goal of promoting sustainable development and ensuring that the benefits, risks, and impacts of decisions about energy distribution are distributed fairly amongst all parties. SEA can be used to assess the potential benefits and impacts of a JT plan and to identify ways to ensure that the transition is fair and equitable for all stakeholders. Similarly, assessments for JT in a country can inform the development of SEA by highlighting the needs and interests of workers, communities, and vulnerable populations.

In short, both JT and SEA are important vehicles for promoting sustainable development and ensuring that the benefits, risks, and impacts of decisions regarding the energy transition are distributed fairly among all those involved.

[13] Abram et al. (2022)

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 1

BACKGROUND TO STRATEGIC ENVIRONMENTAL ASSESSMENT

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July 2024

Updated October 2024

Version 1

IAIA
International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 1

BACKGROUND TO STRATEGIC ENVIRONMENTAL ASSESSMENT

1.1 WHY WE NEED SEA

Governments are responsible for setting the strategic direction of development in a country. They do this mainly through preparing policies, plans, and programs (PPPs). In the past, the development of such PPPs tended to give only limited attention to the impacts their implementation might have on environmental or social factors. The assessment of impacts was mainly left to when individual development projects were promoted during PPP implementation through project-level environmental and social impact assessments (EIAs/ESIAs). But such assessments focused mainly on the immediate and local impacts of those individual projects and did not focus on the big picture, and they rarely addressed the cumulative impacts likely to result from other development projects. As a result, PPPs sometimes led to unforeseen and significant, widespread environmental and social impacts that were very costly to address or, in some cases, led to critical social consequences and irreversible environmental damage.

In the late 1980s and 1990s, the need to assess the environmental and social risks and impacts of implementing policies, plans, and programs was recognized, and a number of countries began to introduce strategic environmental assessment (SEA) as a separate process from EIA (e.g., Australia, Canada, Denmark, Netherlands).

SEA is now globally recognized as one of the most useful processes to promote sustainable development. The preface to this guidance provides a rationale for why the energy transition needs SEA. Chapter 3 provides a discussion of the legal and institutional basis for SEA (see also Section 1.11).

1.2 WHAT IS SEA AND HOW DOES IT DIFFER FROM ENVIRONMENTAL IMPACT ASSESSMENT (EIA) AND CUMULATIVE IMPACT ASSESSMENT (CIA)

SEA is defined as a process for assessing the environmental and social risks and impacts of implementing policies, plans, and programs (PPPs), and providing information to decision-makers so that the implications of such impacts can be considered and responded to when formulating and implementing PPPs[1] (Box 1.1). But SEA can also be usefully applied in circumstances where no actual PPP has yet been prepared (e.g. to assess the impacts of options for renewable energy development). The basic stages and elements of SEA are elaborated in Chapter 2.

While the term SEA does not specifically incorporate the social dimension, this is nevertheless an integral focus of the process.[2] To indicate clearly that social considerations are fully included in SEA, some organizations (particularly multilateral development banks) prefer to use the synonymous term Strategic Environmental and Social Assessment (SESA). In this guidance, the term SEA is used, as this is overwhelmingly used in individual countries in legislation and regulations.

The scope of application of SEA collectively encompasses policy, legislation, plans, programs, and development-related strategies across a range of sectors (such as energy or transport), geographical areas (national, regional/provincial, or local/municipal), or issues (such as climate change or biodiversity). But SEA is most commonly, although not exclusively, applied to development-related PPPs with a particular focus on the energy, transport, waste, and water sectors, and spatial and land use zoning plans. Lead government agencies usually initiate the SEA process, but external financing organizations (e.g., multilateral development banks and bilateral donors) may also require an SEA to be undertaken to comply with their safeguard policies.

[1] OECD-DAC (2006)
[2] In the past, some statutory bodies required that SEA should focus only on environmental issues.

Box 1.1: The purpose of SEA

The purpose of SEA is to ensure that environmental and social considerations (and their relationship with economic concerns and drivers) inform and are integrated into strategic decision-making in support of environmentally and socially sound and sustainable development. Thus, SEA identifies the relevant environmental and social effects/impacts (both positive and negative) on receptors[3] of implementing a PPP.

In particular, the SEA process assists authorities responsible for PPPs, as well as decision-makers, to consider:

- Key environmental and social trends, opportunities, and constraints that may affect or may be affected by the PPP;
- Environmental and social objectives and indicators that are relevant to the PPP;
- Likely significant environmental and social effects of available options and alternatives in the implementation of the PPP, including under different scenarios;
- Priority environmental and social receptors;
- Measures to avoid, reduce, or mitigate and manage adverse effects and to enhance positive effects, and
- Views and information from relevant authorities, the public, and — as and when relevant — in potentially affected neighboring countries (e.g., where cross-border initiatives or impacts are involved).

In the context of applying SEA to PPPs concerned with the energy transition, a core aim of SEA is to support spatial planning by identifying areas where renewable energy development and associated infrastructure (e.g., transmission lines, access roads, electricity storage facilities, and ports, harbors, and terminals) may pose a high risk. SEA especially can identify areas of high environmental and social sensitivity, and recommend how such risks can be mitigated and managed.

Generally, the application of SEA within a country depends on the types of PPPs being undertaken and the specific SEA provisions (laws and regulations) of that country.

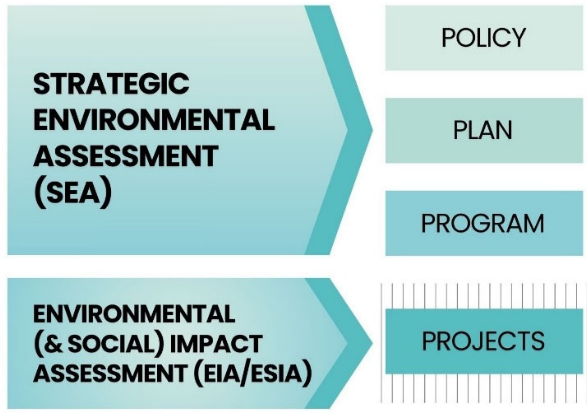
The SEA process is based on key principles (see also Section 1.4), including:

- Early proactive consideration of the environmental and social effects of strategic actions;
- Broad institutional and public engagement;
- Analysis and integration of qualitative and quantitative information;
- Early warning of potential cumulative effects and large-scale changes, and
- Identification of best practicable options for implementing the PPP, including projects that may be undertaken as a result of their implementation.

As noted by the OECD/DAC guidance for SEA (2006), there is a hierarchy of levels in decision-making comprising policies, plans, programs, and projects (Figure 1.1). Logically, policies shape the subsequent plans, programs, and projects that put those policies into practice. Policies are thus at the top of the decision-making hierarchy. Policies, plans, and programs (PPPs) are more “strategic” than projects as they determine the general direction or approach to be followed towards broad goals.

[3] A receptor is a component of the environment or social fabric that could be adversely affected by causal factors (e.g., pollution, dust) due to implementing a PPP, e.g., habitats, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape, communities, people, livelihoods, human health, rights, etc.

Figure 1.1: SEA, EIA and the decision-making hierarchy



SEA is applied to these "higher" strategic levels and deals with assessing broadly defined proposals with a wide range of options usually available for assessment. As one moves down the hierarchy from policies to projects, the nature of decision-making changes, as does the type of environmental assessment needed. Environmental Impact Assessment (EIA)[4] is used to assess the impact of projects that put PPPs into tangible effect. It is done at the project level and deals with assessing well-defined proposals where a limited range of alternatives are usually available to assess.

SEA can provide the strategic framework for many projects likely to arise when a PPP is implemented. It identifies key environmental and socioeconomic issues that individual EIAs/ESIAs should address in more detail, providing site-specific or localized detail. Thus, SEA streamlines the EIA scoping requirements. It can also eliminate the need for EIAs/ESIAs for numerous small, similar types of projects that may be likely to address similar suites of issues, and enable such projects to require only an Environmental and Social Management Plan (ESMP).

There is no one approach to SEA. Rather, it embraces a family of approaches (on a continuum of increasing integration of environmental, social, and economic considerations) and uses a variety of tools. This contrasts with EIA, which tends to follow a single, fixed, prescriptive approach. SEA extends the aims and principles of EIA further upstream in the decision-making process, beyond the project level, when major alternatives to a project are still possible. It fills a critical gap left by the relatively codified procedures and process of project-level EIA in that SEA uses much more flexible, adaptive, and diversified approaches to inform strategic decision-making at the PPP level. In other words, there is no single recipe for an SEA. Every SEA needs to be tailor-made, designed, and undertaken in a manner that suits the specific context and needs. Indeed, the process design may even need to change during execution of the SEA, e.g., if political circumstances change (elections), unexpected events happen (economic recession, pandemic), or new insights arise that may require different choices (climate projections). Such events may provide a reason to reconsider the process and redo a number of SEA steps. Good SEA needs to adjust to such apparently erratic but unavoidable occurrences, either when the SEA is a parallel process or is fully integrated into the PPP process (see Figure 1.4).

SEA can complement and strengthen EIA at the project level by:

(a) Identifying prior information needs and potential impacts and providing the planning context and parameters for subsequent EIAs of projects designed to implement a PPP.

[4] As with SEA, EIA should address both the environmental and the social dimensions of projects. Some organizations prefer to use the term Environmental and Social Impact Assessment (ESIA) to emphasize this point. However, sometimes, stand-alone social impact assessments (SIA) are undertaken as well as other more focused (spin-off) forms of impact assessment such as biodiversity impact assessment and health impact assessment. Good practice EIA should cover all these aspects.

(b) Providing guidance on the "type" of projects that would be appropriate to be undertaken when implementing the PPP given the environmental and socioeconomic risks and potential impacts identified by the SEA. In contrast, an EIA assesses the potential impacts of a project on the receiving environment and social setting.

(c) Making EIA and the project review process more streamlined and efficient by addressing many issues at a higher strategic level, including concerns that may relate to project justification so that EIAs can be designed to focus on local and site, or project-specific concerns.

Table 1.1 compares and contrasts SEA and EIA and summarizes their roles in decision-making.

Table 1.1: SEA and EIA compared

SEA	EIA
Applied to PPPs and sometimes legislation, with a broad and long-term strategic perspective.	Applied to specific and relatively short-term (life-cycle) projects and their specifications.
Ideally takes place at an early stage in strategic planning.	Takes place at early stage of project planning once parameters are set.
Considers a broad range of alternatives to the PPP or alternative scenarios for a PPP, taking into account environmental and socioeconomic objectives.	Considers limited range and types of alternatives - those for achieving the objectives of the individual project.
Conducted independently of any specific project proponent.	Usually prepared and/or funded by the project proponent.
Assesses the environmental and socioeconomic opportunities and benefits, and the risks and potential impacts of implementing a PPP, and provides guidance on the types of downstream projects that would therefore be suitable/not suitable.	Assesses the potential impacts of a particular project on the receiving environment and social setting.
Focus on policy, plan, and program implications for future lower-level decisions.	Focus on obtaining project approval, and rarely with feedback to policy, plan, or program consideration.
Multi-stage, iterative process with feedback loops.	Well-defined, linear process with clear beginning and end (e.g., from feasibility to project approval).
May not require an SEA report in a formally prescribed format (as there is no single approach to SEA). Sometimes may require that a draft PPP include an environmental statement.	Preparation of an EIA document with prescribed format and contents is usually mandatory (EIA usually follows a standardised approach). This document provides a baseline reference for monitoring.
Emphasis on avoiding environmental and social impacts and meeting sustainability objectives in policies, plans, and programs. Includes identifying macro-level development outcomes.	Emphasis on mitigating environmental and social impacts of a specific project, but with identification of some project opportunities, off-sets, etc.
Should incorporate consideration of cumulative impacts relating to implementation of PPPs.	Considers cumulative impacts of a particular project in combination with all other projects and activities in a given time and space.

1.3 SEA AND CUMULATIVE IMPACT ASSESSMENT (CIA)

Cumulative impact assessment (CIA) is typically applied at the individual project level as part of the environmental impact assessment process (EIA). It is often used to assess how the specific (and possibly limited) impacts of an individual project (pressures/stressors), when combined with other projects and activities (including, for example, in the same geographical area or acting on the same receptor), might combine to generate significant cumulative impacts on selected valued environmental and social components (VEC)[5] (receptors) in a given time and space.

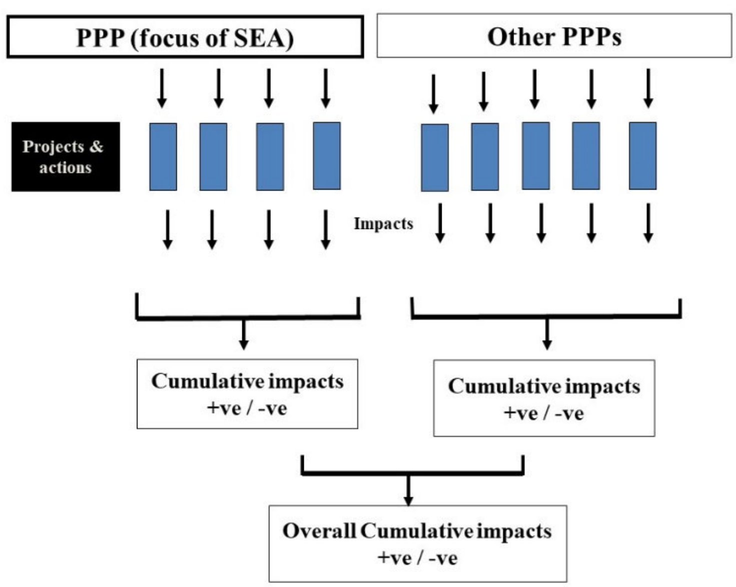
Sometimes, regional impact assessments are needed to identify the cumulative effects that various projects or actions can produce at a regional level beyond the individual project level. The identification, evaluation, and management of such impacts is normally done under an SEA process.

Any pressures or stressors on a receptor will contribute to its state at the time of assessment. But when developing and implementing a PPP (through multiple projects), it is critical to have a perspective on how receptors will be affected in the future. This is why CIA is a core, fundamental component, and a key principle of SEA by setting thresholds for future projects for environmental and social factors. These thresholds can then be used by project-level EIAs in a much more effective and robust way than can be achieved by “traditional” project-level CIA.

Guidance is being prepared by The Biodiversity Consultancy and IUCN plus a range of industry and NGO partners to address this gap between current and future pressures/stressors on receptors in the context of the renewable energy transition. If CIA is done well at the strategic level, developers can integrate the identified thresholds directly into ESIA in a much more robust way than can be achieved via 'traditional' project-level CIA-in-ESIA.

SEA seeks to identify and recommend management measures for the impacts on selected VEC that are likely to arise from implementing PPPs or their alternatives. Figure 1.2 indicates how a particular PPP (being subjected to an SEA) will lead to a range of projects and development actions (to develop renewable energy and associated infrastructure), each of which may give rise to impacts (environmental and/or socioeconomic, and positive or negative).

Figure 1.2: The cascade of cumulative impacts



[5] See Annex 19 for definition of VEC

Projects and actions resulting from implementing other renewable energy PPPs as well as PPPs for other non-energy sectors may also give rise to such impacts. The overall cumulative effective of all such impacts may be considerable.

Thus, as an example, if the implementation of a renewable energy PPP (through a future suite of projects and associated infrastructure) is assessed to have significant potential cumulative impacts in a particular geographical area or nationally (e.g., by destroying habitat for endangered wildlife species), these impacts may be even more significant (and may even threaten extinction of a species in an area or nationally) when the cumulative impacts arising from developments in other, non-energy sectors, are also taken into account. Thus, an SEA must look beyond the specific energy transition PPP it is concerned with and consider whether implementing other energy PPPs, as well as non-energy PPPs, may compound potential cumulative impacts. Done well and early enough, SEA can avoid the cumulative impacts of multiple individual renewable energy projects by providing siting criteria before individual project-level decisions are made.

Through addressing potential cumulative impacts, an SEA can recommend overall mitigation requirements, including acceptable thresholds of impacts that should apply to individual projects. However, managing and mitigating impacts at the project level so that they remain below a threshold is the responsibility of the individual project developer(s) (which should be monitored via the appropriate regulatory process). Managing cumulative impacts beyond the project level requires collaborative actions between multiple parties and coordination by a responsible agency or regulator to be successful.

1.4 BASIC OBJECTIVES AND PRINCIPLES FOR SEA

SEA aims to systematically integrate environmental and social considerations (and their relationship with economic concerns and drivers) into policy-making, planning, and decision-making processes to better ensure that a proposed PPP is compatible with sustainable environmental and social management. It aims to support time-efficient and cost-effective development planning by avoiding the need to reassess some issues and impacts at the project level at a time when changes to the overarching policy and planning framework is more difficult (e.g., when an issue or impact was effectively dealt with at a strategic level).

Early suggestions for SEA principles have been made[6] and performance criteria for SEA were developed by IAIA in 2002.[7] The latter concentrate primarily on procedural aspects of an effective or good quality SEA. Building on these, SEA Guidance developed by the OECD Development Assistance Committee provides a set of SEA principles which have broad support.[8] They recommend that to be influential and help improve policy-making, planning, and decision-taking, an SEA should:

- Establish clear goals;
- Be integrated with existing policy and planning structures. Ideally the SEA process/steps should be aligned closely with the planning process so that key information is provided at the critical stages of policy-making and planning, in the right (usable) manner and delivered to the appropriate decision-makers to support them in their roles/tasks (see Box 1.2);
- Be flexible, iterative, and customized to context;
- Analyze the potential effects and risks of the proposed PPP and its alternatives (including the “do-nothing” option) against a framework of environmental and social quality (sustainability) objectives, principles, and criteria at an early stage when all options are still being considered;
- Evaluate environmental and socioeconomic impacts (positive and negative; direct, indirect, and cumulative; trans-boundary and other unintended consequences) and propose mitigation measures for negative potential impacts and to enhance environmental and social

[6] Sadler and Verheem (1996) and Dalal-Clayton and Sadler (1998)
[7] International Association for Impact Assessment (2002)
[8] OECD DAC (2006)

management. It should identify how to achieve the best environmental and/or social benefits while minimizing damaging environmental and/or social risks and impacts;

Box 1.2: SEA integrated with land use planning in Namibia

A ***parallel but integrated SEA model*** has been applied several times in Namibia over the past 10 years. In all cases, the SEA was commissioned to run in parallel with the development of an Integrated Rural Land Use Plan (IRLUP) for five different regions of the country. Whilst the SEA teams had their own terms of reference, they worked closely with the IRLUP teams. Combined meetings involving both teams (each comprising consultants) and the client (the Ministry of Lands and Resettlement) were held at the inception stage. These meetings enabled the teams to plan their respective activities and ensure appropriate coordination between them. Examples of combined activities included:

- Joint stakeholder consultations with rural communities (typically villages);
- Focus group meetings with government agencies and private sector interest groups;
- Baseline data gathering and sharing; and
- GIS outputs (mostly maps).

Draft IRLUP reports were shared with the SEA team, and SEA analysis was provided back to the ILRUP teams. The cross-fertilisation of evolving ideas, analyses and outcomes resulted in IRLUPs that generally incorporated sustainability thinking. It also meant that environmentally inappropriate development ideas could be ‘red flagged’ or, in some cases, scrapped altogether before the final IRLUP was compiled.

Source: Peter Tarr, SAIEA, Namibia (2024)

- Identify environmental and socioeconomic opportunities and constraints;
- Address the linkages and trade-offs between environmental, social, and economic considerations (and their relationship with economic concerns and drivers);
- Provide explicit justification for the selection of preferred options (alternatives) and for the acceptance of significant trade-offs (e.g., between different sectoral policy objectives);
- Involve key stakeholders and encourage public consultation;
- Include an effective, preferably independent, quality assurance system during the SEA process; and propose an effective, formal, independent, quality-assurance review and performance-evaluation mechanism for after SEA completion; and for monitoring of PPP outputs and environmental and social indicators;
- Be transparent throughout the process, and clearly communicate the results;
- Be cost-effective, encourage synergies, and avoid duplication of efforts; and
- Provide opportunities to build capacity to conduct SEA and to use the SEA results.

In designing effective SEA approaches, practitioners need to be aware of the following:

- Strategic planning is not linear, but rather a complex and iterative process influenced by interest groups with often conflicting interests and different agendas; it is therefore important to look for “windows of opportunity” to initiate SEA during cycles of the decision-making process and to influence and inform PPP development and decision-making. SEA needs to be flexible and responsive to these opportunities;

- Relationships between alternative options and environmental and socioeconomic effects are often indirect, so they need to be framed in terms relevant to all stakeholders (e.g., politicians, government agencies, and interest groups). One way of doing this is by linking environmental and social effects to policy priorities and the UN Sustainable Development Goals;

- Strategic issues cannot be tackled by a one-off analysis; they need an adaptive and sustained approach as strategies and policy-making take shape and are implemented;

- The value of SEA in strategic planning depends greatly on the capacity within the responsible authorities to maintain the process and act on the results, and willingness to engage with the process, and

- The success of an SEA depends upon its effective implementation which will require preparation of a strategic environmental and social management plan (SESMP – see Chapter 2, Section 2.7.2).

In practice, governments will usually need to commission a team of experts to carry out the SEA process. The team should have the right to express its professional views in the SEA Report. While the government officials developing the PPP in question should make the decisions on what to present in the final PPP, the latter should provide reference to the findings of the SEA, and it should explain how the results of the SEA were used in the development of the PPP and explain/justify why recommendations from the SEA are not accepted/incorporated, emphasizing the importance of transparency.

1.5 IMPACTS-LED VERSUS OBJECTIVES-LED SEA

Most SEAs conducted in the world are "***impacts-led***." Like EIA, they start from an existing baseline of environmental and social conditions and make predictions about how a proposed or revised PPP will change this baseline over time. They have a strong focus on assessing impacts and recommending mitigating measures to remedy the negative impacts.

Some SEAs elect to follow an ***"objectives-led"*** approach; they predict whether the PPP will help or hinder achieving a range of Environmental and Social Quality Objectives (ESQOs) (discussed in Section 2.5.1). Although the ESQOs may overlap with the PPP's objectives, they essentially act as an independent sustainability/environmental/socioeconomic benchmark against which implementation of the PPP can be tested. In situations where critical baseline data may be lacking, inadequate, outdated, or unreliable, and/or where environmental aspects are less tangible "on the ground" for spatial mapping purposes (e.g., greenhouse gas emissions), an objectives-led approach to the SEA is preferable. An objectives-led approach may also be more suitable for those PPPs that specify desired outcomes or endpoints. For such PPPs, the SEA can help evaluate whether these PPP outcomes will be impeded or aided by pursuing the ESQOs.

Impacts-led SEA is more re-active and less influential, while objectives-led SEA is more proactive and more influential.

A key consideration in deciding which of these approaches to use will be the nature of the PPP, including the level of detail and specificity. A high-level policy is likely to require an objectives-led approach as it will be impossible to assess change in the baseline and attribute impacts to the PPP. Whereas for a more geographically specific program of potential projects it is more likely that a baseline/impact approach would be possible/appropriate.

1.6 THE RELATIONSHIP BETWEEN SEA AND THE PPP PROCESS

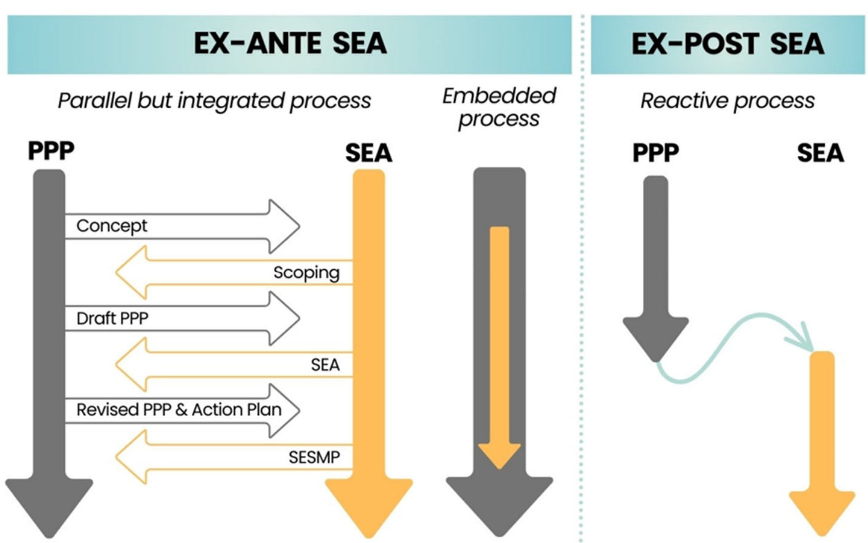
PPPs include a range of instruments, e.g., national and sectoral policies, spatial development frameworks, environmental and social management frameworks, integrated development plans, master plans, and land use plans. Frequently, SEA is formally required for such PPPs (see Chapter 3). But it can also be applied where multiple similar projects are concentrated in time and space and for very large developments or "mega projects" (e.g., transnational pipelines), which can give rise to extensive and cumulative impacts (direct and indirect) over large geographical areas. In this guidance, the latter are included under the umbrella of PPPs. In many ways, such SEAs are like regional assessments.
A critical question is: when should SEA be carried out? There are two options: *ex-ante* and *ex-post.*

- ***Ex-ante SEA***: Ideally, an SEA is most beneficial when undertaken prior to or during the preparation of a PPP (Figure 1.4). The processes of developing a PPP and undertaking an SEA should be mutually reinforcing to promote more sustainable development (as described in Box 1.2). The environmental and socioeconomic information and analysis provided by the SEA can optimally inform the preparation of the PPP, can help focus decisions on the most sustainable options, and can assist in clarifying (restructuring, rewording) PPP drafts to promote effective implementation. The SEA can identify new opportunities, particularly to maximize benefits and avoid, minimize, or mitigate negative impacts and promote positive outcomes, and can highlight where there may be potential risks, conflicts, or inconsistencies between PPPs. This can prevent the cost of rectifying mistakes.

- ***Ex-post SEA***: An SEA can also be undertaken on a PPP that has already been drafted or on an existing PPP that is already being implemented. This is a reactive process (Figure 1.4). Such SEAs are less influential on a PPP than those carried out in parallel to PPP development because there is usually less uptake of the SEA's recommendations. However, it can still be beneficial to identify environmental and social problems that have arisen and identify where modification of the PPP may be required. This is particularly useful where revision of a PPP is being considered.

No matter which "model" of SEA is followed, the desired outcome is a better PPP rather than the production of an SEA report, as well as better environmental and socioeconomic outcomes.

Figure 1.4: How SEA can relate to the PPP process



The government officials involved in developing the PPP and the team undertaking the SEA should work together, as closely as possible, be fully aware of what each other is doing, and seek opportunities to organize common events, e.g., stakeholder meetings and workshops to achieve the best possible PPP and SEA outcomes (see example from Namibia in Box 1.2). However, in many situations, SEAs are still undertaken in isolation from the process of developing the PPP to which they relate, thus reducing their utility and influence. Undertaking an SEA in isolation from the PPP process should be avoided.

Development of the PPP normally enables public authorities to analyze development trends, opportunities, and threats, and to propose development interventions and implementation arrangements. The SEA process should ideally examine individual outputs of the PPP-making process and it may propose necessary amendments to maximize their environmental and social benefits and to minimize their negative environmental and social impacts and risks. As such, the development of PPPs and the SEA process follow a very similar logic, and this is the basis for the approach recommended in this guidance.

An SEA process should be designed to fit into the logic and steps of this PPP-making process so that it delivers critical information to aid better decisions at the most appropriate points. Furthermore, the SEA process will need to be flexible and iterative so that it can be modified and adjusted as necessary, e.g., when there are changes in the process, timeline, or focus of the PPP, or even unexpected events that disturb the PPP process (e.g., sudden elections, pandemics). At the outset, it can be hard to predict how the SEA will unfold. In practice, every SEA is a learning process and needs to be capable of modification if it is found that a particular approach is working less well than expected.

Planning procedures tend to be well codified with a linear sequence of steps as suggested by the arrows in Figure 1.4. Thus, it is important to design an SEA process so that it fits with these PPP steps, which provide “windows of opportunity” for critical information generated by an SEA to support better decisions and to meaningfully influence the focus and content of the PPP. Ideally, to have maximum utility, an SEA process should be fully embedded within the PPP process so that its outcomes immediately and directly can influence PPP development without having to seek opportunities to do so. In effect, they would be a single intertwined process. But there are few, if any, examples where this is yet the case. Thus, as indicated above, SEA is currently better carried out in parallel with PPP development, with their steps aligned and integrated.

Policies are often general and directional and rarely include specified activities. So, from a procedural perspective, an SEA at the policy level will have little in common with the simple, linear, technical nature of a project-level EIA. It is also argued that SEA at the policy level also requires a particularly strong focus on institutional factors and facilitating constituency-building and strengthening of stakeholders in the policy process.[9]

There may be situations where multiple development activities in a particular sector or across a particular geographical area are reported to be giving rise to environmental and social impacts but are not currently being addressed, controlled, or regulated because a PPP has not yet been developed or is not yet proposed. In these circumstances, an SEA can be very helpful to assess and establish the nature and extent of environmental and social issues arising and to provide recommendations on policy/planning measures that could be taken to address such concerns. It can also set the stage for the project-level environmental and social impact assessments that may follow.

1.7 SCALE AND TIME REQUIRED FOR AN SEA

There is no one-size-fits-all approach to SEA. Options can vary along a spectrum from rapid to full (more detailed) assessment (compared in Table 1.2). These options are not tightly delineated and can be stand-alone exercises or undertaken in sequence. Thus, a full SEA could build on and deepen a rapid SEA. But a rapid SEA is not a required prior step to a full SEA.

There is an urgent need for the energy transition to combat climate change. In response, all around the world, we are seeing an increasing rush of project proposals for renewable energy generation. In

[9] OECD/DAC (2006) and World Bank (2011)

these circumstances, it is argued that we simply cannot wait for full-scale impact assessments to be undertaken and that a still credible but leaner process is needed.[10] Equally, for similar reasons, there is a convincing case for applying rapid SEAs to energy PPPs in the first instance to provide early, but robust, assessment information and guidance to support PPP decision-making, particularly by identifying where there are high risks of significant environmental and socioeconomic impacts. Such rapid SEAs would contribute to, and shorten, the scoping stage for subsequent full assessments.

Table 1.2: Full and rapid SEA compared
(Source: Adapted from a graphic by R. Verheem)

Stage/component	Full SEA	Rapid SEA
Overall nature and aim	• A comprehensive assessment following international principles/standards of good practice • Usually undertaken when required by law/regulation or by safeguard policies/framework of funding agencies	• Light dive aiming to provide critical information on key issues and the main likely impacts • Particularly useful where there are budget or time limitations • May point to the need for a subsequent full SEA
Timeframe and budget	• Generally, 6-12 months (sometime longer depending on complexity) • Considerably more than for a rapid SEA. Varies according to the length of the process and the complexity. Comprehensive SEAs typically average US $500,000 to US $700,000	• 1-2 months, depending on complexity • Usually a small budget (US$40-60K) to cover professional fees and venue hire
Steering/Advisory committee	• Very useful to have in the case of a complex and large SEA that spans many sectors and government agencies, and possibly also representation from the private sector and NGOs	• Not needed
Baseline studies	• Required. May be a combination of existing and new studies	• Not required, primarily desktop review
Specialist studies/research	• Additional specialist studies may be required, especially where critical data is lacking or out of date, or where seasonal issues require to be addressed	• Not required
Stakeholder consultation	• Required. This is a basic principle of SEA and should be extensive; at least two rounds during the SEA process: once during scoping to help identify key issues and enable stakeholders to present their perspectives, and again toward the end to present/discuss the findings and recommendations	• Generally, not required, except if there are directly affected parties and the impacts on them are likely to be significant • Focus group meeting(s) of key involved players
Team and resources required	• Usually a larger multidisciplinary team, with a senior team leader and other members clustered thematically	• Usually, a small team of experts from key disciplines will suffice
Process	• Starts with initial literature review, baseline study/report if literature	• Usually some initial literature review • Interactive brainstorming/workshopping within the team and possibly including a

[10] Alan Ehrlich. Presidential address to the conference of the International Association for Impact Assessment, Dublin, 27 April 2024)

Stage/component	Full SEA	Rapid SEA
	readily available. May require specialist studies (see above) • Stakeholder engagement (see above), and carefully-planned focus group meetings • Review of the legal and regulatory framework and institutional roles and capacities, interactive brainstorming/ workshopping within the team, and including key stakeholders • Can be impacts-led or objectives-led, or both. For objectives-led SEA, development of Environmental and Socioeconomic Quality Objectives (ESQOs) as basis for assessment • Consideration of alternatives and scenarios • Use of linkage diagrams to indicate impact flows and routes to cumulative impacts • Impact identification and assessment of likely impacts and significance (e.g., scoring) of alternatives/scenarios, possibly with a deeper drive for the preferred alternative/scenario • Preparation of an environmental and social management plan (SESMP)	few "outside" subject experts to add information and value • Identification of key environmental and socioeconomic issues • Development of linkage diagrams to indicate impact flows and routes to cumulative impacts • Assessment of likely impacts and significance (scoring) etc., to enable the team to quickly identify key issues, alternatives, assess likely impacts and identify measures for mitigation/impact management • Generalized management actions and road map of key actions and next steps
Report	• Usually, a substantial and well-illustrated report and SESMP with many appendices depending on the subject and context • In some cases, the key outcome is the revised PPP, rather than a comprehensive SEA report	• Usually a very brief report (10-30 pages, plus annexes) • Should include narrative and tables • Unlikely for there to be a detailed Strategic Environmental and Socioeconomic Management Plan (SESMP) but a road map of key management actions could be prepared
Formal review and approval	• Depends on the jurisdiction. In only a few countries is a formal technical review of an SEA required (e.g. Bhutan), prior to an approval • In some countries it is required to provide the final draft to stakeholders for review. In any case, it is good practice to make this available on an SEA website • Often the SESMP requires some monitoring and evaluation, possibly for decades into the future	• Depends on the jurisdiction, but unlikely to be required • Usually, a rapid SEA would serve the purpose of an "advisory memorandum" that is similar to an executive summary

In all circumstances, the timeline of an SEA will need to be carefully thought through and designed according to a range of possible background factors:

- ***The particular focus of the SEA***, e.g., whether a PPP or other instrument such as a strategy, or a spatially extensive development such as a large regional infrastructure initiative, or a cross-border initiative such as a proposed railway, pipeline, or transnational protected area. In some circumstances, there may be a complex, larger-scale environmental challenge that does not fit into existing or proposed PPPs (e.g., climate change), a common situation in lower- and middle-income countries that lack a strong tradition of strategic planning. In such cases, an SEA may be commissioned to feed into a decision-making framework developed on a case-by-case basis;

- ***The PPP preparation and decision-making process*** (key steps, who involved, timescales, etc.), as this will dictate the SEA design;

- ***Key factors influencing the SEA*** like geographic and/or jurisdictional scope, existing data, and timeframe for rolling out renewable energy to meet a country's climate targets;

- ***The context***, including geographical factors that may limit access (e.g., in particular seasons), or requirements to gather new data including seasonal or multi-year data;

- ***The availability of existing information*** and any gaps which may require additional time and cost to address;

- ***The capacity of the requesting institution*** – sometimes this can prolong the process until there is internal understanding of the role and modalities of SEA and consensus is reached on the aims and requirements of the SEA;

- ***Available time and budget*** (it is important to understand that time and budget constraints imposed on an SEA will limit what can be done and its utility), and

- ***Political and security considerations***.

A study on the first year of application of the European SEA Directive in the United Kingdom surveyed 201 authorities that had conducted SEAs of plans.[11] It concluded that most of these SEAs required approximately 70–80 person days to complete (roughly half for scoping and half for the SEA report). According to the Netherlands Commission for Environmental Assessment, experience shows that small municipal SEAs can be carried out in as little as 30 working days, medium-scale SEAs require 50 - 100 working days, and more complex large-scale SEAs require between 150 - 300 working days, depending on the amount of information to be processed.[12]

A complex SEA, especially one covering multiple sectors, may take over a year to undertake, sometimes much longer, and require a large team of experts (Section 1.6). A longer pre-SEA period may be necessary to collect data that may be required, particularly when time series information or data covering several seasons is deemed necessary. At the other end of the spectrum, in some circumstances, it is possible to conduct SEA as a rapid exercise. For example, a rapid, desk-based SEA of Namibia's Fourth National Development Plan was undertaken over a month. It was led by two SEA experts working with invited subject-expert focus groups.[13]

1.8 COSTS OF SEA

Undertaking a full SEA usually involves the costs for the following inputs and steps:

- Fees and operational costs (e.g., travel/accommodation, workshops/meetings and administration) for the practitioners engaged to undertake the SEA;

- Designing the approach and methodology and testing tools, usually during the initial stages of SEA application. Costs may be reduced by using commonly applied methods which have proved to work well in SEA[14];

- Gathering basic data sets and analysing the baseline. In many SEAs, field work is often limited to ground-truthing visits, especially where there is good available information. Where there is limited

[11] Therivel and Walsh (2005)
[12] NCEA (2020)
[13] Dalal-Clayton and Tarr (2015)
[14] e.g., impact matrices, modelling, scenario analysis

basic data, field work may be necessary, and this can add significant costs (and time). However, most of this work occurs during the first SEAs undertaken in a particular region/sector. Subsequent SEAs (e.g., when a PPP is revised) can build upon the data gathered by previous SEAs and the additional costs will be limited to obtaining specific new data that may be required;

- Carrying out analyses and providing inputs to support the elaboration of the PPP concerned (always needed);
- Implementation and monitoring frameworks for SEA recommendations;
- Training in circumstances where capacity and understanding of SEA are low, and
- Consulting stakeholders and managing the entire SEA process (always needed).

There can also be costs associated with a legal challenge to a PPP, which can delay an SEA and downstream mitigation measures recommended by the SESMP.

There is very limited information on the actual costs of SEAs, as it tends to be a confidential matter, but the cost will vary due to the length of the process and the complexity of the chosen design.

A recent study based on a literature review[15] examined SEA costs over the entire lifespan of the process and compared costs against benefits. It notes that available data is commonly derived from SEA procurement budgets, which largely reflect consultancy costs. In Europe, SEA costs range up to US$ 1 million with significant variations. The cost of SEAs for typical local development (or land-use) plans, which account for a large proportion of SEAs in Europe, was found generally to be up to US$100,000. In other regions of the world, costs were generally higher, from less than $350,000 to over US$ 1 million. It is noted that alternative approaches are also being explored, particularly in emerging nations, that cost much less. Rapid SEAs, for example, can cost less than 20% of the time and cost of conventional SEAs. [16] The study concludes that for a national-scale, one-off policy like a national energy policy, the cost can be assumed to be roughly US$100,000 to $1 million, although this will depend on the approach and process followed and the complexity of the PPP concerned.

In rare cases, some complex SEAs might be expected to cost between $1 and 2 million if they are particularly complex and will require longer than a year to undertake (e.g., when new research or seasonal studies are needed).

Contingency reserves are very important, as SEAs often require additional or unforeseen tasks to be undertaken; at least 10-15% of the total SEA budget should be allocated to them. Additional costs may be foreseen for any follow-up activity to the SEA to evaluate the effectiveness of its implementation. It is particularly important to ensure that costs for a fully inclusive and transparent stakeholder consultation process throughout the entire SEA process are included.

A study for the European Commission (EC) on the costs and benefits of EIA indicated that introducing SEA to regional and local land-use planning usually increased planning costs by 5 to 10%.[17] However, these costs are marginal in comparison with the costs of the implementation of plans or programs (i.e., financing all activities and projects proposed by the planning document). The EC also found examples of good SEAs that increased planning costs by less than 5%, but the costs depend on the amount and detail of alternatives elaborated and the extent of their assessment.

A rapid SEA can be expected to cost US$ 40,000 – 60,000.

1.9 WHO SHOULD CARRY OUT SEA?

The SEA process needs to be owned by the authority responsible for the PPP concerned. This will help to avoid the SEA report being ignored and shelved. Such "ownership" means that the authority concerned should "lead" the process (provide strategic direction, coordinate with other government

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[15] Therivel and Gonzalez (2020)
[16] Dalal-Clayton and Tarr (2015)
[17] European Commission (2006)

agencies, undertake necessary formalities, assist with access to information, etc.). However, in most situations, the responsible authorities lack SEA experience and skills, and a team of knowledgeable and experienced experts needs to be engaged to conduct the SEA. This team needs to coach the responsible authority on the role, benefits, and modalities of SEA to help increase its awareness and capacity regarding SEA. Such coaching will, in turn, enhance the authority's ability to lead and guide the team of SEA consultants on aspects of the SEA. It can also benefit the responsibility authority, other government agencies with an interest in the SEA, and key stakeholders if an awareness-raising workshop about the SEA (reason for SEA, modalities of process, how to engage, etc.) is organized early in the SEA process (preferably during the inception phase).

A group of knowledgeable and experienced experts should comprise the core SEA team with environmental and social knowledge and skills, and experience in conducting SEAs. One of these should take the role of team leader with responsibility for overall coordination, liaising with the SEA proponent, team management, quality control, etc. A range of other subject specialists may be required to make shorter specific inputs/studies on required subjects.[18] Ideally, the team should be comprised of national experts with the relevant range of environmental and social expertise. In circumstances where national experience and skills in undertaking SEA are limited, it is advisable to engage a few experienced international consultants to work with the national team members (at least the lead environmental and social experts, one of whom should be the team leader to guide the process). The team should ensure that they have capacity in the local language.

The SEA team should be invited to all planning meetings regarding PPP development and other relevant activities and have full access to all relevant documents or other sources of information produced or referred to within the PPP process.

Wherever possible, the SEA team must be responsible for leading out and coordinating consultation efforts related to the SEA (see Section 1.10). This will ensure that stakeholders fully understand who is conducting the SEA, on whose behalf, and why it is important to obtain stakeholder support and buy-in to the SEA process (see below).

In some circumstances, the SEA proponent may elect to establish a broad-based, multi-stakeholder steering committee for the SEA to provide oversight, advice, support, and guidance (see Chapter 14). This is a form of collaborative governance that is crucial to tackle multi-sector challenges and to ensure inclusive stakeholder engagement throughout the SEA process. It also helps to ensure that the process and outcome are more influential.

1.10 ENGAGING WITH STAKEHOLDERS

For SEA to be successful and meaningful, and support progress towards sustainable development, it will need to engage with a wide range of stakeholders throughout the process. Broadly, stakeholders should include:

- All those organisations and individuals with a legitimate interest in the PPP and who may be affected by PPP outcomes;
- The Ministry of Energy (or equivalent) and other relevant government ministries/agencies and others involved in decision-making relevant to the PPP being assessed at all levels (from national to local). Where possible, officials from such ministries/agencies should be involved directly in undertaking key steps and analyses of the SEA process to build their ownership of the process and products;
- Civil society (who may be represented by CSOs and NGOs);
- The private sector, and
- Multi-lateral development banks, bilateral donors and aid agencies that may be funding the SEA or supporting the implementation of the PPP.

[18] Examples of expertise that may be required include (note that this is not a comprehensive list): energy technologies, coal-fired power plants and coal-mining, health and safety, biodiversity and ecosystems, protected areas, climate change, transport, tourism, planning, urban issues, archaeology and cultural heritage, GIS, public consultation, governance, institutional and legal issues.

Many of these actors will have roles to play in developing and/or implementing the PPP or SESMP or will likely be affected by PPP implementation.

PPPs concerned with the energy transition are likely to affect all inhabitants in a country, but it is almost impossible to give all inhabitants the opportunity to be engaged in the process. Therefore, consultation via CSOs that are valid representatives of affected communities is a reasonable and acceptable approach. However, this decision will not be simple and will require engagement with a range of stakeholders to ensure that this representation of interests will be acceptable to all.

For the PPP to be well constructed, address the most important issues, and be successfully implemented, it will be necessary for stakeholders (including representatives of local communities and the public) to understand the process, be able to engage meaningfully with it, and influence its outcomes. In other words, stakeholder "buy-in" is vital to the SEA process.

Best practice public engagement in SEA should include the elements listed in Box 1.3.

Box 1.3: Elements of best practice stakeholder engagement in SEA

Meaningful

- Ensure adequate time and resource for the engagement process (particularly when developing SEA terms of references and budget);
- Provide information/explanation about the SEA (e.g., need, focus, process) to stakeholders;
- Provide input that informs the SEA process and decision-making;
- Start early and continue throughout the process;
- Encourage two-way communication, and
- Allow the process to accommodate stakeholders' own agendas, and where these are not directly relevant, direct them to the most appropriate agency or organization.

Planned

- Have consensus (through dialogue with decision-makers and stakeholders) on how stakeholder engagement is to be conducted, with clearly defined objectives, scope, and techniques/approaches for engagement, and
- Be tailored to support (and not disrupt or unduly delay) the PPP development schedule/process (sometimes joint/shared stakeholder engagement events can be organized).

Open and build trust

- Be accessible to all stakeholders;
- Explain the benefits of engaging and participating;
- Enable access to relevant information, and
- Provide for a free exchange of information, using a variety of communication channels (e.g., website, newspaper notices, newsletters, radio, etc.).

Inclusive

- Ensure different perspectives are addressed by the SEA.

Collaborative

- Encourage participants to work together on identifying issues and ways to address problems.

Transparent

- Communicate how stakeholder inputs will be used, and
- Provide feedback to stakeholders on SEA progress, outcomes, and recommendations, particularly through user-friendly materials (including in local languages).

In Chapter 2, guidance is provided on how stakeholders should be involved in the different stages of the SEA process.

1.10.1 Roles and responsibilities of key stakeholders

Table 1.3 sets out the roles and responsibilities of stakeholders, including government agencies, communities and individuals, private organizations, non-governmental organizations, and others having an interest or stake in the SEA process and outcomes of the PPP.

Table 1.3: Roles and responsibilities of key stakeholders

Stakeholder	Role and responsibilities
Lead agencies	PPPs are mainly developed by sector ministries and implemented by their respective line agencies. The responsibility for instigating an SEA of a PPP, therefore, should lie with the relevant sector ministry. The lead agency is responsible for managing the SEA process, usually through the commissioning of a team of expert consultants to undertake the technical process. Where SEA is formalized by legislation and a government agency is designated to be responsible for the system, the lead agency will usually also be required to submit an SEA report (and accompanying SESMP) to that designated body to be reviewed and approved. The lead agency will likely be involved in implementing the SEA recommendations together with other responsible agencies and institutions. Increasingly, influential SEAs are the responsibility of an inter-agency steering committee where the sharing of responsibility and decision-making is a starting point. Where international organizations (e.g., multilateral development banks or bilateral donors) are involved in supporting the SEA or in funding PPP implementation, the lead agency will usually be required to submit the SEA report to such organizations for review and approval (particularly where such organizations are required to satisfy their own environmental and social safeguard requirements) and to meet funding requirements.
Statutory bodies with designated responsibility regarding SEA	Legislation covering SEA usually will assign formal responsibility for overseeing the national SEA system, developing regulations, providing guidance, and reviewing SEA reports to a particular government agency (often the Ministry/Department of Environment or Environmental Protection Agency). Where there is no statutory body or legislated process, responsibility for reviewing reports would need to be assumed by the lead agency (possibly through commissioning independent experts to help).
Civil society (including communities, individuals, marginalized groups)	All those members of civil society (either individually or through representative bodies) who have an interest in or might be affected by a PPP should be provided with opportunities to be informed about the PPP. They should be able to engage in the SEA process (expressing their concerns and perspectives on issues and proposals), comment on draft SEA reports, and be informed of its results, etc. To foster engagement, information should be available and communicated in ways that different stakeholders (e.g., indigenous people) can access and understand (e.g., summarized in local language).
Indigenous Peoples	Sometimes, Indigenous Peoples' organizations are erroneously lumped into civil society organizations (CSOs). But Indigenous Peoples (IPs) form distinct societies with their own laws, languages, epistemologies, ontologies, and methodologies, including in the area of renewable energy. They can often be adversely affected by renewable energy developments. Strong efforts are required to ensure that indigenous peoples are engaged in an SEA, fully informed, and enabled to present their perspectives and concerns. Legislation and/or the environmental and social safeguards policies of financing organizations may expect or require Indigenous communities to give their prior and informed consent to certain projects and activities arising when implementing a PPP.
Environmental assessment practitioners, academics, and researchers	Lead agencies will usually depend on environmental assessment practitioners (national and international) to undertake an SEA. There may be a need for specialized research or case studies to provide key data for an SEA, which would usually be undertaken by national experts, academics, and researchers.
Development finance organizations and donors	It is common practice for international development finance organizations (e.g., MDBs) or donors to require SEA for sectoral support and large development

Stakeholder	Role and responsibilities
	programs. They may provide funding for individual SEAs. They will usually be required to approve the terms of reference (TOR) for the SEA and to review SEA reports. National finance organizations, including banks and trust funds, may also require SEA if they are funding part of PPP implementation.
Private sector	The private sector is likely to be involved in implementing many aspects of PPPs (particularly in the energy sector) by investing in the business opportunities that they create. It is important that their views on the PPP are considered. The private sector can also be responsible for an SEA of a PPP where a sector has been privatized (as in some countries, e.g., the rail sector in the UK).
NGOs/CSOs and other independent organizations (e.g. trade unions, religious organizations)	NGOs and independent organizations should be involved as stakeholders in SEA where appropriate. Often, they hold important information and can make expert contributions to the assessment process and analyses.

1.10.2 Methods to engage with stakeholders

Stakeholder participation should be a continuing process that runs throughout all stages of the SEA (as described in detail in Section 3.3.6 and Annex 1).

The SEA process should be ideally conducted in conjunction with consultation organized for the preparation of the PPP itself. Also, existing communication channels can offer efficient means for conducting consultations for the SEA. However, additional methods will be required at times. Participation processes should be used that provide the best means to ensure that stakeholders can engage effectively and that their viewpoints are given proper consideration.

The method of engagement should be to a large extent dictated by the purpose, i.e., information giving, information gathering, consultation, participation, collaboration, or delegated authority. Different methods lend themselves to these different purposes. Annex 1 describes various approaches that can be used to engage with stakeholders, including:

- Printed material inviting comments;
- Displays and exhibits;
- Information hotline/staffed telephone lines;
- Internet/web-based consultations;
- Questionnaires and response sheets;
- Surveys;
- Public hearings and meetings;
- Workshops and focus group sessions;
- Advisory committees;
- Social media, and
- A dedicated and interactive website.

It is important to note that public hearings or questionnaires, which are often used for consulting the public during EIA processes, may not deliver the most effective consultations within the SEA process. Instead, problem-solving workshops, roundtables, an advisory panel, focus groups, online exchanges, or structured interviews with key informants may provide more efficient and user-friendly means for obtaining inputs from the relevant stakeholders during the SEA. It will be important to organize targeted meetings/sessions with women (facilitated by a woman) in communities or with women's or other vulnerable groups as, in many societies, they are often reluctant (or even restricted) to express their views in mixed gender events.

Similar approaches can be applied to consultation with Indigenous Peoples including the use of an indigenous facilitator.

Usually, the following analyses benefit from stakeholder input (particularly as a consequence of their local knowledge):

- Determination of key environmental and socioeconomic issues related to the PPP;
- Identification of knowledge or data gaps;
- Analysis of environmental and socioeconomic trends without the PPP and under different development scenarios, and assessment of alternatives;
- Assessment of future environmental and social trends as influenced by the actions proposed in the PPP;
- Identification of appropriate mitigation and enhancement measures, and
- Suggestions for monitoring and follow-up for SEA implementation.

Stakeholder input in each of these stages can be facilitated by formulating clear questions to help them in submitting or making their comments.

A grievance mechanism should be established to enable stakeholders to complain if they feel that their opinions have not been sufficiently addressed or responded to.

1.11 BUILDING CAPACITY FOR SEA

As indicated in Section 1.3, one of the basic principles of SEA is to provide opportunities to build capacity to conduct SEA and use the SEA results.

The full and effective engagement of stakeholders (Section 1.9) provides a means to increase understanding of the benefits and modalities of SEA amongst a wide range of interested parties. But more planned and targeted capacity-building efforts for SEA may be warranted.

In some countries, previous experience of commissioning and conducting SEA, or in implementing recommendations set out in a SESMP, may be absent or limited, particularly within government. Indeed, experience shows that in many countries, government officials with responsibilities for preparing and implementing PPPs have very little understanding of SEA and how it can help to improve PPPs and their implementation.

In such circumstances, various actions might be considered, and could usefully be included within TORs for an SEA, e.g.:

- One or more government officers (e.g., from the government department/agency responsible for environmental assessment) could be ***seconded as members of the SEA expert team*** (either full- or part-time) to enable them to be embedded in the process, gain operational experience of undertaking an SEA, and thus help increase government "ownership" of the recommendations;

- Provision of SEA ***guidance documents and case studies*** of similar SEAs;

- An SEA ***awareness-raising event*** (as suggested in Section 1.9) at the earliest possible stage in the SEA (preferably during the inception stage to provide key actors with information about what SEA is, its role and benefits, and how it is planned to conduct it). This will be particularly beneficial for government officials (particularly from the proponent ministry and others likely to be later involved in implementing the SESMP) as well as other key stakeholders;

- ***SEA workshops*** that are undertaken to present various phases of the SEA process offer an opportunity for stakeholder participation and capacity-building and also help guide the SEA process;

- ***Training courses/exercises*** could be conducted (for particular government agencies and other interested stakeholders) on SEA (in general), on specific steps/stages of an SEA, and/or on particular methodologies used, and

- An SEA does not end once the SEA and SESMP reports are submitted. Implementation of the recommendations follows and will likely continue over years. In some countries, those government agencies with roles and responsibilities to implement the actions recommended in an SESMP will require a degree of guidance and support to interpret the findings of an SEA and to both understand and carry out the tasks and roles assigned to them. This could be provided by a dedicated SEA implementing agency, which may be an independent consultancy with experience in SEA. Thus, it might be advisable that, when preparing TOR for an SEA, time and budget are included to enable the provision of "***follow-up" support*** to assist the government agencies involved to prepare for and undertake their responsibilities for the recommended management actions.

1.12 EFFECTIVENESS OF SEA

Almost 30 years ago, an international study of the effectiveness of SEA[19] suggested four ingredients for an SEA to be effective:

- Appropriate timing in initiating the assessment so that the proposal is reviewed early enough to scope for the development of reasonable alternatives;
- Clear, specific directions in the form of terms of reference or guidelines covering priority issues, timelines, and opportunities for information and input at key decision-making stages;
- Quality information and products fostered by compliance with procedural guidelines and use of "good practices" and
- Receptivity of decision makers and proponents to the results of the SEA, founded on good communication and accountability.

A recent follow-up study by the same authors based on expert opinions has highlighted the status of SEA today regarding its effectiveness.[20] Key points include:

- Major extensions and improvements have occurred in SEA systems and institutions, knowledge and expert capability, guidance, tools, and data availability;

- Shortfalls and deficiencies in current practice are also evident in the uneven quality of SEA reports, overly legalistic and bureaucratic approaches, insufficient public participation, limited influence on decisions, and, by extension, on levels of environmental and social protection, and superficial consideration of sustainability matters, and

- Recommended steps to move SEA forward include strengthening applicable laws, regulations, and participative methods; identifying new modalities and web-based and digital tools to advance practice; furthering research and in-depth case analysis of SEA effectiveness, particularly the impact on decision-making; and facilitating more innovative applications to sustainability purpose.

Extending from the above, an SEA can be judged to be effective if

- Quality information is delivered that is relevant and appropriate and can be seen to inform or influence the content of a PPP and related decision-making, and it does so in a timely manner for key decision-making stages;
- Decision-making is made more effective and efficient, improves governance, and sets a direction for sustainable development;
- The SEA builds awareness and understanding of environmental and socioeconomic issues and how they interact among all key stakeholders;
- The SEA builds technical capacity for undertaking future SEAs;
- The SEA identifies environmental and socioeconomic opportunities and risks (potentially significant negative impacts and their likely consequences);
- Recommendations, usually presented in an SESMP, are acted on meaningfully and effectively by government or other agencies to implement measures that (a) boost opportunities to enhance achieving environmental and socioeconomic quality objectives, or

[19] Sadler (1996); Sadler and Verheem (1996)
[20] Sadler and Verheem (2024)

(b) to avoid and mitigate risks and negative potential impacts that would impede achieving such objectives.

Of course, it may not be easy to determine if some changes are directly. or even partially a consequence of the findings and recommendations of an SEA, as so many other factors are likely to also have an influence, e.g., political, economic, and security considerations. Furthermore, change may not be immediate; it may take place over time and incrementally, and it may vary spatially.

Overall, performance and delivery provide the essence of SEA effectiveness, "measured" in terms of decisions, outcomes, and achievement of policy aims – i.e., what SEA contributed in a given process or over a series of applications.

In a recent paper, a set of 10 key performance indicators (KPI) for strategic environmental assessment effectiveness have been suggested for Ireland (Table 1.4).[21] The KPIs are related to the requirements of the EU SEA Directive and are unlikely to be pertinent for all jurisdictions.

An SEA will have a greater chance of being effective if it is undertaken following internationally accepted principles for good practice (discussed in Section 1.4), including meaningfully engaging with all key stakeholders, being conducted in a transparent manner, and integrated as much as possible with existing policy and planning structures.

[21] Therivel and Gonzales (2024)

Table 1.4: Key performance indicators of SEA effectiveness in Ireland
Source: Therivel and Gonzales (2024)

SEA effectiveness dimension	**Key performance indicators**		**Data source**				
			SEA report	SEA statement*	Monitoring report	Plan	Planner interviews
Context	1	SEA documents are easy availability on a public website.	√	√	√		
Procedural	2	Consideration of realistic and appropriate “within plan” alternatives.	√				
	3	Assessment of cumulative impacts of the plan plus other plans, projects, and external trends.	√				
Pluralist	4	Environmental authority recommendations taken on board (either integrated into the plan or a reason given that directly responds to the concerns, where the concerns are within the ambit of the plan).	√	√		√	
	5	Public recommendations on SEA documents taken on board (either integrated into the plan or a reason given that directly responds to the concerns, where the concerns are within the ambit of the plan).	√	√		√	
Substantive	6	Changes made to the plan in response to proposed SEA mitigation measures.	√	√		√	
Normative	7	SEA contribution to environmental improvement (focus on key impacts of the plan, tests against relevant environmental targets, leads to plan changes towards achieving environmental targets).	√	√			√
Knowledge & learning	8	For cyclical plans, SEA monitoring carried out for the previous cycle of the plan, and monitoring findings referred to in the current SEA.			√		
	9	Planning team documentation of lessons learned from this SEA and suggestions for improving the next round of SEA.	√	√			√
Transactive	10	Planning team documentation of the costs and benefits of SEA, and what can be done to improve its benefits.		√			√

*: Article 9.1b of the European SEA Directive requires the preparation, after plan adoption, of an ‘SEA Statement’ that describes the influence of the SEA process on the plan.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 2

STAGES AND TASKS IN SEA

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IAIA International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 2

STAGES AND TASKS IN STRATEGIC ENVIRONMENTAL ASSESSMENT

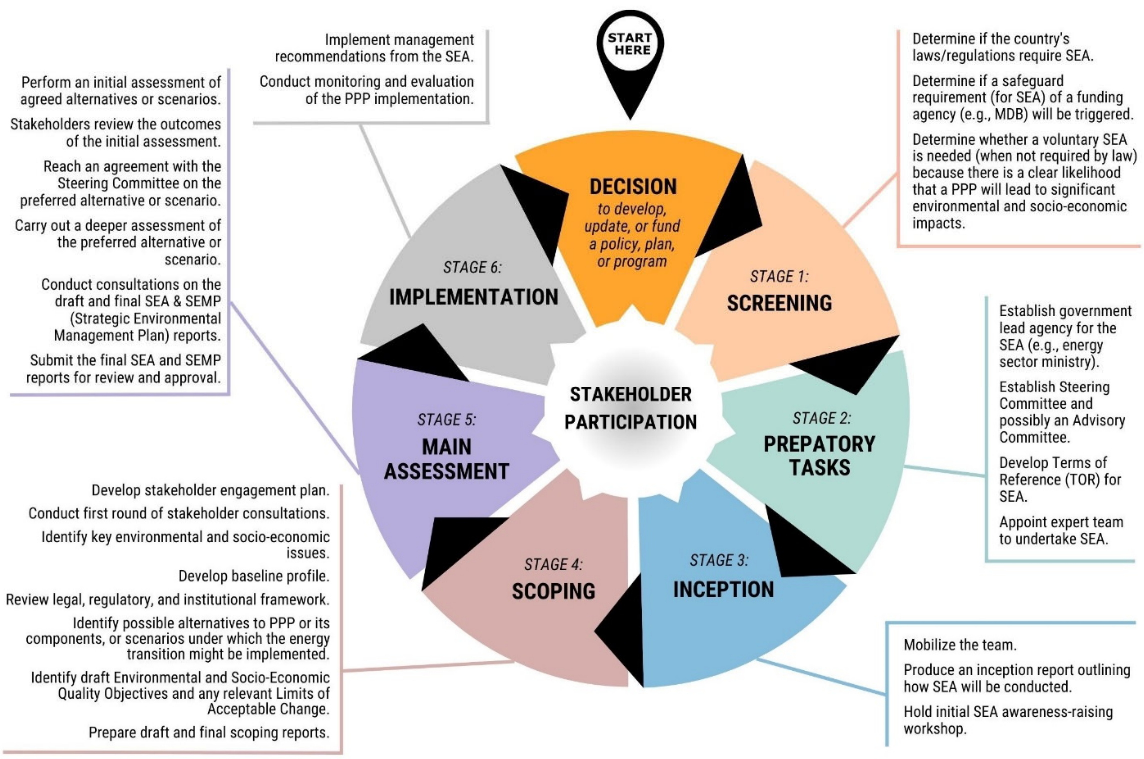
The stages and elements discussed in this chapter are considered generic to all full strategic environmental assessments (SEAs) (see Chapter 1, Section 1.7, and Table 1.2 for comparison of rapid and full SEA) and will be applicable to any SEA undertaken for a policy, plan, and program (PPP) concerned with the energy transition. They are not repeated in the chapters on renewable energy sub-sectors in Parts B and C. These stages and elements are based on internationally accepted principles for SEA good practice.[1]

A fundamental principle of SEA is that there should be stakeholder participation throughout the process. This is discussed in Section 2.10.

2.1 THE SEA PROCESS AT A GLANCE

The main stages and elements of the SEA process will need to conform with requirements in national, legal, or regulatory requirements and may, therefore, differ from country to country. Typical stages are shown in Figure 2.1 and described in the following sections.

Figure 2.1: Typical stages in the SEA process



[1] OECD DAC (2006)

2.2 STAGE 1: SCREENING

Screening is the procedure to identify whether SEA is formally needed by law or regulation, is required by the safeguard policies of a lender/financing organization (e.g., a multilateral development bank), or is necessary because significant concerns have been raised that there is a clear likelihood that an energy PPP or regional energy development proposal will lead to significant environmental and socioeconomic consequences (Box 2.1).

Box 2.1: Key tasks of the Screening Stage

- The proponent screens its proposed PPP to determine if it is required by law or regulation to be subjected to an SEA. Depending on national legislative requirements, this may involve determining if the PPP is likely to have significant environmental and social risks or impacts. The proponent may convene an expert group to help with screening and/or seek advice from the competent authority.
- The environmental and social safeguard policies and frameworks of a funding organization (e.g., an MDB) may also trigger the need for an SEA or equivalent, whether or not one is formally required by a country's law or regulation.
- Where there is no legal mandate or requirement for SEA, it may be apparent and agreed that a proposed PPP or proposed major development activities in a geographical area would benefit from information and recommendations generated through an SEA undertaken on a voluntary basis.
- In any of the above circumstances, where it is determined that an SEA is required, the proponent should proceed to Stage 2.

Arguably, given the scale and speed of the energy transition, SEAs (and complementary processes such as spatial planning) are essential for renewable energy rollout and expansion. But SEA for the energy transition must be pragmatic and proportionate. In some countries, it may be more difficult to undertake because of limiting factors such as lack of governance structures, expertise, capacity, and budgetary resources.

A country's SEA law and/or regulations will indicate whether SEA is required for all types of PPP or for specific categories of PPP. Screening is used to determine whether a proposed PPP (or revision of an existing one) falls into one of these categories. In some countries, the proponent of a PPP (usually a line ministry or department) may be required to undertake some initial analysis to determine if there is potential for a PPP to result in significant environmental and social impacts, which might trigger a formal requirement for an SEA. Screening should be undertaken by the proponent of a PPP.

Where a country has no regulatory mandate for SEA, an SEA-type exercise may still be extremely beneficial, e.g., in terms of how best to meet obligations, targets, or goals under international or national obligations (Paris Agreement, Global Biodiversity Framework, Sustainable Development Goals, etc.), or for increasing lender or developer confidence. The energy transition is global, and potentially, countries without an existing legal requirement for SEA could be the ones where the benefits of SEA are greatest in terms of promoting sustainable development. There is a need for pragmatic and scalable approaches to SEA that can be implemented in countries without legislation for SEA or where it is still emerging.

Lenders' environmental and social safeguard policies and frameworks will also indicate whether an SEA (or equivalent, e.g., SESA) is required. Lenders will usually engage with the relevant government ministries about initiating the process and may provide funding for it.

Where national laws or regulations do not specifically prescribe which PPPs require an SEA, then the criteria listed in Box 2.2 can be used to determine whether an SEA would be beneficial. A screening form is provided in Annex 3 based on these criteria. It can be used to document the result of the screening procedure and includes a record of the decision on whether an SEA should or should not be carried out.

Box 2.2: Screening criteria

1. Characteristics of the PPP itself:

- Degree to which the PPP sets a framework for projects and other activities, either with regard to the location, nature, size, and operating conditions or by allocating resources.
- Degree to which the PPP influences other policies, plans, and programs.
- Relevance of the PPP for the integration of environmental and socioeconomic considerations (and their relationship with economic concerns and drivers), with a view to promoting sustainable development.
- Environmental and social concerns relevant to the PPP.
- Relevance of the PPP for the implementation of national legislation on the natural or human environment (for example, PPPs linked to waste management or water protection) or social conditions.
- Extent to which the proposed PPP is likely to be politically or publicly acceptable or contentious.
- The PPP is unprecedented.

2. Characteristics of the impacts and of the areas likely to be affected:

- Probability, magnitude, duration, spatial extent (geographical area and size of the population likely to be affected), frequency, uncertainty, and reversibility of the impacts.
- There are inherent uncertainties, and the level of confidence in predicting the impacts of the proposed PPP is low.
- There are important information gaps, making it difficult to predict impacts.
- Cumulative nature of the impacts and whether they are likely to be significant (both additive and synergistic impacts).
- There are likely to be trans-boundary impacts (i.e., the PPP is likely to affect other administrative units, regions, or countries).
- Risks to the environment, social conditions, human health (e.g., due to accidents), safety, and/or the integrity of social or ecological systems are considered to be high.
- Social and/or ecological systems have low resilience and high vulnerability to disturbance or impact (e.g., poor communities, vulnerable groups, or sensitive ecosystems).
- Value and vulnerability of the areas likely to be affected due to:
    - Having unique, special, or highly valued natural elements (e.g., threatened biodiversity, critical, or sensitive habitats);
    - Protected areas (e.g., nature reserves, heritage sites, Ramsar sites) or areas of recognized local, district, national, or international importance for conservation and biodiversity importance;
    - Areas of unique, special, or highly valued cultural or spiritual elements;
    - Existing levels of environmental quality are close to defined limits of acceptable change (i.e., there is a definite risk that limits of acceptable change will be exceeded); or environmental quality standards have been exceeded;
    - Areas subject to intensive land-use and rapid change;
    - Vulnerable groups that could be affected.
- Impacts on areas or landscapes that have a recognized national or international protection status.
- The PPP is likely to result in major changes in actions, behaviors, or decisions by individuals, businesses, NGOs, or government that could lead to:
    - Induced development of infrastructure or other changes in urban or rural land use;
    - Loss or degradation of natural habitat or of areas important for nature conservation;
    - Adverse impacts to biodiversity or provision of ecosystem services;
    - Major changes in the pattern of settlement, land occupation, and/or demographics in an area;

- Major changes in the development or use of technology that could have negative implications for worker, community, and individual health and/or safety;
- Introduction of alien and potentially invasive organisms;
- Changes in society's consumption of energy and in particular fossil fuels, and therefore, in emissions of pollutants, carbon dioxide, and other greenhouse gases;
- Changes in the rate of society's consumption of and/or demand for natural resources, including water and materials;
- Impacts on energy security; or
- Transport, storage, and processing of hazardous and non-hazardous waste materials.

2.3 STAGE 2: PREPARATORY TASKS FOR THE PROPONENT

As soon as a decision is made to conduct an SEA, preparatory tasks can be initiated by the proponent – the government body or other agency developing the PPP. While in most cases this body will likely appoint a team of SEA experts to undertake an SEA, in some instances an SEA might be conducted by the government itself. Either way, it is important that the SEA is, and is seen to be, government-owned and government-led.

Box 2.3 lists a range of tasks that should be undertaken by the PPP proponent.

Box 2.3: Key tasks of the Preparatory Stage

- Determine whether other institutions (including donors) have carried out or intend to carry out an SEA relevant to the PPP in question and, in such circumstances, seek to engage in a ***joint process.***
- Determine ***who will undertake the SEA*** – the proponent, or another government agency, or a team of consultant experts.
- Determine ***who will fund the SEA*** – the lead government agency or an MDB/development cooperation agency? In either case, the government should always lead the process.
- Establish an ***in-house management group*** – one or more individuals with responsibility for managing the SEA process. A person should be designated as a point of contact for the SEA.
- Establish a multi-stakeholder ***Steering Committee*** for the SEA. Its role will be to offer leadership and take key decisions on the SEA process and recommendations, provide a cross-institutional platform to increase understanding of and buy-in to the process, and provide high-level advice and guidance when needed throughout the process.
- Consider whether to establish a separate an ***Advisory Committee*** that would provide advice on technical matters.
- Prepare ***TORs for the Steering Committee, Advisory Committee,*** and any other representative bodies established for the SEA covering roles and responsibilities.
- Consult with the Steering Committee and Advisory Committee (if established) to ***agree on the approach to the SEA*** (to guide the TOR) and secure buy-in and ownership of the SEA, prepare an agreed "roadmap" as a starting document, and publicly announce that an SEA is to be undertaken.
- Develop ***SEA Terms of Reference*** (refer to Annex 2 for an example) based on the basic principles of SEA (see Section 1.4) and setting out the framework for the SEA.

- Appoint a team of experts (***consultant team***) where so decided to undertake the SEA. It is likely that, where national skills and expertise in SEA are limited or lacking, proponents will need to rely on external (expatriate) consultants to lead the work. But it will be important to include national consultants to ensure the team has access to critical local knowledge and also to build capacity.

  Also:

- Confirm sources of funding (if not from the proponent's budget);
- Agree on the vision for the SEA and its goals;
- Identify the schedule for SEA start and completion;
- Identify opportunities for integrating the SEA process with the PPP development and decision-making process, and identify key decision points that can be assisted by SEA outputs.
- Undertake initial consultations with key government agencies and institutions likely to be involved in the SEA or implementing a SESMP to explain about the need for the SEA and the process involved in order to build understanding and support.
- Identify any need for training for relevant government personnel and others (e.g., NGOs) to explain SEA, its need, role, benefits, and modalities. Such training should be provided at an early stage during the Inception Stage or Scoping.

2.4 STAGE 3: INCEPTION

Once the SEA team is formally appointed, the expert members of the team should be mobilized and meet with the proponent for initial discussions on how the SEA will be conducted. Any ***issues requiring clarification*** should be raised. These could include aspects of the Terms of Reference. The inception stage will normally be short (e.g., 4-6 weeks) and will normally require the submission of an Inception Report setting out how the team will undertake the SEA, methods to be used, a timeframe for activities, etc.

Experience shows that PPP development rarely follows a smooth and predictable path. Sometimes, when the SEA is commissioned, the focus and content of the PPP can still be unclear, and some assumptions in this regard will be necessary to design the SEA. The assumptions may need to change later. In other cases, there may be a change in policy direction (e.g., following an election). Therefore, as indicated in Section 1.6, the SEA will need to be flexible and iterative (with constant dialogue with the proponent) so that it can be modified and adjusted to changing circumstances.

Experience from undertaking SEAs shows that most stakeholders and government officials in government agencies (particularly those that commission SEAs, receive the reports, and will have responsibility to implement recommendations) have little or no prior awareness or understanding of what SEA is. Neither do they understand how it can help the PPP process (preparation and implementation) and how it can be of benefit. So, it is important to organize, during or soon after the SEA inception stage, an *awareness-raising event* (usually a workshop) for stakeholders. This should provide a basic background to the nature, role, and benefits of SEA, explain why it is being conducted for the particular PPP in case, outline how the SEA will be conducted and how stakeholders can engage in the process, and indicate stakeholder roles and responsibilities. Such an initial workshop will help to generate understanding of the SEA process, build support and ownership, and encourage anticipation of the outcomes (reports and recommendations) and willingness to consider how best to consider and act on the recommendations. The workshop should be organized by the institution responsible for the SEA and should involve all stakeholders that have participated previously in the SEA process.

2.5 STAGE 4: SCOPING

During the scoping process, the SEA team should confirm the focus and content of the SEA, define the scope of the analyses needed, the stakeholders to be involved, the approach and methods to be used, the data and information sources to be considered, and the relevant criteria for assessment. Scoping provides an opportunity to focus the scoping report on the important issues to maximize its usefulness to the authorities, decision-makers, and public. It does not preclude changes in the scope of the report if the need for them becomes apparent at a later stage.

The scoping process should be open and iterative, involving key stakeholders (see Section 2.10) to:

- ***Review the context*** of the SEA;

- ***Explain to stakeholders*** the role, modalities, and added value of SEA. One of the tasks of scoping is a review of the country's legal, regulatory, and governance framework (see Box 2.4). This should also analyze the formal and informal approaches to environmental and social assessment and management applied in the country (these may vary by sector). During any SEA training and during discussions with sector ministries, the SEA team should explain how such existing sectoral approaches (as far as they relate to the energy transition) are relevant to the SEA and what added value can be provided by SEA. In particular, the team should identify how SEA can help what the sectoral ministries and agencies are already doing, e.g., integrated water resources management (IWRM) in the water sector, feasibility studies in the infrastructure sector, master planning in the power sector, etc. This engagement with sectors should be undertaken upfront and feed into the design of the SEA process;

- ***Identify alternatives*** to the PPP to be assessed in the next stage. Scenarios can also be considered as alternatives, especially where multiple renewable energy options are being considered for the energy transition;

- ***Identify key environmental and socioeconomic issues***. It is important to focus the assessment on the key issues that really matter and avoid trying to cover all possible (minor) concerns, as this will overload the SEA and lead to legitimate criticism that it is overcomplicated. It is important to re-emphasize that an SEA is not a large EIA and that the types of issues it should focus on should be more strategic and of a cumulative nature. Nevertheless, many of the issues likely to be identified and those likely to be raised by stakeholders will be based on peoples' experience from the implementation of past or existing renewable energy and other projects. Project-based impacts will give rise to cumulative impacts, and addressing the latter is a key principle of SEA;

- ***Identify and confirm the focus and content*** of the SEA;

- ***Identify relevant environmental and social quality objectives (ESQOs), targets, indicators, and decision criteria*** to use during the subsequent stages to select a preferred alternative – helped by stakeholder interviews, a review of the policy and legal framework, situation analysis, and the identified critical issues, and

- ***Identify baseline and other data requirements*** and initiate collection; and identify any critical information gaps.

A pragmatic view needs to be taken on how much can be achieved during an SEA, given the available time, resources, and existing knowledge about key issues (is sufficient and reliable baseline data available? Is there a need for research or supplementary field work and how will this be carried out?).

Box 2.4 summarizes the tasks to be undertaken during scoping.

Box 2. 4: Key tasks of the Scoping Stage

- ***Clarify TOR*** with the proponent, raise any concerns, suggest modifications based on professional experience, and agree on any adjustments required including as regards:
    - A realistic time scale for the SEA (start to completion);
    - The required documentation (reports to be prepared);
    - What stages of the PPP decision-making process should the various aspects of SEA be aligned with? (Need to map out the decision-making process to identify "windows" of opportunity);
    - How to integrate SEA findings, outcomes, and conclusions into decision-making at points when options and proposed activities are being developed and evaluated.
- Clarify ***PPP objectives***.
- Meet with the ***Steering Committee*** to present the approach to be followed and seek its assistance to support the scoping work.
- Establish a dedicated ***SEA website.***
- ***Stakeholder analysis*** – map those who have a direct interest in the PPP and may be affected by its implementation and what their main concerns about the environmental and/or social issues are likely to be (see Section 2.10).
- Prepare a ***stakeholder engagement plan*** (SEP) setting out (a) who should be involved in the SEA (including agencies that have various decision-making mandates within the spatial boundaries of the PPP and the SEA study area), (b) how and when they can/should engage in the process (identifying their roles and responsibilities and practical arrangements), and (c) presenting the results of preliminary stakeholder mapping (see Section 3.3.6). The latter may require consultations with the government where there are any sensitivities regarding stakeholder engagement. It may also include assessing stakeholders' interests to be involved in the SEA process.
- Start ***stakeholder consultations,*** including ***interviews*** with key stakeholders (organizations and individuals), and ***stakeholder workshops*** to explain the SEA (reason and process), to identify baseline data and PPPs held by consultees, and for consultees to assist in scoping key issues and identifying SEA objectives. *(Note: stakeholder consultation should be undertaken throughout the duration of the SEA process (see Section 2.10).*
- Develop and agree on the ***assessment methods*** to be used for the SEA (see Annex 6 for an overview of selected analytical and decision-making tools for the SEA).
- Determine if the SEA should be (a) ***impacts-led,*** (b) ***objectives-led*** (see Section 1.5), or both.
- Identify ***key sources of data and information*** to determine what data is required, what studies (and sources) are already available, and what the remaining gaps are.
- Initiate ***collection of baseline data*** and ***new research/field studies*** (where required), determine the ***minimum information*** needed to carry out SEA scoping effectively, and when this needs to be made available during PPP development (*note: in some circumstances, where critical information is lacking and requires special studies that may need considerable time to undertake (e.g., to gather seasonal data), and this may signal a need to consider deferring the SEA or extending the timeframe* (see Section 2.5.4)).
- ***Initial literature review*** (published or unpublished reports by government or others, grey literature, donor documents, etc.) to identify relevant environmental and socioeconomic concerns, information, data, and trends*.*
- ***Inventory and review of other PPPs*** (to include PPPs related to the PPP being assessed (i.e., the target PPP), or that might have an influence on the target PPP, or that might be affected by implementing the target PPP) to document aims, objectives, and key themes of relevance to the target PPP (see Section 2.5.6 and Annex 5).
- Identify whether ***other assessment processes*** apply to the PPP and, if so, determine the best way to deal with any overlaps between the assessment systems.
- Analyze the ***legal, regulatory, and governance framework*** (laws, decrees, directives, regulations, etc.), and identify ***synergies and conflicts*** in their objectives (this may signal where policy revision may be required to achieve PPP and sustainable development objectives).
    - Include and analyze the formal and informal approaches to assessment applied in the country (these may vary by sector).
- Initiate a ***review of institutions*** that are likely to have a role in implementing the SESMP, covering mandates, roles, responsibilities, and capacity to undertake their functions.
- Identify ***international conventions, treaties, and accords*** to which the country is a signatory.

- Identify ***key environmental and socioeconomic issues*** that the PPP should take into consideration, the main ecosystem services that stakeholders depend upon and in what ways, and screen out issues that are less important at this stage.
- Decide what ***technical studies or consultations*** are required to assess the impacts and identify information gaps and analytical methods to be used.
- Based on key themes and issues, develop ***draft environmental and social quality objectives*** (ESQOs), targets, and indicators to provide a framework for assessment and monitoring of the PPP (see Section 2.6.3).
- Determine ***Limits of Acceptable Change*** (LAC) (see Section 2.5.2).
- Identify reasonable ***alternatives or scenarios*** (to the PPP or to possible PPP components). These should be realistic, practicable, and relevant, and should include the "status quo" or "do nothing" option (see Section 2.5.3). Establish goals, objectives, and decision criteria (e.g., for selecting the preferred alternative to the PPP or components of it) and who should be involved (other agencies, stakeholders, etc.).
- ***Identify Relationship with other SEAs/EIAs*** – Identify the relationship between the SEA being undertaken and other SEAs and project EIAs.
- Determine whether the ***SEA report should be topic-based or task-based*** (a suggested list of issues to be covered in an SEA report is provided in Annex 4).
- Preparation of a ***draft scoping report*** and circulation or disclosure for stakeholder or public comment.
- Convene a ***scoping workshop*** to obtain stakeholder feedback.
- Preparation of ***final scoping report*** updated in response to comments. Publicly disclose the report through the lead agency website or some other means.

2.5.1 Setting draft SEA environmental and social quality objectives (ESQOs)

As discussed in Chapter 1 (Section 1.5), an SEA can be impacts-led or objectives-led. A decision needs to be reached regarding which approach is appropriate, or both.[2] Where the SEA involves an objectives-led approach, Environmental and Social[3] Quality Objectives (ESQOs) should be developed to help to focus the SEA and ensure important issues are not left out in the process, and to provide a framework for the assessment of the PPP and its alternatives or scenarios. In an objectives-led SEA, the assessment determines whether implementation of the PPP will enhance or impede the attainment of the agreed ESQOs.

ESQOs are specified targets and aims agreed upon during an SEA for environmental and social quality (e.g., prevention of loss of biodiversity, improved job opportunities, etc.) that should be met when implementing a policy, plan, or program. ESQOs should be developed as a response to key environmental and socioeconomic risks identified during scoping. They should be consistent with legal standards, objectives already set in existing policies, SDGs and climate change targets, and commitments the country has made under international conventions and treaties to which it is a signatory.

The following processes will help in the development of draft ESQOs.

- ***Clarification of PPP objectives*** to assist in deriving the spatial and temporal scale to be covered in the draft SEA ESQOs;

- ***Compatibility analysis*** to determine if the objectives of the PPP being assessed are in line with the proposed environmental, social, or other objectives, as well as with those in other government PPPs or commitments to international conventions, regional agreements, etc., or with the UN

[2] An objectives-led approach to SEA may be preferable when the focus is complex and at a very high level covering multiple PPPs, thus making it difficult to separate impacts likely to arise under different PPPs, or when an impacts-based approach is likely to be problematic (e.g., when there are inadequacies in the availability of baseline data (see Section 1.5).
[3] Social objectives may also include health, cultural, aesthetic, and other values, and may include economic objectives.

Sustainable Development Goals (SDGs). This may involve a careful examination of the policy and legal framework;

- Relations between the objectives of the proposed PPP and the relevant ESQOs may be easily presented through ***simple matrices*** that may provide the basic description of impacts. An example of a simple compatibility matrix is provided in Annex 7. Various conflicts, antagonisms, and synergies may be easily visualized using, for example, simple symbols or colors that indicate:
  - Absolute conflict/constraints (red);
  - Considerable conflict/constraints (orange);
  - Considerable positive impact or synergy (light green);
  - Full synergy – the proposed objectives resolve an existing environmental or sustainability problem (dark green);
  - Impact is uncertain (blue);
  - Impact is insignificant (no color);

- ***Conflicts need to be resolved*** or specific recommendations given on which areas may require resolution to ensure that the objectives are mutually supportive;

- ***Stakeholder consultation*** with relevant lead agencies and the public to determine how they will be affected and to ensure their concerns are included in setting ESQOs. It will also assist in the prioritization of boundaries, issues, or alternatives to consider, as well as outcomes. Stakeholder comments may lead to the development of other pertinent social and environmental objectives;

- Obtain ***consensus from stakeholders***.

Some examples of ESQOs and indicators are shown in Table 2.1. More are provided in Annex 8.

Table 2.1: Some example SEA environmental and socioeconomic quality objectives and indicators

SEA topics / key issues	Possible environmental and social quality objectives	Possible Indicators (ways of quantifying the baseline, prediction, monitoring)
Biodiversity, fauna and flora	• Avoid damage to designated wildlife and ecological sites and protected species	• Reported levels of damage to designated sites/species
Population and human health	• Create conditions to improve health and reduce health inequalities	• Life expectancy • Hospital admissions
Water and soil	• Limit water pollution to levels that do not damage natural systems	• Quality (biology and chemistry) of rivers, canals, and freshwater bodies and of soil
Air	• Limit air pollution to levels that do not damage natural systems	• Number of days of air pollution / Levels of key air pollutants by sector and per capita
Climate factors	• Reduce greenhouse gas emissions	• Carbon dioxide (CO_2) emissions
Cultural heritage and landscape	• Preserve historic buildings, archaeological sites, and other culturally important features	• Percentage of historic buildings and archaeological sites ‘at risk’

In the SESMP, indicators will need to be established to help monitor whether management recommendations for achieving the ESQOs are being met (see Box 2.14).

2.5.2 Limits of acceptable change

Scoping should determine relevant Limits of Acceptable Change (LAC) or thresholds to inform the evaluation of the potential significant environmental and social impacts of a PPP and/or to determine appropriate indicators to be recommended by the SESMP for monitoring (see Box 2.14). A key principle of SEA is that it sets the criteria for levels of environmental or social quality and identifies what change is considered acceptable. In some circumstances, it may be appropriate to select a LAC/threshold as an indicator.

LAC can be derived from various sources, such as existing international or national standards, legislation, guidelines, targets for environmental quality in management plans or programs, and State of the Environment (SoE) reports. If there are no appropriate LACs, they can be developed during the SEA through stakeholder engagement, inputs from specialists, and the findings of the situation assessment. LACs and thresholds may also be identified or clarified during the subsequent detailed assessment stage.

2.5.3 Identifying alternatives to a PPP or elements of a PPP and use of scenarios

A key principle of SEA is to consider alternatives to a PPP or elements of a PPP. This provides a means to identify and explore different ways (different options, choices, or courses of action) to deliver a PPP's objectives while addressing environmental and socioeconomic issues.[4] The timely consideration of alternatives in SEA and the planning process provides an opportunity to identify and explore ways of accommodating the future development needs of an area or sector, taking into account the intrinsic environmental and socioeconomic conditions.[5] Alternatives should be realistic, reasonable, viable, and implementable options that promote environmental and socioeconomic benefits while fulfilling a PPP's objectives.

Identifying alternatives is likely to be easier where the SEA is focused on a specific PPP (e.g., for hydropower, solar, or wind generation). However, where the SEA is focused at a higher and broader meta-level (e.g., for the wide range of energy options likely to be considered for the energy transition), considering PPP-specific alternatives is likely to be impossible. In such circumstances, it may be preferred to assess the impacts of implementing transition changes under different scenarios (see below).

SEA has the most influence during the early PPP development stage because a comparative evaluation of the need or demand for a new PPP or need to modify an existing PPP and an impact evaluation of a broad range of alternatives can be conducted before any irrevocable decisions are made. Such early consideration of alternatives can reduce the need for remedial measures at later stages in the development planning process, particularly when alternatives become increasingly constrained when moving downstream in that process, ultimately reaching the project level.

A range of sources can trigger how to identify alternatives. These include:

- Analysis of strategic policy or action objectives, the policy context, environmental and social quality objectives, and existing and predicted environmental, social, or sustainability problems;
- Consideration of hierarchy alternatives (Box 3.5), and
- Suggestions raised by key stakeholders and by planners or contained in previous SEAs or other assessments.

The alternatives assessed in the SEA could represent different ways of delivering each target.

The early (initial) consideration and assessment of alternatives can reduce the need for remedial measures at later stages in the development-planning process, given that alternatives become increasingly constrained as planning moves from policy to plan to program level, ultimately arriving at the project level. This concept is usually referred to as the hierarchy of alternatives, illustrated in Box 2.5.

[4] González *et al*. (2015)
[5] González *et al*. (2015)

Alternatives are formulated bearing in mind the identified key environmental and socioeconomic issues and the likelihood of generating opportunities, benefits, and potential negative impacts that might arise. Generally, expert judgment, authority requirements, and key stakeholder inputs are combined to formulate and agree on reasonable alternatives.

The Steering Committee should confirm which alternatives should be initially assessed by the SEA and subsequently determine which is/are the preferred alternative(s) for deeper assessment.

Box 2.5: Hierarchy of alternatives

Need or demand: is it necessary? (often relevant to policy level)

- Are the developments envisaged in the PPP necessary?
- Can the need be met without implementing the PPP and without any new developments or infrastructure, etc.?
- Can the developments envisaged in the PPP be avoided?
- Are there any realistic opportunities for managing development demand, e.g., through regulatory, economic, or administrative tools or other measures that promote behavioral changes?

Mode or process: how should it be done? (often relevant to plan level)

- Are there technologies, methods, or processes that can meet the need with less environmental damage or social change than “obvious” or traditional methods?
- Has best-available technology been considered?

Location and timing: where should it go? (often relevant to program level)

- What alternative locations could be considered?
- Timing and implementation (when and what to do in detail? Usually considered by project-level EIA)
- When and in what sequence should development be carried out?
- What details matter and what requirements should be formulated to ensure effective implementation?

Scenarios

Another way to address alternatives is through the use of scenarios. These (existing or developed for the SEA) can be used to examine how implementation of energy transition options might unfold different under different potential futures. These scenarios could represent, for example, different rates for the energy transition and replacement by renewables (e.g., high. medium, low) or different time periods (e.g., near-term, medium-term, longer term). They could also include different economic growth regimes (e.g., high, medium, or low growth) or scenarios for climate change. Scenarios will be influenced by key drivers of change (see Box 2.7). They can also be considered as alternatives (see Annex 9 on scenario development).

Box 2.6 presents examples of scenarios used for a SEA undertaken for the energy transition in Indonesia.

Box 2.6: Scenarios for the energy transition in Indonesia
(Source: Ciera Group and PT Hatfield Indonesia, 2023)

In November 2022, the Government of Indonesia (GoI), the Asian Development Bank (ADB) and key development partners signed a Memorandum of Understanding (MOU) towards the retirement of coal fired power plants (CFPPs), a reduction of CO_2 emissions, and a transition to renewable power under ADB's Energy Transition Mechanism (ETM).

A StEA is being prepared to assess the environmental and social risks, impacts, and opportunities of the energy transition in Indonesia. To do this, three scenarios were developed:

Scenario 1: "***Business as Usual"*** considers continued fossil fuel (coal) energy production, no early retirement of CFPPs, and increased use of natural gas. In this scenario, there is a slight and natural increase in renewable energy generation.

Scenario 2: "***Moderate Energy Transition"*** demonstrates a slight retirement of CFPPs by 2060 where there is no new growth in fossil fuel usage and renewable energy responds to any new additional energy demand.

Scenario 3: "*Rapid Energy Transition"* represents a total retirement of CFPPs by 2060 where a full transition to renewable energy production meets or exceeds future energy demand.

Where scenarios are used/developed, these should be agreed by the Steering Committee.

When developing scenarios, it is important to take into account drivers of change (Box 2.7).

Box 2.7: Analyzing drivers of change

When analyzing the current and potential future environmental and socioeconomic conditions, it is important to reflect on how drivers of environmental and socioeconomic change (such as the energy transition, macro-economic factors, and climate change and globalisation) will affect ecosystem functions and services, as well as human well-being and economic development.

The sources of risk stemming from the environment and social activity as well as the risks to the environment and socioeconomic fabric should be examined. For example, degraded ecosystems caused by routing access roads and transmission lines through protected and sensitive areas may, in the long run, lead to a lack of clean water or reduced soil fertility which, in turn, will affect human health and livelihoods.

The links between socioeconomic factors (e.g., livelihoods, food security) and specific ecosystem functions that might be affected by renewable energy development should be addressed. For example:

- How finite are available resources in areas proposed for renewable energy development?
- How might such developments affect social power relations (e.g., where there is an influx of non-local construction workers) and influence livelihood opportunities for different gender groups?
- How will the siting and deployment of renewable energy projects affect issues of food security in prime agricultural land or impact biodiversity in natural or critical habitats?
- How might renewable energy development affect access to services, education, employment, and health?
- How is energy security to be addressed in moving from fossil fuel generation to renewable energy sources?

Consideration should be given to how PPP implementation as well as disasters may affect ecosystem functions and have an impact on health and livelihoods.

2.5.4 Identifying baseline information requirements and initiating collection

SEA needs to be based on a thorough understanding of the potentially affected environment and socioeconomic systems. So, a critical step for the SEA team is to identify and acquire critical baseline information, drawing from all relevant sources. This must involve more than a mere inventory (e.g., listing flora, fauna, landscape, urban environments, ethnological, or cultural groups). Particular attention should be paid to important ecological systems and services, their resilience and vulnerability, and significance for human well-being. Existing environmental and social protection measures and/or objectives set out in international, regional, national, and local PPPs should also be reviewed. Scoping will be very important in identifying what issues are important and to focus what data collection is required. Baseline data should cover the issues listed in Box 2.8.

Box 2.8: Required baseline information

Note: Not all of the listed information will be "required" in all cases; scoping key issues should be used to focus on what is relevant.

Biophysical

- Air quality, with particular focus on the occurrence of pollutants in the air;
- Climate, including future climatic change scenarios for the region and country, and vulnerability to climate change;
- Noise and vibration;
- Topography, soils, and geology;
- Risks of natural disasters, particularly earthquakes, landslides, and flooding;
- Surface water and groundwater resources, quality and quantity, and chemical characteristics;
- Ecosystem services, especially wetlands (riverine areas, lakes, etc.) and forest areas, nature conservation and protected ecosystems, and biological corridors;
- Biodiversity (flora and fauna), rare and threatened/endangered species, endemic species and habitats, species of commercial importance, invasive species (terrestrial, aquatic, marine);
- Land use and use of natural resources.

Socioeconomic conditions and human health

- Population dynamics;
- Employment status, poverty, skills, livelihood, and education profile;
- Sanitation issues;
- Economic profile of the country, including analysis of key economic drivers (e.g., tourism, hydropower, lifestyle investments, recreation) and associated multipliers and spin-offs;
- Human health profile, especially communicable (e.g., HIV/AIDS, COVID) and non-communicable diseases (e.g., diabetes, cancer prevalence);
- Archaeology and cultural heritage;
- Recreational aspects;
- Social-economic aspects;
- Land use, transportation, infrastructure, agricultural development, and tourism.

Physical infrastructure and social facilities and services

- Distribution of current and planned energy infrastructure (including planned renewable energy facilities, transmission lines, and grid analysis);
- Distribution of urban centers, types of current and expected future settlement development (e.g., municipal changes/expansion), population dynamics, land and property values, land use and availability;
- Water supply and use (city/towns, other settlements, agriculture, etc.) and likely future scenarios for demand and use;
- Dams (hydropower, storage);
- Transport, traffic, power lines, pipelines, roads, and other related infrastructure;
- Industrial infrastructure;

- Current and planned water and waste management and supply infrastructure (including assessment of state of infrastructure); and
- Current and planned schools, hospitals, clinics, recreation, religious, cultural, and retail facilities.

Governance and decision-making

- Institutions, structures, and decision-making systems relevant to energy management and energy transition implementation (e.g., regarding the allocation of permits and associated compliance monitoring for large projects) and for those institutions at a regional or international level that may influence energy transition implementation.

2.5.5 Analysis of baseline information and sensitivity mapping

The analysis of baseline information should include trend analysis to examine changes over time, with and without the proposed PPP. See Annex 11 for more details on trend analysis; it provides fictional examples of the assessment of impacts of past and future environmental and social trends as influenced by the actions proposed in a PPP for terrestrial biodiversity.

An SEA can be supported by a robust and data-led spatial planning exercise, involving identification of technical, environmental, and socio-economic constraints to implementing a PPP. A core component of such planning is sensitivity mapping, or what is also called the identification of “go or no-go zones” (see Box 2.9) to identify areas where renewable energy developments should be avoided due to their sensitivity for biodiversity and social receptors. Such mapping can be undertaken relatively rapidly with existing data (desk-based) or can be a more intensive process such as full scale Marine Spatial Planning.[6] Sensitivity maps are a powerful tool for protecting nature and vulnerable communities whilst facilitating the transition to renewable energy to reduce global emissions.

Box 2.9: Sensitivity mapping

Source: Biodiversity A-Z (2019)

Sensitivity mapping provides a visual representation of risks and assets that may be exposed to them. Multiple environmental sensitivity mapping approaches exist, with methods and uses varying based on stakeholders’ values, drivers of change, data availability, and the technical capacity of the users. Sensitivity mapping is often carried out using geographic information systems (GIS) technology. The amount and/or type of data used to produce a sensitivity map will affect and limit its potential uses. Nevertheless, environmental and social sensitivity mapping can have a wide variety of applications. These include but are not limited to:

- Helping decision-makers understand where protection of valuable environmental assets or social values is needed, which could aid the development of protected area networks or identifying low value lands for renewable energy development;
- Informing governmental and private sector spatial planning at the project level, targeting activities to the locations where they will have the lowest impact;
- Supporting all stages of impact management, including prevention, mitigation, preparedness, operations, relief, recovery, and integration of lessons learned, and
- Aiding situational awareness and response strategy development for responders and decision makers during an incident.

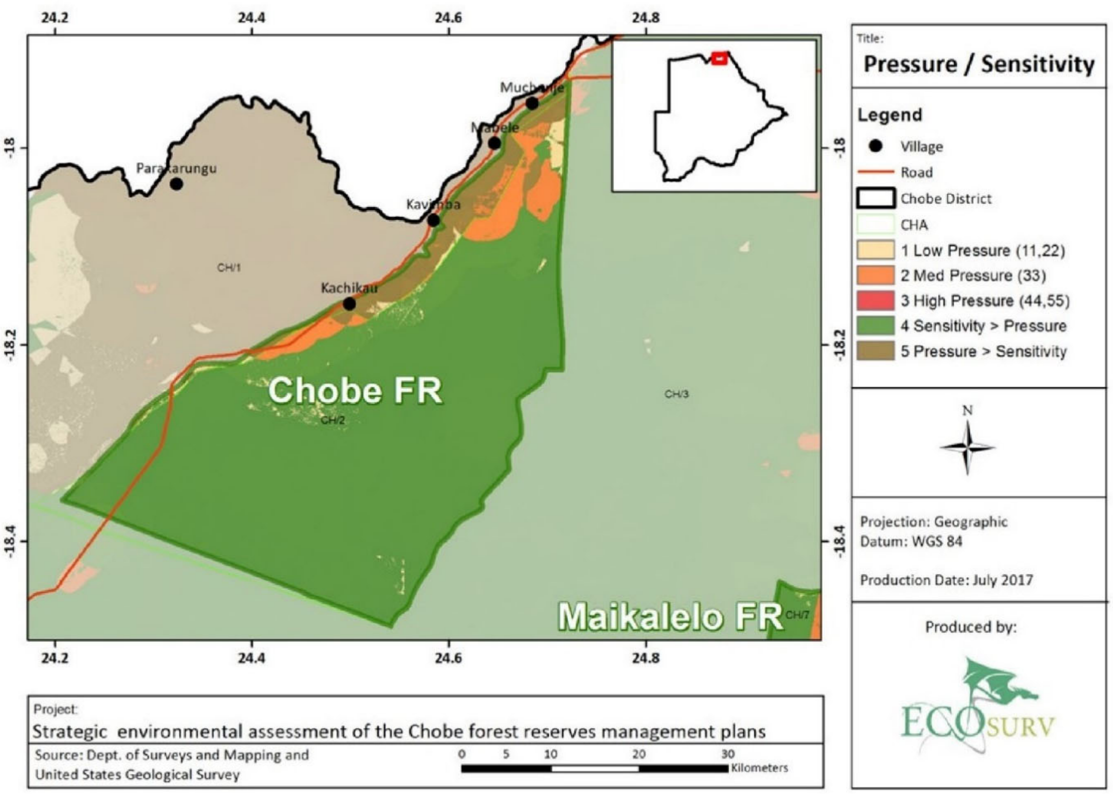
During scoping, sensitivity mapping of areas vulnerable to environmental and social pressures should be initiated by evaluating and interpreting the environmental and social baseline information, taking account of drivers of change (Box 2.7). This will help to identify the environmental and socioeconomic opportunities and risks/constraints in relation to the proposed PPP. The baseline information also provides a benchmark against which alternatives/scenarios can be evaluated.

If placed in poorly chosen areas, renewable energy developments can end up have serious consequences for ecosystems or local communities. For example, offshore wind farms can cause considerable harm to fragile marine ecosystems, with seabirds being particularly sensitive. Whilst not replacing site-specific assessments of environmental impacts, sensitivity maps can dramatically reduce conflicts with nature by identifying areas where the negative impacts of offshore wind farms and grid infrastructure will be higher or lower.

[6] For more information, see: mspglobal2030.org

Figure 2.2 shows a map depicting pressure and sensitivity in the Chobe Forest Reserve, Botswana (see Annex 18 for further details of the sensitivity mapping process).

Figure 2.2: Map showing pressure and sensitivity in the Chobe Forest Reserve, Botswana
Source: ECOsurv (2018)



Such information allows the selection of locations for development that minimize harm to nature and communities. It can reduce uncertainty and save time and eventually costs for developers. Sensitivity maps can help to speed up existing planning processes, inform and corroborate EIAs for projects once locations are selected for development, and avoid conflicts between stakeholders, which can lead to significant delays.

The World Bank, via the Energy Sector Management Assistance Program (ESMAP), is currently developing guidance for environmental and social sensitivity mapping to support early spatial planning for offshore wind development in emerging market contexts. It is designed to be complementary to (or a precursor to) full-scale spatial planning processes like marine spatial planning, or SEA.

Existing guidance for sensitivity mapping includes Birdlife's AVISTEP (Avian Sensitivity Tool for Energy Planning)[7] and the EU Wildlife Sensitivity Mapping Manual.[8]

Sensitivity mapping and analysis will also enable the SEA team to assess the adequacy and reliability of available information and data and identify whether additional information may be required. In some cases, it may be necessary to commission specialist studies on subjects/themes of particular importance to the PPP/SEA. Where vital information is lacking or inadequate, there may be a need to undertake or commission new research, e.g., where data is required on annual or seasonal trends or from other jurisdictions (such as adjacent countries in the case of an SEA of a PPP with cross-border implications).

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[7] Birdlife International (n.d.)
[8] Allinson, T., Jobson, B., Crave, O. et al. (2020)

The sensitivity mapping and analysis should be informed by the scoping process and, in turn, help to inform it.

2.5.6 Consistency analysis of PPPs and legal instruments

As indicated in Box 2.4, one of the critical steps in scoping is to identify and analyze:

- all relevant PPPs that might be related to the PPP being assessed (the target PPP) or that might have influence on or be affected by the target PPP; and
- relevant laws, decrees, directives, and regulations.

Analysis should be undertaken of such PPPs and legal instruments to check their consistency with each other and with the target PPP. This should include identifying synergies, overlaps, and antagonisms (particularly in terms of their environmental and social objectives). Such analysis will help to:

- Identify where the target PPP and candidate ESQOs to be used in the SEA might conflict with other instruments or where there is potential to generate synergies, enhanced benefits, and win-win outcomes;
- Increase the efficiency of the new/revised target PPP; and
- Identify where policy reform or modification of legal instruments might be necessary to ensure alignment to foster progress towards sustainable development.

Analysis can be summarized in a tabular or comparative matrix format. Annex 5 provides an example of such a review conducted for the preliminary SEA of Bhutan's Road Sector Management Plan (2016).

2.5.7 Submission and review of scoping report

A *Scoping Report* should be prepared, incorporating, as an annex, the terms of reference as finally agreed on by the proponent. It should indicate how the scoping was conducted and cover the issues listed in Box 2.3.

The proponent should circulate the draft scoping report to key stakeholders (including the competent authority) for review and make it available for public comments. A workshop may be considered to discuss the scoping report and obtain feedback from participants. The scoping report should also be posted on the SEA website, if developed, to obtain additional feedback. Other forms of social media may also be used.

Annex 10, Section 1, *Scoping* (*Consolidated Checklist for the Quality Assurance, Review, and Performance Evaluation of a Comprehensive SEA*) can be used to review the scoping process and scoping report. The checklist should be included in the scoping report as an annex so that a check can be made by interested parties to determine that the scoping has been conducted thoroughly.

2.6 STAGE 5: THE MAIN ASSESSMENT

2.6.1 Introduction

This stage is the heart of the SEA process and involves an assessment of the likely risks and impacts of implementing the PPP and its alternatives, or of implementing energy transition options under different scenarios. The full spectrum of potential impacts, including those due to associated infrastructure, must be considered, including positive and negative, direct and indirect, cumulative, and transboundary environmental and socioeconomic impacts. Such impacts can result from individually minor but collectively significant actions taking place over a period when implementing the PPP of energy transition options (see Section 2.6.4. for discussion of cumulative impacts). In addition, the impacts should be considered over time and spatial scale (e.g., short-, medium-, and long-term). Permanent impacts at local, national, regional, or international scales should be identified. The comparative evaluation of alternatives should highlight potential irreversible impacts or irreplaceable loss of natural capital, as well as risks to social and ecological systems.

In subsequent chapters addressing particular types of renewable energy development (Chapters 5-11), the retirement of coal-fired power plants and closure of coal mines (Chapter 12), and associated infrastructure (Chapter13), the guidance discusses the main environmental and socioeconomic issues and associated impacts that are relevant to strategic decisions.

Key tasks of the main assessment are summarized in Box 2.10. Various methods (analytical tools) can be used as described in Annexes 6 and 12.

Box 2.10: Key tasks of the main assessment stage

Assessment steps will need to be designed according to the context, nature of the PPP and other factors; but would usually involve:

- *Initial assessment of agreed alternatives* to the PPP or its components, or agreed scenarios. The proponent should then select a preferred alternative(s) or scenario (if these are being used as alternatives) and provide an explanation of how the findings of the initial assessment of alternatives and consultations were considered in its selection.
- *Deeper assessment of preferred alternative(s)* or scenarios.
- Preparation of *SEA report and SESMP* which sets out management recommendations (including monitoring requirements) and suggested mitigation measures to avoid significant adverse impacts and measures to enhance benefits.

The assessment should involve:

- Continued analysis of available baseline data, filling of data gaps and collection of critical new data from research/field studies;
- Continued stakeholder engagement;
- Identification of potential environment and socioeconomic risks and impacts (positive and negative, direct and indirect, cumulative, transboundary). This is best done to compare two situations: (a) *risk situation* when no safeguards are applied and no mitigation measures applied; and (b) *mitigated situation* when safeguard and mitigation measures are fully and effectively applied;
- Identification of whether the ESQOs will be likely to be enhanced or impeded by implementing the PPP under consideration;
- Identification of options for enhancing positive impacts and avoiding/minimizing/mitigating negative impacts;
- Preparation of the framework for the SESMP.

2.6.2 Two stages of assessment

The main assessment should be undertaken in two main stages:

- ***Initial (light) assessment*** of the alternatives to the target PPP, its components, or of agreed upon scenarios.
- ***Deeper assessment*** of preferred alternative(s) or scenario – more focused and detailed.

The ***initial assessment*** should also include a zero alternative (the “business-as-usual” alternative), which implies the continued use of fossil energy systems and existing (but not new) renewable energy facilities not already in the pipeline, and all of the impacts associated with these.
A simple scale (i.e., 1, 2, 3; low, moderate, high) for indicating likely negative and positive impacts of implementing the PPP or indicating the likelihood that implementation will either enhance or impede achieving ESQOs is likely to be appropriate for the initial assessment. Other more complex scales

(four, five, or more) could be selected if there is good knowledge of the ESQOs, but this will add time for discussion with the team.

In circumstances where the SEA focuses on the energy transition in general (with multiple options and multiple PPPs), the SEA will need to be tailored to that situation, and an objectives-led and scenario-based approach is likely to be the most appropriate. Table 2.2 shows ESQO scoring matrices (environmental and socioeconomic, respectively) for initial assessment of three scenarios undertaken for an energy transition SEA in Indonesia in 2023-2024.

Another such example where multiple PPPs were involved is an SEA conducted for the SW Region of Bangladesh for Conserving the Outstanding Universal Value of the Sundarbans, which addressed 89 separate PPPs across 28 sectors and key themes.[9] In this case, the SEA involved:

- preliminary assessment of all 89 PPPs (using simple scoring: high, medium, low potential impacts);
- initial assessment of the impacts of implementing this suite of PPPs under three scenarios (taken as alternatives) – high, medium, and low growth; followed by
- deeper assessment of the high growth scenario (the government’s primary economic development policy) on a key sector basis.

A report on this initial assessment should be circulated to stakeholders for comment, and then the selection of a preferred alternative(s) should be confirmed by the proponent, taking into account the views of the Steering Committee. The proponent should provide an explanation of how the findings of the initial assessment of alternatives and consultations were considered in deciding on the preferred alternative(s).

The ***deeper assessment*** of the preferred alternative(s) or scenario confirmed by the Steering Committee should be more focused and more detailed. This could involve:

- Focusing on particular renewable energy sectors or areas for development (e.g., regions of the country); and/or
- Using a more detailed scoring scale for positive or negative impacts/effects (i.e., 1 – 5; slight, moderate, very, significant, very significant).

[9] CEGIS/Integra (2021)

Table 2.2: ESQO scoring matrix for initial assessment of energy transition scenarios, Indonesia
Source: Ciera Group and PT Hatfield Indonesia (2024)

A: Environmental

Theme	#	Objective	Risk Score by Scenario			Mitigated Score by Scenario		
			1	2	3	1	2	3
Environmental								
Climate change	1	Mitigate effects of climate change, through emission reduction.	-3	-2	-1	-2	0	3
	2	Increase resilience and adaptation of energy supply and infrastructure to climate change impacts	-2	-1	-1	-1	2	3
Habitats, biodiversity, and protected areas	3	Minimize loss of terrestrial and marine habitats, biodiversity and ecosystem services	-1	-2	-3	-1	-1	2
	4	Minimize deforestation	-1	-2	-2	-1	-1	0
	5	Reduce encroachment and degradation of protected and ecologically sensitive areas	-1	-1	-2	0	1	2
Air quality	6	Reduce air pollution	-3	-1	-1	-2	1	2
Noise and vibration	7	Minimize disturbance caused by noise and vibration	-1	-1	-2	0	0	-1
Surface water quality	8	Reduce water pollution (surface and groundwater)	-3	-1	-1	-2	0	1
Solid waste	9	Reduce waste disposed to landfills (e.g. by increasing repurposing, recycling, and reuse of assets)	-3	-2	-2	-2	0	1
	10	Improve safe handling, storage, and disposal of solid waste, including hazardous waste	-3	-2	-2	-2	0	1
Materials use	11	Minimize use of non-renewable and toxic materials used in developing new assets	-3	-2	-1	-2	0	1
Water use	12	Minimize use of local water resources and ensure efficient use/reuse of water	-3	-1	-1	-2	0	1
Land contamination and degradation	13	Maintain soil quality and reduce land contamination	-3	-2	-1	-2	0	0
	14	Minimize soil, riverbank and seabed erosion, and sedimentation of surface water	-1	-1	-2	0	1	0
Land-use change	15	Minimize loss and degradation of productive agricultural land, forests, grazing land, and fisheries	-2	-2	-3	-1	0	1
Visual impacts	16	Minimize extent of visual change to landscape and loss of aesthetic value	-1	-1	-3	-1	0	0
Cultural heritage	17	Preserve heritage sites (historic buildings, archaeological and cultural sites)	0	-1	-2	0	0	0
Health and safety	18	Ensure population health, and safety of communities and workers	-3	-2	-2	-1	0	1

B: Socioeconomic

Theme	#	Objective	Risk Score by Scenario			Mitigated Score by Scenario		
			1	2	3	1	2	3
Economic growth	19	Enhance economic development and diversification, and increase in economic growth (regionally & nationally)	1	1	-1	1	2	2
Employment and skills	20	Enhance opportunities for employment and skill development	1	1	-2	2	2	2
Local economy and livelihoods	21	Minimize loss of livelihoods including for vulnerable groups and adat communities	-1	-1	-3	0	2	1
	22	Enhance equitable opportunities for new/improved and diversified livelihoods	-1	-1	-3	1	2	2
Gender and vulnerable groups	23	Minimise gender inequality and minimise vulnerable groups being disadvantaged	-1	-1	-2	1	2	2
Food security	24	Improve food security	-2	-2	-3	-1	1	1
Physical and economic displacement	25	Minimize physical and economic displacement	-2	-2	-3	0	1	1
Public services and infrastructure	26	Maintain and improve local public facilities and services	0	0	-1	2	2	3
Human rights	27	Avoid infringement of human rights of workers, communities and vulnerable groups (including in supply chains)	-2	-1	-1	1	1	1
Migration	28	Minimise outmigration	0	0	-1	0	0	0
	29	Minimise influx and competition with local workers in RE facilities	0	-1	-2	0	1	1

Scenarios: 1 Business-as-usual. **2** Moderate rate of ET. **3** Rapid ET.

2.6.3 Tools for assessment

Apart from matrices, a wide variety of other tools that can be applied during an SEA. Common tools are listed in Table 2.3. Many of these are also commonly used in EIA/ESIA. The listed tools and others are described in Annexes 6 and 12 (with additional information in Annex 9 on scenario development). The most suitable method depends on the approach adopted (whether impacts-led, objective-led, or both) and the SEA team members' specialized competence in the analytical subject area, professional experience, and judgment.

Table 2.3: Common assessment tools available to SEA

Tools for predicting environmental and socioeconomic impacts	Tools for analysing and comparing options/alternatives
• Carrying capacity analysis • Checklists • Delphi technique • Ecological/environmental footprint analysis • Expert judgement* • Land use partitioning analysis • Mapping transmission channels • Matrices* • Modelling/forecasting* • Network analysis and linkage/flow diagrams* • Participatory assessment • Quality of life assessment • Indicators, multi-metric indices* • Scenario analysis* • Significance thresholds • Social and economic analysis/surveys • Spatial analysis*, e.g. GIS-based analysis (including overlays, capacity/habitat analysis) • SWOT (strengths, weaknesses, opportunities, threats) analysis • Trends analysis/extrapolation	• Compatibility appraisal • Cost-benefit analysis • Least cost analysis • Impact matrices • Multi-criteria analysis • Opinion surveys • Policy impact matrix • Risk analysis/assessment • Modelling • Scenario analysis • Vulnerability analysis

* Tools often used to assess cumulative impacts

Notes: See Annexes 6 and 12 for descriptions of methods.
Some of these tools depend on expert judgement of the practitioners involved.

Both the initial and deeper assessment tasks should focus on the risks that implementing the PPP, its alternatives, or different options for the energy transition under different scenarios could result in significant environmental and/or socioeconomic impacts and enhance or impede achieving environmental and/or socioeconomic objectives.

The assessment should address:

- The character of the risks/impacts (what exactly causes the risks/impacts or assumptions for the predictions);
- The opportunities and the positive impacts or benefits that may arise from PPP implementation;
- Probability and key uncertainties (Box 2.11). Uncertainties must be properly acknowledged and included as a caveat to the SEA conclusions, recommendations, and subsequent decisions;
- Geographic scale; directly and indirectly affected geographic areas that will become of specific concern;
- Frequency, duration, and reversibility; and
- Key concerns associated with the impacts.

If symbols are used to summarize the assessments and make the results of the assessments easy to present, such as in tables, they should be clearly described in a legend.

Box 2.11: Role of uncertainties in the SEA
Source: MONRE (2008)

Each SEA process will be constrained by numerous uncertainties. These may be caused either by the lack of data (e.g., baseline trends in the affected environment, about scales, timing, or locations of proposed developments, etc.) or by the built-in limitations in analytical approaches and tools used in the SEA. It is important to ensure that all key uncertainties that inevitably occur in the SEA process are properly understood and acknowledged.

Where SEA is performed *ex ante*, it is clearly focusing on predictions ahead of implementation, a key source of uncertainty. This underscores the value of developing scenarios for a range of possible outcomes to take into account such uncertainties.

The initial and full SEA reports must therefore document any uncertainties or limitations in the SEA. SEA experts should not be afraid to acknowledge such limitations; on the contrary, a proper acknowledgement of uncertainties increases the quality and credibility of the entire SEA.

If the PPP includes proposals for individual projects that will require EIA, the SEA should provide suggestions on the specific scope and focus of such EIAs (e.g., recommending specific issues that should be assessed).

2.6.4 Direct, indirect, cumulative, and transboundary impacts

Potential positive and negative environmental and socioeconomic impacts need to be identified, which may fall into different categories, including:

- ***Direct impacts***: the direct interaction with an environmental, social, or economic component of activities associated with options within the PPP or its alternatives that initiate and locate specific project activities;

- ***Indirect impacts***: those which are not a direct result of activities undertaken when implementing the PPP (usually projects and developments), often produced away from or as a result of a complex impact pathway. Indirect impacts are also known as secondary or even third-level impacts;

- ***Cumulative impacts*** and induced/synergistic impacts, e.g., those arising from large-scale schemes such as infrastructure project development in combination with other multiple projects and activities in a given time and space that lead to snowballing and cumulative impacts on valued ecosystem components, as well as those from implementing other PPPs and major development initiatives. Cumulative impacts may also include consideration of impacts arising as a result of climate change;

- ***Larger-scale impacts*** that have regional and global effects. Impacts also may be permanent, temporary, or synergistic.

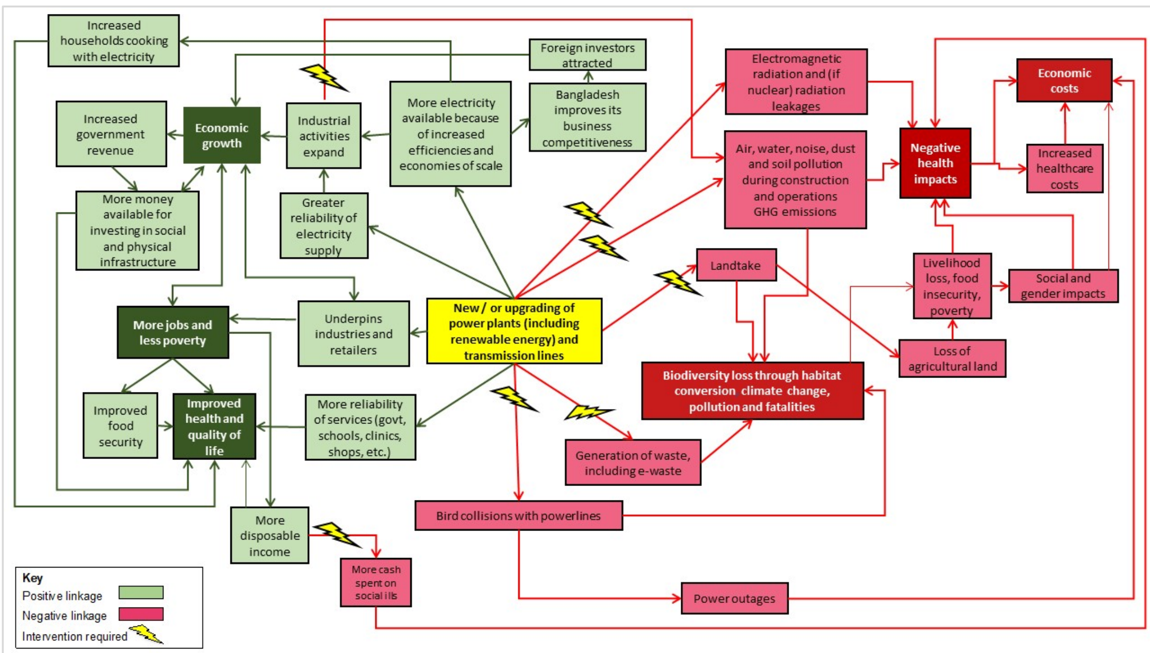
- ***Trans-boundary impacts:*** those that occur outside the immediate focal area of the PPP, e.g., in another district or region, or in another country.

The target PPP is likely to be implemented through a variety of actions and initiatives (often projects), each of which will give rise to a range of impacts. The impacts of an individual project (e.g., a single wind farm or hydropower dam) may not be particularly significant or may be confined to a particular area and be capable of management or mitigation. But the impacts from multiple projects and actions, whether of the same kind (e.g., multiple hydropower dams in a watershed) or different initiatives (e.g., a combination of different renewable energy facilities), can be very considerable and spread across a very wide area. These are their *cumulative impacts*. But it is also necessary to consider the impacts of other PPPs, strategies, plans, and projects in the area covered or influenced by the PPP. They will also generate their own suites of impacts. When all of those impacts are combined with the impacts of the PPP being assessed, then the overall cumulative impacts can be very large indeed, as depicted in Figure 1.2.

Impacts are not a matter of simple cause-and-effect. They are subject to cascading primary, secondary, tertiary, and subsequent level impacts. This generates a complex web of interacting and cumulative linkages that need to be understood by policymakers and decision-takers. Developing a picture of such linkages is a complex process and takes considerable time to brainstorm. Figure 2.2 is an example of a linkage diagram that shows the pathways for cumulative impacts to arise that were identified during an SEA in Bangladesh.[10] Figure 2.3 shows workshop participants constructing a linkage diagram during an SEA of development in Pohnpei State, Federated States of Micronesia. Figure 2.4 is an example of how cumulative impacts are the total impacts of multiple actions on a receptor.

Figure 2.2: **Linkage diagram for power and energy: new or upgrading of powerplants and transmission lines in Bangladesh**

Source: CEGIS/Integra (2021)



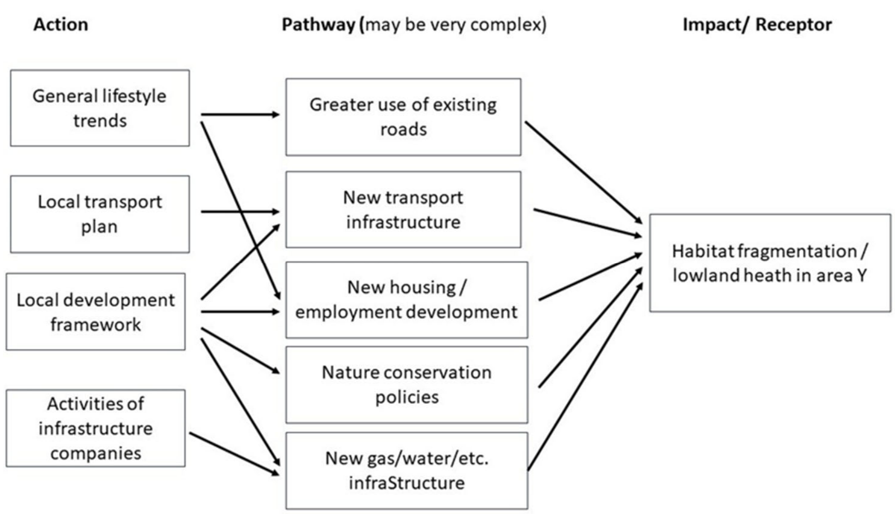
Main cumulative impacts

Positive: Economic growth, more jobs and less poverty, and improved health and quality of life
Negative: Economic costs, negative health impacts, loss of biodiversity through habitat conversion, climate change, pollution, and fatalities.

[10] CEGIS/Integra (2021)

Figure 2.3: Constructing a linkage diagram for SEA of Pohnpei State, Federation of Micronesia, March 2019
Source: B. Dalal-Clayton (n.d.)

Figure 2.4: Example of how a cumulative impact can arise when implementing a PPP
Source: Therivel (2005)



2.6.5 Evaluating the significance of impacts

The concept of significance is at the core of impact assessment, impact evaluation, and decision-making. Deciding whether a PPP is likely to cause significant environmental and/or social impacts is central to the practice of EIA. Similarly, in SEA, impacts, trade-offs, and options or alternatives need to be assessed in terms of significance to determine optimum choices and eliminate unacceptable ones.

There is no single best method for determining the significance of impacts. Various formal methods include using ratings (see examples in Table 2.4 and Annex 13), ranking, weighting, and/or scaling. Future scenario building and back-casting methodologies can be used to determine significance in particular sectors and/or to help translate "facts into meaning." The review of other PPPs and targets during scoping is key to providing information on significance.

Table 2.4: Example of scale for rating significance of impacts used in Kenya
Source: NEMA (2012)

Significance	Criteria
High	• Exceeds or threatens to exceed legal thresholds or standards. • Exceeds or threatens to exceed functional thresholds or LAC for health and safety; may result in irreversible, irretrievable, or irreplaceable loss of ecosystem services. • Norms or Limits of Acceptable Change (LAC) established by society.
Medium	• Controversial LAC; no societal agreement on these limits.
Low	• Preference thresholds for individuals, groups or organizations; not for broader communities or society.

Key elements that should be considered in determining significance include the characteristics of the actual impacts and the area likely to be affected:

Impact characteristics:
- The probability, duration, frequency, and reversibility of the impacts (e.g., ecosystem fragmentation);
- The geographical extent of the impact;
- The magnitude (scale) of the impact;
- The cumulative nature of the impacts;
- The transboundary nature of the impacts;
- The risks to human health or the environment (e.g., due to accidents); and
- The magnitude and spatial extent of the impacts (i.e., geographical area and size of the population likely to be affected).

Importance of the affected area due to:
- Its value and vulnerability;
- Special natural characteristics or cultural heritage;
- Exceeded environmental quality standards or limit values;
- Intensive land use;
- The impacts on areas or landscapes that have a recognized community, district, national, or international protection status or value.

Annex 14 provides a checklist of questions that can be applied when determining impacts and their significance.

2.6.6 Restoration

Implementing a PPP will usually involve a range of actions that will often take the form of individual projects or developments. Where mitigation measures proposed by an SEA (and subsequent project-level EIAs) are inadequate, ineffective, or not undertaken, actions and projects can result in environmental or social harm and degradation (e.g., unnecessary or excessive deforestation; loss of habitats, biodiversity, and ecosystem services; soil erosion; pollution; involuntary resettlement, etc.). The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. It will usually lead to demand and need for land and ecosystem restoration (see Box 2.12). This need will also arise at sites of projects that have come to the end of their useful life (e.g., coal mines or retirement of coal-fired power plants). This may involve situations where funds are not available for restoration if the company is no longer in business.

Box 2.12: Land and ecosystem reclamation and restoration

Land restoration, which may include renaturalization (also called rewilding in some countries), is the process of ecological restoration of a site to a natural landscape and habitat that is safe for humans, wildlife, and plant communities. Ecological destruction, to which land restoration serves as an antidote, is usually the consequence of pollution, deforestation, salination, or natural disasters. Land restoration is not the same as land reclamation, where existing ecosystems are altered or destroyed to give way for cultivation or construction. Land restoration can enhance the supply of valuable ecosystem services that benefit people.

Land restoration can include the process of cleaning up and rehabilitating a site that has sustained environmental degradation, such as those by natural causes (e.g., desertification) and those caused by human activity (strip mining), to restore that area back to its natural state as a wildlife home and balanced habitat.

Land restoration is also at the core of the UNCCD's mission, as actions that protect and revitalize land resources such as soil, water, and biodiversity are critical to achieving Land Degradation Neutrality (LDN) by 2030 and constitute a proactive way to build resilience to drought[11].

The Kunming-Montreal Global Biodiversity Framework was developed under the UN Convention on Biodiversity and was adopted in December 2022[12]. It includes four global goals and 23 targets for 2030. Target 2 is to "*Ensure that by 2030 at least 30 percent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration in order to enhance biodiversity and ecosystem functions and services, ecological integrity, and connectivity."*

The UN Decade on Ecosystem Restoration (2021-2030) aims to promote the UN's environmental goals; specifically, it aims to facilitate global cooperation for the restoration of degraded and destroyed ecosystems, along with fostering efforts to combat climate change, safeguard biodiversity, food security, and water supply. While much focus is on promoting restoration activity by national governments, the UN also wishes to promote such efforts from other actors, ranging from the private sector and NGOs to individuals.

Ecosystem restoration promotes the idea that developments should transition from a "do no harm" approach to a "do more good" approach. Thus, SEAs should not only identify how the energy transition and renewable energy PPPs can be framed to avoid, minimize, and mitigate harm to the environment, but also consider how such PPPs can promote opportunities to "do more good," particularly downstream when individual projects are planned, sited, and implemented. This could look at measures such as the repurposing of retired coal fired power plants, the rehabilitation of coal mines, and reparations for outstanding environmental and social legacies.

Ecosystem restoration is also the last stage in the circular economy when projects come to their end of life, in that any residual impacts can be minimized and that the former development site can be repurposed or returned to other uses.

2.6.7 Assessing trade-offs

SEA is a process that should support the consideration of environmental and socioeconomic concerns in policy-making and planning. This includes indicating where such concerns (the main pillars of sustainable development) interact, either positively or negatively. This is often achieved by highlighting potential synergies or conflicts (antagonisms) between elements of the PPP or between the assessed PPP and other PPPs.

[11] United Nations Convention to Combat Desertification (n.d.)
[12] UNEP (n.d.)

Synergies provide potential to maximize positive environmental and socioeconomic benefits and impacts. Conflicts between PPPs (or elements of a PPP) have the potential to generate negative impacts, and an SEA should analyze these to identify where such impacts can be minimized, avoided, or mitigation measures put in place. Addressing conflicts will often require planners and decision-makers to make trade-offs. It is the role of SEA to highlight the areas of potential trade-off that would enable positive impacts to be enhanced and negative ones minimized, and to provide appropriate data and analysis. The provisions on trade-offs in existing agency guidelines should be followed.

Consideration of trade-offs is increasingly becoming a standard practice in SEA, and it is an effective measure to help reverse the current ecological deficit[13], in terms of biodiversity and ecosystem services. SEA can be a catalyst for addressing complex development problems and alternatives under conditions of high uncertainty, where multi-stakeholder groups with diverse and sometimes conflicting objectives could be affected. In addressing sustainability, the goal is to seek "win-win" outcomes from development. In a situation where resources are limited and when two or more conflicting objectives are being pursued, the most common outcome is that society loses in one aspect (e.g., loss of biodiversity) at the expense of another (e.g., socioeconomic development). To promote sustainability, it is critical to consider a holistic balance of various forms of capital: financial, natural, human, social, and public (i.e., infrastructure which supports production). SEA can play a critical role in identifying where such balance is possible and where trade-offs may be required.

A trade-off usually refers to losing one quality or aspect of something in return for gaining another quality or aspect. For example, in the case of offshore wind development, fishing may be restricted in the vicinity of the turbines, resulting in a loss of income for fisherfolk. It could be argued that this is compensated through other gains (e.g., less CO_2 emissions, other types of employment, production of electricity, etc.). By setting out such potential trade-offs, an SEA can help decision-makers with regard to their choices regarding the spatial location for wind farm development.[14] A trade-off implies a decision to be made with full comprehension of both the upside and downside of a particular choice.

Trade-off decisions are generally of two types:

- *Compensation and substitutions*. These can be straight forward where one option can be substituted for another, e.g., to eliminate a natural wetland and replace it with a constructed wetland of comparable ecological value elsewhere in the watershed – provided it provides the same values as a natural one – or an option can be provided to compensate for a particular risk or loss.

- *Net gain and loss calculations*. These are not always done explicitly or openly, and the measurement and comparisons are often difficult and sometimes objectionable, e.g., the jeopardized interests of a local community displaced by a new dam balanced against water supply security for a larger number of downstream rural communities.

Loss/gain accounting is quite a different prospect for biodiversity than for social values. In terms of biodiversity, loss/gain accounting is foremost about identifying the required amount of mitigation associated with an option, making sure the preventative stages of the mitigation hierarchy are optimized, and then reviewing the feasibility of achieving net gain via remediation measures. Trade-offs might be a consideration then for offsets (e.g., if net gain cannot be achieved like for like). In this sense, trade-offs MUST be acceptable to stakeholders or the option should not be pursued (the exception might be where it is legally mandated, but stakeholder acceptance is still a key factor).

While trade-offs may not always be acceptable, it is important that a justification is always provided and that the process is as transparent as possible. Significant adverse impacts could be justified if the alternative is worse.

Table 2.5 provides a basic working list of rules to guide trade-off deliberations. These rules can be used as a checklist when dealing with trade-offs within SEA.

[13] An 'ecological deficit' occurs when the footprint of a population exceeds the biocapacity of the area available to that population. Conversely, an 'ecological reserve' exists when the biocapacity of a region exceeds its population's footprint.

[14] Erik Zigterman, personal communication (2024)

Table 2.5: General trade-off rules
Source: NEMA (2012)

Rule	Description
Maximum net gains	Seek to attain mutually reinforcing, cumulative, and lasting contributions that bring the most positive overall results in sustainability (including ecological, social, and economic aspects).
Burden of argument on trade-off proponent	Burden of proof rests on the proponent of the trade-off who has to prove that the trade-off is unavoidable and acceptable.
Avoidance of significant adverse impacts	No trade-off that causes significant adverse impacts on any sustainability areas (ecological, social, economic) can be justified unless the alternative is worse.
Protection of the future	No displacement of significant adverse impacts from the present to the future can be justified unless the alternative is of an even more significant adverse effect.
Open process	Proposed trade-offs must be addressed through open involvement of all stakeholders, particularly those who will be affected by the trade-offs.

A number of tools have been designed specifically for dealing with trade-offs, for example, cost-benefit analysis and consideration of opportunity costs, matrix-based appraisal methodologies, multi-criteria assessment scenario comparisons, and life cycle assessment.

2.7: REPORTING

A variety of reports (formal and informal) may be produced during an SEA process (Table 2.6). Some will require circulation to stakeholders (and in some cases to the public) with a request for comments. Some of these will require formal review.

Every effort should be made to make SEA reports accessible to stakeholders and the public, particularly to non-specialists (e.g., non-technical summaries) and in major local language(s). The use of social media is gaining increasing importance to effective disclosure of SEA reports.

2.7.1 The SEA report

The SEA results need to be reported (e.g., aspects of the technical analysis and the rationale for conclusions and recommendations). An SEA report can at times be very technical, but it must be presented in an understandable format, in the official language used in the country for government business (and in English where international financiers are involved in funding the implementation of the PPP).

Table 2.6: Reports produced during an SEA

Report	SEA stage when report required (Table 3.1)	Requires circulation to stakeholders for information and comment	Must be provided to the public for information and comment	May require formal review	Comment
Inception report	Stage 3				If required by TOR
Scoping report	Stage 4	√	√		Should incorporate stakeholder engagement and communications plan
Special studies and research reports [15]	Stage 3/4				May require to be completed before SEA can proceed to Stage 3. Should be submitted with the SEA report
Draft SEA report	Stage 5	√	√		
Draft SESMP (when required as stand-alone)	Stage 5	√	√		
Final SEA report	Stage 5	√	√	√	
Final SESMP (when required as stand alone)	Stage 5	√	√	√	
Record of stakeholder events	Stage 5		√		A record of numerous meeting/workshops (participants, comments) may better be presented as a stand-alone report, to reduce undue length of the SEA report
Monitoring reports on PPP implementation – may be subsumed in SESMP (where required) annual reports	Stage 6			√	On-going throughout PPP implementation

Note: In some countries there may be requirements to submit other reports/documentation.

An SEA is usually complex and can run to a considerable length. But is very helpful to minimize unnecessary text by using diagrams, graphics, and summary tables. In addition, a concise, non-technical summary is critical and should adequately summarize and explain the SEA findings to all stakeholders, including local communities. The non-technical executive summary should contain the title of the report and it should summarize:

- Proposed PPP, objectives and SEA methodology;
- Consultation process;
- Alternatives that were studied and the selected option(s) (preferred alternative(s));
- The affected area(s);
- Environmental and socioeconomic analysis;

[15] The scoping process may identify the need for special reports or research where critical information or data is inadequate, unreliable, or not available. Supporting reports should be prepared on any such specialist studies, including on methods used, data acquired and analyzed, etc. They may be concerned with, but not limited to, specific subject matter areas such as health issues, biodiversity, ecosystems, land use, protected areas, archaeological and heritage sites, institutional arrangements, skills and capacities, or review of legal instruments.

- Expected impacts and benefits;
- Proposed mitigation and enhancement measures; and
- Proposed monitoring program.

Because the non-technical executive summary is likely to be the only part of the SEA report that is read by the public (and by other stakeholders), its quality is critically important for obtaining informed stakeholder comments on the Draft SEA Report. This executive summary should also be made available in the official language of the country and dominant local languages.[16]

Annex 4 lists issues that are usually required to be covered in an SEA report. Additional chapters and/or sections may be added as required.

The main SEA report should include an annex analyzing the main stakeholder perspectives and indicating how they have been addressed (these can be presented in an issue-response table). However, the inclusion of annexes detailing all stakeholder events, all participants, and all comments (many of which may cover essentially similar issues) will considerably lengthen an SEA report and may better be presented as a stand-alone Record of Stakeholder Events.

Key points from all special and supplementary reports should be reflected in the appropriate chapters of the main SEA report.

2.7.2 Strategic Environmental and Social Management Plan (SESMP)

It is becoming increasingly common to prepare a separate Strategic Environmental Management Plan (SESMP)[17] to accompany the main SEA report. The SESMP is an effective reference document and management tool to frame and guide the implementation of recommendations and proposed management measures, including monitoring and follow-up procedures, to ensure the effectiveness of these measures once implemented.

Where a separate SESMP is prepared, it should amplify (but not replace) sections on mitigation and monitoring included in the SEA report. This should not be seen as a duplication of effort. Both the SEA report and SESMP will serve different functions and should be capable of being used without having to cross-reference each other. Box 2.13 sets out what kind of recommendations should be made in a SESMP. Further details on the role of a SESMP and its contents are provided in Annexes 15 and 16.

[16] Digital Story Maps can be used for non-technical summaries (NTS) to aid visualization and understanding, particularly when consultations are conducted on the SEA process

[17] In this guidance, the term Strategic Environmental and Social Management Plan (SESMP) is preferentially used to emphasize that it should address both environmental and social concerns. In some literature and countries, the term Strategic Environmental Management Plan (SEMP) is used.

Box 2.13: Measures to enhance opportunities and benefits, and mitigate risks and adverse impacts

There are no blueprints for this task. Recommendations should be made (and explained) on the issues listed below:

- Opportunities for optimizing development objectives or priorities pursued by the PPP;
- Opportunities for optimizing specific proposals/components within the PPP (e.g., alternative development methods and locations, scale, and sequencing/timing of proposed developments);
- Opportunities for changes to the legal and regulatory framework in regard to the PPP;
- Opportunities for optimizing implementation of the PPP, such as issues to be addressed in project-level assessments (e.g., preliminary advice on the scope of EIAs for specific projects or prescribing assessments for projects that are vulnerable to extreme climatic change conditions);
- Measures to avoid negative environmental and social impacts arising from PPP implementation, e.g., through changes in the proposed development objectives, priorities, or actions;
- Measures to enhance PPP benefits and,
- Changes in other relevant PPPs (often called "flanking measures"), where inconsistencies, overlaps, or antagonisms between PPPs have been identified.

Impacts due to climate change in the PPP area should also be considered, and, if possible, measures proposed to enhance resilience and mitigate such impacts.

Opportunities should be identified for the PPP to enhance achievement of the Sustainable Development Goals (SDGs) and other sustainable development objectives. The aim is to develop "win-win" situations where multiple, mutually reinforcing gains can be achieved simultaneously through:

- Strengthening the economic base and enabling economic objectives to be achieved;
- Improving social conditions and providing equitable conditions for all, and
- Protecting and improving management of the environment.

Where such win-win outcomes are impossible, the trade-offs must be clearly documented to guide decision-makers.

There are likely to be situations where some negative environmental and/or socioeconomic impacts cannot be avoided. These will usually be addressed by project-level EIAs recommending mitigation measures – for which a ***mitigation hierarchy*** should be followed (see Figure 2.5). The SESMP can suggest (in a table) generic mitigation measures for particular types of projects. Caution should be exercised if analysis indicates a potential for major, irreversible, negative impacts on the environment or social conditions. This may often suggest selecting less risky alternatives. For less-threatening situations, standard mitigation measures can be used to minimize adverse impacts to "as low as reasonably practicable" (ALARP level).

Figure 2.5: The mitigation hierarchy

Practical arrangements for environmental and social monitoring should be recommended to ensure that:

- Information is recorded and assessed (against environmental and social quality objectives and indicators (see Box 2.14) identified by the SEA and those incorporated in the PPP) on the environmental and socioeconomic impacts (including cumulative and transboundary impacts) of the PPP and downstream development projects/initiatives that may be implemented. This is done to determine if the objectives and recommendations are being met;
- Any unforeseen adverse impacts are identified in order to be able to undertake appropriate remedial actions;
- A mechanism is included to signal when steps are required to enhance benefits or to remove or reduce risks and negative impacts. The proposed mechanism should take into account existing national legislation and provisions regarding EIA; and
- A timeline is presented for monitoring and follow-up actions. Where possible, it may also be useful to present a summary of the costs of SEA implementation.

A ***stakeholder consultation procedure*** should be elaborated for the mechanism to monitor and evaluate the environmental and social dimensions of PPP implementation.

Procedures and measures should be recommended to ensure ***compliance with relevant safeguards*** (national and international where applicable) during implementation of the PPP and downstream projects/initiatives. National regulations should take precedence in the case of a nationally-driven SEA. Where such national safeguards do not exist, then reference can be made to incorporate the requirements of other international standards (e.g., IFC, WHO, multilateral development banks).

Guidance and recommendations for EIAs of individual projects that may arise during PPP implementation.

Thus, the SESMP should act as an overarching framework and roadmap for addressing the cumulative impacts of projects, development initiatives, and activities planned to be implemented under the PPP. Commitments in this regard should be incorporated in the PPP as an integral part, but they may be in less detail than in the SESMP, and the PPP will cover much more ground.

The SESMP should set out the roles and responsibilities of different jurisdictions, authorities, and actors in implementing the SESMP. As far as possible, recommendations should identify responsible parties.

Further information on the role of a SESMP is provided in Annex 15.

Box 2.14: Indicators

The SESMP should propose indicators to be used in monitoring to determine whether ESQOs and SEA recommendations are being met. Indicators are useful to communicate complex information in a simple way for decision-making and management. In SEA, they help to:

- Describe current levels and trends in environmental and socioeconomic quality;
- Gauge impacts;
- Evaluate progress towards achieving ESQOs and sustainability objectives;
- Relate key strategic issues to the SEA study;
- Enable adaptive and corrective management during PPP implementation;
- Establish criteria for an ongoing monitoring framework.

Some aspects of achieving goals and objectives are better evaluated in a qualitative manner; in that situation, a written description of the envisaged objectives can be compared with what was practically achieved.

> It can be useful to link indicators to *Limits of acceptable change (LAC).* These are extremes in environmental or social quality beyond which society would find further change unacceptable. LAC relates to a level of environmental quality (usually biophysical) or social quality that is either desired or would be tolerated by society (often a qualitative value).

In developing the recommendations set out in the SESMP, the team should prepare an initial or provisional set of such recommendations and discuss these with the key government or other agencies likely to have a key role in their implementation. This is vital to ensure that those agencies understand the rationale for the recommendations and their potential role in their implementation, are able to interrogate them with the team, can identify where these are realistic and practical or not (for whatever reason), suggest alternatives (where necessary), and agree to them. This process is important to secure buy-in to the SESMP recommendations and will enhance the likelihood that they will be accepted and acted on effectively.

To aid this process, it is highly recommended to identify and appoint a ***Task Group*** of contact point representatives from key agencies at an early stage in the SESA process so that its members are cognizant of the process and are ready to engage in discussions on key recommendations. In countries where the establishment of such a Task Group may take time due to bureaucratic requirements, such early establishment is particularly recommended.

2.8 REVIEW OF FINAL REPORTS

2.8.1 Quality assurance / technical review of SEA/SESMP

Designing an SEA to include the tasks and practices outlined in the various stages of the process (see Figure 2.1) will provide a basic level of process quality. However, a specific measure of quality control assurance will be needed, e.g., to ensure the credibility of the assessment in the eyes of stakeholders. These measures will depend on the nature, context, needs, and timeframe of the specific PPP. For further guidance, see Annex 10.

The SEA process described in this guidance sets out the following options for quality control checks.

Administrative review

Administrative review of draft SEA reports and SESMPs should be undertaken by the PPP proponent (Section 2 (Report Presentation) of Annex 10 (Consolidated Checklist for the Quality Assurance, Review, and Performance Evaluation of a Comprehensive SEA) can assist with this step).

Scrutiny workshop

A scrutiny workshop may be organised by the proponent with the competent authority to jointly examine the first draft of the SEA report and its recommendations and agree any revisions and amendments.

Lead agency and stakeholder review

The PPP proponent should send the draft SEA report and draft SESMP at the same time to relevant sector lead agencies (e.g., Ministries of Energy, Transportation, Health, and Agriculture). Lead agencies and other stakeholders should be allowed sufficient time (generally 30 working days) to review the documents and submit comments.

One of more stakeholder workshops should be organized to discuss the reports. A national workshop should be organized (Figure 2.5). In countries that have disparate and remote regions (e.g., geographically dispersed island nations), a number of regional workshops will be advisable to enable stakeholders to participate. The use of remote consultation techniques (e.g., Microsoft Teams, Zoom, Google Meet, WhatsApp) may be useful where face-to-face meetings are not possible.

Figure 2.5: National workshop to discuss draft report of SEA of SW Bangladesh and the Sundarbans, February 2021
Source: B Dalal-Clayton (2021)

Public review

Where possible, the PPP proponent should ensure that at least two notices regarding the draft SEA report (and draft SESMP) are published, each one week apart, in newspapers, on the SESA website, or via social media with a nationwide circulation, and announced in other local media. The public generally should be allowed 30 working days (from the date of the first advertisement) to submit comments.

The invitation for public comments (notice) should state (a) the nature of the PPP, (b) where the PPP and SEA documents can be found (e.g., on the dedicated SEA website, at particular government offices), and (c) how, by when, and to whom comments should be submitted.

Formal technical review

The PPP proponent may be required by some national SEA regulations to submit a specified number of copies (possibly in specified format) of the draft SEA report and draft SESMP, and possibly additional documents (e.g., an Environmental Statement summarizing information in the SEA report) to the competent authority for formal review. The PPP proponent may be required to cover various related costs, such as:

- Verification surveys;
- Formal review by the competent authority;
- Coordination of the stakeholder engagement review process (e.g., coordination of a Technical Advisory Committee) and the public review process;
- Compliance checks by the competent authority or others of the PPP implementation; and
- Any other required steps or functions as may be determined by the competent authority.

A formal technical review by the competent authority of the final SEA report and final SESMP may also be required in some jurisdictions (see sections 3-8 of Annex 10).

The competent authority may seek support for such review by the following:

- Commissioning ***independent external experts*** to conduct a technical review;
- Establishing a ***Technical Advisory Committee*** (TAC) to undertake the review; or
- Establishing an ***Independent Expert Commission*** (applicable for transnational shared resources).

[Note: where an SEA is likely to have transnational impacts, it will be necessary to advise the authorities of the concerned country at the outset, agree on how to address such impacts (perhaps with experts from both countries taking part in the SEA), and agree how to jointly review the SEA report. As indicated above, the nomination of experts to the Independent Expert Commission to represent the country on transboundary issues will be necessary. The respective notification protocols and procedures would apply].

Before submitting the final SEA report (and final SESMP where required) to the competent authority, the PPP proponent shall ensure quality-assurance of the SEA using the same checklists as the internal and external reviewers will use (see Annex 10). The PPP proponent should endorse the final SEA report (and final SESMP where required).

2.8.2 Key questions and criteria for reviewing the SEA report

Note: Reviewing the SEA process (rather than the report), outcomes, or performance is considered in Section 3.7, "Monitoring and Evaluation."

The most important outcome of an SEA, and thus measure of success (see also Chapter 1, Section 1.12 on SEA effectiveness), are the positive changes that are made to the PPP. Key questions related to the comprehensive review of an SEA Report include:

- The changes made to the PPP as a result of the main assessment stage of the SEA (Stage 4);
- The quality of information presented in the SEA report;
- The level of stakeholder participation and response to stakeholder comments;
- The definition of the environmental and social quality objectives (ESQOs);
- The adequacy and quality of the assessment and mitigation of environmental and social impacts; and
- The planned implementation framework, timing, follow-up activities, and constraints.

Box 2.15 presents criteria that can be used for internal, informal, or formal review of SEA reports by the proponent, the competent authority, expert committees, or others to check whether an SEA has been conducted properly and whether all required information is included in the SEA Report.

Box 2.15: Review criteria for SEA reports
Source: Adapted from MONRE (2008)

Addressing key issues

- The purpose and objectives of the PPP and SEA are made clear.
- Links with other related PPPs are identified and explained.
- Environmental and social issues that are relevant to the PPP are determined.
- The assessment focuses on significant issues.
- Reasons are given for eliminating issues from further consideration.
- The framework of SEA objectives is appropriate to the PPP and identified environmental and social issues.
- Mechanisms have been provided to allow stakeholder inputs into SEA recommendations and decisions.

Alternatives and scenarios

- Realistic alternatives of the PPP are considered, and the reasons for choosing them are documented.
- Alternatives include 'do minimum' and/or 'business as usual' options wherever relevant.
- The environmental and socioeconomic impacts (both adverse and beneficial) of each alternative are identified and compared.
- Inconsistencies between the alternatives and other relevant PPPs are identified and explained.
- Assumptions behind the development of alternatives are provided, and reasons are given for selection or elimination of alternatives.
- A range of realistic scenarios were developed and assessed.

Baseline information
- Relevant aspects of the current state of the environment and socioeconomic conditions and their likely evolution without the PPP are described.
- Environmental and socioeconomic characteristics of areas likely to be significantly affected are described, including areas wider than the physical boundary of the PPP area where it is likely to be affected by the PPP.
- Relevant data gaps are identified, as are the means to address them.

Prediction and evaluation of likely significant environmental and social impacts
- Both positive and negative impacts are considered, and the duration of impacts (short, medium, or long-term) is addressed.
- Likely secondary, cumulative, and synergistic impacts (positive and negative) are identified where practicable.
- Inter-relationships between impacts are considered where practicable.
- The prediction and evaluation of impacts make use of relevant accepted standards, regulations, and thresholds.
- A ranking of significance is provided.

Uncertainties
- Methods used to carry out the SEA are described.
- Deficiencies in background information or methods are explained.

Mitigation and enhancement
- Measures envisaged to prevent, reduce, and offset any significant adverse impacts of implementing the PPP are indicated, or to enhance any positive impacts.
- Issues to be taken into account in project consents are identified.

SEA Report
- Is clear and concise in its layout and presentation.
- Uses simple, clear language and avoids or explains technical terms.
- Uses maps and other illustrations where appropriate.
- Explains the methodology used.
- Explains who was consulted, what methods of consultation were used, and how the consultees' views have been taken into account.
- Identifies sources of information, including expert judgment and matters of opinion.
- Contains a non-technical summary covering the overall approach to the SEA, the objectives of the PPP, the main options considered, and any changes to the plan resulting from the SEA. The summary is provided in local languages as required and complies with any accessibility requirements.
- Technical, procedural, and other difficulties encountered are discussed; assumptions and uncertainties are made explicit.
- Clearly identifies how recommendations have been incorporated in the PPP.

Management of the SEA process
- The SEA is carried out as an integral part of the PPP-making process.
- Relevant authorities and the public concerned are consulted in ways and at times that give them an early and effective opportunity within appropriate time frames to express their opinions on the draft PPP, SEA Report, and SESMP.

A system to review, chapter-by-chapter, the content of an SEA Report is presented in Sections 2 to 8 of Annex 10:

Section 2 of the checklist reviews the *Report Presentation* (i.e., is it complete, adequate, clear, etc.). It can support the administrative review of the draft SEA report, ensuring that the draft SEA is of sufficient quality to be sent out to stakeholders for review. Sections 3 to 8 of the checklist focus on the review of various chapters of an SEA:

- Section 3: PPP description;
- Section 4: Policy, institutional and legal framework, and links;
- Section 5: Description of the environmental and social baseline;
- Section 6: Assessment of impacts, determination of impact significance, and evaluation of alternatives;
- Section 7: Mitigation and environmental management and monitoring plan;

- Section 8: Consultation process.

When reviewing a *SESMP,* it will be necessary to check that the plan covers all the issues listed in Annex 16, and that it is presented in a clear and easy-to-use manner.

2.9 STAGE 6: IMPLEMENTATION OF THE SESMP

2.9.1 Institutional arrangements

If the recommendations and management framework proposed in the SESMP are to be meaningfully and effectively implemented, it is important that the ***SESMP is endorsed and adopted*** by the Steering Committee and the Lead Agency (which should include inter-ministerial representatives) since a number of sector ministries will be likely to have a role and responsibilities for components of the SESMP and taking recommended actions.

Such endorsement will be more readily achieved if a Task Group of contact point representatives from key sector agencies has already been successfully engaged in the SEA process from an early stage (as recommended in Section 2.7.2) and has been closely involved in reviewing and agreeing the proposals set out in the SESMP.

Effective implementation of the SESMP will be more likely if an ***inter-ministerial oversight body*** is appointed. This could be the existing SEA Steering Committee or another appropriate body.

It will also be important to establish a ***SESMP Coordinating Unit*** (or similar dedicated body) to be responsible for day-to-day management and coordination of SESMP implementation. This would report to the oversight body. This unit would need to be staffed by several technical and administrative personnel. Outline functions for such a unit are listed in Box 2.16.

Box 2.16: Recommended functions of a SESMP Coordinating Unit (SCU)

- Establish and maintain procedural arrangements to ensure that the SESMP monitoring system runs effectively and that data collected from year to year are replicable, comparable, and auditable. This should include:
  - Regular liaison with focal persons in all SESMP implementing agencies to ensure that their monitoring responsibilities are established and undertaken (as required);
  - Collating all monitoring data gathered by different organizations/departments (as specified in the SESMP). The SCU might use published data from other sources as well.
- Maintain/organize continuous dialogue and interaction (including through consultations and workshops as needed), as required, with all implementing agencies;
- Evaluate and interpret submitted monitoring data along with the submitting agency and request necessary clarification/corrections, if required;
- Submit interpretative summary reports along with advice or recommendations;
- Prepare periodic overview reports (suggested every three years) on progress in implementing the recommendations of the SEA and SESMP. These should be approved by the oversight body;
- Develop and maintain an interactive SESMP website where all relevant reports and documents are made available (the existing SEA website could be a starting platform);
- Liaise with the mass media if required;
- Identify the need for awareness-raising programs on the SESMP, targeted at implementing agencies, stakeholders, and the public and private sector. These should cover the needs and role of the SESMP (e.g., how it operates), key environmental and socioeconomic issues that are being addressed, and how stakeholders can engage and provide inputs;
- Coordinate budget allocation for SESMP actions and associated monitoring functions;
- Be a point of contact and liaison for all communications to participants in the SESMP process, and

- Be responsible for arranging (and acting as Secretariat for) SCU bi-monthly meetings with all respective focal points of ministries and organizations.

2.9.2 Monitoring

Monitoring is an important function of SESMP implementation to determine whether the recommended actions and management measures have been undertaken and have been successful. Among such measures should be a program to monitor the indicators selected to track whether ESQOs have been achieved. Such monitoring is critical to determine where management measures are having success and, where not (e.g., where environmental or social trends are negative), to enable corrective measures to be identified and recommended.

Information tracking systems can be used to monitor and check progress. Monitoring of cumulative impacts may be appropriate for PPPs that will initiate regional-scale change in critical natural assets. Methods and indicators for this purpose need to be developed on a case-by-case basis.

2.9.3 Evaluation of the SESMP results and influence of the PPP

At some point during or after implementation of the PPP, a formal evaluation of the SESMP's management and monitoring results should take place as part of the revision or renewal of the PPP. This will be necessary to determine whether the outcomes of the PPP have been achieved, fully or in part.

Key questions to help evaluate the performance of the PPP and the influence of the SEA include:

- The accuracy of the assumptions made during the SEA;
- The influence of the SEA on the PPP process;
- The implementation processes of the PPP;
- Progress towards achieving the Sustainable Development Goals and accountability;
- The environmental and socioeconomic outcomes of PPP activities;
- The impacts on institutional, legal, governance, and capacity-building issues that highly influence the PPP implementation process, and
- Any required corrective actions, adjustments, or next steps.

The proponent should undertake such an evaluation in consultation with the competent authority. Consultants may also be engaged to provide an independent evaluation.

Role of evaluation

Evaluation should examine whether an intervention has achieved intended outputs and outcomes. The challenge is to define clearly how to measure these achievements in an objective and robust manner. The approach can be kept relatively straightforward if it focuses on elements that can be measured more objectively than others (instead of on elements where it is difficult to determine a cause-effect relationship). Evaluating the influence of an SEA will involve examining plausible cause-effect relationships and making an informed judgment about the extent to which the SEA influenced PPP design, implementation, and outcomes (see also Chapter 1, Section 1.12).

It may not be necessary to obtain absolute scientific proof, but it is necessary to engage in a reflective process to evaluate and improve on previous decisions. The aim is to learn how to continuously improve the integration of sustainability into decision-making and how to improve the use and efficiency of SEA as a tool to support sustainable development. In this context, SEA evaluation can also help to:

- Improve learning on the linkages between PPP formulation, assessment, and practical outcomes;
- Achieve PPP goals by identifying ex-post adaptation requirements for those implementation mechanisms/actions that failed to deliver intended outcomes; and

- Support the accountability of decision-makers and involved stakeholders by making the results of decisions transparent.

Evaluation should lead to concrete results, for example:

- Positive recommendations on future actions;
- Ex-post adaptation of implementation measures or even the PPP decision(s) itself (e.g., in the case where serious deviations from previous assumptions endanger the achievement of specific goals); and
- Specific measures to develop capacity, tailored to help overcome implementation gaps.

The most important outcome of a good quality SEA is that it significantly influenced the achievement of positive development results and will have enhanced the effectiveness of the PPP.

A systematic approach to monitoring and evaluation can be supported by checklist(s). Sections 9-11 of Annex 10 focus on evaluation, Section 9 reviews decision making, Section 10 provides IAIA's SEA process review checklist, and Section 11 is the SEA performance monitoring evaluation checklist.

2.10 STAKEHOLDER ENGAGEMENT IN SEA

Stakeholder involvement in SEA is a key principle of full SEA[18] (see Sections 1.4 and 1.10). The International Association for Impact Assessment has issued international best practice principles for participation in impact assessment[19] which should be followed in SEA.

As indicated in Figure 2.1, stakeholders should be engaged throughout the entire SEA process, even, in some circumstances, during screening when there can be some limited or specific stakeholder engagement (e.g., with statutory environmental agencies).

A key step in the scoping stage is to identify/map the key stakeholders (see Section 2.10.3) and develop a plan/strategy for how and when they can contribute to the SEA. Stakeholder consultations should be organized in two main rounds:

- ***First round*** *(during scoping)*: to explain why the SEA is being conducted, indicate how and when stakeholders can engage in the process, and gather stakeholder perspectives on the PPP and the key environmental and socioeconomic issues likely to be associated with its implementation. This will help the team to focus the SEA on the critical issues.

- ***Second round*** *(after the main assessment stage):* to present the findings of the SEA and its recommendations and seek stakeholder feedback on these.

In addition, throughout the SEA process, specific engagement with stakeholders may be warranted, such as focus group meetings or workshops on particular issues (e.g., to verify proposed ESQOs, alternatives, and scenarios, and to address particular concerns such as the use of natural resources or challenges for Indigenous Peoples). Furthermore, the draft SEA and SESMP reports should be made available for public comment, and stakeholder involvement may also be required to monitor implementation of the SESMP. Stakeholder engagement is discussed further in the following sub-sections.

2.10.1 Minimum requirements for participation

At an absolute minimum, the PPP proponent must meet with the main stakeholders to inform them about the PPP and SEA being undertaken and to solicit their views about it. The ideal elements of stakeholder participation in an SEA are listed in Box 1.3. Understanding the decision-making authority of different stakeholders and how they interact with each other and the environment and socioeconomic

[18] Note: A rapid SEA will reply mainly on expert inputs.
[19] André, P., Enserink, B., Connor, D., & Croal, P. (2006) and Morrison-Saunders, A., & Arts, J. (2023)

conditions is essential for good analysis and process management. Relevant regional and/or country representatives should also be included when transboundary impacts are anticipated.

PPPs concerned with the energy transition are likely to affect all inhabitants in a country. But it is almost impossible to give all inhabitants the opportunity to be engaged in the process. Therefore, the option that CSOs represent the voice of the people is a reasonable and acceptable approach. In any case, during the early stages of scoping, there should be discussions between the proponent and the SEA team about how consultation will be undertaken, who should be consulted (identification of SEA stakeholders), what preparations will be needed before, during, and after consultation, and how the results of consultation should be disclosed.

2.10.2 Stakeholder analysis, engagement plan and communication plan

Stakeholder engagement during scoping

During scoping (see Section 2.5), stakeholder mapping should be undertaken to identify stakeholders, determine their potential interest and influence, and as a basis for preparing a draft stakeholder engagement plan and a communication plan. Box 2.17 indicates the broad categories of stakeholders that should be included in the mapping.

Box 2.17: Main categories of stakeholders

Broadly, stakeholders should include:

- The Ministry of Energy, or equivalent, other relevant government ministries/agencies, and others involved in decision-making relevant to the PPP being assessed at all levels (from national to local), particularly the ministries for environment, water, and land. For PPPs concerned with the energy transition, where multiple sectors will be involved, the engagement of multiple authorities will be necessary.
- All those organizations and individuals with a legitimate interest in the PPP and who may be affected by PPP outcomes;
- Civil society (who may be represented by CSOs and NGOs);
- Vulnerable groups, Indigenous Peoples, and other interests that may not have specific representation:
- The private sector;
- Multilateral development banks, bilateral donors, and aid agencies that may fund the SEA or support the implementation of the PPP.

The methods adopted to engage stakeholders will need to be determined according to their purpose.

A variety of meeting methods should be considered to ensure that all stakeholders are reached and involved, including “town hall” meetings, workshops, focus groups, key informant interviews (one-on-one or small groups), surveys, social media, etc.

Generally, SEAs draw the attention of ‘public representatives’ rather than individuals. If the public has limited experience with being engaged at the strategic level, it is critical to include an *education component* in the public engagement process to inform stakeholders what SEA is about, its objectives, and to raise awareness of the ways in which they can make their views known and contribute.

It is important to identify and engage those stakeholders who may be the most exposed to environmental degradation and adverse socioeconomic change as a result of the PPP. In general, environmental and socioeconomic pressures tend to affect the poor and vulnerable populations more significantly. Women, men and youth, and Indigenous Peoples' groups should be included in this public engagement process to draw on all relevant knowledge and ensure their meaningful inclusion. Culturally sensitive consultation norms should be taken into account (e.g., language, representation, world views, etc.). It will also be important to explain energy transition in the context of the SEA, as this may not have been conveyed to a great extent at the onset of the SEA process.

As mentioned above, the SEA process relies on effective and sustained public engagement. PPP decisions are embedded in the political domain and involve political dynamics, including the engagement of the stakeholders who are likely to be most affected or who are most vulnerable. One challenge is to ensure that public engagement is meaningful, transparent, and continuous, and not just a case of providing stakeholders with detailed, comprehensive information. The engagement process must provide an *opportunity to influence decisions* over the life of the SEA process.

Stakeholders are comprised of many interest groups, often with conflicting objectives (e.g., gender differences) with different rights and responsibilities, educated and uneducated people, young people and elders, Indigenous groups, and different economic and cultural groups. The role of the public consultation in SEA should be to provide a mechanism for identifying and trying to *solve differing views in a constructive and meaningful way.*

Stakeholder groups identified as most affected by a given PPP may be politically and/or socially marginalized and may have little or no experience in providing input to decision-making. Public consultation processes will have to identify the best way to ensure that the socially marginalized groups (e.g., the poor, minority ethnic groups, itinerant/migrant groups, other vulnerable groups) can participate effectively and can have their viewpoints given proper consideration. This may involve reaching out to stakeholders who do not have access to the internet, lack access to public libraries, speak a different language, are illiterate, have cultural differences, or have other characteristics that need to be considered when planning for their engagement. In some cases, special means of engagement may be required, e.g., women of the SEA team meeting with a women's group or use of an Indigenous-led facilitator when meeting with Indigenous groups.

Authorities that, because of their environmental and socioeconomic responsibilities, are likely to be concerned by the impacts of implementing the PPP, must be consulted on the scope and level of detail of the information to be included in the SEA Report.

Depending on the nature of the political institutions and their internal functions, the SEA stakeholder engagement process should be integrated, to the extent possible, with the public engagement process for the development and implementation of the PPP itself. This will help to emphasize both the positive contributions and potentially harmful impacts of the PPP. More problematic issues should involve more extensive consultation.

Stakeholder engagement during assessment and implementation phases

Stakeholders have a clear role to review the outcomes of the draft SEA report and recommendations in the draft SESMP, identify gaps and errors, and challenge assumptions and conclusions. This should be the focus of the second main round of stakeholder consultations. However, it may not need to be as extensive as the first round. But should, at least, include multi-stakeholder workshops at the national level and in the main regions.

Once the PPP is approved and is being implemented, stakeholders will have key roles to play in monitoring whether the environmental and social quality objectives agreed to and used in the SEA are being met and whether mitigation plans are being fully and effectively carried out. The SESMP will recommend a monitoring and auditing program for this purpose. It should also set out the roles and responsibilities of governmental bodies and other stakeholders to implement the SESMP as well as the opportunities for civil society groups to engage in this process (e.g., data gathering, informal reporting of changes, etc.).

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 3

LEGAL REQUIREMENTS AND COMMITMENTS TO APPLYING SEA, AND INSTITUTIONAL ROLES

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Links to the complete guidance document and to individual chapters are also available.

CHAPTER 3

LEGAL REQUIREMENTS AND COMMITMENTS TO APPLYING STRATEGIC ENVIRONMENTAL ASSESSMENT, AND INSTITUTIONAL ROLES

3.1 THE LEGAL BASIS FOR STRATEGIC ENVIRONMENTAL ASSESSMENT

Environmental impact assessment (EIA) was first introduced in the USA under the National Environmental Policy Act (NEPA) in 1969. The Act applies to "proposals for legislation and other major federal actions significantly affecting the environment." The US Council on Environmental Quality interpreted this to include policy, programs, and plans (PPPs). While EIA practice in the US tended to mainly address projects, programmatic environmental impact statements (focused on PPPs) also became an integral element of the implementation of the Act.

From the late 1980s and during the 1990s, strategic environmental assessment (SEA) and similar procedures were introduced by legislation and experimented with as a separate process from EIA in a small number of high-income countries, e.g., Australia, Canada, Denmark, and the Netherlands. But since then, nearly all high-income countries have adopted SEA (particularly European countries under the EU SEA Directive; see Section 3.2), and the number of low- and middle-income countries adopting SEA is rapidly increasing, with around 100 countries across the world now having legal provisions for its application. While many of these countries have formalized SEA through regulation and have established mandatory procedures, in others the legislation remains more of a framework with regulation pending. In countries without legal provisions for SEA, it is often applied on a voluntary basis.

Processes across countries vary considerably. In those countries with no formal provision for SEA, it is often applied on a voluntary basis, and some countries have developed an active body of voluntary SEA practice (e.g., Colombia, South Africa, and Thailand). Thus, several categories of practice can be recognized:

- Mandatory regulation for SEA, including a procedural regulation;
- General provisions for SEA but no procedural regulation;
- Application of EIA regulation for policies, plans, and/or programs;
- Voluntary regulation of SEA, often based upon a policy and guidelines but no procedure;
- No regulation of SEA, but voluntary practice.

Some countries have made statutory provision for SEA under EIA or planning law. In these systems, EIA-like requirements and procedures are usually followed and apply particularly to SEA for plans and programs. Other countries have established SEA through administrative order, cabinet directive, or policy guidelines. In these systems, SEA is applied as a separate or modified process from EIA, as in Denmark, Hong Kong, The Netherlands, and the UK (in England, SEA for land use/spatial planning is integrated into sustainability appraisal). In Canada, the 2010 Cabinet Directive on the Environmental Assessment of Policy, Plan, and Program Proposals (SEA) was rescinded and archived on 1st April 2024. It was replaced by a Cabinet Directive on Strategic Environmental and Economic Assessment.[1]

3.2 INTERNATIONAL DIRECTIVES, PROTOCOLS, SAFEGUARDS, DECLARATIONS, AND COMMITMENTS

A number of international directives and protocols have set legal requirements to undertake SEA. Most notable is the EU SEA Directive 2001, which introduced a standardized approach and was

[1] Government of Canada (2024) This new Directive focuses on the potential environmental and economic considerations of key government decisions, with a special focus on climate change and biodiversity. It applies to proposals submitted to Cabinet for decision, specifically Memoranda to Cabinet and Treasury Board Submissions, regulatory proposals subject to the Cabinet Directive on Regulation, and funding requests submitted to the Prime Minister and the Minister of Finance for decision.

transposed into domestic law by 2004 in all 27 member states of the EU. The Directive applies to a wide range of public plans and programs (but not policies), including those prepared for agriculture, forestry, fisheries, ***energy***, industry, transport, waste/water management, telecommunications, tourism, town and country planning, or land use, and which set the framework for future development consent of projects.

The provisions of the Directive strongly influenced those of the SEA Protocol to the UN Economic Commission for Europe (UNECE) Convention on EIA in a Transboundary Context [2] (agreed in 2003). The latter is similar to the EU Directive on SEA but with distinctive features, such as a special emphasis on health impacts alongside environmental ones. The protocol is legally binding on convention signatories with regard to plans and programs and is discretionary concerning policies and legislation.

Some UN conventions have started to recognize the value of SEA. The Convention on Biological Diversity (CBD) has prepared voluntary guidelines on the integration of biodiversity in EIA and SEA, 2006.[3] In March 2023, a new treaty on protecting marine life in international waters (the High Seas Treaty) was concluded under the Convention on the Law of the Sea (UNCLOS) and was formally adopted in May 2023. Under the treaty, participating parties are obliged to conduct environmental impact assessments when a planned activity may have an effect on the marine environment or when there is insufficient knowledge about its potential effects. In such cases, the party possessing jurisdiction or control over the activity is required to conduct the assessment. Parties under the treaty are required to consider conducting a SEA for plans and programs related to their activities in areas beyond national jurisdiction but are not obliged to conduct one.[4]

A number of multilateral development banks have adopted environmental and social safeguards that either promote or require borrower countries to undertake SEAs, SESAs, or equivalent processes for particular proposed initiatives that they are financing (e.g., the World Bank, the Inter-American Development Bank; see Table 3.1).

Other international organizations have also made commitments to promote SEA. For example, the Paris Declaration on Aid Effectiveness was adopted in 2005 and reaffirmed in Accra in 2008 at ministerial-level forums convened by the Organisation for Economic Co-operation and Development (OECD). It committed bilateral donors and partner countries to “develop and apply common approaches to SEA.” More recently, the fifth session of the UN Environment Assembly (March 2022) adopted a resolution supporting strategic planning of sustainable infrastructure by applying SEA. [5]

By identifying and focusing on the key environmental and socioeconomic concerns related to a PPP, SEA is able to identify where opportunities can be maximized and risks/impacts avoided or mitigated in relation to environmental and socioeconomic commitments made under international legal conventions and agreements to which a country is a signatory and to regional and UN organizations. Similarly, for the same reason, SEA can also support countries and agencies to ensure that individual PPPs contribute positively to the achievement of the Sustainable Development Goals and meet international commitments to combat climate change and promote corporate social responsibility.

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[2] UNECE (n.d.). The UNECE Protocol on SEA was negotiated under the 1991 UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) to extend the scope of the Convention, but it is a legally distinct instrument. It is an international agreement open to all UN member states; so far, 37 states and the EU are signatories. The Protocol provides for legal obligations and a procedural framework for the implementation of SEA in countries that are parties to it.

[3] Convention on Biological Diversity (n.d.)

[4] Read more about the High Seas Treaty (https://en.wikipedia.org/wiki/High_Seas_Treaty)

[5] UNEP (2022)

Table 3.1: International financial institutions (IFI) requirements for and reference to SEA

IFI	Requirement for or Reference to SEA
UN Development Program	• Social and Environmental Standards (2019).[6] • Social and environmental screening procedure (2019). P.21, entry 58.
World Bank	• Environmental and Social Safeguards framework (2017): ESS 1: Part B. Entry 23.
African Development Bank	• Integrated Safeguards System Policy Statement and Operational Safeguards (2023).[7]
Asian Development Bank	• Safeguard Policy Statement (June 2009) (p66). • Draft revision (2023)
Inter-American Development Bank	• Environmental and Social Policy Framework (2020)[8]: (Ch 3.5). • Implementation Guidelines for the Environment and Safeguards Compliance Policy, Revised version, July 2019. Policy Directives B.3 and B.5 (new guidelines are currently under review).
European Investment Bank	• Statement on Environmental and Social Principles (2009)[9] • Environmental, Climate and Social Guidelines on Hydropower Development (2019)[10]; Cumulative Basin Wide impacts, P.7.

3.3 SCOPE AND CONTENT OF LEGAL INSTRUMENTS

Laws prescribing the use of SEA vary considerably in their scope and content. In some countries they are of a framework or enabling nature and merely make provision for its introduction. They assign responsibility for SEA to a designated authority (e.g., ministry or agency), establishing a new government body or designating additional responsibility to an existing agency, but leave such a body to make subsequent regulations for the formal activation of the SEA system. In other countries, laws are more detailed and set out all the major provisions for the SEA system. Thus, either a law or a regulation will usually:

- State the objectives of the law/regulation;
- Set out any general principles;
- Assign functions, powers, roles, responsibilities, and staffing for aspects of the SEA process;
- Establish any related or supporting bodies (e.g., Advisory Council), their composition, terms of reference, and regulatory of meetings;
- Indicate the types of PPPs for which SEA is mandatory;
- Define terms used in the law/regulation;
- Set out the required steps and procedures;
- Establish appeals procedures (e.g., concerning decisions);
- Indicate reporting requirements;
- Describe administrative arrangements;
- Set any fees or payments that may be due.

A regulation for SEA may cover some of the above elements, but would usually focus much more on specific aspects of the SEA process, such as:

- Preliminaries, e.g., definitions, objectives, role of SEA proponents, access to information, modalities, and general requirements;
- Screening to determine which PPPs require SEA;
- Public participation requirements;
- Scoping requirements;

[6] UNDP (2019)
[7] AfDB (2023)
[8] IADB (n.d.)
[9] EIB (2009)
[10] EIB (2019)

- Steps in the main assessment stage;
- Reporting requirements;
- Monitoring and evaluation;
- Notification and registration of documents and decisions;
- Administrative matters;
- Annexes (e.g., forms).

3.4 RESPONSIBILITY FOR SEA IMPLEMENTATION AND INSTITUTIONAL ROLES

Legislation and associated regulations provide a formal national (and in some cases sub-national/regional) platform setting out the circumstances in which SEA must be undertaken, the policies, plans, and programs (PPPs) to which it must be applied, and the specific requirements for how the process should be conducted, including roles, responsibilities, required documentation, monitoring procedures, etc.

The government ministry developing or revising the PPP will usually be the ***lead agency*** responsible for instigating an SEA. For renewable energy PPPs, this will normally be the ministry with a mandate for energy, or a sub-directorate specifically responsible. The lead agency will be responsible for conducting the SEA (usually through hiring experts or consultants to undertake the technical work). However, increasingly, an inter-agency ***Steering Committee*** is established for an SEA to share responsibility and decision-making and to foster buy-in to the process, with the lead agency as the chair or convenor. In some situations, it has been found useful to include representatives not only of the key authorities (executive staff), but also other authorities, NGOs, and stakeholders.

Where there is a formal SEA system, usually prescribed by legislation and regulations (or their equivalent), a government agency will normally be designated as the "***competent authority***" for SEA (usually a department within the ministry responsible for environmental affairs or a specialist environmental protection agency) and will have responsibility to develop guidelines and, in some countries, to review and approve SEA reports. Depending on the particularities of the legislation/regulations, such competent authorities may also be designated to issue approvals or authorizations (normally in writing and possibly notified in the government gazette or equivalent). To ensure close integration of social, labor and health issues, multiple ministries may require to be consulted and coordinated early in the SEA process.

For a renewable energy sector PPP, the SEA Steering Committee should be convened and chaired by the lead agency (ministry responsible for energy). It should include members from:

- All key sector ministries;
- Financing organizations (e.g., MDBs, donors);
- Renewable energy associations;
- Private sector companies (or the representative body) involved in investing in renewable energy facilities;
- National NGOs, civil society organizations, Indigenous Peoples, and others (as appropriate, e.g., women's organizations and vulnerable groups, special interest groups, and labor unions).

Its role will be to provide overall support and guidance for the SEA process, to facilitate access to critical information, to review reports, to build ownership of the SEA process amongst key actors, to disseminate information about the SEA process and its results, to advocate for the uptake of its recommendations, and to review the latter.

Having a Steering Committee in place helps to provide transparency for the SEA process and provide a mechanism for holding the government to account over how it addresses the recommendations put forward in the SEA. It also helps to build credibility, trust, and transparency, and provides an additional senior-level platform for all stakeholders to channel their views into the SEA process.

The ***Strategic Environmental and Social Management Plan*** (SESMP) produced alongside the SEA report will set out the proposed institutional arrangements, roles and responsibilities for its implementation, and grievance mechanisms. These will aim to ensure maximum efficacy to deliver environmental and social safeguards and required mitigation and management actions to minimize environmental and socioeconomic risks and impacts and maximize opportunities for benefits. A SESMP often acts as an action and investment plan. See also Chapter 14 for more on SEA and institutions.

3.4 THE CHALLENGE OF MEETING GOOD PRACTICE IN SEA

Chapters in Part A of this guidance describe good practice in undertaking SEA. They draw from the best elements of existing international and national guidelines and build on experience from SEA practice over the last 30 years of what works well and what is required to deliver credible and beneficial outputs and influential outcomes. This guidance is also framed around internationally agreed principles for SEA, as described in Section 1.3. It can therefore be viewed as a standard to aim for. But this guidance may differ from the specific requirements set out by a country's SEA regulations or guidelines.

A country's SEA system requirements and regulations may differ from those of an external financier or organization (e.g., a multilateral development bank). The latter usually set their requirements at a high level based on good practice principles.

There is no one-size-fits-all approach or single recipe for SEA. Each one must be designed to be fit and appropriate for purpose and tailored to the specific need and context. The SEA practitioners/consultants must interpret the terms of reference for each SEA, then propose, discuss, and agree on the approach to be followed with the client, and aim to pursue the best practice possible in the prevailing circumstances. The goal should always be to try to undertake the SEA according to the principles in Chapter 1, Section 1.3.

In some countries, SEA is still a relatively new process where skills and experience may be limited or lacking. So, it must be acknowledged that it might not always be feasible to achieve or meet the ambitions of international good practice. For everyone, SEA remains a journey of 'learning by doing' with progressive improvement through usage and iteration.

A compendium of available SEA guidelines for countries, regions, and various organizations is provided on the IAIA website (see: https://www.iaia.org/pdf/hot-topics/Inventory-of-SEA-guidelines.pdf)

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 4

NATIONAL/REGIONAL ENERGY POLICIES, PLANS, AND PROGRAMS

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CHAPTER 4

NATIONAL/REGIONAL ENERGY POLICIES, PLANS, AND PROGRAMS[1]

4.1 THE CHALLENGES FACED BY ENERGY PLANNING

All countries face the challenges of climate change, and most have already taken steps to promote the transition away from fossil fuel consumption to enable and promote investment in renewable energy. It is reported that solar and wind are now being installed at a rate that is three times faster than all other new electricity sources combined.[2]

Traditionally, energy plans have played a strong role in setting the framework for regulations in the energy sector (e.g., concerning the type of power plants that can be built or prices that can be charged for fuels). They focus on estimating demand and determining the types of energy sources to be used to meet it. However, over the past three decades, energy systems have been deregulated in many countries, resulting in reduced long-term energy planning. Decisions have increasingly been left to the market. In the last few years, this trend has reversed following increasing concerns over the threat of climate change.

As a result, many countries have already, or are now in the process of, reviewing, revising, or developing new national energy policies, strategies, and plans to respond to the climate change threat so as to reflect the need for developing renewable energy and how they will achieve this.[3] In developing such PPPs, countries need to balance their energy interests against the interests of other sectors,[4] the people, and the future of the planet, and this adds a further layer of complexity to the tasks that governments face. There are considerable benefits to cross-sectoral integration in developing these energy PPPs (Box 4.1).

Box 4.1: Benefits of cross-sectoral integration in developing energy PPPs

Cross-sectoral integration can offer substantial benefits for the energy sector, including enhanced efficiency, opportunities to promote sustainability, economic savings, resilience, technological advancement, and more coherent policy frameworks. By breaking down silos between different sectors, integrated energy systems can better meet the demands of a growing population while addressing the urgent challenges of climate change, biodiversity decline, and resource depletion. For example:

- Excess heat from industrial processes can be used for district heating.
- Electric vehicles can act as energy storage devices for load balancing in the electricity grid.
- Agricultural waste can be a resource for bioenergy production.

[1] Prepared with substantial contributions from Roel Slootweg (SevS, Netherlands) and Arend Kolhoff (Netherlands Commission for Environmental Assessment)

[2] Blakers and Ruther (2023)

[3] In addition to other renewable energy options, national energy policies increasingly recognize the growing importance of hydropower — new, reconstructed, and especially pumped hydropower. The latter can "shift" surplus energy from solar and wind power by pumping water to a reservoir and subsequently generate electricity when wind is low or at nights when it is needed by consumers. See: https://www.eurelectric.org/publications/energy-storage-enabling-higher-integration-and-utilisation-of-variable-renewables.

[4] Through their demand for space and their potential biophysical and social impacts, energy PPPs have direct linkages with other sectors. For example, in marine environments, increased competition is being observed between fisheries, shipping, wind power, and biodiversity conservation objectives. Similarly, hydropower schemes in river basins may result in downstream erosion problems, create obstacles for river navigation, lead to reduced fisheries, and degrade valuable riverine and wetland ecosystems. Access roads for wind turbines and power lines may open up pristine areas for uncontrolled exploitation.

- Cross-sectoral collaboration can spur innovation and new business opportunities, such as integrated energy services and smart grid technologies.
- Integrated approaches can align different sectors towards common goals such as carbon neutrality and energy security, making plan implementation more effective.

SEA is a process that seeks such alignment of PPPs and can play a facilitating role in bringing different sectoral interests together.

An energy policy or plan usually sets out a government's strategy regarding the production, distribution, and consumption of energy. It may include sections addressing legislation and standards, international treaties, guidelines for energy conservation, taxation and energy subsidies, and other matters.[5] Frequently a dominant issue is the risk of a mismatch between energy supply and demand (the energy crisis). Increasingly, energy PPPs are now addressing the costs of energy and environmental issues — notably greenhouse gas emission reduction. Such PPPs aim to guide the future of local, national, and regional energy systems, reflecting the needs resulting from population growth and consumption patterns.

Despite these new challenges, energy planning remains a largely technical and economic exercise. Yet, wider environmental and socioeconomic (including cultural) factors are highly relevant to developing models for meeting future energy demands. But these have largely been neglected. This is especially true in addressing issues affecting underrepresented, marginalized, and vulnerable populations, e.g., Indigenous Peoples, urban poor, future generations, and stewards of cultural heritage and natural systems.

The energy transition is fueling a rapid increase in the demand for land for large energy generation facilities (e.g., solar farms, wind farms, hydropower) and the associated infrastructure (e.g., for transmission lines, access roads, energy storage facilities), as well as for mines to access the minerals required for the technologies involved (e.g., lithium). This links the domain of energy PPPs directly to spatial planning frameworks such as land use planning, regional development planning, river basin management planning, coastal zone management planning, and marine spatial planning.

For most countries, the energy transition will be gradual (over many decades). As new renewable energy options are explored, committed to, and developed, many countries are still likely to continue to rely on coal, oil, and other fossil fuels for some time to come (despite clear evidence that planetary boundaries have already been breached).[6] So, there will be a continued reliance on a mix of energy sources (both fossil fuel-based and renewables-based), and energy policies, plans, and strategies will be likely to continue to reflect this. In addition, where countries are committed to transitioning to renewable energy sources, few are likely to focus on a single form of renewable energy. Most will include a mix of renewable energy types in the mix being considered and developed.

Green hydrogen and ammonia are receiving considerable attention in the development of energy plans. The ‘green’ element of this is dependent on deriving the high amounts of energy required to drive the chemical process from renewable sources, particularly solar and wind power (see Chapter 11).

4.2 HOW SEA CAN BENEFIT THE PROCESS OF DEVELOPING AN ENERGY PPP?

The benefits of using SEA are discussed in detail in the preface to this guidance and amplified in Chapters 1 and 2. Table 4.1 lists some added benefits that are specific to developing energy PPPs.

[5] Wikipedia contributors (2024)
[6] Stockholm Resilience Centre (2023)

Table 4.1: Added benefits of SEA for energy PPPs

Current practice in developing energy PPPs	Possible contribution of SEA
Demand driven: goal is to provide the energy needed.	• Supply focus: identify what renewable energy supply can be generated sustainably[7], considering interests and demands from other sectors.
Economy and technology dominate the final outcome.	• Environmental and socioeconomic consequences of alternative development pathways are also assessed and may lead to a different outcome.
Focus on the energy sector.	• Alignment/consistency with other (multi-) sector and spatial PPPs. • Analysis of opportunities (or win-wins) for cross-sectoral collaboration. • Addressing cumulative and synergistic effects with other PPPs.
Involvement of public and private energy stakeholders.	• Broad stakeholder engagement, including potentially affected actors; structured involvement process.
Planning for ambitious targets.	• Assesses institutional roles and capacities and where clarification and/or harmonization may be necessary (may lead to reduced level of ambition).
No formalized process.	• SEA process regulated by law (in an increasing number of countries) with in-built guarantees for stakeholder participation and public review

4.3 INCREASING APPLICATION OF SEA IN THE ENERGY SECTOR

Table 4.2 lists examples of SEAs conducted for a wide range of PPPs for the energy sector in many countries. The table shows that:

- SEA in support of national energy planning is increasing worldwide but is not yet common practice;
- SEA supporting hydropower is widely applied in South and SE Asia, increasingly as part of river basin planning;
- SEA is also applied in support of oil and gas development, both on land and off-shore;
- SEA supporting wind is widely applied in Europe, often as part of spatial planning, and
- The names and scope of planning documents differ widely and include, for example, energy policy, plan, strategy; energy and climate plan, or renewable energy plan; etc.

Section 4.5 provides further information on the status of SEA application to energy PPPs.

[7] Hydropower is renewable as long as rainfall feeds a river system; sustainability is sometimes questionable, as particularly dams with reservoirs are associated with significant biodiversity impacts, and deep reservoirs in a wet tropical climate can emit greenhouse gases, comparable or greater than coal-fired power plants.

Table 4.2: SEAs supporting PPPs in the energy sector and multi-sector PPPs with an important (renewable) energy component
Source: NCEA, Netherlands

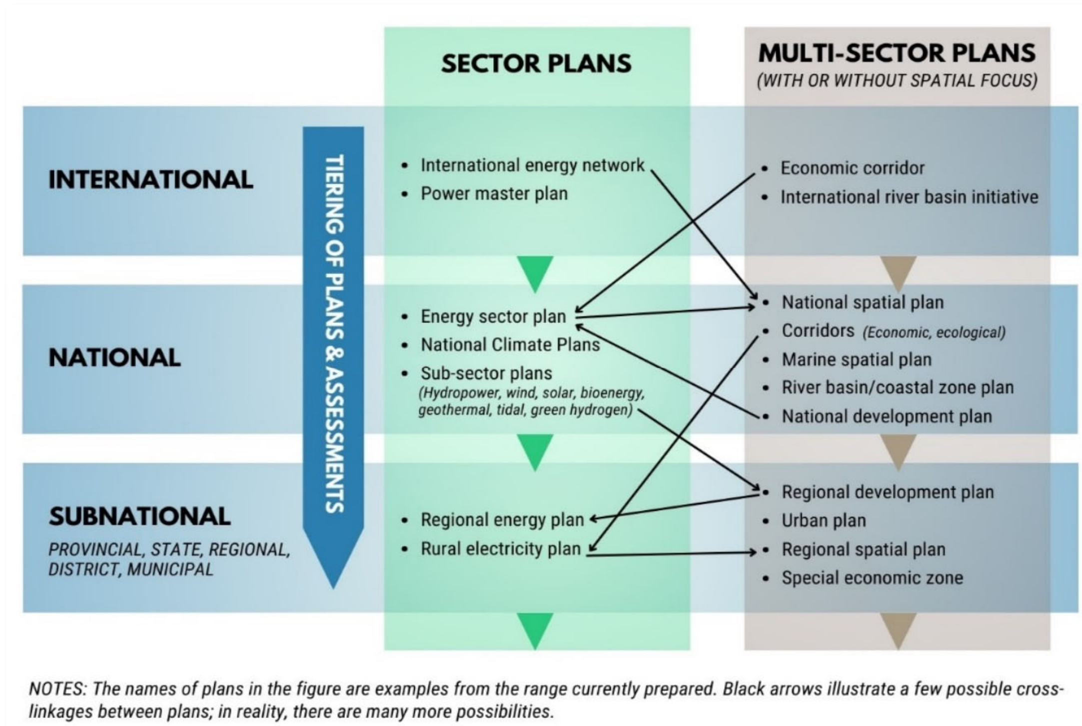
ENERGY SECTOR PPPS SUBJECT TO SEA		MULTI-SECTOR PPPS SUBJECT TO SEA	
International level			
Energy policy	Nile equatorial lakes region 2007	River basin plan	• Kenya/Tanzania 2012
Mekong hydropower plan	• Mekong River 2010		
Power development plan	• Greater Mekong Sub-region 2015		
Energy strategy	• European Union, 2022		
National level			
Energy policy	• Slovak Republic 1997, 2000 • Canada 2002 • Czech Republic 2002 • Ghana 2009 • Myanmar 2014 • Rwanda 2015 • Zambia 2019 • Nigeria 2022	National spatial plan	• Netherlands 2011, 2013 • Montenegro 2015
Energy plan	• Belgium 2008 • Vietnam 2011, 2014, 2019 • Estonia 2014 • Australia 2015 • Taiwan 2015 • Samoa 2017 • Cape Verde 2017 • Angola 2018 • Nigeria 2019 • Bhutan 2019 • Philippines 2021 • Ghana 2022 • Nigeria 2022	River basin plans	• Croatia 2015 • Rwanda 2015 • Vietnam 2008 • Georgia 2010 • Bolivia 2012
		Marine spatial plan	• Germany 2009 • Estonia 2015 • Netherlands 2016 • Sweden 2018 • Ireland 2023 • Scotland 2023
Energy and climate plan	• EU member states 2018-2023 • Serbia 2023	Corridor plan	
Energy strategy	• Montenegro 2013 • Serbia 2015 • Jordan 2020 • Scotland 2023 • Zambia 2023		
Renewable energy plan	• South Africa 2015, 2019 • Azerbaijan 2016 • Zambia 2022		
Off-shore energy plan (mainly wind)	• UK 2003, 2004, 2005, 2006, 2008, 2009, 2011, 2014, 2016, 2017, 2018, 2019, 2022 • Ireland 2010 • Netherlands 2014, 2021		
Hydropower sector plan	• Nepal 1997, 2014, • Lao PDR 2004 • South Korea 2007 • Vietnam 2009 • Albania 2018 • Myanmar 2018		
Oil and gas sector (on land and off shore)	• Ghana • Cyprus • Tanzania • Uganda • Mozambique • Kenya		
Sub-national level			
Electricity supply plan	• Canada 2012	Regional development plan	• Tanzania 2015, 2016
Hydropower development plan	• Vietnam 2008 • Bhutan 2011 • India 2012, 2014 • Pakistan 2014	Regional energy strategies	• Netherlands 2022
		Spatial plan	• Montenegro 2010 • Serbia 2010

Note: The search was based on archive material and a web search conducted in English. SEAs reported in local languages (other than English) are not included. The names of PPPs may have changed.

4.4 HOW SEA FOR THE ENERGY SECTOR RELATES TO THE PLANNING CONTEXT

The optimal use of SEA to support planning in the energy sector will be determined by the wider context of the particular planning framework in a country (or state, region/province, municipality), i.e., beyond the context of the energy sector itself. Figure 4.1 presents a generalized and simple tiered typology of such frameworks. It differentiates between plans at the international, national, and sub-national level (the horizontal boxes represent the so-called planning tiers). Depending on the administrative organization of a country, the sub-national level can be further detailed at lower levels, for example with a municipal level. A federal country will also have a distinction between federal and state planning responsibilities.

Figure 4.1: Hypothetical typology of planning frameworks of relevance to the energy sector and their tiering to levels of government



The left-hand vertical box represents, in a simplified manner, the hierarchy of ***energy sector planning*** (plans prepared by energy ministries/departments as the lead authority, although this can involve government agencies, regulatory bodies, and private sector companies with delegated responsibilities). The instruments developed may include strategies, policies, plans, programs (PPPs), and ultimately the implementation of energy projects and developments. Program and project levels are not included in the figure.

The right-hand vertical box represents ***multi-sector planning*** frameworks in which the energy sector and other sectors have an interest, act as stakeholders, and where collaboration is essential.[8] In its

[8] In a regional development plan, for example, the energy sector is an essential driver of development. Development planning provides indications of the future energy demand for which an energy authority will need to define infrastructure investment needs to guarantee the supply and distribution of various types of energy and energy carriers. In spatial planning frameworks (including river basin and coastal zone management plans and marine spatial plans), the zonation of sector interests is regulated. Energy sector interests relate to locations for energy generation types (e.g., wind, solar, hydropower, etc.), power facilities, and corridors for pipelines and powerlines. The allocation of ecosystem services (water for hydropower; biomass for bioenergy) can also be regulated.

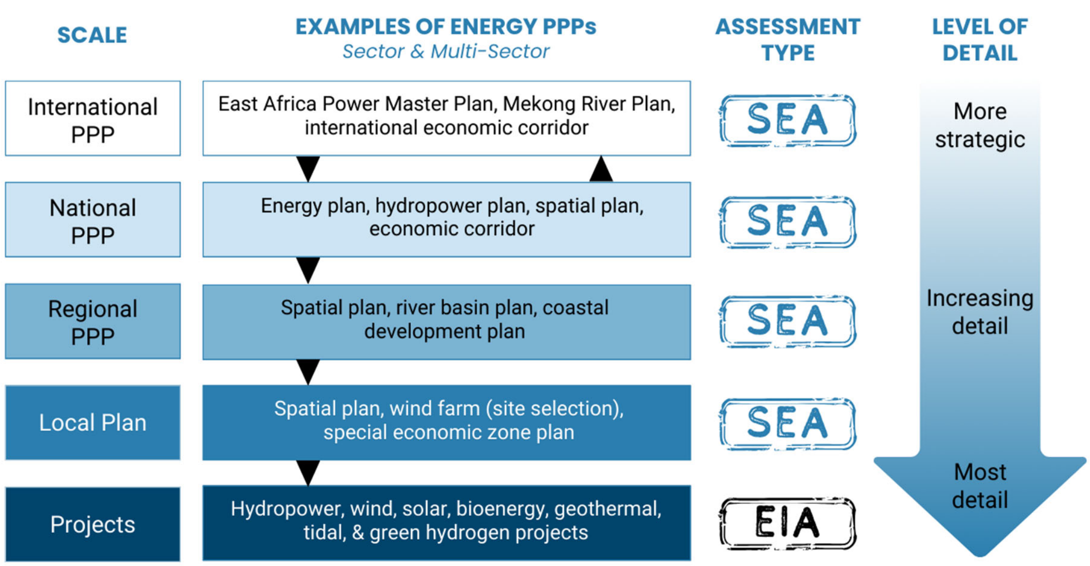
most simple representation, this encompasses (i) all types of spatial planning, including land use and river basin planning, coastal zone and marine spatial planning (Annex 21 discusses the role of spatial planning for energy planning), and (ii) all types of development planning ranging from international economic corridors to regional development plans (Annex 22 discusses linkages between the energy sector and other sectors).

Each country will have a different set-up and terminology for its planning framework. All countries are likely to have energy sector plans, but not necessarily at all levels of government. Similarly, many countries will have an overarching development strategy or vision, sometimes supported by regional development plans without spatial focus. Spatial planning frameworks are far less common. Member-states of the Commonwealth of Nations may have followed the example of British town and country planning. But in low- and middle-income countries, spatial planning is still particularly uncommon. Yet, there is a noticeable increase in countries starting to develop regional spatial development plans.

SEA can and has been applied at all the levels of planning shown in Figure 4.1 and for both single sector plans (including for energy) as well as for multi-sector development and spatial plans. Planning situations differ widely in terms of scope. They can be broad and strategic, with little detail at higher levels, or narrowly focused and with a high level of detail at lower levels. As discussed in Chapter 1, Sections 1.2 and 1.7, there is no one-size-fits-all approach to SEA and each one must be tailored and designed according to the context and needs of energy planning in the country (or more locally), while following basic principles (see Chapter 1, Section 1.4) and stages/steps (see Chapter 2). In these circumstances, in designing an SEA, it will be critically important to understand the complex, interconnected, dynamic elements of a country's energy system (generation, distribution, consumption/use) and how efficient, reliable, affordable, and sustainable they are. These elements shape energy plans, investments, and outcomes at national, regional, and global levels. Energy systems now need to be responsive to a number of issues linked to the energy transition, which will require concerted efforts from governments, businesses, civil society, and international organizations to transform energy systems in a manner that is environmentally sustainable, socially inclusive, and economically viable (see also Annex 23).

The level of detail involved (for plans, SEAs, and project EIAs) will increase through the hierarchical tiers[9] of policy-making, planning, and projects (see Figure 4.2).

Figure 4.2: Tiering of plans, projects and environmental assessments



Adjusted from Therivel and González del Campo (2021)

[9] Tiering is the organized transfer of information and issues from one planning level and assessment level to another (e.g., SEA to EIA). Effective tiering has the potential to streamline and strengthen not only the impact assessment processes but also the associated plans and projects.

In theory, SEA can be applied at all levels, or tiers, in the planning hierarchy. Higher-level SEA can inform lower-level assessments and plans, thus effectively funneling assessment questions to a higher level of detail on more narrow planning decisions (see Annex 23). In practice, however, the planning hierarchy is not always perfectly tiered, and SEA is definitely not applied at all planning levels. More often than not, SEA gets a one-time opportunity to contribute relevant information to a tier of planning steps. When defining the process, design, and scope of an SEA, it is therefore vital to understand the position of the plan to be assessed in the overall planning hierarchy of the country, keeping in mind that the SEA will, in any case, provide important information to define the scope of the ultimate project ESIAs at the lowest tier.

Box 4.2 provides some hypothetical examples regarding planning frameworks to illustrate the issues that may need to be addressed when deciding on the role of SEA.

Box 4.2: How SEA can support energy planning: some hypothetical examples

Example 1: Country with national energy plan but no spatial planning

This is a common situation in many low- and middle-income countries. The national energy policy has to set the national energy mix and define energy infrastructure interventions to meet future energy demands. This is done without having concrete spatial policy directions and not addressing other sectors' interests in geographically defined areas.

Very often this is partly solved by developing sub-sector plans, such as a hydropower master plan, which identifies suitable locations for power facilities in all river basins. Yet, the focus remains on energy production, usually not fully taking into account the interests of other sectors, including nature conservation interests, let alone having a view on potential contributions to sustainable development goals that go beyond the energy sector boundaries.

SEA can fill the void in spatial information. Apart from assessing the consequences of planned energy sector interventions, it can also assess the suitability of locations based on an assessment of the expected cumulative effects of all sector plans on a particular region, river basin, or marine area. SEA can identify relevant actors and stakeholders and engage these in the process. The SEA can thus contribute significantly to the energy planning process, for example, by providing better information on a realistic contribution of particular energy types to the energy mix or indicating the need to avoid locations where other interests will give rise to social unrest and/or legal procedures (including areas of high biodiversity interest).

Example 2: Country with national energy plan and regional spatial plans (sub-national level)

In this situation, the national energy plan informs the regional spatial plans regarding energy infrastructure needs for which suitable locations need to be identified. Conversely, the spatial plans can inform the energy planning process on future regional developments, providing possible estimates for energy demand.

SEA ideally has two possible entry points:

- the energy policy level and the regional spatial plan. The focus of an energy policy SEA will be on coordination and coherence with other national sector policies, identifying drivers of environmental change (affecting water, air, land, biodiversity), and setting boundaries of sustainability.
- The focus of the second option will be the geographical delineation of areas sensitive to drivers of environmental change (e.g., high biodiversity areas), identification of areas providing critical ecosystem services (e.g., essential water storage or supply areas), areas where cumulative effects may occur, and areas where people are vulnerable to impacts.

Climate vulnerability also has a geographical focus. If only one of the two planning processes is subject to SEA, the scoping for the SEA process has to cover both entry points as much as possible.

Example 3: Country with a national energy plan and an international power pool partner

The intermittency of renewable energy sources has given rise to international planning and development of energy infrastructure networks to secure a stable electricity supply. SEA can inform coordinated decision-making amongst the participating countries, e.g.,

- on developing alternative trajectories of international energy corridors with a comparison of impacts (spatial focus); and
- on governance arrangements and international coordination for environmental monitoring and management, including possible gaps (regulatory focus).

Annex 24 provides details of the EU Energy Union's requirements for National Energy and Climate Plans, which are subject to SEA under the EU SEA Directive.

SEA can play a vital role in providing relevant and timely information on important environmental socioeconomic issues (opportunities to maximize benefits and how to minimize, mitigate, or manage risks and negative impacts). In this way, SEA can support decision makers to make well-informed decisions. The key environmental and socioeconomic issues likely to be associated with different types of renewable energy development, retiring coal-fired power stations and coal mines, and associated infrastructure (e.g., transmission lines, access roads, etc.) are discussed in Section 4.8 below and in detail in Chapters 5-13.

Annexes 25 and 26, respectively, list key planning decisions and associated issues that will need to be addressed by SEAs for energy sector plans (left-hand vertical box in Figure 4.1) and multi-sector plans (right-hand vertical box in Figure 4.1). These annexes provide insight into the wide variety of sectoral, cross-sectoral, and spatial issues that may need to be addressed before a well-informed decision on energy planning can be taken. Real-life case examples from various countries around the world are referenced. The cases do not necessarily exactly follow the logic of the tables in these two annexes (for example, the Wind and Solar Spatial Plan from South Africa is both an energy plan and a spatial plan), illustrating the fact that real life is diverse and does not fit with schematic tables.

Through its emphasis on stakeholder engagement, SEA provides a process to facilitate communication and dialogue that is critical in developing the tiered range of energy and associated PPPs shown in Figure 4.2. Such communication should be fostered between PPPs in the tiers (vertical communication), ideally in both directions and between the PPPs for different renewable energy types (horizontal communication) (Figure 4.3).

Figure 4.3: Communication between the tiers and types of energy plans

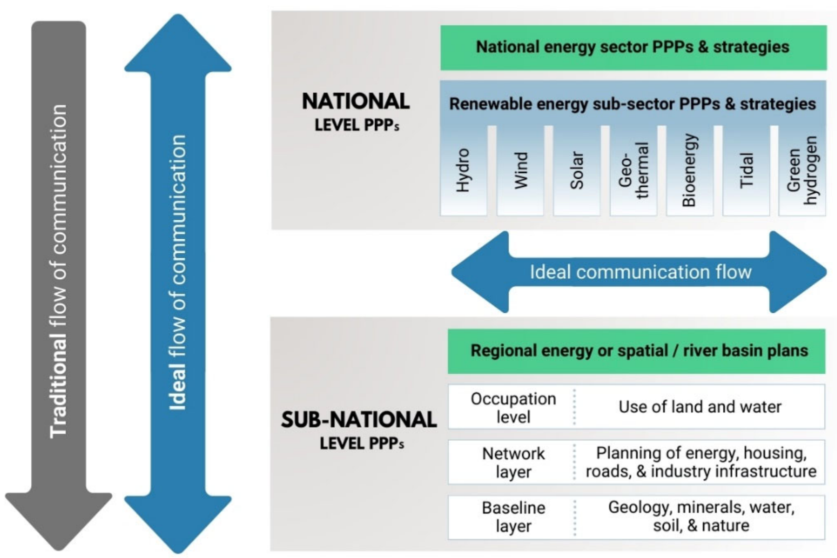


Table 4.3 compares the functions of SEAs undertaking at national and regional levels

Table 4.3: SEA for national and regional planning compared
Source: adapted from NCEA (2019)

SEA for national planning	SEA for regional planning
SEA assists national energy ministries, departments, and agencies in: • Linking energy sector development to ***infrastructure development needs*** governed by other ministries/departments (e.g., road, rail, transmission lines, transport, water management). • ***Aligning energy sector PPPs*** with other national policies, e.g., by avoiding conflicts with labor rights policies. • Identifying where ***institutional roles and responsibilities*** may require clarification or harmonization. • Assessing the adequacy of existing ***institutional capacity*** and identifying capacity required for ***compliance and enforcemen***t mechanisms. • Identifying where the energy sector and other sector ***laws and regulations*** require revision, updating, or strengthening, e.g., in relation to environment, health and safety, cultural heritage, and biodiversity conservation/management, etc. • Addressing ***cumulative effects*** of renewable energy developments, e.g., multiple hydropower dams in a single catchment. • Identifying ***skills required for new employment opportunities***, needs for technical and vocational training, and spin-offs (e.g., potential for creating small- and medium-sized enterprises or value-adding industries). • Identifying needs for investment in ***research and development*** in renewable energy technologies. • Ensuring consideration of environmental and social aspects of ***coal mines and/or coal-fired power plants early retirement/closure or repurposing*** and adoption of appropriate measures for rehabilitating affected areas. • Ensuring consideration of environmental and social aspects of ***safe disposal of toxic materials*** at end-of-life of renewable energy projects (e.g., safe disposal of used solar panel and wind turbine components).	SEA supports regional authorities by: • Assessing potential positive and negative ***interactions*** with other productive sectors, such as livestock, farming, and fisheries. • Establishing ***priorities for conservation and development*** and characterization of stakeholders. • ***Improved governance*** between regional and national levels in relation to energy planning. • Encouraging ***regional inter-sectoral coordination*** to increase the efficiency of the transport network, rural and urban planning, and biodiversity conservation efforts. • Addressing human ***rights***, land use rights, and community participation. • ***Planning for public services*** (education, health care, public water supply) where new renewable energy schemes are expected.

Energy policy-making and planning has traditionally focused on estimating demand and determining the types of energy sources to be used to meet it. More recently, other goals, such as minimizing the cost of energy while addressing environmental concerns, particularly reducing greenhouse gas emissions, have been incorporated. Such policies and plans aim to guide the future of local and national regional systems, reflecting the needs resulting from population growth and consumption patterns.

Despite these new challenges, energy policy-making and planning remains a largely technical and economic exercise. Wider environmental and social (including cultural) factors are highly relevant to developing models for meeting future energy demands but have largely been neglected.

Energy planning is often conducted within governmental organizations but may also be carried out by large energy companies such as electric utilities or oil and gas producers. It may involve input from different stakeholders drawn from government agencies, local utilities, academia, and other interest groups. Energy planning is frequently undertaken using integrated approaches that consider both the provision of energy supplies and the role of energy efficiency in reducing demands.

Energy plans have traditionally played a strong role in setting the framework for regulations in the energy sector (e.g., concerning the type of power plants that can be built or prices that can be charged for fuels). But, as noted above, over the past three decades, in many countries, energy systems have been deregulated, resulting in reduced long-term energy planning, and decisions have increasingly been left to the market. In the last few years, this trend has reversed following increasing concerns over the environmental impacts of energy consumption and production, particularly considering the threat of global climate change. Sustainable energy planning is particularly appropriate for communities that want to develop their own energy security while employing the best available practices in their planning processes.

As for any other SEA, its application to energy PPPs should seek to merge with and support the process of development of the PPP to achieve maximum influence on its design and content. The experience of Vietnam in applying SEA to support preparation of successive Power Development Plans (PDPs) illustrates an evolution in SEA integration (Box 4.3).

Box 4.3: Evolution in SEA integration in Vietnam's Power Development Plans

Source: ADB (2018)

The case of Viet Nam's Power Development Plans (PDPs) illustrates how incorporating SEA into the planning process for successive PDPs ensured that they were based on a more thorough understanding of their implications for the economy, society, and environment of the country.

The first integration of SEA into the PDP was done in the preparation of the Hydropower Master Plan in the context of PDP VI. This pilot SEA considered the potential impacts of 21 large-scale hydropower schemes included in PDP VI. Five scenarios were considered: one with a base case consisting of the existing schemes included in PDP VI, and four that progressively reduced the number of hydropower schemes and replaced them with least-cost alternatives (generally thermal power) identified through the PDP process. The impacts of alternative generating sources were considered in each scenario, providing a meaningful analysis of the different options to meet the needs for generation capacity defined in PDP VI.

The lessons learned from the pilot SEA showed that changes were needed in the PDP planning process to ensure that social and environmental impacts were fully integrated into the plans for the sector. The SEA proposed a detailed model of how this was to be achieved and to inform the development of the SEA in PDP VII, which was based on the experiences and capacities developed in the execution of the pilot hydropower SEA linked to PDP VI.

The original PDP VII was prepared in 2011–2012 to guide the development of the power sector for the period 2011–2030. It analyzed future electricity demand scenarios by sector, considering potential economic and social development trends. It also assessed the most effective, least-cost power generation options for meeting likely future demand patterns. The SEA was done simultaneously with the preparation of the PDP. While there was close coordination at the different stages of analysis during the PDP and the SEA preparation, there were also limitations in the extent to which the SEA was fully integrated into the PDP process.

Awareness of these impacts and concerns that the demand projections were too high led to a revision of PDP VII. The preparation of the revised PDP was based on the SEA from the original plan, with the scenarios in the analysis defined in relation to impacts identified in the SEA and related to the achievement of policies on renewable energy and energy efficiency.

The latest version of Viet Nam's PDP—the revised PDP VII (RPDP VII)—is a model of good practice in integrating an SEA in the preparation of a strategic plan that is important not just for Viet Nam but for the power sector of other countries, particularly in the Greater Mekong Subregion. The

SEA provided an understanding of the implications of the different development options in the PDP, leading to significant changes in the final contents of the plan, ensuring better alignment to the national development policies of Viet Nam and that it more effectively reflected specific national targets in areas such as renewable energy and greenhouse gas (GHG) mitigation.

See also Annex 28.

Regional cooperation will be of increasing importance in developing such PPPs as there will be collective opportunities for diversifying electricity generation mixes and reducing reliance on fossil fuel resources.

4.5 STATUS OF SEA PRACTICE IN THE ENERGY SECTOR

Despite repeated calls to include more strategic forms of impact assessment in energy planning, decisions about renewable energy development are still predominantly approached on a project-by-project basis.[10] Nevertheless, energy plans and programs, and sometimes policies, are subject to SEA in many parts of the world (as illustrated in Table 4.2). In Europe, for example, energy plans are explicitly listed in the SEA Directive (2001/42/EC) while in low- and middle-income countries, energy is, next to transport, the most important sector in which SEAs are required to be undertaken.

An overview of the current state of research on and practice of SEA in the energy sector[11] concludes that SEAs for energy PPPs have similar shortcomings to SEAs in other sectors. In particular, the assessment of cumulative effects and the consideration of alternatives are currently done poorly. The study observes that, almost without exception, plan alternatives instead of strategic alternatives are developed and assessed in practice. Based on detailed case reviews, the study identifies meaningful energy alternatives from policy to program levels (Table 4.4).

Table 4.4: PPP levels and energy alternatives
Source Geissler *et al.* (2021)

Level	Characteristic	Alternatives	Energy alternatives	Methodology
Policy	Federal course and guidance	• System alternatives • Strategic options	• Alternative energy concepts • Variations in energy mix • Renewable sources • Distribution options	Broad-brush, qualitative (e.g., scenario analysis)
Plan	Strategy for a spatial or sectoral planning section	• Development strategies within the sector, plan variations	• Energy supply strategies • Broad spatial alternatives • Degree of exploitation • Infrastructure options	Quantitative and qualitative methods (e.g., impact matrices)
Program	Schedule of activities in a specific area	• Alternatives to proposed actions (site, scope, mode)	• Site alternatives (bundle of projects) • Degree of exploitation • Restriction options	Quantitative (e.g. MCA, CBA

Early examples of SEAs for energy policies are from the Czech and Slovak Republics (Box 4.4) and the UK, where the Department for Business, Energy & Industrial Strategy (BEIS) (formerly DTI, BERR, and DECC) has undertaken a sequence of Offshore Energy SEAs (OSEA) focused on oil and gas since 2001 (Box 4.5).

[10] Nwanakezi *et al.* (2022)
[11] Geissler *et al.* (2021)

A recent case study used renewable energy transitions in Saskatchewan, Canada, to demonstrate how a transitions-based SEA framework can be applied to explore the capacity needs, opportunities, risks, and obstacles in existing institutions and governance arrangements for low-carbon transitions (Box 4.6).

Box 4.4: SEA of energy policy in Czech and Slovak Republics
Source: Dusik (2003ab)

SEA of Czech Energy Policy (1997): This identified objectives and measures for the development of the entire sector (electricity, coal, and gas), including future privatization and use of economic instruments. It also addressed the future use of nuclear power, including specific project issues:

- Whether to stop or proceed with a second nuclear power plant already approved and partly built; and
- Whether to change the limits for open-cast coal mining, which would result in the destruction of additional villages in North Bohemian and North Moravia.

The SEA process focused mainly on the elaboration of the report. Extensive scoping included a national public hearing to comment on the draft policy and the proposed assessment methodology. The scoping process initiated the development of three distinct scenarios of energy mixes. These could be achieved by the use of available administrative, legal, and economic instruments to regulate behavior of companies and individuals. The scenarios were extensively modeled and assessed against a set of 16 categories of environmental, social, and economic impacts. A public review of the draft SEA report was held in the main chamber of the Czech Senate.

SEA of the Slovak Updated Energy Policy (EP 1997): This comprised a number of steps:

- Provision of information to the public about preparation of the EP;
- Expert review, including presentation of opinions for public discussion;
- Public forum on the EP with participation from state and professional bodies, industry, universities and research institutions, NGOs, and the media;
- Statement by the Ministry of Environment (MoE) on the basis of expert opinion, other comments, and public discussion;
- Conclusion of the public discussion, with the Statement of MoE and the Statement of the Ministry of Economics sent to all participants, and
- Submission of a new version of the proposed EP to the Slovak government, which was subsequently approved.

The SEA process had a number of positive features, notably with regard to public consultation and input. But NGO representatives strongly criticized the shortcomings of EP-1997 and weaknesses in the policy development process itself, which lacked adequate environmental, health, and socioeconomic assessments.

Box 4.5: Offshore energy SEAs in the UK
Source: Department for Energy Security and Net Zero (2013)

Since 2001, the UK has undertaken a series of Offshore Energy SEAs (OSEA) considering various areas of the UK continental shelf (SEA areas 1-8), in addition to an SEA for Round 2 wind leasing. The more recent Offshore Energy SEAs (OSEA, OSEA2, OSEA3, and OSEA4) incorporated the entire UK continental shelf, with the exception of Northern Ireland and Scottish territorial waters for renewable energy, and Scottish territorial waters for carbon dioxide transport and storage. These SEAs covered technologies such as oil and gas exploration and production, gas storage and offloading (including carbon dioxide transport and storage), renewable energy (including wind, wave, and tidal power), and offshore hydrogen production and transport.

As these SEAs have been carried out, the process has evolved and continues to improve. It includes consultation with the public, environmental authorities, and other bodies, together with such neighboring states as may be potentially affected. The process is guided by a Steering Group comprising departmental representatives, conservation and other agencies, NGOs, industry representatives, and independent experts. The diverse members' roles are to act as technical peers, guiding the selection of SEA methods and identifying the right information sources.

Box 4.6: SEA for energy transitions
Source: Nwanakezie et al. (2022)

A study showed how applying SEA to renewable energy transitions in Saskatchewan, Canada, identified significant benefits, opportunities, and risks in renewable energy transitions. Opportunities existed to address energy security concerns and promote distributed generation, but perceived risks included the immediate economic impacts of transitioning away from a fossil-based economy, reliability risks owing to the intermittent nature of renewables, and political uncertainty about the future electricity landscape. The results showed the need for clear transition goals and implementation strategies, including full commitment to the transition agenda. For transitions-based SEA, results highlighted the need for transparency and accountability to ensure effective implementation and the difficulty in establishing new assessment regimes. The lessons of this study appear broadly relevant for addressing low-carbon transition challenges and opportunities in other jurisdictions.

EU requirements for member states to produce National Renewable Energy Action Plan (NREAP) and National Energy and Climate Plans (NECP) and how SEAs apply to these are discussed in Annexes 24 and 36.

4.6 GUIDANCE AND TRAINING FOR DEVELOPING ENERGY PPPS

It is often difficult to know whether individual governments have issued internal guidance for developing energy PPPs, as this information may not be made public.

The EU has issued guidance for preparing progress reports on the implementation of National Energy and Climate Plans (NECPs) (see Annex 36 for discussion of NECPs).[12] It sets out principles and good practice and describes how the reports should address a range of issues. But there is no specific requirement to subject the NECPs to an SEA process.

In the USA, guidance is available for community energy strategic planning (USDE 2013) (Box 4.7), while in the UK, Energy Systems Catapult has published ***guidance on how to create a Local Area Energy Plan*** (LAEP) (Box 4.8). Both suggest a series of steps for the process.

Training

The International Renewable Energy Agency (IRENA) provides capacity building support to countries for developing or updating national energy masterplans through its Masterplan Development Support Program.[13] The program typically spans one to two years and includes several weeks of in-country training to calibrate a system planning test model, explore energy planning scenarios, and develop a national energy masterplan document. In-country sessions are complemented by online training and other meetings.

[12] EU (2022)
[13] For more information, see: www.irena.org

Box 4.7: Guide to Community Energy Strategic Planning (CESP), USA

Source: USDE (2013)

In 2013, the US Department of Energy prepared a Guide to Community Energy Strategic Planning (CESP) (USDE 2013). It offers the following 10-step process for creating a robust strategic energy plan for a local government and community that can help save money, create local jobs, and improve national security:

1: Establish and charge a leadership team;
2: Identify and engage stakeholders;
3: Develop an energy vision;
4: Assess the current energy profile;
5: Develop energy goals and strategies;
6: Identify and prioritize actions;
7: Put together a financing strategy;
8: Develop a blueprint for implementation;
9: Plan to evaluate, and
10: Develop, adopt, and publicize the CESP.

The guide offers tools and tips to complete each step and highlights examples from successful planning efforts around the country. It aims to help local governments and community stakeholders use the CESP framework to build on initial energy successes by moving from single projects and programs to a comprehensive, long-term energy strategy that delivers benefits for years to come.

A CESP is seen not as a static document but rather as a long-term blueprint to focus and guide efforts and actions toward a defined energy vision. The plan articulates goals, develops strategies and actions to meet the goals, and identifies and allocates resources to assure effective completion of these strategies.

Box 4.8: Guidance on how to create a Local Area Energy Plan (LAEP), UK

Source: Energy Systems Catapult (2024)

In the UK, Energy Systems Catapult has published ***guidance on how to create a Local Area Energy Plan*** (LAEP). It is aimed at local government organizations who are looking to create a plan to help them meet their net zero goals and climate emergency declarations.[14] A LAEP sets out the change required to transition an area's energy system to Net Zero in a given timeframe. This is achieved by exploring potential pathways that consider a range of technologies and scenarios, and when combined with stakeholder engagement, leads to the identification of the most cost-effective preferred pathway and a sequenced plan of proposed actions to achieve an area's Net Zero goal.

The guidance provides a detailed description of a 7-stage end-to-end process:

1. Preparation;
2. Stakeholder Identification and Engagement;
3. Understanding and Representing the Current Local Energy System;
4. Modelling Options for the Future;
5. Scenario Refinement and Selection;
6. Actions, Priorities, and Decisions, and
7. Create the Plan.

[14] See the full Guidance on creating a Local Area Energy Plan: https://es.catapult.org.uk/guide/guidance-on-creating-a-local-area-energy-plan/

4.7 STEPS IN UNDERTAKING AN SEA FOR AN ENERGY SECTOR PPP

As for any SEA, one carried alongside or as an integrated component of developing or reviewing an energy sector policy, plan, program, or equivalent (e.g., a strategy), should follow the basic stages and steps set out in Chapter 2.

In most countries having legislative or regulatory requirements for SEA, energy sector PPPs are specifically identified as requiring an SEA. Similarly, multilateral development banks usually require an SEA/SESA to be completed when they are providing funding for energy sector development, such as initiatives to support the energy transition. Examples regarding the latter include an SEA initiated in 2022 by the Asian Development Bank in Indonesia and scoping for a possible SEA in the Philippines (2023-2024), both linked to implementing the Energy Transition Mechanism in countries in Southeast Asia.

4.8 ENVIRONMENTAL AND SOCIOECONOMIC ISSUES THAT AN ENERGY PPP WILL NEED TO ADDRESS

At the level of energy planning, several key environmental and social issues need to be addressed to ensure sustainability, equity, and resilience (Box 4.9). Addressing these issues requires an approach that considers the interconnections between energy, environment, and society. SEA can contribute by incorporating sustainability principles, equity considerations, and stakeholder engagement mechanisms into energy planning for governments to promote a transition to a more resilient, equitable, and sustainable energy future.

Box 4.9: Key environmental and socioeconomic issues for energy planning

- ***Climate change mitigation***: Energy policies must prioritize reducing greenhouse gas emissions to mitigate climate change. This involves promoting the transition to low-carbon energy sources and implementing measures to improve energy efficiency and reduce energy waste in accordance with the Nationally Determined Contributions under the Paris Agreement (see Box 1 in the “Background to this guidance and the energy transition: in the preliminary sections).

- ***Air quality and public health***: Fossil fuel combustion for energy generation contributes to air pollution, which has significant public health impacts. Energy policies should include measures to reduce air pollutants such as particulate matter, nitrogen oxides, sulfur dioxide, and volatile organic compounds to protect human health and improve air quality.

- ***Water resources management***: Energy production and consumption can have significant impacts on, but also depend on, water resources through activities such as cooling of power plants (water temperature), hydraulic fracturing (fracking) for natural gas extraction (pollution), hydropower generation (hydrological changes), and hydrogen production (freshwater withdrawals).

- ***Biodiversity conservation***: Energy infrastructure development such as dams, transmission lines, access roads, and renewable energy installations can disrupt ecosystems and threaten biodiversity. Energy policies should incorporate measures to minimize habitat destruction, preserve biodiversity hotspots, restore degraded ecosystems that are providing important ecosystem services, and mitigate impacts on sensitive species and ecosystems.

- ***Land use and land rights***: Energy infrastructure development requires land (or sea). This can lead to conflicts over land rights, displacement of communities, and loss of agricultural land or natural habitats. Energy policies should promote sustainable use of land and marine areas, respect indigenous and local land rights, and prioritize land conservation and restoration efforts.

- ***Energy access and equity***: Access to affordable, reliable, and clean energy services is essential for poverty alleviation, economic development, and social equity. Energy policies should prioritize universal energy access, particularly for marginalized and underserved populations, through initiatives such as rural electrification programs, off-grid solutions, and subsidies for low-income households. Benefit-sharing can be a mechanism to compensate communities affected by, for example, solar and wind parks or transmission lines in terms of low-cost energy or sharing in financial benefits via private-public mechanisms.

- ***Just Transition[15] for workers and communities***: The transition to a low-carbon economy may have adverse social and economic impacts on workers and communities dependent on fossil fuel industries. Energy policies should include measures to support affected workers through retraining programs, job creation initiatives, income support, and community development projects to ensure a just transition to sustainable energy.

- ***Community engagement and participation***: Engaging and consulting with local communities and stakeholders is essential for building trust, addressing concerns, and ensuring the social acceptability of energy projects (see Chapter 1, Section 1.10). Energy policies should promote meaningful community engagement processes, including stakeholder consultations, public hearings, and participatory decision-making mechanisms.

- ***Environmental justice***: Energy policies should address environmental justice concerns by ensuring that the benefits and burdens of energy development are equitably distributed among all segments of society, particularly vulnerable and marginalized communities. This requires considering social demographics, socioeconomic status, and historical inequities in energy policy design and implementation.

- ***Resilience to climate change and natural disasters***: Energy infrastructure is vulnerable to climate change impacts and extreme weather events such as hurricanes, floods, and wildfires. Energy policies should promote climate resilience by enhancing the robustness and reliability of energy systems, diversifying energy sources, and integrating climate risk assessments into infrastructure planning and design.

The main sources of non-renewable energy of critical concern as regards climate change are carbon-based fossil fuels such as coal, oil, and natural gas. These are burned to generate energy in power stations and internal combustion (vehicle) engines.

As far as reducing reliance on fossil fuel-based energy production is concerned, this guidance focuses on the need for retirement of coal-fired power plants and the closure of associated coal mines (Chapter 11). The renewable energy sources addressed by the guidance are: hydropower (Chapter 5), wind (Chapter 6), solar (Chapter 7), bioenergy (Chapter 8), geothermal (Chapter 9), tidal (Chapter 10), and green hydrogen/ammonia (Chapter 11). For all renewable resources discussed in these chapters, it is essential to also consider the impacts of associated infrastructure (see Chapter 13).

For all these sources, there is a relatively common set of issues for which there is potential for environmental and socioeconomic impacts to arise for which management and mitigation measures need to be addressed (see Tables 4.5 and 4.6, respectively). The specifics of these issues for different energy developments are addressed in subsequent chapters.

Many of the environmental and socioeconomic issues discussed in Chapters 5–12 will appear to be at a project level. This is because most of our knowledge of these issues is derived from experience implementing energy generation activities around the world, both for fossil fuel and renewable energy developments and projects. These are the very issues likely to be identified during scoping for an SEA (see Chapter 2, Section 2.5), either because stakeholders are familiar with them or, often, because they have been directly affected by them. It is important to understand these issues because they may give rise to cumulative impacts from multiple projects when a PPP is implemented, and a critical role of SEA is to identify the potential and risk of cumulative impacts arising. Furthermore, these are the issues that

[15] See Section 5 in Preface

may require to be addressed by changes to existing laws, regulations, or PPPs, and this is a matter on which an SEA should make recommendations.

Given the challenges of climate change and international commitments concerning GHG emissions, new or revised energy PPPs need to focus on how to change the balance in energy sources to reduce GHG emissions, promote and invest in renewable energy options, reduce long-term cumulative impacts, and ensure that energy development does not add to pressures on the planetary boundaries. Many countries have already made considerable progress in this transition. An SEA for a national or more local energy PPP seeking to promote this transition will need to address all these issues (as applicable).

Table 4.5: Environmental issues associated with closing coal-fired power plants/coal mines and developing renewable energy facilities

Theme	CFPP	Coal Mines	Geothermal	Hydropower	Solar	Tidal	Wind	Bio-energy	Green H & NH_3
	Early Retirement	Closure	Development						
Integrity of habitats and preservation of biodiversity									
Integrity of protected & sensitive areas									
Delivery of ecosystem services									
Maintenance of air quality									
Fresh water use/demand									
Maintenance of water quality									
Waste (solid, gas, liquid, toxic, hazardous, spoil, & pollution)									
Land/water contamination									
Noise and vibration									
Greenhouse gas emissions									
Land degradation (erosion/sedimentation/deforestation)									
Land/marine use change									
Flooding									
Hydrological change (rivers, estuaries)									
Demand for mineral extraction									
Risk of earthquake damage									
Land drainage									
Visual impacts									

Note: Issues may be directly related to the retirement/closure of CFPPs/mines or development of RE facilities, or indirectly to the need for associated infrastructure (e.g., access roads, transmission lines) and material sourcing (e.g. minerals).

Table 4.6: Socioeconomic issues associated with closing coal-fired power plants/coal mines and developing renewable energy facilities

Theme	CFPP	Coal Mines	Geothermal	Hydropower	Solar	Tidal	Wind	Bio-energy	H & NH_3
	Early Retirement	Closure	Development						
Economic growth									
Legacy socioeconomic issues									
Employment and labour conditions									
Local economy and livelihoods									
Gender and vulnerabilty									
Indigenous communities									
Food security and price									
Skilled workers									
Health and safety									
Physical and economic displacement									
Conflicts									
Migration									
Community engagement and cohesion									
Public services and infrastructure									
Cultural heritage									
Human rights									

Note: Issues may be directly related to the retirement/closure of CFPPs/mines or development of RE facilities, or indirectly to the need for associated infrastructure (e.g., access roads, transmission lines) and material sourcing (e.g., minerals).

4.9 DESIGNING THE SEA PROCESS AND CHALLENGES IN IMPLEMENTING ITS RECOMMENDATIONS FOR ENERGY SECTOR PLANNING

When designing the process of an SEA applied to an energy plan, it will be important to ensure that it has the best chance of supporting and influencing the plan, i.e., to ensure that the SEA is as effective as possible (see Chapter 1, Section 1.12). In this regard, it is critical that the government agency commissioning the SEA consider how the SEA can be integrated with the planning process to the greatest extent possible. Section 1.5 (Chapter 1) provides a discussion of how SEA relates to the plan development process and how *ex-ante* SEA provides the best opportunity for influencing plan preparation.

In seeking to best design the SEA process, the expert team will need to work with the relevant government agencies to clarify the process and steps involved in developing a new, or revising an existing, energy plan. This is necessary to determine when critical steps and decisions in plan development will be made and when products and recommendations of the SEA can best support and inform the planning process.

At the same time, when designing the SEA process, the key actors involved in developing/revising the plan should be identified and a strategy developed to make sure that they are informed of the SEA, understand how it can help their work, are involved in (e.g., kept informed) of SEA progress, and receive essential information at appropriate and critical times.

A key product of an SEA will be a Strategic Environmental and Social Management Plan (SESMP) (see Section 2.7.2 and Annex 16, which sets out the recommended content of a SESMP). The SESMP should be developed in close consultation with those government and non-government agencies and organizations that are likely to have a role in its implementation so that they are involved in agreeing its contents and recommendations, verifying that they are achievable and proportionate to identified key issues, and ensuring that roles and responsibilities are fully understood and “bought into.” A key challenge to implementing SESMP recommendations (e.g., for environmental or social management or for monitoring key indicators) is that there is often a lack of adequate technical skills, capacity, and equipment, and budget allocations may be insufficient. This means that the SESMP should address where capacity strengthening and/or training may be required, and it should be fully costed where possible.

Furthermore, there is sometimes a lack of clarity over institutional mandates and jurisdictions, and thus rivalries and “defence of turf.” This may be the result of unclear or overlapping legislation or regulations. It can lead to institutional conflicts regarding roles and responsibilities to implement SEA/SESMP recommendations. These potentials should be addressed and solutions found when consulting on the content of the SESMP.

Once the implementation process has been agreed to by all parties involved, it will be critical to monitor the progress of implementation and make any additional changes required to ensure success.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 5

HYDROPOWER

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International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 5

HYDROPOWER

WHY IS SEA IMPORTANT TO HYDROPOWER?

An overall rationale for why it is important to use Strategic Environmental Assessment (SEA) to support the energy transition is provided in the preface to the guidance.

It is becoming increasingly clear that hydropower projects should be managed at a watershed or basin level. In this context, SEA can provide critical information to support better decision-making for hydropower planning and development, including identifying where there might be significant environmental and/or socioeconomic risks not only at the individual project level, but across the entire watershed. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple hydropower schemes/developments. These impacts can arise:

- Along individual rivers within a country (critical to understand the impacts of multiple often uncoordinated schemes/projects).
- Along transboundary rivers that flow across boundaries between countries (critical to anticipate potential disputes between countries).
- Along multiple rivers in a particular catchment (critical for catchment planning).
- Along multiple rivers in several catchments where inter-basin transfers are taking place.
- Across all catchments in a country (critical for national energy and hydropower planning).

The SEA process will:

- Identify and focus on ***key environmental and socioeconomic issues*** and the concerns of likely affected stakeholders, including local communities, marginalized groups, and Indigenous peoples. This could be on a national scale (for a national-level PPP [policies, plans, and programs]), or for an individual catchment/river scale (if the SEA is catchment-based). Issues associated with hydropower development are discussed in detail in Section 5.5 and are summarized in Table 5.3.

- Identify/recommend if there are ***areas that should be avoided*** for hydropower development ("no go" areas) because of particularly high risk to the environment and/or people and local communities, or preferred areas where the risks are lower.

- Inform where hydropower projects could best be sited (e.g., in particular watersheds or locations).

- Inform project design (e.g., preferred type of dam given constraints in a watershed or along a river).

- Make subsequent project-level ***EIAs/ESIAs*** *(environmental impact assessments/ environmental and social impact assessments)* ***more efficient and cheaper*** by addressing the big picture upstream and downstream across the watershed, and by addressing potential cumulative impacts and identifying the broader issues that individual project EIAs/ESIAs should focus on in more (site-specific) detail.

- ***Engage stakeholders*** (along a river course, in a single or all catchments—both upstream and downstream)—including communities, marginalized groups and Indigenous peoples which can be particularly affected by hydropower developments. Stakeholders should be informed early of proposed or possible policy options or plans, and they should be given opportunities to provide their perspectives and present their concerns as early as possible. This will enable key issues to be identified and verified at a basin level. It will also help build understanding and support for hydropower development and avoid future misunderstanding and possible conflicts. Such misunderstanding and conflicts are in many cases, and increasingly, the root causes for early project termination.

Section 5.1 discusses the benefits of SEA to the development and implementation of hydropower PPPs.

The stages and tasks in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

5.1 HOW SEA CAN BENEFIT THE HYDROPOWER SECTOR

Section 5.5 focuses on the environmental and socioeconomic issues and impacts associated with hydropower development, drawing mainly from global experience of implementing individual hydropower projects and comments on how such impacts can effectively be managed. In addition, recommendations are made regarding higher level planning mechanisms for sustainable hydropower development at a basin level. This Section summarizes how SEA can address the issues and benefit three different stages in the preparation and implementation of hydropower PPPs—planning, assessment, and management.

5.1.1 Planning

SEA can have the greatest benefit at the planning phase, when PPPs for renewable energy (or specifically for hydropower) are being prepared, updated, or revised, and prior to individual hydropower projects being proposed/developed. However, such synchronization is rare. Energy transition requires strategic planning, and SEA can assist to make well-informed decisions accepted by the public, decision-makers and hydropower developers. This will be particularly important where hydropower will either supplant or support baseload generation provided by fossil fuels.

If initiated sufficiently early in the hydropower PPP preparation process, SEA offers the following benefits:

- ***Considers alternatives*** within hydropower and “to” hydropower development—through broadscale and inclusive stakeholder consultations that allow the most desirable alternative basin/energy development pathways to be selected, Thus, SEA helps to identify alternative water-driven development pathways for socioeconomic development and supports energy demand planning at basin level.

- ***Identifies locations*** suitable and preferred for hydropower development (e.g., particular catchments/basins) as well ***areas to be avoided*** (“no go” zones) in terms of risks and potential impacts), aiding subsequent selection of sites for individual hydropower projects at a basin level.

- Identifies watershed catchment areas important for the ***sustainable functioning of existing or planned hydropower facilities***, along with legal and on-the-ground measures needed for the protection or improved management of these catchments.

- ***Supports basin/catchment planning and integrated water resource management*** (IWRM). In countries with hydropower potential, SEA can support river basin planning to identify the most suitable sites in terms of economic benefits and social and environmental acceptability. This is particularly important where multiple cascade hydropower developments are proposed within a single basin. This will allow for identification of key ecosystems (aquatic and terrestrial) within the river basin that need to be adequately conserved, and the range of natural or managed river flows that would sustain these ecosystems.

- ***Supports planning for energy integration*** whereby opportunities for hydropower and other forms of energy generation are identified and assessed (e.g., pump storage in combination with solar/wind).

- ***Supports cascade development planning*** for siting optimization.
- ***Improves hydropower and energy policies*** pertinent to hydropower development.
- ***Increases the efficiency*** of multi-level institutional review and coordination of sector development.
- Directs spatial planning for the ***optimal coordination of other land and water uses*** (including conservation areas).
- Identifies specific issues for ***stakeholder engagement*** planning and strategies for effective consultation and communication for the sub-sector.

5.1.2 Assessment

SEA can help inform PPP development and guide hydropower schemes/projects by assessing their environmental and social risks and impacts as follows:

- ***Optimizes strategic assessment of hydropower PPPs and hydroelectric development schemes*** (e.g., multiple hydropower projects in a particular catchment) to understand higher level environmental and social impacts and risks and their policy and planning consequences.
- ***Addresses cumulative effects*** of and impacts on other water users and uses (such as irrigation, water supply, riverine and coastal fisheries, navigation, biodiversity conservation, and recreation as well as other hydropower plants, including transboundary aspects). SEA ***defines and prioritizes water uses*** (including for the environment) during times of water shortages. It ***elaborates different water use scenarios*** to maximize water use outcomes that will assist decisions on specific investments.[1]
- ***Identifies key sensitive areas*** which could include protected areas, world heritage sites, key biodiversity areas, populated areas, and important cultural heritage sites.
- ***Integrates consideration of climate change*** to assess the suitability and future viability of the proposed hydropower developments.
- Addresses ***how to balance or achieve trade-offs*** between adverse impacts and identifies ***opportunities to enhance synergies*** (win-win outcomes) between environmental, social, economic, and other concerns.
- Provides direction and ***streamlining of project level ESIA*** and approvals in the sub-sector.

5.1.3 Management

The timely and early (*ex ante*) application of SEA can offer early solutions to the management of potential risks and impacts of hydropower PPPs (and subsequent projects/scheme):

- Contributes to ***basin wide strategic management plans***, identifying opportunities for ***cascade management*** and optimizing hydropower generation across multiple projects and reducing cumulative environmental and social impacts, and ***optimizing environmental flows*** and opportunities for ***coordinated flow management***.
- Identifies where ***institutional capacity*** needs to be developed for the effective implementation of SEA and Strategic Environmental and Social Management Plan (SESMP) recommendations.

[1] Slootweg (2023).

- Identifies ***opportunities for trade-offs*** (between environmental, social and economic considerations) for the hydropower sub-sector.

- Identifies where revised or new ***legislation, policies, and regulations*** for the hydropower sub-sector may be required.

- Promotes ***regional cooperation mechanisms*** to help enhance the modalities and benefits of SEA, particularly where transboundary and regional economic considerations need to be addressed.

- Improves ***data collection/sharing and monitoring*** requirements for the sub-sector.

- Helps identify ***efficiency measures/options for power generation*** in the sub-sector.

- Develops a specific ***environmental and social management plan*** (SESMP) for the sub-sector at a national, regional, or catchment level (addressing, e.g., sediment management, fisheries, navigation, biodiversity, relocation of people/communities, compensation, conflict management, etc.).

- ***Integrates climate change adaptation and resilience*** into hydropower planning and development.

- Coordinates the management of ***cumulative and transboundary impacts*** between multiple proponents, agencies, and interested parties.

- Enhances the ***credibility of hydropower development*** and review in the eyes of affected stakeholders, leading to smoother implementation and reduced conflict.

- Provides for ***easier access to funding*** from international development banks by examining higher level transactional and reputational risks.

- Improves ***private sector involvement*** in addressing environmental and socioeconomic concerns by providing a higher-level strategic approach to managing relevant environmental and social risks beyond the project level. This contributes to selecting the best alternatives in terms of type of renewable energy and helps to better justify selection of hydropower projects as the best option compared to other renewable sources.

5.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE HYDROPOWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA identified only one guideline specifically focused on the hydropower sub-sector,[2] while there are numerous guidelines for conducting environmental impact assessments (EIA) for hydropower projects.[3]

The report of the World Commission on Dams (2000)[4] set out comprehensive guidelines for dam building. It describes an innovative framework for planning water and energy projects that is intended to protect dam-affected people and the environment and to ensure that the benefits from hydropower are more equitably distributed.

Subsequently, a broad and extensive literature has become available on hydropower development. Some selected examples include general guidelines (but not concerned with SEA) covering issues

[2] Annandale, D. and Hagler Bailly Pakistan (Pvt) Ltd. (2014)
[3] e.g., REMA (2008), UKEA (2009), IHA (2021c)
[4] WCD (2000)

such as social impacts and risks,[5] environment and climate,[6] tools,[7] Indigenous people,[8] health and safety,[9] developers and investors,[10] affected peoples and livelihoods,[11] and infrastructure safety.[12] The International Hydropower Association (IHA) does not use or promote the use of SEA, but, in 2010, it published the Hydropower Sustainability Assessment Protocol (HSAP)[13] (updated 2020) which offers a way to assess the performance of a hydropower project across more than 20 sustainability topics. Subsequently the IHA launched its Hydropower Sustainability Standard which covers topics relevant to SEA in the hydropower sub-sector (Box 5.1).

Box 5.1: IHA Hydropower Sustainability Standard

The IHA Hydropower Sustainability Standard is a global certification scheme (the first of its kind for renewables), outlining sustainability expectations for hydropower projects around the world. It aims to help ensure that hydropower projects provide net benefits to the local communities and environments they interact with. The standard covers 12 environmental, social, and governance (ESG) topics, including biodiversity and invasive species, water quality, hydrological resource, cultural heritage, governance, labor and working conditions, climate change mitigation and resilience, and more.

In support of the Standard, IHA has published a suite of “how-to-guides” offering a deep dive into specific sustainability topics such as resettlement, labor and working conditions, biodiversity and benefit sharing. Embedded in the standard are four key project-based tools: guidelines of good industry practice, the hydropower sustainability assessment protocol (HSAP), the GRES (GHG Reservoir) tool, and the hydropower sustainability ESG gap analysis tool (HESG).

All documents are available at www.hydropower.org.

5.3 HYDROPOWER INSTALLED CAPACITY

Since 1995, the hydropower sub-sector has more than doubled in size from 625 GW to almost 14001,300 GW, with China having, by far, the greatest installed capacity (see Table 5.1 and Figure 5.1).

Table 5.1: Hydropower installed capacity in 2022
Source: IHA (2023)

Country	Installed Capacity (GW)	Country	Installed Capacity (GW)
China	415	Spain	20
Brazil	110	Switzerland	18
USA	102	Vietnam	17
Canada	83	Venezuela	17
Russia	56	Sweden	16
India	52	Austria	15
Japan	50	Mexico	13
Norway	34	Iran	13
Turkey	32	Colombia	13
France	26	Rest of World	275

[5] e.g., Cernea (2004), EIB (2019)
[6] EIB (2019)
[7] e.g., HSC (2020)
[8] e.g., IHA (2021c), IHA (2022), IHA (2022b)
[9] e.g., IFC (2018)
[10] e.g., IFC (2015b)
[11] e.g., IHA (2020)
[12] e.g., IHA (2021)
[13] For more information, see “Hydropower Sustainability Assessment Protocol” (https://www.hydropower.org/publications/hydropower-sustainability-assessment-protocol)

Italy	23		
Total			***1397***

According to the International Hydropower Association,[14] hydropower generated around 4,400 terawatt hours (TWh) of clean electricity worldwide in 2022 (c.15% of the world's electricity), and Paraguay and Costa Rica achieved a 100% renewable electricity supply, with hydropower as the backbone. In some countries, almost all electricity generation comes from hydropower, e.g., Norway and Nepal. Global hydropower potential is shown in Figure 5.1.

Figure 5.1: Global Hydropower Potential Capacity 2022
Source: IHA (2022)

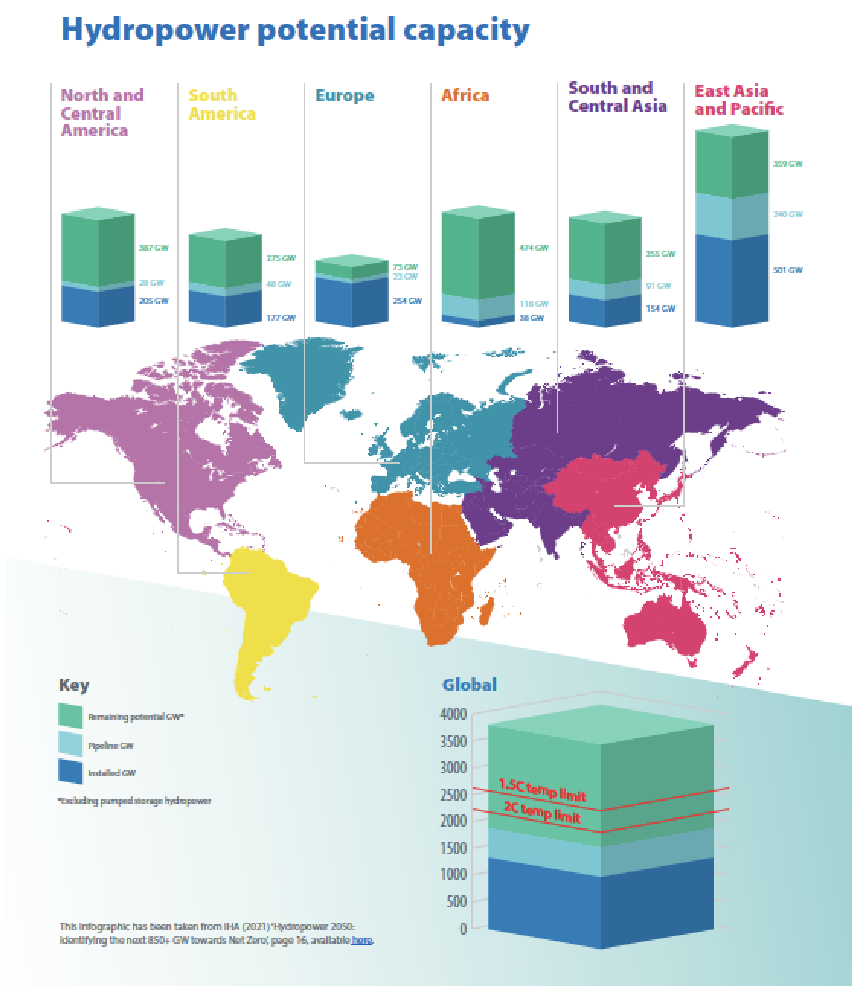


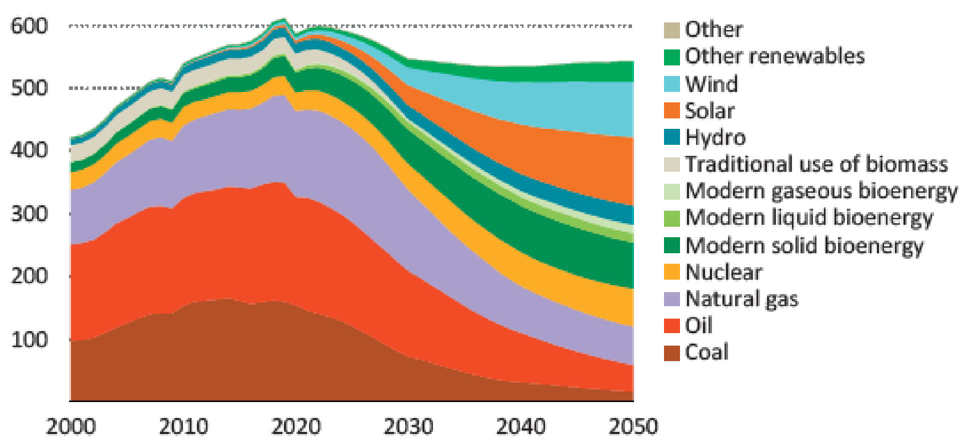
Figure 5.1 shows that the highest hydropower potential lies in Asia, South America, and Africa, and this is where SEA is much needed in future. According to the International Energy Agency and the International Renewable Energy Agency, at least 850 GW of new hydropower is needed to keep global warming below 2°C cost-effectively. However, to meet the more ambitious Net Zero target to

[14] IHA (2023)

limit temperature rise at below 1.5°C, hydropower development must double to at least 2,500 GW based on today's capacity.[15]

The importance of hydropower in the future global energy mix cannot be underestimated. Hydropower currently generates more electricity than all other renewable technologies combined and is expected to remain the world's largest source of renewable electricity generation into the 2030s. Thereafter, it will continue to play a critical role in decarbonizing the power system and improving system flexibility as other renewable sources are brought on-stream.[16] Figure 5.2 shows the importance of hydropower in the global energy mix to 2050.[17]

Figure 5.2: Global Energy Mix to 2050
Source: IHA (Undated)



5.3.1 Application of SEAs in the hydropower sub-sector

A recent international inventory identified 37 SEAs conducted for the hydropower sub-sector during the period 1995 – 2019[18] (Table 5.2). Sixteen (43%) of these were specifically focused on hydropower PPPs, while another sixteen (43%) addressed hydropower as part of broader PPPs for the overall energy sector. A few (5, 13%) dealt with hydropower as part of multiple PPPs covering multiple sectors.

[15] For more information, see "Hydropower 2050: Identifying the next 850+ GW towards Net Zero" (https://www.hydropower.org/publications/hydropower-2050-identifying-the-next-850-gw-towards-2050)
[16] International Energy Agency (Undated)
[17] For more information, see "Hydropower 2050: Identifying the next 850+ GW towards Net Zero" (https://www.hydropower.org/publications/hydropower-2050-identifying-the-next-850-gw-towards-2050)
[18] Kolhoff and Slootweg (2021)

Table 5.2: SEAs for energy sector, multi-sector and hydropower sub-sector, for regions (columns) and type of PPPs (rows) for the period 1995-2019
Source: Kolhoff and Slootweg (2021)

Type of PPPs per sector*	Asia	Africa	Europe	Americas	Total
Energy sector, including hydropower					
International	1	1			2
National**	5	4	4		13
State/provincial				1	1
Sub-total	*6*	*5*	*4*	*1*	*16*
Hydropower sub-sector					
International river basin	1				1
National**	6		1		7
State/provincial	3		1		4
River (sub-basin)	3		1		4
Sub-total	*13*		*3*		*16*
Multiple sectors, including hydropower					
International river basin		1		1	2
National river basins(s)**	2	1			3
Sub-total	*2*	*2*		*1*	*5*
Total	**21**	**7**	**7**	**2**	**37**

* Includes all SEAs applied for PPPs in the energy sector at international, national and state level have been included in the inventory. In two of these SEAs, hydropower is not included as an energy source. All SEAs applied for PPPs in multi-sectoral PPPs are included, in which hydropower is considered. All SEAs applied in the hydropower sector are included in the inventory.

** Selected cases: National energy plan Viet Nam, National hydropower plan Myanmar, State level hydropower plan India and Pakistan, Multi-sector River basin plan Rwanda.

5.4 BACKGROUND TO HYDROPOWER GENERATION

There are two types of renewable energy generation: ***dispatchable*** (sources of electricity that can be dispatched on demand at the request of power grid operators) and ***variable*** (intermittent renewable energy sources [IRES] that are not dispatchable due to their fluctuating nature, such as wind power and solar power).

Currently, hydroelectric power plants generate around 16% of the world's electricity.[19] "Storage" (both reservoir and pumped) hydropower plants (see below) generate dispatchable electricity[20] and can therefore be integrated with wind and solar projects which are characterized by variable (intermittent) generation.

In hydropower plants, electrical energy is produced by exploiting the potential energy of the water thanks to a difference in height ("head"). Water is taken at a certain height from a river or reservoir and conveyed through headrace works (e.g., canals, tunnels, penstocks), passed through hydraulic turbines connected to an electric generator, and finally discharged to the river (the same or another one) at a lower height.

5.4.1 Installation types

Hydropower projects come in many different sizes (e.g., high to medium head), designs, and configurations. The nature of their environmental and social impacts is determined by how they store and use water. Broadly there are four distinct types of hydropower schemes: run-of-river, reservoir, pumped storage, and offshore hydropower[21]:

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[19] IHA (2022c)

[20] Dispatchable generation refers to sources of electricity that can be programmed on demand at the request of power grid operators, according to market needs.

[21] International Hydropower Association (2022)

- ***Run-of-river hydropower plant***: a hydropower plant with no (or very small) storage capacity that uses flowing water from a river to spin a turbine. It provides a non-dispatchable supply of electricity (base load) that fluctuates depending on the natural flow in the river.

- ***Storage hydropower plant***: a system that stores water in a reservoir. Storage hydropower plants typically provide peak loads, concentrating the production according to the demands of the system, thanks to the possibility to operate independently of the hydrological inflow for many weeks or even months.

- ***Pumped storage hydropower plant***: can store water both in an upper and a lower reservoir. Depending on the relation between the reservoir capacity and the natural water inflow to it, different "pumping" modes are possible:

    (a) When the natural flow in the river is zero or negligible, the plant operates in "pure pumping" mode and the cycle of the water is closed. When water is released from the upper reservoir to the lower one, the turbines provide energy to the generators.
    (b) Hydraulic pumps can lift water from the lower to the upper reservoir, using electric energy from the grid, when convenient or necessary for its stability.

    The pump storage hydropower plant acts as either a "generator" or as an "engine" in the two different operational modes. Some "reversible" hydraulic turbines can also carry out the pumping function; otherwise, two different, specific hydraulic systems need to be connected to the electrical turbines. As with storage hydropower plants, pumped plants also provide peak loads. Furthermore, they can absorb excess energy in the grid, acting as a "battery."

- ***Offshore hydropower***: a less-established but growing group of technologies that use tidal currents or the power of waves to generate electricity from seawater (usually referred to as tidal power (discussed in Chapter 10).

Facilities can be also classified as (a) single-purpose—which are used only for hydroelectricity generation, or (b) multipurpose—which are designed and used for other purposes such as water supply, irrigation, aquaculture, or flood control. Hydropower power plants can also be classified on the basis of installed capacity as follows[22]:

- Very Large: Exceeding 5,000 MW, feeding into a large grid
- Large: exceeding 100MW, and usually feeding into a large grid
- Medium: 15 – 100MW, usually feeding into a grid
- Small: 1 – 15 MW, usually feeding into a grid
- Mini: 100 kW – 1 MW, either isolated or feeding into a grid
- Micro: 5 kW – 100 kW, usually provides power for a small community or rural industry in remote areas away from the grid
- Pico: from a few hundred Watts up to 5 kW

However, classifications vary from country to country as there is currently no common consensus among countries and hydropower associations regarding the upper limit of small-scale hydropower plant capacity. For instance, some European Union countries like Portugal, Spain, Ireland, Greece, and Belgium accept 10 MW as the upper limit for small-scale hydropower installed capacity, while others place the maximum capacity from 3 to 1.5 MW. Outside the EU, this limit can be much higher, as in the USA (30 MW) and India (25 MW).[22]

5.4.2 Hydropower installation components

The typical components of a hydropower plant are reservoir (if present) with its dam and outlet works, intake works, head race, surge shaft or head pond, penstocks, power station and tail-race. In addition,

[22] See Classification of Hydroelectric Power plants (https://www.engineeringenotes.com/power-plants-2/hydroelectric-power-plant/classification-of-hydroelectric-power-plants/29422)

there will be associated infrastructure, including transmission lines and access roads (see Chapter 13).

Reservoir

The configuration of a reservoir is dependent upon the topography where the dam is situated and can vary from large and shallow impoundments covering thousands of square kilometers (e.g., Three Gorges, China, and Itaipu, Brazil) to narrow and deep reservoirs that can be up to several hundreds of meters in depth (e.g., Lianghekou hydropower station, China). A reservoir can mitigate floods in some circumstances, as the reservoir can store peak flows and control the release of water to the downstream river course, lowering the peak value and shifting it ahead in time.

In addition, due to its ability to concentrate water storage, a reservoir plant can produce hydropeaking (the discontinuous release of turbined water due to peaks of energy demand) causing artificial flow fluctuations in the river downstream. This can result in a series of environmental and social impacts due to flow modifications.[23]

Dams

Dams are the most recognizable features of hydropower facilities. They are constructed to create a reservoir (in storage plants) or to provide a fixed water level for the diversion of water (in run-of-river plants). They are structures designed to resist the "push pressure'' of contained water. Depending on the constituent materials and the static principles exploited, the main types of dams are:

- Gravity (concrete or masonry, resisting with its weight).
- Arch (concrete, resisting with arch effect, leading pushes to the sides of the valley).
- Embankment (earth fill or rockfill, with various schemes for water tightness).
- Buttress and multiple arches.
- Barrage (where the most part of the height is closed by mobile gates).

Often, more than one type is present in the same dam (composite dam).

The choice of the type depends on a range of factors including:

- The head—height difference between the upstream water level and downstream turbines.
- Shape and size of the valley.
- Geology and geotechnical characteristics of the valley.
- Availability, quality, and cost of construction materials.
- Availability and cost of labor and machinery.

Outlet works

Outlet works are necessary both for controlling floods and for emptying a reservoir. The first function is normally carried out by spillways; the second one by bottom outlets.

Dams must be designed to cope with floods. Spillways are built to provide a path for water to flow over or around the dam. On concrete dams, spillways are usually constructed to allow water to flow downstream in a safe way and respecting the maximum design levels in the reservoir. They can be an integral part of a dam or stand as autonomous works located at a different site on the reservoir. A spillway can either be equipped with gates (controlled spillway) or consist of a fixed, specially shaped edge (uncontrolled spillway).

Waterways

Water is conveyed to power stations through intakes and various hydraulic works (constituting the "head race") such as tunnels (pressurized or free surface), open channels, surge shafts (in pressure plants) or head ponds (in free surface plants), and/or penstocks, depending on the plant scheme. A

[23] Greimel *et al*. (2018)

typical intake is fitted with control gates and a steel mesh trash rack that prevents rubbish such as logs or floating trash being carried down into the turbines.

Surge towers (or surge shafts) are built between the headrace tunnel and the penstocks in a hydropower pressurized water scheme to prevent the rise back of pressure peaks into the tunnel (water hammer) after rapid flow variations.[24]

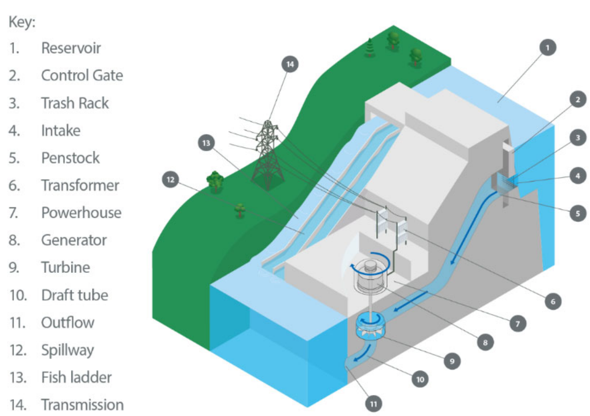
As well as in the “head race” works, tunnels and channels can also be present as “tail race” works, for conveying water from the powerhouse back to the river. The exit point location affects the length of river section “dried” because of the diversion. This can be counterbalanced by releasing an “ecological” flow just downstream of the dam.

Power stations

Power stations (or power houses) (see Figures 5.2 and 5.3) contain the turbines (and the pumps in case of a pumped plant), electric generators, transformers, all the mechanical and electrical auxiliary systems, and the automation and control devices. They may be located near the water storage or up to several kilometres away. Similarly, the point where the water is returned to the river can be close to or far from the power station. Their location, including even underground, is determined by the topography, the design targets, and many technical factors such as available room, geology, environmental issues, etc. The choice of turbine type will depend on the flow and head. Connected to the turbines are the electric generators.

Figure 5.2: Inside a hydro power house
Source: Wikimedia Commons

Figure 5.3: Major components in a hydroelectric plant
Source: The International Hydropower Association [Types of Hydropower]



[24] The Constructor (2020)

5.5 ENVIRONMENTAL AND SOCIOECONOMIC ISSUES ASSOCIATED WITH HYDROPOWER DEVELOPMENT

During scoping for an SEA, key environmental and social issues should be identified together with stakeholders. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) to be used in an "objectives-led approach" to SEA (see Chapter 2, Section 2.5.1). The subsequent assessment phase predicts how achieving the ESQOs will either be impeded or enhanced because of hydropower activities.

The key issues will be identified by reviewing relevant documents (e.g., EIAs of hydropower projects and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, etc.), online databases such as IBAT (Integrated Biodiversity Assessment Tool),[25] interviews with key informants, and through multiple stakeholder consultations at national to local levels. Many of the issues will be well known because of knowledge gained from implementing a large number of hydropower development projects over the past 25-30 years.[26]

At the individual project level, these issues will be the primary focus of an EIA which should recommend how to manage or mitigate impacts of hydropower project activities (including constructing a transmission line and access road) that might be likely to arise.

Implementing a PPP for the hydropower sub-sector will involve multiple projects, schemes, and activities, some directly concerned with the construction and operation of sites and facilities; others linked to associated infrastructure (e.g., transmission lines, access roads, borrow pits/quarries, etc.). Thus, there is a risk that the combined impacts of individual developments/projects in a cascade development scheme may become highly significant as they become cumulative. An SEA should focus on the potential for such cumulative impacts to occur and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project in combination with other projects (and which should be addressed firstly by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it and the need for implementation of comprehensive management measures among multiple interests to mitigate cumulative impacts. Such measures could include designating selected river segments for permanent protection from dams or similar infrastructure.

Table 5.3 summarizes the range of environmental and socioeconomic issues associated with hydropower development. During scoping, a key task is to determine which issues the SEA should focus on.

[25] See Integrated Biodiversity Assessment Tool (IBAT) (https://www.ibat-alliance.org/)

[26] See International Commission on Large Dams (ICOLD) (https://www.icold-cigb.org/) and International Hydropower Association (https://www.hydropower.org/).

Table 5.3: Environmental and socioeconomic issues associated with hydropower development

ISSUE	COMMENT
Environmental	
Loss of habitats and biodiversity (terrestrial)	• Inundation by dams and reservoirs and loss of important terrestrial habitats. • Deforestation (for hydropower sites, dams, roads, and transmission lines, and release of stored carbon. • Fragmentation of habitats and creation of barriers to wildlife movements. • Clearing for access roads and transmission lines and consequent disturbance to migration and increased road kills. • Increased poaching and hunting due to increased access to areas. • Disturbance to fauna from noise, vibration, and dust from blasting and other construction. • Drowning of species during reservoir impoundment. • Introduction of invasive species. • Changes in diversity or makeup of the plant and animal communities due to changes in ecosystems. • Impacts on ecosystem services, such as trees used for fuel. • Submersion of caves used by bats. • Impacts on terrestrial fauna from changes to aquatic ecosystem (e.g., loss or reduction of food sources). • Loss of riparian habitat due to inundation and erosion. • Collision of flying birds and bats with overhead power lines leading to electrocution. • Electrocution of birds and certain mammals that perch on power pole structures and touch electrified wires.
Loss of habitats and biodiversity (aquatic)	• Loss of riparian habitats (floodplain forests, seasonal wetlands, river islands, sandbars, rocky outcroppings, etc.) through permanent inundation or seasonal changes to river flow regime. • Change from lotic (moving water) to lentic (relatively still water) habitat in new reservoir. • Dam walls prevent migration of fish to vital breeding or feeding areas, upstream or downstream of the dam. • Organic matter decomposition in the base of the dams over time can deplete water oxygen and kill fish and aquatic organisms. • Fish killed or injured by powerhouse turbines and/or by tail races/spillways. • Increased fishing (overexploitation) due to (a) increased access (e.g., to previously inaccessible areas) via access roads and transmission lines, or as result of workforce in the area; and (b) creation of popular fishing areas where fish concentrate. • Blockage of fish movements. • Fragmentation of aquatic systems, including populations of fish and other aquatic life. • Change in sediment and nutrient flows due to river flow changes can affect biodiversity, and can decrease sediment loads downstream. • Change in riparian habitats due to hydropeaking[27] and aggressive river effects in the event of releases: loss of interface between land and the river due to riverbank erosion. • Fragmentation and loss of or changes to aquatic ecosystems and connectivity in river system: animal migration, fish movements, and plankton drift can be blocked both up and downstream by a dam. • Loss of downstream floodplain habitat: regulation of a river by a dam and reservoir reduces the magnitude and duration of flood flows, which reduces downstream flooding and sediment transport.

[27] Hydropeaking refers to frequent, rapid, and short-term fluctuations in water flow and water levels downstream and upstream of hydropower stations. Such fluctuations have far-reaching effects on riverine vegetation.

ISSUE	COMMENT
	• Introduction of invasive alien plant and animal species leading to changes in ecosystem structure and composition.
Land-use changes	• Inundation of land (for reservoirs) leading to direct loss of productive land or loss of habitat. • Reservoirs may also be used for irrigation, fishing, supply of water, and for recreational purposes. • Changes in river flow regime, nutrient flows and sediment transport leading to indirect loss of agricultural land and less productive agricultural land downstream (e.g., river no longer flooding crops when required). • A dam or hydropower infrastructure may alter access to an area, leading to indirect changes in land use such as loss of productive land.
Erosion and sedimentation	• Clearance and disturbance to vegetation and soil in areas surrounding dams and rivers, resulting in erosion (gullying and sheet erosion) and sediment runoff into the river, especially during intense rainfall (during construction and in a reservoir catchment). • Landslides: ground movements such as mudflows and debris flows that occur due to project construction. • Erosion and instability of riverbank or bed (and adjacent areas, e.g., following changes in river flow and geomorphology). • Erosion of rim or boundary of reservoir and increased sedimentation in reservoir. • Changes in the geomorphology of river channels and increased erosional forces downstream due to sediment retention. • Increased sediment runoff into rivers or streams at vehicle crossing points during construction. • Sediment retention and accumulation over time (e.g., in dam bottom—reducing dam capacity, or locally in riverbeds). • Issues downstream due to release of sediment-laden water.
Land and ecosystem restoration	• Hydropower developers can maximize the adaptive benefits (regarding climate change) of watershed restoration by avoiding areas where the risks of destroying important wetlands are high, or avoiding forest clearing (e.g., around reservoirs for access roads and transmission lines) where the risks of soil erosion are highest, reducing unnecessary sediment flows and slowing runoff in order to protect and optimize reservoir storage.
Air quality	• Air pollution from machinery and vehicles (construction equipment, lorries, workers' buses, etc.). • Dust from land clearing and construction, vehicles on dirt roads. • Dust from exposed areas of dam margin following drawdown operations. • Decreased air quality during drawdown operations and exposure of reservoir areas. • Smoke from any burning of vegetation cleared for a hydropower project.
Water quality	• Sewage, solid waste, and polluted runoff into dams and rivers during construction (runoff from dumping of excavated materials) can contaminate surface and groundwater. • Oil or chemical spills during construction or operation. • Pollution from the catchment can collect in reservoirs. • Pollution from any waste dumps submerged by the reservoir. • Release of heavy metals from sediments. • Organic decomposition: decomposing of organic material during the early years of operation leading to the consumption of oxygen. • Reservoir stratification: separation of reservoir water into oxygenated and deoxygenated zones (due to organic decomposition) and unseasonal temperature water released to downstream. • Change in water quality due to sedimentation during construction, and altered flows during operation with increased turbidity: increase in the cloudiness or haziness of water caused by individual particles. • Changes in flow regime may increase the concentration of pollutants and result in the release of nutrient-laden water. There may also be inflows of sediment, and pollution or hazardous substances from construction and from the wider catchment, and dumping of excavated materials.

ISSUE	COMMENT
	• Contamination of surface and groundwater—particularly during construction. • Impacts of degraded water quality downstream. • Eutrophication due to fertilizer runoff in the catchment (nitrogen, phosphorus, and other nutrients) and enrichment in dams.
Hydrology	• Flow of rivers can be changed significantly due to presence of a dam or weir. • Reduced water for downstream use (e.g., irrigation, consumption). But sometim.es dams/reservoirs are used to supply irrigation water. • Changes downstream: significantly reduce or alter patterns of flow between the intake and the powerhouse. • Altered flow regime and sediment flows downstream of the powerhouse. • Reservoirs offer opportunity to control floods and manage drought (climate adaptation and disaster-risk reduction).
Greenhouse gases	• Hydropower can reduce GHG emissions where it replaces coal as a fuel source. • GHG emissions (carbon dioxide, methane, nitrous oxide) from reservoirs (particularly from the burning of cleared vegetation before filling, or the decomposition of submerged vegetation after filling) and from vehicles and fuels used in machinery and camps during construction.
Noise and vibration	• Noise and vibration impacts during construction (from machinery, vehicles, blasting, drilling, machinery).
Spoil	• Significant amounts of spoil material may require disposal (where reuse is not an option) due to tunnelling and excavation activities.
Flooding	• Inundation of new areas to create impounded reservoir. • Flash floods downstream (due to breaches, overtopping, emergency releases, or severe hydropeaking). • Dam break resulting in loss of life (human and wildlife), danger to communities, damage to infrastructure, erosion. • Reservoirs can be used to regulate water flow and control flooding.
Socioeconomic	
Physical and economic displacement	• Physical displacement and relocation of people and their structures due to reservoir impoundment and associated project facilities • Loss of economic and livelihood activities, such as agriculture, animal grazing, fishing. • Loss of income from small business and enterprise activities.
Benefits of reservoirs	• Storage of water for use in irrigation, both large- and small-scale (increasing yields, opportunities to grow range of crops), contributing to economic growth and livelihood opportunities. • Opportunities for fishing. • Recreational opportunities. • Flood and drought management.
Cultural heritage	• Loss of (and loss of access to) religious, cultural, historical and archaeological sites, and properties submerged by dam and in downstream locations or destroyed or damaged due to transmission lines, access roads, or other associated project facilities (quarries, construction camps, equipment staging areas, disposal sites, etc.).
Employment and labor conditions	• Job opportunities with hydropower companies and their contractors. • Loss of jobs with existing enterprises and public administration when people are displaced/resettled. • Forced labor and child labor on hydropower projects.
Health and safety	• Pollution of downstream and upstream areas. • Insufficient and poor water quality for worker camps due to the water source being affected. • Influx of migrant workers may lead to an increase in communicable diseases (infectious diseases such as influenza, sexually transmitted infections (STIs), and HIV/AIDS), drug and alcohol use, gender-based violence, and conflict.

ISSUE	COMMENT
	• Impacts on fish and human health from methyl mercury releases from sediment into the water column and food chain. • Increased road traffic accident and fatalities, particularly during construction. • Accidental drowning in reservoirs. • Risks of dam failure and natural disasters, landslides. • Impacts on communities due to rock blasting. • Electrical safety incidents. • Fatalities at the construction site and substandard accommodation of workers. • Pressure on health services (e.g., high demand on essential drugs) during construction. • Potential for increase in vectors for human transmissible disease, e.g., malaria and schistosomiasis (particularly due to dams) in areas where these diseases are endemic.
Migration	• Influx of people looking for work during construction. • Tension between immigrants and workers. • Retrenchment of construction work forces.
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk. • Increased domestic and gender-based violence due to relocation and in-migration of workers to remote areas. • Gender equity and employment opportunities on new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies. • Opportunities for vulnerable groups to engage in the decision-making processes and in inclusive dialogue about hydropower development.
Public services and infrastructure	• Loss and relocation of public services and infrastructure due to inundation by dams. • Pressure on local pre-existing health services and infrastructure, equipment, human resources due to projects, immigration, accidents during construction, etc. • Increased pressure on the host communities’ public services when displaced people relocate. • Improvement (investment) to infrastructure (e.g., roads and bridges, schools, health centers, and administrative buildings). • Heavy vehicles and transportation damage existing roads and bridges.
Community cohesion and engagement	• Weakened community cohesion resulting from self-relocation and community relocation. • Risk of internal conflict due to increased stress as result of lost income. • Opportunities for communities to engage in the decision-making processes about hydropower development. • Increased tension between the communities, NGOs, activists, and hydropower companies.
Conflicts	• Conflicts over: o Lack of perceived project benefits accruing to local communities (e.g., access to power and water services). o Environmental degradation (e.g., from the reduced water quality). o Loss of land or access to resources/areas used for livelihoods or cultural activities. o Working conditions among those employed in construction or operation. o Tensions between immigrants and local workers/communities. o Transboundary conflict between states (e.g., over dams restricting water flow).

5.5.1 Environmental Issues

Hydrology

A hydropower project will normally change the hydrological flow regime of a river. Depending on design choices, this may be a significantly reduced or altered pattern of flow between the intake and the point where water is returned to the river. It may also mean an altered flow regime downstream of where water is returned to the river. Rivers that are already regulated by either hydropower or irrigation projects can be less sensitive to new hydrological impacts, so it may be environmentally preferable to develop projects on rivers or tributaries that are already impacted by flow regulation.[28] An SEA can identify where it is better to concentrate hydropower development along selected rivers (rather than on all rivers with hydropower potential) in order to reduce impacts at a larger spatial scale. However, multiple schemes on a river can also result in significant cumulative environmental and social impacts on habitats and species and downstream users.

Changes to a river's hydrological regime can negatively impact its aquatic ecosystem and can disrupt important environmental flows (E-flows) and associated ecological processes. The health and integrity of a river system will usually depend on a range of high, medium, and low flows. Most rivers experience natural annual low flows which reduce connectivity and limit species migration. This may be positive for native species which can often out-compete invasive species that have not adapted to low flows. Natural low flows also create seasonal habitats such as sandbars, rocky outcrops and temporary pools that are important to the breeding and survival of many species. So, maintaining low flows at their natural timing and level can maintain the abundance and survival rate of native species. For example, the Nam Theun 2 Dam in the Lao People's Democratic Republic provides for such downstream flow (Figure 5.4). Medium or base level flows will usually occur during most of the year. These flows maintain the hydro-geomorphology of a river which, in turn, maintains habitat, temperature, and dissolved oxygen levels to support aquatic species. Short high flow events are also important to prevent vegetation from encroaching on river channels and to move sediment and organic matter downstream. High flows can also reduce water temperature and increase dissolved oxygen, which can trigger ecological processes such as spawning and migration. Consequently, river flows altered by a hydropower project can lead to a reduction in health and integrity of the river system.[29]

Figure 5.4: Dam at Nam Theun 2, Lao People's Democratic Republic, with downstream flow provision

Photo credit: A. Javellana/ADB

[28] Opperman *et al*. (2015)
[29] World Bank (2018).

In some very large storage reservoirs, the filling of the reservoir may take more than one year, with a risk that downstream flows will not be adequately maintained, and this can lead to the degradation of downstream ecosystems and potential loss of habitats and biodiversity.

Dams can both contribute to and alleviate flooding and can reduce disaster risk. Large reservoirs can provide storage capacity to attenuate water flow during high rainfall events, reducing downstream floods. However, in the event of an inappropriate timing of a large release of water (or accidental release) or in the unlikely event of a dam break, this can cause downstream flooding, loss of human life and biodiversity, and damage to communities and infrastructure.

Reservoirs also provide opportunities to release water to downstream areas in the event of drought as a climate adaptation response.[30] However, this requires planning, depending upon the inflows of the previous season, the reservoir capacity, the seasonal energy production plan, the reservoir operational rules included in the concession/permission acts and/or possibly superimposed by the authorities for drought emergency purposes, the other co-present needs (e.g., electric system), etc.

Water quality

There can be a range of negative impacts on water quality throughout the construction and operation phases of a hydropower project.

During construction, the main impact on surface water quality is an increase in sediment load from construction site erosion/sedimentation or from spoil heaps. This erosion increases suspended solids and turbidity of river water, which may affect aquatic biodiversity and downstream water users. Poorly managed sewage and solid waste from the construction camp can pose a risk to drinking water. Accidental spills of oils and chemicals used during construction will contaminate soil and can also enter water courses. The spillage of wet concrete into a river can cause serious depletion of dissolved oxygen and negatively impact on aquatic species (even resulting in deaths).

Run-of-river projects tend to have minimal impact on water quality during the operational phase, although they may change the erosion and sediment dynamic of the river (see next sub-section).

Reservoir projects can have a significant impact on water quality in the operational phase. At the end of the construction phase, the reservoir area is often cleared of vegetation, although this specific measure is not always needed (see below). This can result in soil erosion and sedimentation of the river, reducing water quality. As a reservoir fills, pollutants in the submerged and surrounding soil (e.g., fuels, chemicals, and other substances from previous human activities in the area), can enter the reservoir and then the river system. Water quality in the reservoir can be further compromised from upstream contamination resulting from industrial and human activity.

When the reservoir is full, the decomposition of organic matter in submerged soil and of dead vegetation is likely to cause an increase in biological and chemical oxygen demand and—depending on water residence time—may deplete dissolved oxygen in the water. This sometimes results in anaerobic conditions which will reduce water quality, both in the reservoir and in the downstream river. It can also result in releases of methane (a greenhouse gas) into the atmosphere. The water in the reservoir is likely to be deeper and retained for a longer period than in the river, and this will cause changes in temperature at different depths, with potential for thermal stratification. The latter can also lead to deoxygenated water accumulating at the bottom of reservoir. If this is released to the downstream river via a low-level outlet, it will kill fish in that reach. In the reservoir, anaerobic conditions can liberate contaminants such as sulphides, selenium, ferrous and manganese ions, and organic mercury from the sediments. These can be directly toxic to fish and can bioaccumulate and subsequently be toxic to wildlife and to humans who consume such fish.

In some circumstances, during the first few years of operation after inundation, anaerobic conditions at lower levels (due to the breakdown of vegetation in the reservoir) can lead to the release of odorous hydrogen sulphide, thereby potentially generating grievances in the local community. Large amounts of hydrogen sulphide can be released if water is drawn from the lower levels in the reservoir and passed through the turbines. Water quality issues in reservoirs tend to be most problematic over

[30] Pannier (2021)

the first 5–10 years of operation—when most organic decomposition occurs—and a new equilibrium is reached.

In some situations, water quality can be maintained in the reservoir and downstream (both short- and long-term) by removing biomass from the reservoir area before it is flooded. This can improve water quality within reservoirs that have a relatively long water retention time, as well as downstream. Removing large trees can facilitate boat navigation and fishing with nets. However, pre-impoundment clearing of biomass in the reservoir inundation zone is not always necessary, nor even desirable. In reservoirs with a short water residence time (e.g., a week or less), decaying vegetation will not harm water quality due to the rapid flushing. Moreover, deforestation of slopes within and around the impoundment area will increase soil erosion and downstream sedimentation, particularly (i) during the inevitable time interval between forest clearing and reservoir filling, and (ii) in any areas that are deforested above the usual reservoir shoreline. Submerged trees create a useful habitat for many fish and other aquatic life below the water line, as well as for birds and other wildlife above the water line. In some areas, reservoir-area forest clearing may facilitate illegal logging elsewhere since it can be difficult to verify where the logs are coming from. Finally, pre-impoundment deforestation can be very expensive, since the felled trees often lack sufficient market value to cover the costs of their removal.

Accordingly, deciding how much (if any) vegetation to clear should be assessed on a case-by-case basis, considering factors such as water residence time, the volumes of biomass present (see Figure 5.5) , the need for boat navigation or other special use corridors, wood marketability and economic costs, and the fish and wildlife habitat that the submerged trees would create (Box 5.3).[31]

Figure 5.5: Reservoir at Nam Theun 2, Lao PDR, showing trees remaining after filling

Photo credit: Peter-John Meynell

[31] HSC (2020)

Box 5.3: Cost–benefits of removing vegetation from Nam Theun 2 Hydropower

A detailed study for the Nam Theun 2 project in the Lao People's Democratic Republic found that the cost–benefit balance of systematic vegetation clearance was an unfavorable option. The study identified several difficulties concerning the removal of vegetation:

- Only a small fraction of the rapidly degradable biomass is located in trees or bushes.
- Cutting the vegetation alone does not address the question of disposal of this biomass. Burning is the option most often considered, but it has significant impacts on air quality.
- Exportation of the biomass is not practically feasible.
- Clearance of large areas is technically challenging, particularly in steep terrain which is common for a hydropower project.
- The clearing operation itself has significant environmental and social impacts and poses a risk to worker safety.
- Residues from logging activity can impact operation of the powerhouse.

As such, in some situations, removal of trees over a certain size may be appropriate, especially if the large trees are commercially marketable.

Source: Salignat (2011)

Pollution from human activity in the catchment can accumulate in reservoirs. This can lead to eutrophication due to excess nutrients (especially nitrates) from fertilizer runoff or sewage, untreated industrial waste discharges, or the accumulation of solid waste from rubbish disposal on the inundated lands or upstream.

When water is released from a reservoir, the river downstream will be susceptible to any reduction in water quality generated in the reservoir. Variation in temperature and oxygen levels can negatively impact aquatic species, as can the flushing of sediment (see next sub-section).

Impacts on groundwater tend to be of a more minor nature than those affecting surface water. Groundwater may be affected by accidental spillages of construction materials and oils, or because of poorly designed solid waste disposal facilities. A reduction in groundwater quality can adversely affect communities that rely on groundwater for drinking or irrigation.

Erosion and sedimentation

The clearing of and disturbance to vegetation and soil in areas surrounding dams and rivers during the development of a hydropower project usually leads to an increase in soil erosion and sedimentation of the river, mainly through the construction phase. If the local geology is unstable, landslips, mudflows, and debris flows can all contribute to additional sedimentation loads of a river. During construction, earthmoving activities and road construction can increase erosion, particularly if there is inadequate attention to design and drainage. This often happens when temporary, lower cost, and lower quality access roads are built.

In the operational phase, there is less site erosion as vegetation cover becomes established. An operational reservoir project can significantly change the sediment dynamic of a river. Dams can trap sediment, reducing sediment in the downstream reach. However, large volumes of sediment can be released to a river over a short duration, for example, if the operator needs to remove the sediment from the reservoir (e.g., to maintain storage capacity). Erosion of a reservoir rim can also occur as the water level rises and falls due to peaking operations.

Changes to the erosion and sedimentation dynamic of a river are common issues for all hydropower projects. They affect water quality and can modify the riverbed composition and geomorphology and cause the degradation or loss of habitat for fish and other aquatic organisms.

If a dam captures sediment, the sediment load in the river downstream of the reservoir will be lower than it was before the dam was constructed. This means that, for an equal volume and turbulence of water, the downstream river will have greater capacity to move bed load and to pick up sediment as suspended load. In so doing, the river will erode the riverbed or banks. The water of the river may be referred to as sediment-hungry or aggressive, or the river may be said to have ***hungry-river syndrome***. The flow may erode the riverbed and banks, producing channel incision (downcutting), coarsen bed material (armoring), and remove spawning gravels used by fish. The mix of riverbed material will affect the pattern of downstream erosion: in sand-gravel mixtures (gravel bed rivers) downstream erosion will be controlled by the coarse surface armor layer, whereas in sand bed rivers the erosion will be more dynamic (IHA 2019).

Increased sediment load in the river (due to erosion or sediment flushing from a reservoir) can extend a long way downstream and can smother aquatic vegetation and habitats. This can be particularly problematic where gravel beds provide important habitat for downstream fisheries. More turbid water can also encourage fish to move to cleaner parts of the river. If sediment levels are very high, this can result in the smothering of aquatic invertebrates and can coat the gills of the fish causing death. Where significant erosion risks are likely, protection measures will be required (Figure 5.6).

Figure 5.6: Erosion protection at Nam Theun 2, Lao People's Democratic Republic

Photo credit: G. Joren/ADB

Loss of habitats and biodiversity (terrestrial)

Hydropower projects can have significant negative impacts on terrestrial ecosystems and their associated flora and fauna. The impacts are greater for reservoir projects due to the loss of inundated land. During the construction phase, vegetation must be cleared for dam sites, access roads, and transmission lines, which leads to the destruction or alteration of terrestrial habitats. Such clearance can fragment habitats by restricting the movement of fauna and potentially their access to important feeding and breeding grounds. In turn, the changes to ecosystems can lead to changes in the diversity or composition of plant and animal communities.

During construction, particularly through the displacement of soil, conditions are often created for the spread of alien species (some of which may be invasive), which can be brought in with construction equipment. Introduced invasive alien species are often able to colonize modified habitats and can out-compete and displace native species. Aquatic invasive species can also proliferate in the reservoir from upstream sources (e.g., water hyacinth).

Construction activities can cause disturbance to fauna from vibration, dust, light, and noise from blasting—particularly from quarrying activities. As access roads are developed in an area, there can be an increase in the number of animals killed by vehicles. Improved access can also facilitate increased poaching and hunting and overextraction of resources such as trees used for wood or fuel.

Inundation by a reservoir permanently changes the habitat. If biomass clearance is required, then trees and other vegetation will be cut down, and removed, if valuable. During impoundment, the rising water will slowly disperse fauna, but rescue may be required if animals become trapped and there is a risk that some animals will drown. Caves which provide habitat for bats can also be submerged with the habitat being permanently lost.

When a hydropower project is operational, the impacts on terrestrial fauna are much more limited. However, changes to the aquatic ecosystem may have a negative impact on terrestrial fauna when previous river food sources are lost. Similarly, riparian habitat can be lost or degraded by riverbank erosion upstream and downstream of a hydropower project. Downstream of a dam, changes to the flow regime can lead to the loss or change of floodplain habitat. Regulation of the river by the dam and reservoir reduces the magnitude and duration of flood flows which, in turn, reduces downstream inundation of floodplain habitats.[32] Wildlife movements can also be fragmented or restricted by the presence of a large reservoir (IHA 2021).

Loss of habitats and biodiversity (aquatic)

In the construction phase of a hydropower project, aquatic flora and fauna in the immediate proximity of the site (dam site and powerhouse) will be lost as habitat is removed. Increased sediment loads as a result of site erosion can have a negative impact on fish and aquatic invertebrates. Additionally, riparian habitats can be lost when a stretch of river is inundated by a new reservoir. Habitats which are important for fish breeding and spawning (e.g., deep pools, rapids, riffles, and in-channel wetland areas) can be submerged.

Changes to river flow regime can affect aquatic ecosystems and biodiversity by changing the daily or seasonal patterns of flow. This can be particularly severe if a peaking regime is used (i.e., a project only generates electricity for a few hours of the day). Some projects will divert water around a stretch of river many kilometers long. Such a bypassed stretch can be left dry or with insufficient flow to maintain the original aquatic habitats.

Dams fragment aquatic systems and prevent the migration of fish upstream and downstream. This loss of aquatic connectivity in a river system can also affect plankton drift and potentially remove important spawning grounds. To some extent, fish passage facilities—fish ladders, fish elevators, or trap-and-haul systems—can mitigate the impact, but they normally cannot maintain the natural upstream and downstream movements of fish and other aquatic life.

The creation of a reservoir can result in a range of water quality issues, as described above. Of particular concern at the start of the operational phase is the decomposition of organic matter which can deplete water oxygen, release methane, and kill fish and other aquatic organisms.

Opening up a previously undeveloped area with new access roads can lead to increased fishing. Fishing opportunities can be created by the creation of a reservoir, but dynamite fishing can be particularly damaging. Furthermore, exotic fish may be deliberately added to reservoirs by local people for fishing, and this can result in the decline or loss of native species. Over time, lentic species will also replace lotic species in newly created reservoirs where rivers would have originally flowed. New access roads can also enable an increase in fish poaching. This can be a particular problem where an access road is near to or passes through a protected or ecologically sensitive area.[33] [34]

Land and ecosystem restoration

As discussed above, there are significant risks associated with hydropower development with regard to potential environmental harm and degradation (e.g., unnecessary or excessive deforestation) and destruction of habitats and loss of biodiversity and ecosystem services as well as soil erosion and pollution. This will particularly arise where mitigation measures proposed by an SEA (and subsequent project-level EIAs) are inadequate, ineffective, or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple hydropower developments along a river or along the different rivers of a catchment and compounded further across the entire river drainage system.

[32] IFC (2015b)
[33] IFC (2018)
[34] EBRD (2017)

Such impacts will usually lead to demand for and need for land and ecosystem restoration (see Box 2.12). This need will also arise at sites of projects that have come to the end of their useful life (e.g., when a reservoir has silted up and no longer serves its purpose). When a dam is removed (Box 5.4), restoration can involve:

- Revegetation, which can help to restore natural ecosystem processes and minimize the presence of invasive and exotic species.
- Fisheries restoration.
- Sediment and hydrology restoration.

Box 5.4: Dam removal and ecosystem restoration:
The case of Elwha and Glines Canyon hydroelectric dams, USA

The removal of the Elwha and Glines Canyon hydroelectric dams in Olympic National Park, Washington State, USA, is not only the world's largest-ever dam removal but is also the second largest ecosystem restoration project in the American National Park System.

Construction of the 105-foot Elwha Dam was completed in 1914 and led to the formation of the 267-square-mile Lake Aldwell reservoir. The 210-foot single-arch Glines Canyon Dam was completed in 1925, several miles upstream from the first dam, and flooded the surrounding land, creating the 415-acre Lake Mills reservoir. The dams generated a combined 28 MW of electricity and provided a major boost to expanding local communities and industrial development, in and around the nearby city of Port Angeles in the early 20th century. But they have long since ceased to play a major role in meeting power supply demands.

Construction of the two dams effectively split the Elwha River into three separate entities: the 4.9 miles of the Lower River below the Elwha Dam, the Middle River between the two dams, and the Upper River above the Glines Canyon Dam 8.7 miles further upstream. This had profound negative impacts on the Elwha River watershed, including sediment and silt blockage behind the dams. Construction also led to erosion of the riverbanks, impacts on protected areas, as well as adverse effects on Indigenous people, such as the Lower Elwha Klallam Tribe, who previously relied on native fish populations for sustenance.

Lacking passage for migrating salmon, Glines Canyon Dam blocked access by anadromous salmonids to the upper 38 miles (61 km) of mainstem habitat and more than 30 miles (48 km) of tributary habitat. The Elwha River watershed once supported salmon runs of more than 400,000 adult returns on more than 70 miles (110 km) of river habitat. By the early 21st century, fewer than 4,000 adult salmon returned each year.

The Elwha Restoration Act of 1992 authorized the US Federal Government to acquire the dams for decommissioning and demolition. Following the creation of a diversion channel to allow the continued flow of the river during deconstruction, the dam was fully removed by March 2012 (cost of US$26.9m) and the river was returned to its natural route. The two dams were removed in stages to prevent major disturbances caused by disrupting the many millions of cubic meters of sediment piled up above the dams, as this could potentially cause extensive damage to ecosystems further downstream. The larger Glines Canyon Dam presented greater difficulties, requiring a number of additional measures to deal with the relocation of water and sediment in Lake Mills. The first phase saw the reservoir's levels dropped gradually using an outlet pipe to transport water downstream.

Dismantling involved removing sections of the dam walls from the top down, with the concrete blocks being trucked offsite and recycled. The final stage comprised controlled blasts to clear what was left of the dam wall.

A number of other projects are helping to restore the Elwha River ecosystem, including the installation of facilities to treat water and remove sediment downstream of the dams. The area that was under Lake Mills is being revegetated and its banks are being secured to prevent erosion and to speed up ecological restoration.

The return of Pacific salmon to their spawning streams will be important to the region. Adult salmon bring with them marine-derived nutrients. Decomposing salmon carcasses provide nutrients that link the marine and terrestrial ecosystems. Salmon are known to benefit more than 100 other species. The return of salmon and the entire ecosystem will help to revitalize tribal culture, age-old traditions and previously submerged sacred sites.

Source: Water Technology (2012)

Hydropower developers can maximize the adaptive benefits (regarding climate change) of watershed restoration by: (a) avoiding areas where the risks of destroying important wetlands are high, or (b) avoiding forest clearing (e.g., around reservoirs, for access roads and transmission lines) where the risks of soil erosion are highest, reducing unnecessary sediment flows and slowing runoff in order to protect and optimize reservoir storage.

Restoration projects such as described above are a new occurrence with very few examples in place. However, as many of the world's hydropower project continue to age, dam decommissioning and restoration of affected terrestrial and aquatic ecosystems will become increasingly more common. This will require setting aside sufficient funds to cover large restoration costs.

Waste and spoil

The wastes generated by a hydropower project typically range from benign to potentially very harmful (e.g., toxic chemicals and hydrocarbons). Waste also includes excess spoil or waste rock from excavation, vegetation from clearing, and sewage and wastewater. Many jurisdictions have strict controls over the handling, transport, and storage of certain types of waste. A construction site should generally have dedicated areas that provide effective storage and transport points for wastes.

Human wastes, both solid and liquid, are a management issue at the implementation stage with respect to the large numbers of construction staff and their living quarters. Large construction camps are often developed to service the construction phase of a project. Appropriate refuse, sewage and wastewater disposal need to be planned for and managed and conform to regulatory requirements. Interactions of local fauna with refuse disposal sites (scavenging) can be an issue requiring management.

Spoil is excavated or dredged material that cannot be used in construction because it is either not of the required quality or specification, or because it is surplus to requirements. Significant amounts of spoil can be generated during the construction phase of a hydropower project, particularly if there is a tunnelling operation (Box 5.5). The spoil needs to be reused or stored near to the project site to avoid

Box 5.5: Karot Hydropower Project, Pakistan

One of the most significant impacts identified from the 720 MW Karot Hydropower Project in Pakistan was the generation of significant volumes of spoil from excavations and tunnelling activities. The main impacts identified were land loss due to the large amount of space required to accommodate spoil that could not be reused, and the resulting landscape and visual impacts created by the spoil heaps.

Source: Karot Hydropower Project, Pakistan - Power Technology (power-technology.com)

significant transport costs. It is typically used to make large, terraced piles on land which is not productive for agriculture or not important for conservation. In some cases, spoil can benefit a local community by filling in a steep area of land to make it usable. Key concerns are the gradient of slopes and suitable drainage to maintain stability and avoid erosion.

Earthmoving and quarrying activities can have an impact on soil quality in the project area. Soils can be contaminated as a result of spills of oil and fuel from vehicle operation and maintenance and fuel storage areas. Contaminated soil needs to be removed to special waste disposal sites to prevent contamination of both groundwater and soils.

Agriculture

The inundation of land by a reservoir can lead to direct loss of productive agricultural land. In addition, downstream agricultural land can be impacted by a reduction in nutrients carried in sediment by flood water. This occurs if the hydropower project changes the river flow regime to the extent that it no longer provides flood water to crops when required, such as for flood-recession agricultural systems. This type of agriculture can diminish, or even disappear, if water releases from an upstream dam do not sufficiently replicate seasonal flood flows. Flood water sediment may also be important for agriculture because it carries phosphorus (dissolved and total), nitrates, and ammonium downstream. Without these nutrients, crop yields will be lower. This problem can be countered by applying fertilizers, but this can lead to further environmental problems such as inappropriate use (with associated health hazards) and pollution from fertilizer runoff.[35] However, hydropower dams are sometimes used as reservoirs providing water for the downstream irrigation of crops and over a wider area benefitting more farmers.

Air quality

Hydropower projects do not normally have a significant impact on air quality. There is typical construction-related air pollution from materials extraction, machinery and vehicles (trucks, workers' buses, etc.) and dust from land clearing and from vehicles moving on dirt roads—mainly in the construction phase.

Greenhouse gases

Some reservoirs can be a source of methane and carbon dioxide (greenhouse gases [GHG]). Methane is released if the water in the bottom of a reservoir becomes anaerobic or there are low oxygen conditions, and bacteria decompose organic matter (dead vegetation left from clearing the reservoir site). One metric ton of methane in the atmosphere has a short-term effect on climate that is about 25 times greater than one metric ton of carbon dioxide. Many reservoirs will not be significant emitters of methane, but this risk needs to be carefully checked before a project is developed.

The potential for GHG emissions can be assessed through the IHA G-Res Tool. It uses a conceptual framework that integrates up-to-date science in an online interface to estimate the GHG emissions from reservoirs. Such tools help hydropower companies and researchers estimate and report the net GHG emissions of a reservoir without the need to conduct expensive field sampling campaigns. They are especially valuable in the prefeasibility stage as a screening tool to avoid high-emitting projects.[36]

Hydropower projects do emit GHGs. However, the many myths around GHG emissions and hydropower projects have been addressed by IHA. These myths include the erroneous claims that (i) tropical reservoirs emit more GHGs than temperate reservoirs and (ii) that clearing of vegetation lowers GHG emissions. Instead, GHG emissions in operating reservoirs can be reduced by implementation of operating practices such as changing operating levels, aeration, adding additional inlets above the thermocline, and using methane to generate electricity. The IHA Hydropower Sustainability Standard, as well as the Guidelines on Good International Industry Practice, state that a project with low emissions should have an emissions intensity less than 100 gCO2e/kWh. This emissions level can and should guide future new hydropower development.[37]

Climate vulnerability, and dam and community safety

[35] IFC (2018)
[36] See "Carbon emissions from hydropower reservoirs: facts and myths" (https://www.hydropower.org/blog/carbon-emissions-from-hydropower-reservoirs-facts-and-myths)
[37] Ibid.

Hydropower is considered highly vulnerable to climate change[38] as it is directly related to precipitation patterns, behavior of snow-caps and glaciers, and resulting changes in the quantity and timing of river flows. This affects both the capacity to produce electricity and the safety of dams, for example, when flood gates or spillways can no longer safely evacuate increasing river discharges.

The most obvious risk associated with a hydropower reservoir is dam wall failure, which can have catastrophic consequences for communities, livestock, and wildlife downstream (Box 5.6). Dam failure can be due to:

- Substandard construction materials and techniques.
- Spillway design error.
- Geological instability caused by changes to water levels during filling.
- Poor maintenance, especially of outlet pipes.
- Extreme inflow.
- Human, computer or design error.
- Earthquakes.

Box 5.6: Dam failure: Saddle Dam D, Lao People's Democratic Republic

On 23 July 2018, Saddle Dam D on the Xe Pian-XeNamnoy hydropower project in Champassak and Attapeu provinces collapsed following heavy rain. The Government of the Lao People's Democratic Republic (Lao PDR) immediately suspended new hydropower projects and initiated safety inspections of all existing dams. The dam failure caused devastating floods in both Lao PDR (Figure 5.7) and Cambodia's Stung Treng province, which lies downstream of the dam. 49 people died and 22 were missing and presumed dead. The collapse displaced thousands of people, flooding homes and villages. Over 7,000 people in 19 villages in Attapeu province experienced losses and long-term damage to houses, property, and farmlands. The floodwaters extended far downstream and across the border into Cambodia, affecting an estimated 15,000 people, damaging farms and destroying livestock and property.

Source: International Rivers (2020)

Figure 5.7: Downstream flooding following the collapse of Saddle Dam D in Lao PDR.

Photo credit: Courtesy of the Lao Government

[38] For more information, see "Sixth Assessment Report, IPCC (https://www.ipcc.ch/assessment-report/ar6/)

Dam break risk may be exacerbated by climate change. Depending on location, climate change may lead to changes to (i) annual and seasonal rainfall averages, (ii) the type and seasonal distribution of precipitation, (iii) the ranges of temperatures and precipitation, and (iv) the frequency and severity of extreme weather events. Changes in these conditions will have effects on hydrological and other conditions including, for example, runoff and seasonal patterns of runoff, glacial melt or timing of glacial melt, intensity of floods and droughts, frequency or magnitude of landslides, and sediment transport. Fortunately, dam break is relatively rare due to well-established design and maintenance standards. An emerging issue for hydroelectric projects and climate change in the Himalayas is the potential for dam breach associated with an upstream glacial lake outburst flood (GLOF) (Box 5.6).[39]

Box 5.7: Effects of glacier loss in the Himalayas

A study by NASA and Columbia University, based on an analysis of declassified spy satellite photos from the 1970s, showed that glaciers across the Himalayas have experienced significant ice loss over the past 40 years, with the average rate of ice loss twice as rapid in the 21st century compared to the end of the 20th century. The research team calculated that glaciers have been losing 20 vertical inches (c. 50 cm) of ice per year since 2000. Figure 5.8. shows the extent of glacial retreat on Kokthang Glacier in Sikkim, India.

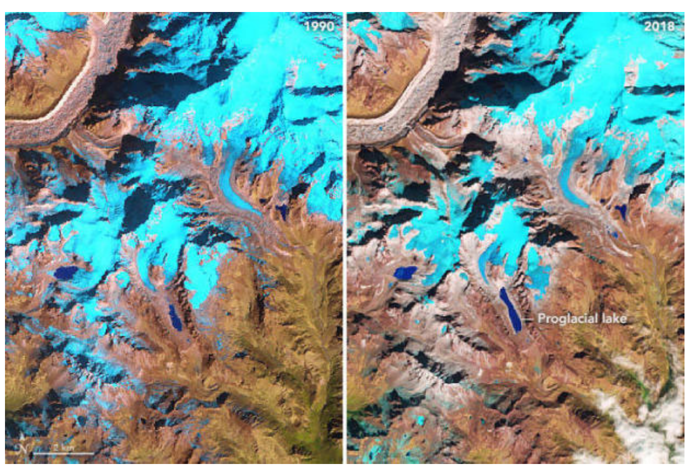
The rapid melting is leading to serious impacts, including increased water flowing down from the mountains which is increasing the potential for flooding. Meltwater lakes are swelling rapidly behind natural dams and are threatening downstream communities with potentially destructive glacial lake outburst floods (GLOF).

But with glacial melt, the volume of dry season release is diminishing with the likelihood of long-term fresh water shortages, It is estimated that around 800 million people depend on seasonal runoff from Himalayan glaciers for irrigation, hydropower, and drinking water. Some villages are reported to have already been forced to move because glacier retreat has reduced their supply of irrigation water to levels that are unviable, and many more are threatened.

Glacial retreat is predicated to lead to changes in regional weather patterns due to the immense size and influence of the Himalayan range.

Sources: Maurer et al. (2019) and "Spy satellites reveal Himalayan glaciers losing ground to climate change (https://www.cbsnews.com/news/spy-satellites-reveal-himalayan-glaciers-melting-climate-change/)

Figure 5.8: Ice loss on the Kokthang glacier, Sikkim, India: 1990 (left) to 2018 (right)
Source: NASA



[39] Qiu (2016)

A range of risks is associated with hydropower infrastructure such as electric shock, drowning, road accidents, and accidents arising from community interactions with project activities.

In the construction phase, there can be risk linked to structures used to support site investigations, e.g., access roads, buildings, test wells, helipads, etc. During project design, adherence with safety standards is an important consideration.

A significant safety risk during the construction period is the risk of flooding. Diversions are constructed to divert water from the river around the construction site. This diversion will have a capacity that can be exceeded during river flood events in which case water can inundate the construction site and the dam which is under construction can be put at risk of failure.

Both construction and operation of hydropower plants can involve structural failure and flooding. An example is the Dhauliganga hydroelectric station in India. In June 2013, there was an unprecedented flash flood, causing massive debris accumulation and the complete submergence of the powerhouse. Damage caused electrical equipment replacement and loss of total generation capacity for more than six months.[40]

Other implementation safety issues include those related to construction such as increase in traffic, heavy machinery on roads, and blasting activities.

Noise and vibration

Various activities during hydropower project construction generate noise and vibrations (truck movements, excavations, removal of vegetation, transport of workers to and from site, etc.). The use of explosives for blasting rock while preparing a dam site and in quarries will create excessive temporary noise and vibration and disturbance for nearby communities as well as wildlife. Quarries may be located at some distance from the dam site, so can increase the number of communities affected by noise. During operation, noise will be limited to generation from the power station and vehicle movements.[41]

Transboundary issues associated with hydropower projects

Hydropower projects can have impacts beyond national boundaries if they change the flow regime of a river that runs from one country to another. It is important that potential impacts are considered on a broad spatial and temporal scale. These can include changes to a river's hydrological regime, its sediment dynamic and water quality, all of which can affect aquatic ecosystems as well as associated fisheries and livelihoods. Key receptors to be considered in assessing the likely downstream impacts of hydropower projects are irrigation schemes, water supply projects, wetlands, fisheries, and biodiversity (aquatic and terrestrial). This issue is particularly relevant when a river runs through several countries, e.g., the Mekong River in Southeast Asia (Box 5.8).

Box 5.8: Multiple hydropower dams on the Mekong River

The Mekong River arises in the People's Republic of China (PRC) and flows through Myanmar, the Lao People's Democratic Republic (Lao PDR), Thailand, Cambodia, and Viet Nam. In the Upper Mekong River Basin, the PRC has constructed 11 hydropower dams (of which two are large storage dams). Another 11 dams, each with production capacity exceeding 100 MW, are being planned or constructed. There are a further 89 projects in the lower basin, of which two are in Cambodia, 65 in Lao PDR, 7 in Thailand and 14 in Viet Nam. Many more dams are planned over the next 10 years, as shown in Figure 5.9.

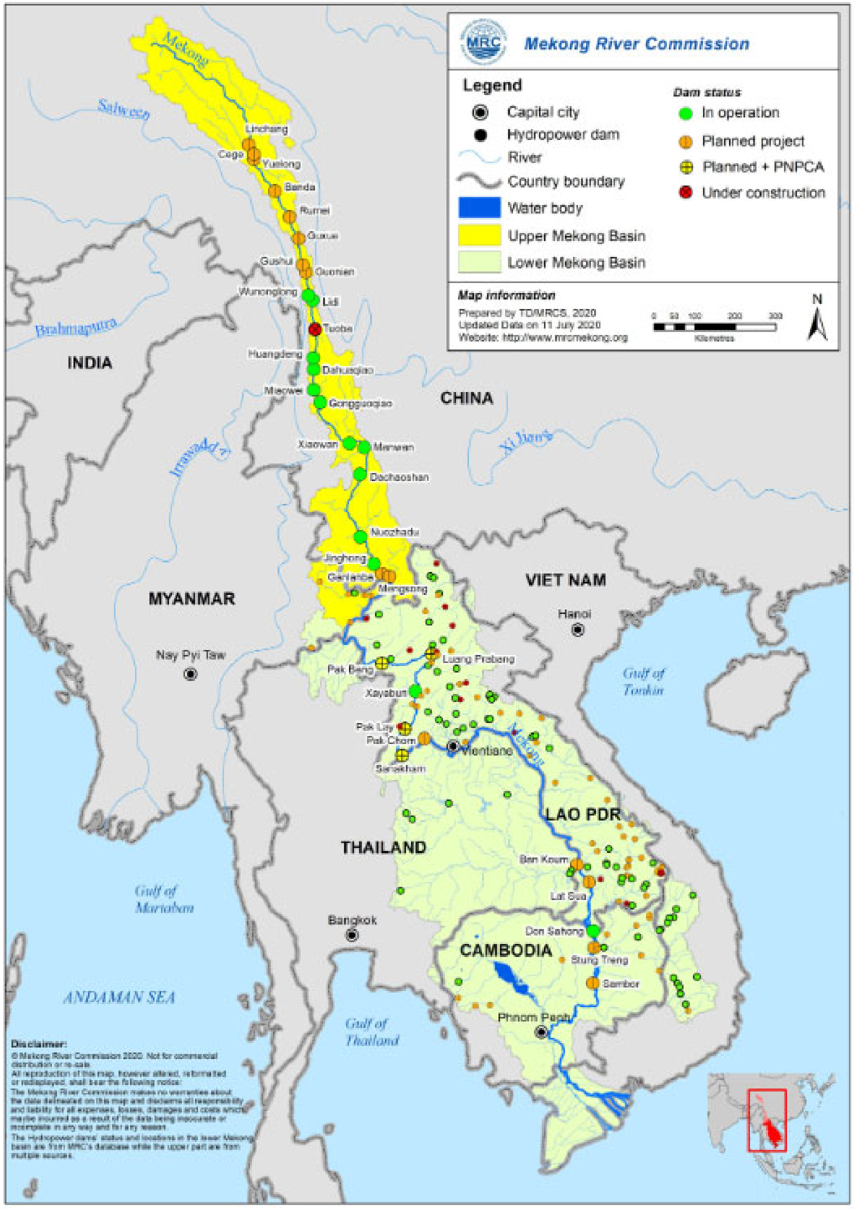
The Mekong River Commission has been established to manage the transboundary issues associated with these projects. It is an intergovernmental organization that works directly with the governments of Cambodia, Lao PDR, Thailand, and Viet Nam to jointly manage their shared water resources and the sustainable development of the Mekong River. Its aim is to promote and

[40] For more information, see https://en.wikipedia.org/wiki/Dhauliganga_Dam
[41] IFC (2018)

coordinate sustainable management and development of water and related resources for the countries' mutual benefit and the people's well-being.

Source: Mekong River Commission for Sustainable Development (Undated)

Figure 5.9: Hydropower developments along the Mekong River
Source: Mekong River Commission for Sustainable Development (2020)



Dams with potential transboundary impacts, such as Xayaburi run-of-river hydroelectric dam on the Lower Mekong River (around 30 km east of Sainyabuli [Xayaburi] town in northern Lao PDR), provide lessons about how dams can cause not only ecological and environmental impacts across an international national border, but also adverse effects on the socioeconomics of the downstream riparian states and communities.[42 43]

[42] IFC (2015b)
[43] Young and Ear (2021)

Location issues and cumulative impacts

Downstream dams in the main river channel are more damaging than dams in upstream river branches. Several dams located in different branches of the same river are far more damaging than a cascade of dams in one branch, if other branches remain untouched and free-flowing.[44] Studies undertaken by, for example, The Nature Conservancy (TNC) in Mexico show that good site selection at basin scale can significantly avoid riverine and terrestrial impacts due to fragmentation, while delivering similar levels of power generation (Box 5.9 and Figure 5.10).

Box 5.9: Hydropower by Design: Helping the hydropower development in Mexico

"Hydropower by Design" is an integral approach to the planning and management of hydropower development at a macro-basin scale and helps prevent negative environmental and social impacts. The Nature Conservancy has used this system-scale approach to help the government of Mexico to reduce investment risks in hydroelectric infrastructure projects in a major tributary of the Gulf of Mexico: the Coatzacoalcos River.

The systemic planning effort at the macro level permits the evaluation of impacts these projects can have on industry and agriculture, on the lives of towns and cities in Veracruz—one of the richest states in Mexico both culturally and naturally—and on the biodiversity that inhabits the river and gives it life,

Source: The Nature Conservancy (Undated)

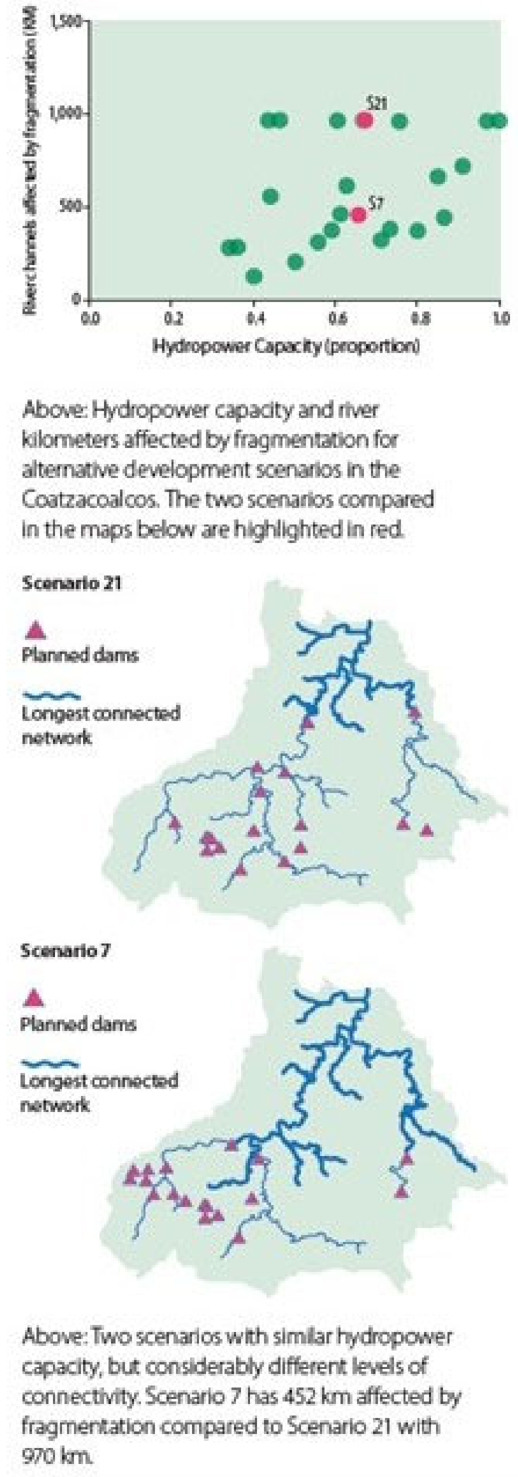
River basin-wide analysis should be applied to find optimal locations, preferably through SEA or cumulative impact assessment.

Mini-hydropower projects are often "invisible" for EIA/ESIA (i.e., they are below the threshold requiring such an assessment). However, potentially they can be very damaging, particularly when constructed in cascade. An EIA/ESIA for the entire cascade would be warranted, but this usually is effectively avoided by investors by taking a one-by-one approach. A river basin management plan and dialogue or a well-designed permit may avoid this, informed by a basin-wide assessment of all existing and planned interventions and water uses/users, through SEA or cumulative impact assessment.

This can involve several innovative planning measures such as implementing a basin wide strategic roadmap for hydropower planning; addressing baseline data gaps in biodiversity, social, and cultural conditions; maintaining downstream E-flows; concentrating cascade hydropower projects in one area of the watershed; conducting basin-wide monitoring during project operations; and providing for the permanent legal protection of free-flowing river segments in the watershed, free from hydropower or other dams (aquatic offsets).[45] [46]

[44] Slootweg (2023)
[45] World Bank Group (2016)
[46] World Bank (2016c)

Figure 5.10: Results from the Nature Conservancy study of Coatzacoalcos Basin in Mexico
Source: IHA (2021)



5.5.2 Socioeconomic issues

Physical and economic displacement

Some hydropower projects cause economic and physical displacement of riparian and other communities and settlements.[47] Economic displacement is defined as the loss of assets, access to assets or income sources, or to means of livelihoods, which could be caused by land acquisition, changes in land use or access to land, restrictions on land use or access to natural resources, or changes in the environment leading to impacts on livelihoods.[48] Hydropower projects can also cause physical displacement from the loss of residential land and shelter. Physical displacement involves risks for both the displaced people and for the host communities receiving them when they relocate.[49]

The amount of displacement will often depend on the type of hydropower project. Run-of-river schemes may cause only limited displacement. But hydropower projects that include a reservoir tend to occupy a large area of land. The land acquisition for a reservoir can affect farmland and grazing lands that are located near the river. Farmers' and villagers' incomes from farming and livestock raising will be lost or reduced when the land is flooded. Large reservoirs can also inundate residential areas and displace an entire community to a new resettlement area (Box 5.10).

Box 5.10: Displacement of people due to development of the Three Gorges project in China

Construction of the Three Gorges Dam on the Yangtze River (Chang Jiang) in Hubei Province, China, was completed in 2006. At the time, it was the largest dam structure in the world (Figure 11). The dam and accompanying hydroelectric plant were built in phases and over the course of many years. It reached its full generating capacity in 2012. The dam allows the navigation of oceangoing freighters and generates hydroelectric power. It was also intended to provide protection from floods, but efficacy on this aim remains unclear.

While the construction of the Three Gorges Dam was an engineering feat, it has also been fraught with controversy: construction of the dam caused the displacement of about 1.4 million people. Hundreds (possibly thousands) of towns and villages were evacuated and later submerged. The area surrounding the Yangtze contains some of the densest clusters of human life in the world. Those forced to relocate were promised compensation for the value of their homes and land. But the majority of relocated citizens were either given far too little in compensation or their dues were allegedly slimmed through corruption and embezzlement; many claim they received only half the land compensation they were promised.[50] This created problems for many as the cities and towns they had to move to were more expensive, driving many people deeper into poverty,[51] landlessness, joblessness, marginalization, and food insecurity.[52] The displaced were often farmers with little formal education, if any. Many opted to return to the Yangtze region.

Flooding the reservoir has forced those farmers still in the region to migrate northward up the mountain slopes, adding to erosion through overutilization of topsoil.

The dam also resulted in the destruction of natural features and countless rare architectural, cultural, and archaeological sites. The dam's reservoir is blamed for an increase in the number of landslides and earthquakes in the region.

Sources: Encyclopaedia Britannica (Undated)
Environmental and Social Issues of the Three Gorges Dam in China (mandalaprojects.com)
Gleick (2009)
Hvinstendahl (2008)

[47] Cernea (2004).
[48] IHA (2020)
[49] WCD (2000)
[50] Hvinstendahl (2008)
[51] See "Chinese Dam Projects Criticized for Their Human Costs" (https://www.nytimes.com/2007/11/19/world/asia/19dam.html#:~:text=The%20Three%20Gorges%20Dam%20is%20projected%20as%20an%20anchor%20in)
[52] Gleick (2009)

Figure 5.11: Three Gorges Dam, China
Source: Wikimedia Commons (2023)

Business activities, whether small, medium, or large enterprises, can also be displaced, affecting their owners and workers. Furthermore, community public facilities such as schools, clinics, public meeting halls, and cultural and religious sites may also be lost or need to be relocated. Often, associated infrastructure such as access roads and transmissions line can also cause physical and economic displacement.[53]

Displacement can impoverish the resettled people, who are often from poor communities. Without adequate mitigation measures and compensation, the livelihoods of displaced peoples can be made significantly worse.[54]

The construction of dams and weirs for both run-of-river and reservoir hydropower schemes can disrupt fishing activities which are often important income-generation activities of the riparian communities. For example, large-scale and transboundary dams along the Mekong River in Southeast Asia have led to less fish migration and lower fishing yields both downstream and upstream of the dams.[55] Hydropower projects can also displace sand mining businesses and the collecting of sand or other aggregate materials from rivers by local people.

The relocation of affected people can create pressure on the public facilities and infrastructure in the host communities, giving rise to tensions between the two groups. The losses endured by the host community can lead to weakened community cohesion and an increase in domestic and gender-based violence.

Benefits of reservoirs

Although dams/reservoirs can have significant negative environmental impacts, they can also provide significant socioeconomic benefits. Sometimes they are used to supply water to downstream areas for the irrigation of crops, increasing agricultural yields and job opportunities and contributing to local and regional economies. Reservoirs generate the opportunity to establish new fishing opportunities and support local livelihoods. Reservoirs can also benefit local and more distant communities by providing a guaranteed source of fresh water to the public and industry. They are frequently used for recreational purposes (e.g., sport fishing, sailing, picnicking). Some large dams are even used for navigation and the use of locks can facilitate transport across the dam.

[53] WCD (2000)
[54] Cernea (2004)
[55] Young and Ear (2021)

However, achieving such benefits is often the result of intense negotiations with authorities and affected communities, sometimes with authorities putting multipurpose use as a requirement to in the design of a hydropower project.

A challenge is to minimize contradictions/competition among multipurpose water uses of hydropower reservoirs, and to set an appropriate governance to allow coordinated/integrated water uses management. Based on twelve worldwide case studies of multipurpose hydropower reservoirs, the SHARE concept was developed as a framework to address such potential conflicts.[56] SHARE refers to a **S**ustainability approach for all users, **H**igher efficiency and equity among sectors, **A**daptability for all solutions, **R**iver basin perspectives for all, and **E**ngaging all stakeholders. As a concept for multipurpose water uses of hydropower reservoirs, it aims to help make use of hydropower reservoirs more sustainable and equitable among all users and uses.[57]

Indigenous communities

The development of a hydropower project may cause both positive and negative impacts on Indigenous communities and people. The International Finance Corporation's (IFC) Performance Standard 7 and the Asian Development Bank's (ADB) Safeguard Policy Statement (SPS) on Indigenous Peoples (2009) recognize that Indigenous peoples can be marginalized due to their sometimes tenuous economic, social, and legal status and their limited capacity to defend their rights and interests. Indigenous peoples typically have strong spiritual, cultural, and economic relationships with their land and waterways. According to the International Hydropower Association's new guide on hydropower and Indigenous peoples,[58] a major negative impact can often be loss of land under Indigenous use. This could be land for which Indigenous peoples' jurisdiction and management may have been previously removed by national governments. Impacts on Indigenous people other than loss of communal lands include the following:

- Reduced or variable flows that could affect the safety, irrigation, water uses, and livelihoods of communities living downstream.
- Loss of ancestral land and cultural resources (cemeteries, tombs, sacred groves, temples, etc.), or reduction of their territory.
- Loss of access to or reduction of resources (e.g., water, fish and animal species, fertile land, and forested areas) and associated nutritional issues.

Box 5.11 provides examples of cases in which indigenous peoples have been displaced and affected by hydropower projects.

Box 5.11: Indigenous peoples affected by hydropower projects: Some examples

Many Indigenous groups have protested against hydropower projects and denounced government approvals for projects. For example, an Indigenous community on the border of Thailand and Myanmar organized a large protest against the Salween River hydropower project in 2017.[a] This unrest occurred, in part, because of inadequate engagement of and consultation with affected communities, and a lack of appreciation of their ties to the land.

In Cambodia, the construction of hydropower projects, such as Lower Sesan 2 Dam, have caused adverse impacts on Indigenous communities (nearly 5,000 people, mostly IPs and other ethnic minorities—Bunong, Brao, Kuoy, Lao, Jarai, Kreung, Kavet, Tampuan, and Kachok—who have lived in villages along the Sesan and Srepok Rivers for generations.[b] The latter were displaced which resulted in disagreements with project proponents.[c]

In Lao PDR, where ethnicity is diverse, a number of Indigenous people have been affected or displaced by hydropower projects, including the multilateral development bank-financed Nam Theun 2 project.[d]

[56] Branch (2017)
[57] Ibid.
[58] IHA (2022)

In Indonesia, displacement of Indigenous people due to hydropower development projects is often reported by media outlets. For example, a 480MW-hydropower project in South Sulawesi affected Pohoneang, Hoyyane and Amballong Indigenous communities. [e]

Sources:
[a] Shah and Bloomer (2018)
[b] Human Rights Watch (2021)
[c] Young (2020)
[d] Nam Theun 2.com. NTPC Document Proforma (namtheun2.com)
[e] Rusdianto (2017)

There are also examples from Southeast Asia of renewable energy initiatives that are being driven by Indigenous communities. Micro-hydro power developments in the Philippines and Malaysia are increasing access to clean energy, reducing harmful pollutants (e.g., from diesel generators, burning wood or charcoal indoors for cooking), and alleviating the work burden on women as well as providing other community benefits. Groups like "Grupo Yansa" (a not-for profit organization based in Mexico) provide support to Indigenous communities interested in developing the renewable energy potential of their land.[59] [60] In Canada, some Indigenous peoples' groups are partnering with the private sector to develop and operate large energy projects.[61] [62]

There are many opportunities for hydropower development to bring benefits to the Indigenous communities. According to the IHA, these benefits include but are not limited to[63]:

- Increased safety by having flood control and regulated flows.
- Support (e.g., financial) to promote and enhance cultural traditions.
- Employment and business opportunities through the project life, including direct employment opportunities, subcontracting services during construction and maintenance, service provision such as food and transportation services, and indirect employment within local communities.
- Investment revenues from project partnerships with indigenous peoples' communities.
- Training (pre-project and during construction and operation) and improved community governance capacity.

Jobs during the construction phase are varied depending on the type and size of hydropower project. The Muskrat Falls hydropower project in Canada advertised that the construction workforce would span more than 70 different types of occupations.[64] While some of the expertise may not be available in Indigenous peoples' communities, the range of needs, especially in larger projects, is considerable, meaning the emphasis should be on matching available local skills to needs among the contracting tiers and service providers.

In some countries, companies choose (for business reasons) or are regulated to offer impact benefit-sharing agreements. One report from British Columbia in Canada identifies several reasons for entering into benefit-sharing agreements with Indigenous peoples including: to further social license to operate, as matter of good neighbor policy, and to provide a competitive advantage to meet consumer demand for ethically produced products.[65] The report indicates that such agreements are not a cure for all conflicts and uncertainties and will not resolve complex legal, political, cultural, and historical issues; nor should one company or project be expected to bear all of the burdens of history nor share current development responsibilities. But each negotiated benefit-sharing agreement is an important step forward that will help reconciliation efforts and shared hydropower project benefits with Indigenous peoples.

[59] Shah and Bloomer (2018)
[60] UNDESA (2021)
[61] CHA (2018)
[62] *Aboriginal Power: Clean Energy and the Future of Canada's First Peoples*. Available at https://www.amazon.ca/Aboriginal-power-energy-Canadas-peoples/dp/1927506190
[63] IHA (2021c)
[64] Muskrat Falls jobs. Nalcor Energy. Accessed October 2013.
[65] Woodward & Company (undated)

Health and safety

Community health and safety issues are associated with hydropower development during both the construction and operational phases.[66] The IHA's guide [67] on hydropower infrastructure (2021) identifies the following issues: road safety, safety around water bodies associated with the hydropower complex, blasting and other construction activities, electrical safety, natural hazards, underground geotechnical hazards, and pressurized conveyance hazards.

Hydropower projects usually involve the use of heavy goods vehicle fleets to transport materials and staff on-site. In many cases, projects increase road traffic, affect road and bridge conditions, and cause accidents. Often there is a need for new access roads or upgrades to existing roads and bridges to transport heavy equipment, but key risks can be neglected in policies, procedures, and monitoring programs: unsafe road design and conditions, unsafe vehicles, speeding, non-use of seatbelts and helmets, lack of driver training, driving under the influence of alcohol or drugs, inadequate post-accident care, and lack of enforcement of traffic rules. Without mitigation measures for these risks, hydropower projects can cause traffic related congestion, accidents, and fatalities.

A major issue is the excavation of large quantities of soil and rock for drilling and creation of tunnels. Construction work creates significant health and safety risks for both workers and local communities from dust, noise, and vibrations; eutrophication; waste disposal; and the potential spread of communicable diseases.

ESIA guidance for hydropower published by the Netherlands Commission for Environmental Assessment (NCEA) identifies numerous vector-borne and tropical diseases associated with the development of reservoirs.[68] These risks are exacerbated in low-income countries in Southeast Asia where water quality regulatory enforcement remains limited.

The IFC hydropower guidance notes that some infectious diseases can spread around hydroelectric reservoirs, particularly in warm climates and densely populated areas. Some diseases (such as malaria and schistosomiasis) are borne by water-dependent vectors (mosquitos and aquatic snails, respectively); others (such as dysentery, cholera, and hepatitis A) are spread by contaminated water, which is frequently present in stagnant reservoirs. Hydropower development projects can also increase other communicable diseases (infectious diseases such as influenza, STIs, COVID-19 and HIV/AIDS), increase drug and alcohol use, and have the potential to increase crime and domestic and gender-based violence due to the immigration and large-scale influx of workers.

As the COVID-19 pandemic has shown, the large workforces often required by hydropower projects need to be managed to avoid being a spreading point for diseases, but there can be challenges, as illustrated by the experience of Karot Hydropower Project in Pakistan (Box 5.12).

Box 5.12: Karot Hydropower Project in Pakistan

Karot Hydropower Project is located on the Jhelum River in Pakistan and is nearing completion (Figure 5.12). The power company faced challenges over managing the spread of COVID-19 early on when no vaccine was available. Trade unions filed a complaint to the IFC (project funder) that the project company undermined the rights of 3,000 workers by restricting their movement, curtailing their freedom of association and collective bargaining (particularly of workers dismissed during the COVID-19 pandemic) and violated the IFC's own performance standards on workplace safety and working conditions, terms of employment, grievance mechanisms, and retrenchment.

Source: Business and Human Rights Resource Center (2021)

[66] Acakpovi and Dzamikumah (2016)
[67] IHA (2021)
[68] NCEA (2018)

Figure 5.12: Karot Hydropower Project, Pakistan
Source: CPEC (https://cpec.gov.pk/project-details/16)

Cultural heritage

Cultural heritage includes:

- Tangible forms of culture such as movable or immovable objects, property, sites, structures, or groups of structures having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values.
- Unique natural features or tangible objects that embody cultural values (sacred groves, rocks, lakes, and waterfalls.
- Intangible forms of culture, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles.[69]

The Hydro Sustainability Secretariat[70] identifies that hydropower schemes can have impacts on cultural heritage at each stage of project development. The construction stage may cause direct and indirect damage to or loss of access to physical cultural resources as a result of excavation, soil compaction, blasting, vibrations, pollution, vandalism, theft, desecration of cultural objects and sites, and groundwater and river flow changes. Construction activities may also be perceived to disturb spirits associated with special sites.[71]

During project operation, impacts on cultural heritage may include the loss of sites inundated by reservoirs (Box 5.13). downstream damage to cultural sites (e.g., through riverbank erosion or flooding) and interruption of ability to continue cultural traditions (e.g., in particular locations) or access specific sites due to changes arising from the project).[72]

Box 5.13: The Bujagali hydropower project and natural heritage in Uganda

The Bujagali hydropower project in Uganda was commissioned in 2011 and is still being cited as a project that negatively impacted the culture of local people. The Bujagali Falls was a place of spiritual healing and traditional culture but was blocked and inundated by the hydropower project.

Source: Umar (2021)

[69] IFC (2021)
[70] HSC (undated)
[71] Ibid.
[72] Ibid.

From 2019 to 2021, a UNESCO World Heritage Centre initiative advocated for the protection of natural heritage in the context of renewable energy projects. Hydropower projects need to be effectively planned, evaluated, and implemented to safeguard world heritage properties.[73]

The IFC's Performance Standard on Cultural Heritage (PS8)[74] sets out good practice for addressing cultural heritage impacts. They require the protection of cultural heritage from adverse impacts, and support for preservation and equitable sharing of benefits from the use of cultural heritage. In September 2021, the International Hydropower Association announced that no new hydropower projects should be developed in World Heritage sites.[75] It proposed a "duty of care commitment" to implement high standards of performance and transparency when affecting protected areas as well as candidate protected areas and corridors between protected areas. [76] [77]

Hydropower projects can support local communities and their cultural heritage by helping to encourage tourism to their location. It is assumed that hydropower plants and accompanying infrastructure reduce the attractiveness of the areas in which they are located for tourism, but some tourists find them acceptable and desirable.[78] Around the world, hydropower projects organize tours and celebrate local culture, e.g., projects at Itaipu at the conjunction of Brazil, Argentina, and Paraguay, and at Niagara Falls on the border between Canada and the US.

Gender and vulnerability

Often, there are gender gaps with women significantly underrepresented in job opportunities in hydropower projects (Box 5.14).

Box 5.14: Gender gaps in the hydropower sub-sector

A recent study for the World Bank looked at gender gaps in the hydropower sector. It was carried out by the Energy Sector Management Assistance Program in partnership with the IHA and the Global Women's Network for the Energy Transition (GWENET).[79] The study reports that women remain underrepresented in the sub-sector, as they are in the overall energy sector in general. It was difficult to determine the degree of under-representation since sex-disaggregated data and gender statistics on employment in the sub-sector are scarce. The report notes that hydropower generates almost two-thirds of renewable energy electricity, and it employs over two million people globally. Hence, the sub-sector has the potential to make a significant contribution to improving diversity and gender equality across the energy workforce.

A hydropower project may affect women and vulnerable groups and impair their ability to access benefits, as they often lack ownership of and rights to property, which affects their access to compensation. A sector study from India[80] shows that women are especially vulnerable when gender sensitivities are ignored or overlooked in the project design and planning phases of hydropower development. These vulnerabilities range from losing their traditional means of livelihood when they lose access to their land, which in turn affects their food security and often their access to water and sanitation as well. Women lose access to and control over resources such as land, rivers, forests, and fodder, and must then deal with increasing workloads.

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[73] UNESCO (2021)
[74] See www.ifc.org
[75] A landmark or area with legal protection by an international convention administered by the UNESCO. (UNESCO World Heritage Centre – World Heritage List)
[76] IHA Website notification September 2021. International Hydropower Association announces new commitment to World Heritage sites and protected areas - UNESCO World Heritage Centre.
[77] See San Jose Declaration on Sustainable Hydropower (San José Declaration on Sustainable Hydropower)
[78] Saeporsottir and Hall (2018)
[79] Energy Sector Management Assistance Program (2021) World Bank-ESMAP Launches Survey on Gender Gaps in Hydropower Sector - As Part of New Study to Support Women's Employment in the Sector. ESMAP. 19 July.
[80] Shrestha *et al*. (2019)

Many large hydropower projects have large workforces that are resident for several years with many construction camps located near to communities. Their presence (often predominantly male, although this is changing) can impact on women's safety and routine activities. World Bank guidance addresses the management of the risks of adverse impacts on communities from temporary project-induced labor influx.[81] It identifies violent and risky behavior resulting from an increase of predominantly male construction workers for large infrastructure projects such as hydropower. Non-local workers can be drawn to the affected area and local workers can have access to relatively high incomes. This can lead to anti-social behaviors (greater alcohol and substance misuse), a heightened risk of sexual exploitation and abuse or sexual harassment,[82] and long-lasting physical and mental health impacts for the community.[83]

Furthermore, a lack of gender diversity within the workforce can limit access for women workers to economic opportunities created by the transition to hydropower. According to the IFC's Powered by Women initiative, which surveyed 20 hydropower companies in Nepal,[84] women make up only 10% of the total number of employees, and only 5% hold technical jobs. Women are inhibited from taking up non-traditional roles in the industry due to various factors: gender stereotyping in the workplace; a lack of women taking up training in science, technology, engineering and mathematics (STEM); a lack of access to formal finance for women-headed businesses; and deprioritizing gender mainstreaming within hydropower companies.[85]

Employment and labor conditions

Globally, the numbers of workers employed in the renewable energy sector increased from 8.1 million (1.3 million in hydropower) in 2015 to 12 million in 2020 (2.2 million in hydropower). [86] [87] The Asia and Pacific region had the greatest new hydropower capacity in 2020 (almost 14,500 MW) followed by Europe (just over 3,000 MW) and South and Central Asia (just over 1,600 MW),[88] providing significant employment. The development of a hydropower project can create job opportunities for local people (Box 5.15), as well an opportunity for vulnerable groups and indigenous communities to acquire new skills through working on the project.[89]

Box 5.15: Long-term employment opportunities in the hydropower sub-sector in the Philippines

In 2021, a Japanese renewable energy developer invested in the development of a 17.4 MW hydropower project in Ifugao Province in northern Luzon, Philippines. After the completion of construction, the wider and extended portfolio of hydropower projects is expected to provide the region with clean energy and long-term employment opportunities for local communities. In the Philippines, the large and small hydropower sector employed close to 53,600 workers in 2021, and this number continues to rise.

Source: Rivera (2021)

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81 World Bank (2016)

82 Such factors should be combined with an understanding of wider sociocultural risk factors within the country context (i.e., pervasive gender inequality, poverty and discrimination, restrictive social and gender norms) to determine the steps needed to safeguard women and girls from harm. For more guidance, see EBRD, IFC, CDC (2021)

83 World Health Organization (2021)

84 See "Powered by Women: Business Case for Gender Diversity and Equality in Nepal's Hydropower Sector" (https://www.ifc.org/content/dam/ifc/doc/mgrt/report-on-business-case-gender-nepal-2020.pdf)

85 See "New IFC report urges companies to take action to boost women's contribution in the hydropower sector" (https://www.ifc.org/en/pressroom/2020/new-ifc-report-urges-companies-to-take-action-to-boost-womens-co#:~:text=Various%20constraints%20continue%20to%20impede%20women%E2%80%99s%20entrance%20into)

86 IRENA (2021a)

87 OECD (2017)

88 IHA (2021b)

89 IHA (2021c)

While labor conditions may vary from one hydropower project to another, there is also a possibility that such projects can breach labor rights. It is common for construction monitoring to identify excessive use of overtime, working successive days without required days of rest, and excessive use of temporary or contract workers. The latter can create a two-tier workforce with repercussions for staff morale and workers not being paid correctly or not being correctly signed up for safety net systems.

The need to engage large workforces in remote areas (where hydropower schemes are often located) can lead to companies providing poor working conditions. In such remote areas, labor inspectors may not be able to regularly monitor projects. Some of the International Labour Organization (ILO) Indicators of Forced Labour[90] were frequently breached by companies during the COVID pandemic, e.g., restriction of workers' movements, isolation, abusive working and living conditions, and excessive overtime. They can also be breached by remote, large-scale construction activities such as hydroelectric projects.

One of the key elements of ensuring just renewable energy transition is ensuring that the workforce includes people from marginalized groups.

Migration

A hydropower project may lead to an influx of migrants and skilled workers seeking business and employment opportunities. Incoming workers and followers, including job seekers and squatters, can lead to adverse socioeconomic impacts on local communities residing near hydropower projects. According to IFC guidance on project-induced in-migration,[91] this may have a wide range of positive and negative impacts. Positive impacts include, among others, business opportunities, improved range of accessibility to goods and services, higher skill base, and increased local tax revenue. However, these impacts can only happen when a hydropower project is well prepared. In many cases, hydropower companies bring in their own staff, do not train local people, and try not to rely on them because they are not qualified enough.

Negative impacts include, among others, pressure on services and land, demand for and shortfalls in products and services, boom and bust cycles related to the construction phase, tensions and disputes among different groups related to benefit distribution, alteration in existing levels of communicable disease, increased incidents of social vices, and increased potential for domestic and gender-based violence and sexual harassment.

According to the IFC's guidance, the amount of in-migration can be influenced by various factors:

- Larger scale projects lead to a greater impact of in-migration; smaller scale projects lead to a lesser impact of in-migration.
- Low capacity leads to a greater impact of in-migration, high capacity leads to a lesser impact of in-migration.
- A higher concentration of people leads to a greater impact of in-migration, while a lower concentration of people leads to a lesser impact of in-migration.
- Many opportunities for compensation and benefits speculation lead to a greater impact of in-migration; few opportunities lead to a lesser impact of in-migration.
- Projects far from urban centers lead to a greater impact of in-migration; projects close to urban centers lead to a lesser impact of in-migration.
- Migration can cause both socioeconomic and cultural tensions between the local community and migrant workers from other regions or countries, especially if there is displacement of local people, economic loss, and loss of sites and religious or cultural practice of significance due to project development.

[90] Rivera (2021)
[91] IFC (2009)

Public services and infrastructure

As indicated in the Section on physical and economic displacement, the resettlement of affected people (e.g., due to the construction of a hydropower reservoir) can increase pressure on the use of the host community's public facilities (schools, clinics, hospitals) and infrastructure.

The IHA guide on people/communities affected by hydropower projects[92] notes that such projects can cause permanent or temporary closures of local infrastructure and services if inundation is required. This may include schools, health centers, shops, roads, bridges, footpaths and tracks, and boat/ ferry transport, transmission and telephone lines, and pipelines. For example, in Sikkim, India, hydropower companies support local area development programs for affected areas through community development projects such as school repair, road and footpath construction, provision of electrification and water supply for villages, and livelihood skill development.[93]

Hydropower projects often fund improvements to, and new, local infrastructure and facilities, not least to support their own workforces (Box 5.16). They also require the construction of new access roads or upgrading of existing nearby roads to transport equipment and for the construction of transmission lines or substations as associated infrastructure. While local communities can benefit from new or upgraded roads, tensions can arise when transmission lines are built, particularly since the electricity generated is not distributed locally (hydropower projects are typically permitted as generating facilities and are not allowed to distribute electricity to local communities). This could be solved by planning early to adjoin to the project a rural electrification program, relying on the energy generated by the project or on rural decentralized systems.

Box 5.16: Hydropower Project Nam Theun 2, Lao, People's Democratic Republic: Contribution to improved public infrastructure and facilities

Before the Nam Theun 2 project began, basic infrastructure and public facilities in the remote Nakai District was lacking or inadequate. Even in the dry season, it took half a day or more to travel between the district and provincial capitals. During the wet season, the Nakai Plateau was virtually inaccessible. The average distance to the nearest health facility was 11 kilometers, usually travelled on foot. Initial health surveys reported poor health conditions for both adults and children, high mortality rates for children under five (120.5 per thousand), widespread stunting and malnutrition, and remarkably high prevalence of parasite infection (59%). 63% of the population on the Nakai plateau lacked access to education, a situation that was of even greater concern for women, most of whom were illiterate. Electricity and communication services were not available to most households.

With project support, basic infrastructure and public facilities have improved. Households have access to electricity and telecommunication services, and most households own at least one mobile telephone. Traders and brokers can now access the plateau and northern villages by road to buy fish. Pigs and ducks can now be sold to collectors or at the market. The project supported the construction of new kindergartens, 14 primary schools, and two secondary schools. 90% of the children are currently enrolled in primary school, compared to 37% before. Two new dispensaries provide improved and convenient access to primary health care. In five years, child mortality of those under five decreased from 120 to 59 per thousand.

Source: Nam Theun 2 dam website. NTPC Document Proforma (namtheun2.com)

Many hydropower projects will build permanent housing for their operational workforce. But hydropower companies could plan early on to redistribute the worker housing they build to local communities after conclusion of construction. By comparison, other types of renewable energy (in

[92] IHA (2020)
[93] Chandy *et al.* (2012)

particular, wind and solar energy) tend to have smaller operational workforces and construct much less housing, and more of it is temporary.

Community cohesion and engagement

Hydropower development projects can have both positive and negative impacts on community relations and engagement. The impacts on community cohesion can include, but are not limited to[94]:

- Impacts to or loss of community resources (e.g., roads, gardens, land, forest, fisheries) and community assets (e.g., community meeting areas, culturally significant features).
- Conflicts between the workforce and the local population and exposure to anti-social behavior.
- Conflicts within the local population. These can arise for a range of reasons, often relating to issues of inequity, including, for example:
    - Access to employment (especially differences in opportunities between ethnic groups – which requires careful management).
    - Compensation measures (which may arise from a lack of clarity on cut-off dates).
    - Eligibility criteria or entitlement provisions (e.g., duration).
    - Access to and extent of training and support.
    - Access to and extent of project benefits.

While the introduction of outsider culture[95] and relationship issues are often raised in hydropower development projects, there are opportunities that projects can improve social relations and engagement (see example in Box 5.17).

Box 5.17: Conflict over the Grand Ethiopian Renaissance Dam

The conflict over the construction of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile River has dragged on for 12 years. Ethiopia has failed to find an amicable solution with Egypt and Sudan, its two neighboring downstream countries, which say the dam threatens to cut off their water supply. But Ethiopia sees the dam as a boon for economic development in a country where half the 120 million citizens live without power. There was a fresh outcry by Egypt in mid-September 2023 after Ethiopia announced that it had finished the fourth and final phase of filling the GERD reservoir.

Source: Kaledzi (2023)

Conflicts and opposition to hydropower projects

Conflicts can arise over a number of issues as follows:

- Environmental degradation (e.g. from reduced water quality).
- Lack of perceived project benefits accruing to local communities (e.g., access to power and water services).
- Loss of land or access to resources/areas used for livelihoods or cultural activities.
- Working conditions among those employed in construction or operation.
- Downstream impacts due to hydropower activities—changes in environmental flows, impacts on fisheries or water quality.
- Loss of access to important spiritual or cultural sites.
- Tensions between immigrants and local workers/communities.
- Transboundary conflict between states (e.g., over dams restricting water flow. See Box 5.17 and 5.18).

[94] IHA (2020)
[95] Cultural beliefs and practices of immigrant workers who come from outside of the project area.

Box 5.18: Conflicts over the Portezuelo del Viento Dam, Argentina

After intermittent starts that date back to the 1950s, Argentina's Mendoza province is preparing to make the Portezuelo del Viento mega-project a reality. The dam in the west of the country promises energy, tourism, and jobs. However, it is a source for conflict with other provinces and social organizations which fear they will run out of water. The dam will be located on the Rio Grande in the department of Malargüe, 300 kilometers from the border with Chile. Its projected height is 185 meters and its reservoir capacity 2,000 cubic hectometers. The project's generating capacity will be 210MW, sufficient to power 130,000 homes.

In addition to the hydroelectric plant, the project involves laying an electric power line, the construction of new sections of National Route 145 (which links Argentina and Chile) and Provincial Route 226, and the construction of a new Villa Las Loicas village, since the original will be flooded. Despite opposition from the government of neighboring La Pampa province, Mendoza is moving forward with the bidding process.

The Grande River is the main tributary of the Colorado River, an important watercourse that runs for 1000 kilometers from the Andes to the Atlantic and crosses five provinces: Mendoza, La Pampa, Neuquén, Río Negro, and Buenos Aires. La Pampa province is opposed to the project, fearing that the dam will reduce the flow of the Colorado River in its territory and affect the quantity and quality of water in the Colorado basin. The province has already initiated several legal actions against Mendoza province and is demanding an environmental assessment throughout the entire Colorado River basin. It claims that Mendoza is not complying with national laws on water management.

The conflict is not new. One hundred years ago, a series of works in Mendoza considerably reduced the volume of water in La Pampa. These included the construction in 1947 of the El Nihuil Dam, which led to the disappearance of the major branches of the Atuel River in La Pampa, forcefully impacting the nearby ecosystem and commercial activities. Nor has Argentina avoided conflicts over mega dams in more recent times. Social and environmental organizations have strongly opposed the construction of the La Barrancosa-Cóndor Cliff hydroelectric complex on the Santa Cruz River in its eponymous southern province.

Source: Profeta (2021)

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 6

WIND POWER

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Links to the complete guidance document and to individual chapters are also available.

CHAPTER 6

WIND POWER

Onshore and offshore wind power are addressed separately in this Chapter in Sections 6.3 and 6.4.

6.1 WHY SEA IS IMPORTANT TO WIND POWER

An overall rationale for why it is important to use Strategic Environmental Assessment (SEA) to support the energy transition is provided in the preface to the guidance.

It is becoming increasingly clear that wind projects should be managed beyond the individual project level. Thus, in the last few years, a number of offshore wind power SEAs have been done for Scotland,[1] the U.K.,[2] and the United States, and are in the planning phase in Canada.[3] In September 2021, the Government of Ireland launched a tender for SEA of the Offshore Renewable Energy Development Plan.[4] In March 2023, the Danish Government called for ideas on the SEA of the plan for Offshore Wind Farms (OWF) in three areas: Nordsøen I, Kattegat II and Kriegers Flak II.[5] Norway has completed an SEA of the impacts of offshore wind power on seabirds.[6] A German-Dutch SEA case study has been prepared for the North Sea.[7] Other countries are examining opportunities for offshore wind, including China,[8] Lithuania,[9] and Portugal.[10]

SEA can provide critical information to support better decision-making for wind power planning and development, including identifying where there might be significant environmental and/or socioeconomic risks. These can arise not only at the individual project level, but also at a broader landscape or regional scale and from multiple, often uncoordinated, schemes/projects. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple wind power schemes/developments, particularly in combination with other variable energy sources such as solar power.

The SEA process will:

- Identify and focus on ***key environmental and socioeconomic issues*** and the concerns of likely affected stakeholders, including local communities, marginalized groups, and Indigenous peoples. Issues associated with wind power development are discussed in detail in Section 6.5 and are summarized in Table 6.3.

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[1] Offshore Wind Scotland (2021)
[2] See "Offshore Energy Strategic Environmental Assessment (SEA): An Overview" (https://www.gov.uk/guidance/offshore-energy-strategic-environmental-assessment-sea-an-overview-of-the-sea-process)
[3] See "Governments of Canada and Nova Scotia launch regional assessment to support future decisions on offshore wind projects in the province" (https://www.canada.ca/en/impact-assessment-agency/news/2023/03/governments-of-canada-and-nova-scotia-launch-regional-assessment-to-support-future-decisions-on-offshore-wind-projects-in-the-province.html)
Governments of Canada and Nova Scotia launch regional assessment to support future decisions on offshore wind projects in the province - Canada.ca
[4] See "Ireland Opens Tender for Strategic Environmental Assessment for New Offshore Renewable Energy Development Plan" (https://www.offshorewind.biz/2021/09/03/ireland-opens-tender-for-strategic-environmental-assessment-for-new-offshore-renewable-energy-development-plan/)
[5] See "Public hearing concerning the strategic environmental assessment of the plan for Offshore Wind Farms in Nordsøen I, Kattegat II and Kriegers Flak II" (https://ens.dk/en/press/public-hearing-concerning-strategic-environmental-assessment-plan-offshore-wind-farms-nordsoen)
[6] See "Strategic Impact Assessment of Offshore Windpower in Norway - Impacts on Seabirds" (https://tethys.pnnl.gov/publications/strategic-impact-assessment-offshore-windpower-norway-impacts-seabirds)
[7] SEANSE (Undated)
[8] See "Potential of China's offshore wind energy" (https://www.science.org/doi/10.1126/science.adh0511)
[9] Ministry of Energy of the Republic of Lithuania (Undated)
[10] Ferreira (Undated)

- Identify/recommend if there are ***areas that should be avoided*** for wind power development ("no go" areas) because of particularly high risk to the environment and/or people and local communities.

- Make subsequent project-level ***EIAs*** *(environmental impact assessments)* ***more efficient and cheaper*** by addressing the big picture upstream and downstream beyond the individual project level, and by addressing potential cumulative impacts and identifying the broader issues that individual project EIAs should focus on in more (site-specific) detail. This may be particularly important when considering offshore wind in combination with onshore wind or other renewable energy generation sources.

- ***Engage stakeholders at a broader landscape or regional scale***, including communities, marginalised groups and indigenous peoples which can be particularly affected by wind power developments. Stakeholders should be informed early of proposed or possible policy options or plans, and they should be given opportunities to provide their perspectives and present their concerns as early as possible. This will enable key issues to be identified and verified at a regional level and to help ***build understanding and support for wind power development*** and avoid future misunderstanding and possible conflicts.

Section 6.5 discusses the benefits of SEA to the development and implementation of wind power PPPs (policies, plans, and programs).

The stages and tasks in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards and principles of good practice (see Chapter 1, Section 1.4). They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

6.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE WIND POWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for the International Association for Impact Assessment (IAIA) was unable to identify any specifically focused on the wind power sub-sector, but a number of guidelines and papers address project-level impact assessment for wind power developments.[11] New guidance on key environmental factors for offshore windfarm environmental impact assessment has recently been released by the Australian government.[12] Guidance for seascape and visual sensitivity for Wales' draft Marine Plan areas was also prepared in November 2018.[13]

6.3 INSTALLED WIND POWER CAPACITY

In 2023, global installed wind capacity was c.1.020 GW (c.945 GW onshore; c.75 GW offshore) (Table 6.1). Many organizations develop scenarios on possible energy futures. The best-known and most influential of these is the World Energy Outlook (WEO) published by the International Energy Agency.[14] The 2022 WEO has three scenarios: stated policies (actual policies by countries), announced pledges (what the countries have promised to do), and net-zero (what is needed to attain 1.5^{o}C increase of temperature by the year 2100). Wind generation will increase 2.5 times in the period 2021-2030 in the stated policies scenario and again 2.3 times between 2030 and 2050. The share of wind in the power sector will increase from 7% in 2021 to 13% in 2030 and 21% by 2050. In the "announced pledges scenario," the increases are respectively 3.1 and 3 times and the share 16% by 2030 and 28% by 2050. To attain a net zero energy system by 2050, the increases have to be even

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[11] e.g., Durning and Broderick M. (2018); EU (2011); GIZ (2018); GP WIND (undated); IFC (2015), MESP (2010); MSEA (2013); Phylip-Jones and Fischer (2013);); Ledec *et al*. (2011); and RVO (2022)
[12] DCCEEW (2023).
[13] See "Stage 3- Seascape and visual sensitivity assessment for offshore wind farms" (https://cdn.naturalresources.wales/media/689508/eng-evidence-report-331-seascape-and-visual-sensitivity-to-offshore-wind-farms-in-wales.pdf)
[14] International Energy Agency, World Energy Outlook 2022 (Paris 2022); the even more recent IEA Net Zero Roadmap 2023 Update (Paris 2023) has comparable figures for the net zero scenario.

larger: 4.2 in 2021-2030 and 3 times in 2030-2050, and the shares will be 21% in 2030 and 32% in 2050. Because wind turbines will generate more electricity, the capacity increase is somewhat smaller. These increases are part of the general conclusion of the IEA—and many other organizations—that a clean and sustainable future implies much more renewable energy, more energy efficiency, and a higher share of electricity in energy consumption. Much more wind energy is a *sine qua non* for a clean energy future.

Table 6.1: Installed wind energy capacity in 2023
Source: Global Wind Energy Council (2024)

Continent/country	Installed capacity (MW)	Continent/country	Installed capacity (MW)
ONSHORE		**OFFSHORE**	
Total onshore	***841,898***	***Total offshore***	***64,320***
Americas	***218,006***	***Europe***	***34,032***
USA	150,433	United Kingdom	14,751
Canada	16,986	Germany	8,311
Brazil	30,449	The Netherlands	4,759
Mexico	7,413	Denmark	2,652
Argentina	3,704	Belgium	2,262
Chile	4,577	Others Europe	455
Other Americas	4,444	***Asia-Pacific***	***41,088***
Africa/Middle East	***10,684***	China	37,775
Egypt	2,062	Japan	188
Kenya	425	South Korea	146
South Africa	3,442	Vietnam	874
Morocco	1,926	Taiwan	2,104
Saudi Arabia	422	***Americas***	***42***
Other Africa	2,407	USA	42
Asia-Pacific	***478,472***		
PR China	4033,325		
India	44,736		
Australia	11,479		
Pakistan	1,817		
Japan	5,026		
South Korea	1,821		
Vietnam	3,924		
Philippines	593		
Kazakstan	916		
Other APAC	4,835		
Europe	***238,315***		
Germany	61,139		
France	22,003		
Sweden	16,249		
United Kingdom	14.866		
Spain	30,562		
Finland	8,873		
The Netherlands	6,754		
Turkey	12,342		
Other Europe	67,527		

6.4 ONSHORE WIND POWER GENERATION

6.4.1 Onshore installation types

Onshore wind turbines capture energy from the wind and produce electricity using long, rotating blades that drive a generator located at the top of the tower behind the blades. The longer the propellers, the more kinetic energy they can catch and "harvest" from the wind. The current tendency in wind power development is for towers to become increasingly taller and blades to be longer to increase power generation of individual units.

Onshore wind is a developed technology, present in 115 countries around the world. The top 10 countries with the largest wind energy capacity in 2021 were China, US, Germany, India, Spain, United Kingdom, Brazil, France, Canada, and Italy.[15]

Wind turbines can be tall, as much as 300 meters in height, to make the most use of available wind. To maximize power generating potential, wind farms are usually located where topography and weather patterns offer the highest potential for significant natural wind. They are often on agricultural land or on hilltops and mountains, often coexisting with other land uses such as livestock grazing or cropping areas. The number of turbines at wind farm sites and output is mostly maximized depending on the wind speeds and the available space on the location and limited by environmental and social issues.

Land used for large-scale agricultural production (e.g., for livestock or cropping) can often be readily combined with wind turbines. In general, a relatively small portion of the productive land is utilized for a wind farm's operation, e.g., turbine siting, access roads and other related assets such as transmission line easements, electrical substations, transformers, and meteorological masts. The landowner usually continues agricultural activities on the remaining land. Typically, there is disruption during the construction phase but only minimal disruption when the wind farm is operational, e.g., for access and maintenance.[16]

A wind turbine comprises four main parts: the base (hard stand), tower, generator, and blades (or propellers). Each turbine is connected by an array of cables that connect to a substation before electricity is fed into the electricity grid. Construction of transmission lines and substations are required.

Construction activities for wind turbines typically include:

- Land clearing and levelling for site preparation and access routes.
- Excavation, blasting and filling.
- Transportation of supply materials and fuels.
- Building foundations involving excavations and placement of concrete.
- Using cranes to unload and install equipment which occupy a lot more space than the turbines themselves.
- Construction and installation of associated infrastructure such as site camps, batching plants, and laydown areas.
- Installation of overhead conductors or cable routes (aboveground and underground).
- Commissioning of new equipment.

As the wind turbine components (turbine blades) are large, special purpose vehicles are often used to transport them to a site. This can be a challenge in areas of steep terrain and in areas where the existing road or access infrastructure is less developed. Where access is limited, new roads and road upgrades may be required and need to be undertaken before construction.

Box 6.1 provides examples of some recent onshore wind farm projects in Southeast Asia.

[15] Power Technology. (2023, September 19)
[16] Australian Energy Infrastructure Commissioner (AEIC). Host Landholder Matters. AEIC website (see www.aeic.gov.au/observations-and-recommendations/chapter-1-host-landowner-negotiations)

Box 6.1: Recent onshore wind farm projects in Southeast Asia

Sidrap Wind Farm, Indonesia. The 75 megawatt (MW) wind farm is in the Sidrap region in South Sulawesi. The project is Indonesia's first utility-scale wind farm and began providing power to the Southern Sulawesi grid in March 2018. The project uses 30 2.5 MW turbines.

Tolo 1 Wind Farm, Indonesia. The 72 MW wind farm is in the Jeneponto Regency area of South Sulawesi. Commissioned in 2019, it has 20 wind turbines, with each tower 134m high using 64m long blades.

Figure 6.1: Construction of a wind turbine for the Tolo 1 Wind farm, Indonesia

Source: www.venaenergy.com

La Hoa and Hoa Dong Wind farms, Mekong Delta, Viet Nam. Currently under construction, each of the 30 MW projects are in Vinh Chau and Soc Trang, Viet Nam. Each project utilizes 8 turbines on 162m tall towers. Both projects include a 110 Kv substation and transmission line, and a total of over 17 Km of transmission lines.

Hanuman Wind Complex, Chaiyaphum, Thailand. The 260 MW complex consisting of five wind farms with 103 turbines is in the northeastern province of Chaiyaphum. It started operations in 2019.

6.4.2 Environmental issues associated with onshore wind power development

During scoping for an SEA, key issues regarding wind power development should be identified. They will be used to focus the SEA on the most important issues, and also to help develop environmental and social quality objectives (ESQOs) (see Chapter 1, Section 1.5; and Chapter 2, Section 2.5.1) that address these issues—to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other wind power development applications, wind profiles and meteorological data, etc.); interviewing key informants; and during stakeholder consultations at national to local levels.

At the individual project level, these issues will be the focus of an EIA which should recommend how to manage or mitigate project impacts associated with these issues that might be likely to arise. Ideally, before individual wind projects are approved, the implementation of a policy, plan, or program (PPP) for the wind power sub-sector should be completed. This will involve the assessment of multiple possible projects, schemes, and activities, their alternatives, and locations. Some of these will be directly concerned with the construction and operation of sites and facilities; others will be linked to associated infrastructure (e.g., transmission lines, access roads). Thus, there is a risk that the impacts of individual developments/projects may become highly significant as they become cumulative. An SEA should be focused on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual wind power applications and overarching SEA planning is not synchronized, and SEA may have to “catch up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how wind power development should proceed.

Table 6.2 summarizes the range of possible environmental and socioeconomic issues likely to be associated with onshore wind power development. Most of these are well known and derive from existing experience of developing and operating wind power projects.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 6.2: Environmental and socioeconomic issues associated with onshore wind power development

ISSUE	CONCERN
Environmental	
Deforestation	• Land clearing and deforestation for wind farms sites and release of stored carbon.
Habitats and biodiversity, and ecosystem services	• Changes to terrestrial habitats due to land clearing and linear developments. • Bird strikes or collisions (with spinning turbines) and habitat avoidance effect for local and migratory birds (including internationally listed endangered species) and bats. Bird and bat fatalities at wind turbines are often greatly underestimated due to the removal of carcasses by scavenging animals. • Potential loss of bat species—information about presence and distribution of bat species is often less established or absent (i.e., relative to bird species), requiring site-specific primary surveys to adequately assess impacts. • Fragmentation of habitats by access roads and transmission lines. • Changed food webs. • Biodiversity impacts may also result from associated infrastructure (transmission lines, roads, and lighting); birds and bats may collide with, or be electrocuted by, overhead power lines. • Due to the typical remote nature of onshore wind turbine generators, access roads required for construction (e.g., wind turbine blade transportation) and operation and maintenance can open new areas of forest or other natural habitats to significant exploitation, including illegal logging, harvesting of forest products, and poaching. • In many parts of the world, bats and birds are vital to ecosystem functioning and their loss could destabilize entire ecosystems.
Greenhouse gases	• Onshore wind power can reduce GHG emissions where it displaces coal or other fossil fuels as a fuel source. • GHG emissions from turbine manufacture, transport to site, maintenance, and decommissioning are low compared to reduction in emissions from equivalent fossil fuel energy production. • Sulphur hexafluoride (SF6)(23,500 times more potent than CO_2) can leak through faulty seals in Ring Main Units (RMU).
Land-use changes	• Loss of agricultural and other productive land from siting of turbines and transmission lines.
Protected areas	• Impact on protected areas (e.g., where wind farms are in, or nearby, protected areas or where access road and transmission lines pass through protected areas) through deforestation, disturbance to fauna, increased poaching, visual impacts affecting tourism, etc.).
Noise and vibrations	• Onshore construction noise from activities such as blasting, piling, construction of roads and turbine foundations, and the erection of the turbines themselves. • Operational noise impacts of onshore wind turbines may also have ongoing impacts. • Blade movement may disrupt behavior and physiology of animals and cause physical damage (mortality to damage of hearing tissues and other organs). • Anthropogenic noise can mask detection of biologically important signals used for communication, predator avoidance and prey detection, and can influence behaviors. • Animals may move out of a noise area, potentially disrupting foraging or breeding.
Air quality	• Dust during construction. • Emissions from construction plant and vehicles—potentially on nearby residences or work sites (offices, etc.). Depends on volume of traffic.

ISSUE	CONCERN
Waste	• Construction waste and decommissioning waste. • Failure to incorporate circular economy production and decommissioning elements in wind turbine and fleet design, e.g., turbine and blade life time, reuse and recycling standards or requirements. • Wind turbine generator blades are made from unrecyclable composite materials and present a problem for disposal in most countries. However, new technology for recycling is emerging.[17]
Water demand	• Water used during construction and operation—particularly an issue in arid environments.
Water quality	• Foundations, underground cables, roads, and infrastructure may result in increased erosion, soil compaction, increased runoff, and sedimentation of surface waters. • Discharge of pollutants in water (used for plant, equipment, and vehicle washing) to ground and subsequent leaching to groundwater. • Release of pollutants (fuels, oils, chemicals, etc.) to groundwater during construction and decommissioning. • Accidental release of liquid wastes during storage, handling, and removal, with subsequent leaching to groundwater. • Accidental discharge of sanitary wastewater to ground and groundwater from the workers' domestic facilities.
Metal and mineral extraction	• Extraction of metals and minerals used for wind turbine manufacturing.
Visual and aesthetic impacts	• The presence of many turbines, pylons, substations and transmission lines changes landscape quality and disrupts the aesthetic value to the local communities. • Safety lights on wind turbines may be a distraction to humans and wildlife. • Shadow flicker may become a problem for nearby humans and wildlife with sensitive receptors. • Wind turbines may reduce the appeal of an area for recreation and tourism.
Land and ecosystem restoration	• Wind farms have a 30–40-year lifespan, after which restoration will be required, unless negotiations with landowners result in agreement to repower or upgrade the equipment and extend the wind farm's operational lifespan.
Socioeconomic	
Human rights	• Mineral mining companies (which supply wind turbine manufacturing companies) are reported to violate rights of communities (e.g., rights to land, livelihoods, ability to undertake traditional cultural practices). • Mineral mining companies are reported to employ forced and child labor.
Employment and labor conditions	• Employment opportunities during construction and operation phases of wind farms. • Job opportunities generated from new investment in mineral extraction for use in turbine manufacturing. • Worker safety (e.g., working at heights).
Health and safety	• Failure of rotor blades. • Failure and toppling of tower structures due to heavy forces of moving blades and extreme weather events. • Heavy load transportation causes traffic management/safety problems. • Increased vehicular traffic during construction. • Burns or electrocution from electrical shocks or arc flashes/fires.
Local economy and livelihoods	• Income from agricultural land will be lost. • Local communities can gain from benefit-sharing schemes.

[17] USDE (2023)

ISSUE	CONCERN
	• Individual landowners may receive lease payments, but these may be less than those received from other sectors (e.g., oil/gas). • Failure to incorporate in design liability and restoration costs for failed or terminated projects.
Shadow flicker	• Shadow flicker (which occurs when the sun passes behind a wind turbine and casts a shadow) may become a problem with sensitive receptors nearby.
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk. • Employment opportunities in construction of new projects relies heavily on skilled outside workers, with potentially limited use of local labor—with consequential potentially adverse effects on community safety, health, and social cohesion through "boom town" impacts. • Limited opportunities for vulnerable groups to acquire new skills and learn new technologies.
Cultural heritage	• Risk of damaging or destroying cultural, historic, and archaeological sites.
Migration	• Tension between local communities, outside workers, and migrants. • Risk of gender-based violence due to influx of predominantly male construction workers. • Pressure on preexisting health services and infrastructure.
Telecommunications and aviation	• Electromagnetic interference to telecommunications systems. • Potential to impact aircraft safety with direct collision or alteration to flight paths. • Disruptions to aviation radar such as signal distortion may be caused by turbines.
Public services and infrastructure	• Wind farm companies may fund Improvements to local infrastructure. • Pressure on local infrastructure due to heavy transportation of wind turbine equipment. • Increased pressure on public services, including health centers. • Increased local government's tax revenues generated from wind farm companies. • Local communities and stakeholders may benefit from revenue sharing or participating financially in the wind farm project. • Degree to which tax revenues levied on wind farms can offset costs to local governments of providing additional infrastructure and services.

Wind energy turbines can have both direct and indirect adverse impacts on the onshore environment during construction, operation and maintenance, and decommissioning.

Habitats and biodiversity

The International Finance Corporation (IFC) has identified potential risks to habitats and biodiversity due to onshore wind power development[18]:

- ***Permanent habitat loss*** due to:
  - ***Land clearing*** for temporary project components such as site huts and worker's accommodation, and for permanent components such as roads, turbine foundations, footings and substations.
  - ***Disturbance and barrier effects*** on species. Operational wind turbines can disturb resident and transitory species (i.e., both terrestrial and birds/bats)—rotating turbines can cause avoidance or movement pattern changes, effectively creating "barriers" to habitats, resources, or the linkages between them. Important bird and bat ***migration pathways*** may be affected by improper siting of wind power facilities.
- ***Fragmentation of habitats*** due to construction of the linear infrastructure needed for onshore wind farms, including access roads and transmission lines.
- ***Aquatic and terrestrial habitats*** can potentially be affected by various activities: widening of road sections or trimming/removal of roadside vegetation, and strengthening (or building) bridges and culverts.
- ***Indirect impacts on biodiversity*** due to the construction of new access roads in previously remote natural habitats. Increased accessibility provides more opportunities for illegal logging and poaching.
- ***Bird, bat, and insect[19] collisions and mortality*** with moving wind turbine blades during operation (Box 6.2). Bats and large soaring birds are especially at risk.

The creation of linear infrastructure including roads and transmission lines can often result in corridors of cleared vegetation or removed habitat. These corridors can cause habitat fragmentation by dividing up previously contiguous units of habitat.

Linear developments, including roads and transmission lines, pose various direct threats to wildlife such as the risk of collisions and resultant mortality with vehicles and electrocutions, impeded access to resources (e.g., food), reduced genetic exchange, behavioral changes, and exposure to pollution. The impact of these corridors on arboreal mammals could be especially pronounced given their aversion to using open ground when the connectivity of the (tree) canopy is lost.

Bird and bat death associated with turbines is a significant problem where protected species are present and migratory and foraging routes are in proximity to onshore wind farms.[20] [21] There has been extensive research on the interaction between birds, bats and wind turbines. In 2022, the US Synthesis of Environmental Effects Research prepared a briefing paper on Bat and Bird Interaction with Wind Energy Development.[22]

The species that are killed by wind turbines are often long-lived, slow to reproduce, K-selected species,[23] for which impacts on a few adults in the population can lead to significant population-level declines. This differs from those predominantly songbird species that are subject to collision with buildings or predation by cats, because there is much more redundancy in those populations, and they can withstand a certain level of annual mortality.

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[18] IFC (2015)

[19] Evidence is accumulating that insects are frequently killed by operating wind turbines, yet it is poorly understood if these fatalities cause population declines and changes in assemblage structures on various spatial scales (see Insect fatalities at wind turbines as biodiversity sinks | Tethys (pnnl.gov))

[20] Thaxter *et al*. (2017)

[21] See "Is it possible to build wildlife-friendly windfarms? (https://www.bbc.com/future/article/20200302-how-do-wind-farms-affect-bats-birds-and-other-wildlife)

[22] A table summarizing the more than 60 articles relevant to the subject is available at https://tethys.pnnl.gov/summaries/bat-bird-interactions-offshore-wind-energy-development.

[23] K-selected species are those that reduce the number of offspring produced in order to increase their quality.

This is particularly important for bats, which provide significant ecosystem services as follows:

- Insect-eating bats have been shown to benefit agricultural outputs by reducing pest insects.[24] Wind farm proposals in areas where the main agricultural pests are night-flying insects should take this into account.
- Insect-eating bats may reduce the number of medically important insect pests such as mosquitoes.[25]
- Fruit-eating bats are important seed dispersers and pollinators and may be vital to forest regeneration.[26]

To address the problem of onshore Wind Energy Facilities (WEFs) having potentially significant impacts on wildlife, particularly birds and bats, through collision impacts, the IFC recently published a good practice handbook on monitoring fatalities.[27] It provides practical guidance on the design and implementation of a Post-construction Bird and Bat Fatality Monitoring (PCFM) methodology at WEFs that aligns with good international industry practice. It aims to help promote global standardization in methodologies for monitoring bird and bat fatalities so that fatality rates can be better compared across sites, landscapes, countries and regions. Although the handbook is principally designed to account for collision risks, the methods were developed also to assess impacts of electrocution on birds and bats at associated power lines.

Key mitigation measures to reduce bird and bat fatalities at onshore wind farms are listed in Box 6.2.

Box 6.2: Key mitigation measures to reduce bird and bat fatalities at onshore wind farms

- Careful site selection, taking care to avoid locating wind farms within protected areas, important bird areas, sites of high conservation value, and areas with significant bird or bat concentrations.
- Short-term shutdowns of wind turbines when important bird concentrations are present (Box 6.3).
- At night, increasing the cut-in speed (the lowest wind speed at which turbines spin and generate power) has been shown to greatly reduce bat mortality, while only minimally affecting power generation.
- Monitoring of bird and bat fatalities at operational wind farms, with transparent data sharing and adaptive management to reduce collisions.
- Biodiversity offsets to assist target species of conservation concern. For example, at the Kipeto wind farm in Kenya, off-site measures to reduce the incidental poisoning of threatened vulture species by livestock herders are intended to offset any vulture losses from wind turbine collisions.

Source: George Ledec, personal communication (2024)

An example of measures taken to protect migrating birds near windfarms in the Gulf of Suez is shown in Box 6.3.

[24] e.g., Williams-Guillén *et al* (2009), Boyles *et al.* (2011), Noer *et al.* (2012).
[25] Reiskind and Wund (2009)
[26] Kunz *et al.* (2011), van Toor *et al.* (2019).
[27] See *Good Practice Handbook on Post-construction Bird and Bat Facility Monitoring for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool* (https://www.ifc.org/en/insights-reports/2023/bird-bat-fatality-monitoring-onshore-wind-energy-facilities)

Box 6.3: Impacts on migrating birds of large wind farm projects in Egypt near the Gulf of Suez

An SEA was undertaken covering an area of 284 km² about 5 km inland from the shores of the Gulf of Suez located northwest of Ras Ghareb in Egypt. It assessed the likely environmental and social risks and impacts of future wind farm developments in the area.

Parts of the Gulf of Suez, especially the area near Gabel el Zayt, are well known as a bottleneck for migrating birds from Europe and western Asia and there were concerns that installing large wind farms in this region may lead to significant impacts on migrating birds caused by collisions with wind turbines or—to a lower degree—by barrier effects. In addition, large wind farms might even affect roosting and local (i.e., breeding) birds by direct habitat degradation or indirect disturbance (due to avoidance behavior of birds).

As part of the SEA, extensive monitoring on birds was conducted in accordance with the EIA guidelines and monitoring protocols for wind energy development projects in Egypt. The monitoring aimed to collect baseline data on large soaring birds (mainly storks, pelicans, and raptors ["target species"]), roosting, and local birds. On that basis, the likely impacts caused by multiple wind farm projects in the area were identified and assessed and appropriate mitigation measures to minimize impacts were defined.

The monitoring focused on bird migration during three different periods: April–May 2016 (spring migration and breeding period), September–November 2016 (autumn migration), and February–May 2017 (spring migration and breeding period).

Though migration of target species was low during some periods, a very high migratory activity was obtained on single days (probably—at least partly—correlated with low wind speeds). Relevant numbers of "endangered" or "vulnerable" species occurred in the study area, in particular Steppe Eagle with 4,740 individuals in spring 2017. More than 1% of the flyway population of ten target species was observed in the whole study area and even at single observation sites. The monitoring confirmed that the area is of high importance for large soaring birds in spring.

The SEA recommended that, to reduce collision risk for large soaring birds at an individual wind farm level during spring migration, an effective shutdown or curtailment program should be established. Two alternate approaches were proposed:

- Fixed shutdown: during the critical migration period in spring (March 1st to May 18th) during daytime (i.e., 1.5 hour after sunrise to 1.5 hour before sunset).
- Shutdown on-demand: turbines are stopped in times of high collision risks, i.e., during periods of high migratory activity or when large flocks approach a wind farm. At two large wind farms, four criteria for triggering the shutdown of turbines were applied:
    1. Threatened species.
    2. Flocks with 10 or more large soaring birds (target species).
    3. Imminent high risk of collision.
    4. Sand storm of high migratory activity or when large flocks approach a wind farm.

Source: Lahmeyer and Ecoda Consultants (2018)

Not all habitat and biodiversity outcomes are negative. Research after constructing wind turbines in the Gobi Desert concluded the development was a win-win strategy that both contributed to the growth of desert vegetation with the advent of a favorable microclimate.[28]

Materials used to construct wind turbines comprise steel, fiberglass, resin or plastic, iron, copper, and aluminium. The magnets used in modern turbines are made using neodymium and dysprosium. The supply chain and source for these materials, and the potential adverse effects to habitat and biodiversity in the locations they are minede, also need to be considered. Figure 6.2 shows the locations of mines for these materials. Some of the countries include places where there are conflicts or where human rights are not well-regulated or enforced.

[28] Kang *et al*. (2019)

Figure 6.2: Producers of minerals and metals used in wind turbines

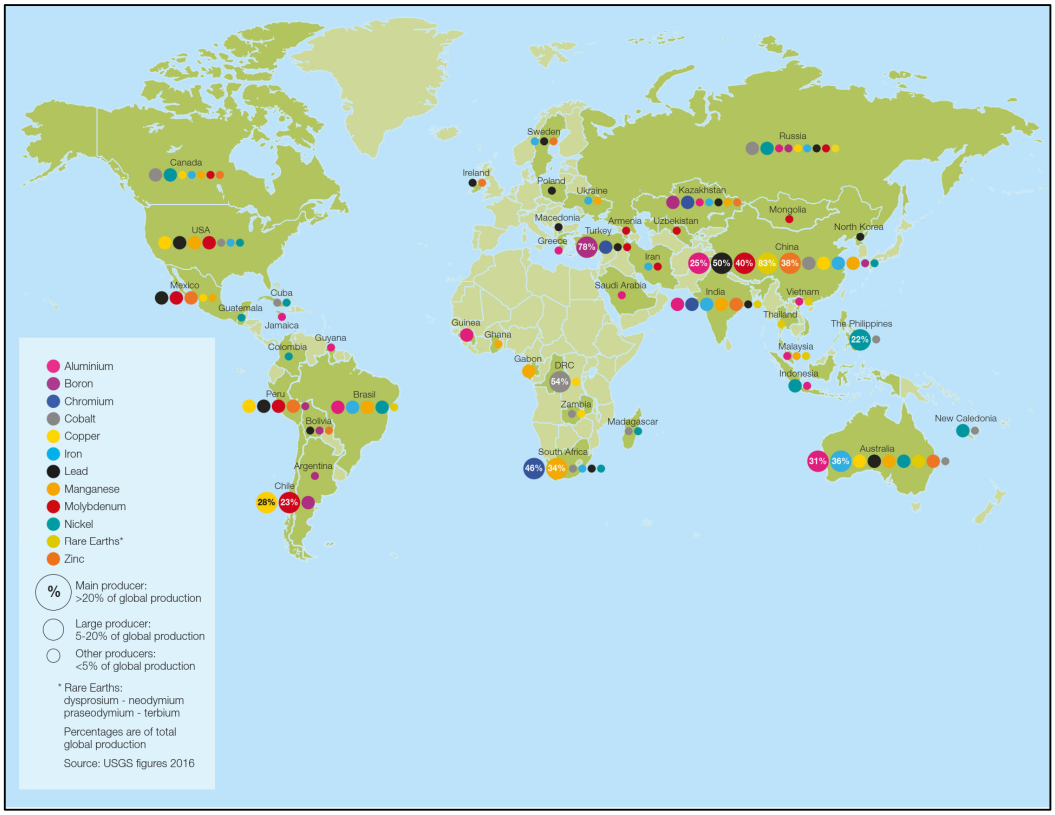

Image credit: Action Aid (2018) and SOMO

Protected areas

Onshore wind farms and their supporting infrastructure can have negative impacts on protected areas and areas of biodiversity importance, either directly by being located within a terrestrial protected area, or indirectly by impacting on the environment near a protected area or area of biodiversity importance.

Protected areas of local, regional, or international importance may include national and international protected areas (including marine protected areas), Important Bird Areas, Key Biodiversity Areas, Alliance for Zero Extinction sites, Ramsar sites (wetlands of international importance), known congregatory sites, and unique or threatened ecosystems.

These sites may be on important migration routes—particularly for birds, or be wetlands or staging, foraging, or breeding areas. They may house bat hibernation areas and roosts, or they may contain important topographical features, including ridges, river valleys, shorelines, and riparian areas.[29] Such sites may also have high value viewshed importance for tourism, historic, and cultural preservation (see *visual and aesthetic impacts* below).

Noise and vibration

Noise can be an issue during both the construction and operation of a wind farm. It can affect nearby residents and communities as well as disturb wildlife. Localized vibration impacts associated with heavy machinery movement may occur during construction, but are not evident once the turbine construction is completed and operation has commenced.

[29] World Bank (2015)

During Construction

During the construction of an onshore wind farm, noise and, in some circumstances, both noise and vibration, is generated by:

- The building of access roads and hardstanding (hard surfaces).
- The erection of wind turbines which includes foundation preparation, tower installation, blade assembly, and electrical infrastructure works.
- Increased traffic noise from delivery and construction vehicles.

Most wind farm projects are in remote locations away from areas sensitive to noise and vibration. As a result, in most circumstances, construction noise and vibration are limited to few sensitive receivers.

During Operation

Noise generation during operation is primarily from the wind turbines themselves. It is caused by aerodynamic turbulence associated with the rotating blades (creating a swishing effect that is commonly audible near each wind turbine) and mechanical noises from within the nacelle. The nacelle houses the gearbox, generator, and drive train at the back of the turbine blades atop the turbine tower.

Wind turbine noise is often assessed for the presence of any special audible characteristics that may cause subjective annoyance and, therefore, increased impact on adjacent noise-sensitive areas. The characteristics that are typically assessed include tonality, amplitude modulation, intermittency, low-frequency noise, and infrasound (low frequency sound).

Ancillary power infrastructure such as transformers and substations also cause some noise, but the impact is typically localized and close to the turbines, with no sensitive receivers in immediate proximity.

Visual and aesthetic impacts

The World Bank Group EHS Guidelines[30] note that wind farm projects can have landscape and visual aesthetic impacts on local communities and change the visual context and setting of the natural landscape.

When the sun passes behind rotating wind turbine blades, it casts a shadow, causing a flickering shadow effect. Shadow flicker may become a problem when potentially sensitive receptors (e.g., residential properties, workplaces, learning, and/or health care spaces/facilities) are located nearby. The problem is likely to be of more significance at high latitudes where the angle of the sun causes longer shadows (i.e., has a large radius of influence) and the magnitude and extent is dependent on the duration, timing, and presence of sensitive receptors.[31]

Local communities may view wind farms as impairing the aesthetic value of their surroundings. Some tourists find wind farms attractive, while others consider that they obstruct the natural landscape.[32] More than a decade ago, wind farms were being touted in the US as a means of boosting tourism and it was found that some tourists were supportive of wind farms being developed near recreation areas.[33]

There are also documented cases of opposition to wind farms because they deter tourism. For instance, research in Germany showed that wind farms were perceived to negatively affect the landscape and views in tourist areas.[34] In some low-income areas, stakeholder concerns about aesthetics are less prevalent or receive less prominence in project decision-making. In certain

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[30] IFC (2015)
[31] Parsons Brinckerhoff (2011a and 2011b)
[32] NRC (2007)
[33] Brown (2014)
[34] Broekel and Alfken (2015)

situations, wind farms can create conflicts between community groups having different perspectives. This can only be expected to increase as the intensity of wind power development increases due the energy transition.

Air quality

Wind farms have negligible impacts on air quality when operational. The main issues are usually dust and vehicular emissions during the construction of access roads and excavations for the turbine towers.

Water quality

Similarly, onshore wind farms have minimal impacts on water quality. During construction, there can be localized increased turbidity in water courses due to soil erosion along access routes and at turbine construction sites. This usually arises if measures to manage soil erosion and drainage are lacking or inadequate.

There can be small-scale spills of hazardous substances such as oils or vehicle fuel during construction. These have a temporary impact on water quality.

Depending on the technology, wind turbines may require water for cooling the generator, transformer and inverter, and occasionally for blade washing to maintain efficiency. This will require abstraction from a local water resource, particularly when local rain patterns are insufficient. Supplies of water available to local communities may be reduced, particularly during dry seasons.

Subject to any additives used, each of these activities pose limited risks to catchment water quality given that only low volumes of water are used.

Waste

Overall, waste production during the construction and operation of an onshore wind farm is not significant. The tower and nacelle are usually made from recyclable steel and copper. Materials used to construct wind turbines include steel, fiberglass, resin or plastic, iron, copper and aluminium. The magnets used in modern turbines are made using rare earths (primarily neodymium and dysprosium). Typically, 85% of a decommissioned wind farm can be recycled.

From a life cycle perspective, the blades (service life of 20–30 years) currently account for most of the non-recyclable waste (plastic polymer and composite materials) from wind turbines when they are decommissioned at the end-of-life, or when wind farms are being upgraded in a process known as repowering. The latter involves keeping the same site and often maintaining or reusing the primary infrastructure but upgrading with larger capacity turbines. During repowering, the blades might be replaced with more modern and typically larger blades.

Wind turbine blades are significant in size and disposing them at their end-of-life of blades involves a complex value chain with several steps and stakeholders. It has been forecasted that, by 2050, the end-of-life waste stream of wind turbine generator blades (from onshore and offshore wind farms) could, cumulatively, be as much as 43 million tonnes worldwide, with China possessing 40% of the waste, Europe 25%, the United States 16%, and the rest of the world 19%.[35]

Decommissioning, reusing, and repurposing blades should be addressed during wind farm planning and design (Figure 6.3), but can be a challenge for some countries,[36] requiring greater attention to value chain incentives and disincentives at national levels. In late 2021, Siemens Gamesa Renewable Energy launched the world's first fully recyclable wind turbine blade at its manufacturing plant in Denmark.

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[35] Liu and Barlow (2017)

[36] Beauson *et al.* (2022)

Figure 6.3: Section of a wind turbine blade repurposed as a bike shelter in Denmark

Source: Siemens Gamesa on Facebook (18 March 2021)

In 2023, Vestas, a wind turbine manufacturer, announced that it had discovered a new chemical process which removes the need to change the design or composition of the material used for wind turbine blades to make them recyclable.[37] It breaks down epoxy-based blades into raw material that can be reused to make new wind turbine blades or can be used for other purposes. Vestas plans to scale up the newly discovered chemical disassembly process into a commercial solution in partnership with other companies. If successful, this will eliminate the need for blade redesign, or landfill disposal of epoxy-based blades when they are decommissioned.

Land and ecosystem restoration

As discussed above, wind power development presents significant risks of environmental harm and degradation, e.g., unnecessary or excessive deforestation when constructing new access roads and transmission lines, destruction of habitats, and loss of biodiversity and ecosystem services as well as soil erosion and pollution. These risks become particularly high where mitigation measures proposed by an SEA (and subsequent project-level EIAs) are inadequate, ineffective, or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple wind farm developments across landscapes.

Such impacts will usually lead to demand for and need for land and ecosystem restoration (see Chapter 2, Section 2.6.6). This need will also arise at sites of projects that have come to the end of their useful operational life—usually after 30–40 years.[38] After this time, the project owner will either decommission the site, restore the area to its previous land use, or negotiate with landowners to repower or upgrade the equipment and extend the wind farm's operational lifespan. PPPs should include measures to ensure contract liability for project abandonment, that dedicated funds are set aside for decommissioning, and restoration by the project owners.

Scottish Natural Heritage has developed guidance for the preparation of decommissioning and restoration plans (DRPs) for onshore wind farms.[39] The guidance is focused on the process of producing a DRP and does not provide detailed advice on methods as each site will have different environmental conditions, as well as different turbine, track, and other infrastructure specifications. It is focused on natural heritage issues and does not provide guidance on matters such as health and safety or the reuse of materials.

Given that most existing wind power projects were installed to supplant power generation from conventional fossil fuel sources, and that they were likely to have been installed at the optimal

[37] See "Newly Discovered Chemical Process Renders All Existing Wind Turbine Blades Recyclable" (https://www.world-energy.org/article/29304.html)
[38] The average lifespan of wind turbine generators is about 20 years.
[39] Scottish Natural Heritage (2016)

location to maximize wind flow, it is likely that most wind projects will continue in the future with upgrades to equipment rather than decommissioning and restoration.

Transmission

Wind energy needs transmission. In Colombia, for example, wind projects encounter substantial barriers as development of transmission networks in la Guajira, the region where most wind projects are aimed for, is slow and cannot keep up with the current pipeline. The project developer has to ensure the connection of the project to the transmission system, but the transmission network is the responsibility of the transmission system operator.[40] Transmission is covered in more detail in Chapter 13.

6.4.3 Socioeconomic issues associated with onshore wind power development

Employment and labour conditions

Wind farm development projects can create job opportunities for skilled and unskilled workers in the host communities and from other places. In 2020, 1.25 million jobs were recorded in the wind industry. It is estimated that, globally, up to 7 million jobs could be generated by wind by early 2030.[41] This increase will continue in the next decades.

In Asia, the employment numbers are particularly high: 550,000 in the PRC and 40,000 in India. A British wind industry report [42] suggests that approximately 15%–20% of the project cost of a wind energy development is for labor, which requires skills[43] typically available from local contractors. Wind farm projects tend to create a relatively small number of employment opportunities for local workers (compared to other renewable energy technologies) during the construction phase, which is often not long (depending on size, between six and 20 months). More jobs can be created depending on the transmission line, substation, and access road requirements. The rest of the labor cost is for more complex and specialist tasks.[44]

The operation and maintenance of wind farms usually requires a very small number of staff and relies on specialist skills. Some companies use drones for wind farm inspections, reducing employment opportunities.[45] Depending on their location, some wind projects will have a large regiment of security staff (normally local) to patrol large areas.

Statistics provided by IRENA[46] do not include employment opportunities in the manufacturing and supply chains of wind turbine generators and blades. As demand for wind turbines increases, there will be more investment in extraction of the metals and minerals required to manufacture wind turbines, and thus more job opportunities created along the turbine supply chain line.

All projects have potential to involve unfair treatment and/or remuneration, discrimination in labor decisions, inappropriate recruitment, and poor working conditions.[47] There can also be unsatisfactory employment arrangements, especially for projects that involve complex supply chains of materials and various contracting tiers.[48] However, many wind projects are well-managed and mitigate such risks. The main infringements of labor rights during construction are related to requirements for excessive overtime and successive days of work without sufficient rest. In addition, some smaller wind projects may use casual workers who do not have sufficient training on the environmental and

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[40] Colombia 2023. Energy Policy Review (https://www.iea.org/reports/colombia-2023)
[41] IRENA (2021a)
[42] CSE (2009)
[43] These include supplying and pouring concrete, laying cables, and basic civil engineering tasks (such as tracks and hard-standing, foundations, trench digging for cables, basic construction for substation housing).
[44] Engineering consultancy, specialist craning, cables and sub-station equipment, bird and bat monitoring and, most significantly, the manufacture and assembly of the wind turbines themselves.
[45] Renewable Energy World (2017)
[46] IRENA (2021a)
[47] Rutherford, N. (2021)
[48] Actionaid (2018)

social management system to meet good international industry practice (GIIP). The sub-section on *human rights* discusses issues concerning the infringement of workers' rights in the supply chains of wind turbines.

Local economy and livelihoods

As with many development activities in rural areas, onshore wind projects often pose a range of risks associated with acquiring land for wind turbine generators, access roads, substations, and transmission lines. Additional land may also be required for associated facilities such as offices and storage sheds, although these are generally not large. During construction, there can be temporary land use needs for workers' accommodation, stockpiles, and laydown areas.

Land acquisition and restrictions on land use can cause both physical and economic displacement. There can be building restrictions (like transmission lines) for land closest to the wind turbine generators. Wind farms (whether linear or disparate) generally require a low amount of land-take. They can easily coexist with a range of land uses, e.g., agriculture and pastoralism.[49] Wind turbine generators typically have small footprints, so physical displacement (relocation) can often be avoided or minimized. In countries in Southeast Asia, wind farms do not appear so far to have caused controversy over land acquisition, nor to have had impacts on livelihoods. In other countries where wind farms have been developed on grazing land (e.g., Uruguay, Mexico, Kenya, and Mongolia), there has been minimal economic displacement or adverse impacts on affected people's livelihoods.

Wind farm companies frequently use leasing arrangements, entering negotiated voluntary land agreements. When a landowner is not interested, the company then modifies the micro-siting arrangements to work with others amenable to an agreement. Leasing agreements (usually for 20 to 50 years) allow companies to pay for smaller footprints (usually in acres) of wider land packages. Payments can combine installation fees for each wind turbine, including access rights plus annual payments.

Challenges can arise when a landowner makes an agreement with the wind company, but renters or neighbors are residing close enough to be affected by the noise or shadow flicker effects.
It is important that companies obtain valid land valuations. Wind projects in Central and South America have faced protests over land under communal use, including by Indigenous communities, when it has emerged that the projects have negotiated leases at rates that are below actual land value. In Mexico, where landowners and users cede their property permanently or temporarily for energy projects,[50] some community members have protested about previously agreed land access by erecting barriers to acquired plots during construction, causing project companies to renegotiate the land rates. The proposed scale of massive wind developments can also be problematic.

Wind farm construction generally requires a small workforce, using local workers plus some non-local workers with specialist skills for short periods of time. In most instances, the non-local workers will rent accommodation. In locations where availability of such housing is limited, rental prices can increase temporarily and a short boost to a localized economy may occur.

Wind farms have a rich history in communal ownership. In Germany, for example, ownership of wind capacity by local communities has been an essential part of primary societal support for *Energiewende* (Energy Turnaround), the energy transition system. In the Dutch Climate Agreement, the ambition is to attain local ownership of half of new installed capacity.[51]

In other regions, benefit sharing (including the payment of royalties) tends to be more typical for hydropower projects than wind. But the Windplan Groen project in Flevoland province in The

[49] The Dam Nai Wind Project - Vietnam (operated by the Blue Circle energy company) provides an example of combining rice cultivation and wind energy generation.
[50] Payan and Correa-Cabrera (2014)
[51] See Government of The Netherlands. "Climate Agreement" (https://www.government.nl/documents/reports/2019/06/28/climate-agreement#:~:text=The%20government%E2%80%99s%20central%20goal%20with%20the%20National%20Climate)

Netherlands is an example where local communities are allowed to invest in the project.[52] The conditions for the construction of the wind turbines of Windplan Groen state that local residents may participate in 2.5% of the total investment. The initiators do not borrow that amount from the banks but from residents who receive an interest payment for it. With a total estimated investment of 500 million euros, the neighborhood can therefore participate for approximately 12.5 million euros.

Health and safety

The IFC's environmental health and safety guidelines[53] recognize that wind turbine projects can pose health and safety risks for both the local workforce and the local community. This will require the imposition of appropriate safety regulations to manage key health and safety risks, such as working at heights.

Local workforce

Occupational health and safety hazards during the construction, operation and decommissioning of onshore and offshore wind energy facilities are generally like those of most large industrial facilities and infrastructure projects. During construction and operation, these may include physical hazards such as working at heights and falling objects, working in confined spaces, working with rotating machinery, remote locations, electrocution or burn risk, and lifting operations.

Some countries have detailed and strict health and safety processes and requirements for wind and other renewable energy development projects (e.g. The Netherlands), and accidents tend to be rare. But in other countries, regulations and requirements may be less strict and accident rates may be higher.

Public and community safety

The main community health and safety impacts are blade and ice throw, effects on aviation, electromagnetic interference and radiation, public access, and abnormal (large or oversized) load transportation.[54]

Blade throw is likely to occur very infrequently, often during storms or due to malfunction. Most of the blade throw would occur on the wind energy facility property. Ice throw can occur in colder climates when moisture freezes to the blade surface but dislodges during operation.

Another safety risk is the failure and collapse of wind turbine systems. Reasons for this are being investigated and may relate to production issues or the increasing size of blades and towers. However, this risk can be offset by incorporating into new turbines continuous monitoring systems that detect anomalous changes to operations and then automatically shut down.

If wind turbines need to be located near airports, military low-flying areas, or known flight paths, a wind energy facility (including anemometer mast) may impact aircraft safety directly through potential collision, or indirectly by requiring alteration of flight paths. Careful site selection minimizes these risks.

Wind turbines can also cause electromagnetic interference with telecommunication systems (e.g., microwave, television, and radio). This interference could be caused by path obstruction, shadowing, reflection, scattering or re-radiation. Further information on telecommunications and aviation is provided in the ensuing paragraphs on aviation and telecommunications in this chapter.

Safety issues may arise with public access to wind turbines (e.g., unauthorized climbing of the turbine) or to the wind energy facility substation. Adequate fencing and signage minimize this risk.

[52] Ibid.
[53] IFC (2015)
[54] Ibid.

One of the main challenges with respect to wind energy facilities lies with the transportation of oversized or heavy wind turbine components (blades, turbine tower sections, nacelles and transformers) and cranes to the site. Transportation of these oversized loads poses safety risks to the community if not planned and permitted, managed and escorted properly. It is important that these transportation plans are also discussed with local communities.

Gender and vulnerability

Areas with the highest wind power potential are remote deserts, plains, and mountain tops—often places with lower-income rural populations, marginalized groups, and Indigenous people. This can lead to displacement (see previous sub-section) and can impact women and vulnerable groups.[55]

There is considerably less physical and economic displacement associated with onshore wind projects than with other types of renewable power generation such as hydropower facilities or solar farms. There are plentiful opportunities for employment during the construction phase of onshore wind projects. It is calculated that there are 1.2 million jobs in the onshore wind power sub-sector globally, 56% of which are in the Asia region. However, only 21% of all global jobs in the sub-sector are held by women. Existing negative perceptions of gender roles and cultural social norms are seen as major barriers to gender equality in the sub-sector.[56]

Box 6. provides an example of a program that aims to promote more gender-inclusive planning processes, sub-sector employment, training, and skills development within the wind energy sub-sector.

It will become increasingly important to attain a "social license" to operate new wind farms and other renewable energy development. This is likely to be enhanced by developers providing benefit-sharing and meaningful community participation schemes for local communities.[57] In Suffolk and Essex in the UK, Galloper Wind Farm established three community funds for the benefit of local communities to support charitable, educational, and environmental activities in the Harwich area.[58]

Box 6.4: Women in Wind Global Leadership Programme

The Women in Wind Global Leadership Programme was launched in 2019 by the Global Wind Energy Council (GWEC), in partnership with the Global Women's Network for the Energy Transition (GWNET). It is designed to accelerate women's careers, support their pathway to leadership positions, and foster a global network of mentorship, knowledge-sharing, and empowerment.

Source: Global Wind Energy Council (https://gwec.net/women-in-wind/about-the-program/)

Indigenous communities

In areas where Indigenous people are located, the development of wind farm projects needs to consider the potential impacts on communal land and traditional practices. Most wind farms are not fenced and, because of their small footprints, there is usually minimal loss of access to natural and cultural resources such as sacred forests, burial grounds, and animistic sites. However, there are some high-profile cases where groups have protested about not being properly consulted and about their free, prior, and informed consent to wind farm projects not being sought. In Norway, the

[55] Differential impacts of displacement and access to any resulting benefits are explored in greater detail in the Hydropower: Gender and Vulnerability sub-section in this report.
[56] IRENA (2020)
[57] San Martin *et.al* (2022)
[58] See Community Funds, Galloper Wind Farm (https://galloperwindfarm.com/community/community-funds/)

Indigenous Sami people have been struggling to preserve their culture and identity as well as their main source of livelihood, reindeer husbandry, and claimed that a wind farm disturbed their reindeer husbandry.[59] In La Guajira, Colombia, Indigenous Wayúu people protested about wind farm companies which "grabbed" their sacred land, affecting their cultural identity and practices.[60]

Members of local Indigenous communities can benefit from some employment opportunities in wind farm projects, either during construction or operations. Provisions for skill development and industry participation programmes for the local and indigenous communities should be negotiated with wind energy companies during project planning and design. During operation, wind farms generally have very low permanent workforces. The Colombian Energy Transition Law of 2019 requires that companies in remote areas spend a share of project revenues within the municipality hosting the project.[61]

Cultural heritage

Wind farms and associated infrastructure such as transmission lines and access roads can cause damage to cultural, religious, historical and archaeological sites (both tangible and intangible heritage)—mainly during construction. However, there are substantial opportunities to design and microsite the turbines to avoid adverse impacts on cultural heritage. The process of seeking free, prior, and informed consent and broad community support can help to identify such sites and avoid adverse impacts on them. Cultural heritage features can also be designated as "no-go" areas during construction for added protection.

Telecommunications and aviation

Wind farms can interfere with electromagnetics, radar signals and telecommunications systems, including local mobile phone coverage and quality. The operation of wind farms may also disrupt aviation radar through signal distortion—with associated safety risks. The degree and nature of the interference will depend on[62]:

- The location of the wind turbine between receiver and transmitter.
- Characteristics of the rotor blades.
- Signal frequency.
- Air traffic control radar.
- Air navigation systems.
- The radio wave propagation in the local atmosphere.

Wind turbines are much larger signal reflectors than those actually targeted by radar systems. Their presence may hide weaker response signals from smaller targets. The rotating blades generate a Doppler shift which is also detected by radar systems. Radar systems are not designed to identify and filter out signals from wind turbines—so important information from the surroundings of a wind farm may be lost, as demonstrated in Figure 6.4. This can be due to the proximity of wind farms and telecommunication antennae.

The hub height for utility-scale, land-based wind turbines has increased 73% since 1998–1999 to about 98 metres (322 feet) in 2022. Wind turbine hub heights are expected to increase to 150m by 2035 as the technology improves.[63] So, if located near airports, military low-flying areas or known flight paths, a wind energy facility could create a risk of collision or require the alteration of flight paths.[64] Such impacts can be avoided and addressed through design, siting and mitigation measures such as marking systems and signal boosting equipment.

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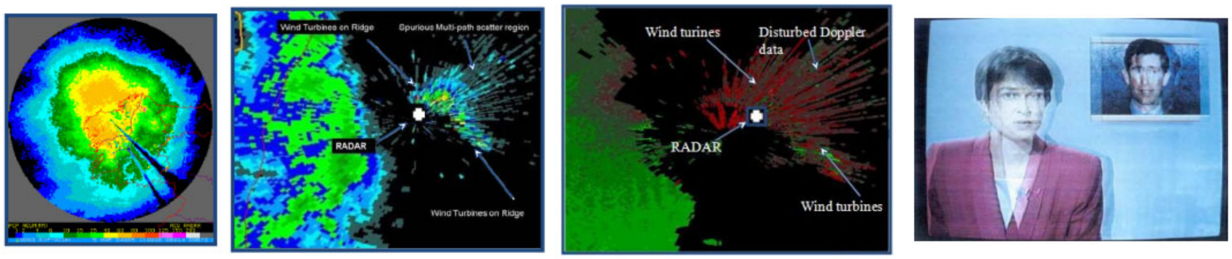
[59] Temizer, S. (2021)
[60] National Wind Watch (2021)
[61] Colombia 2023. Energy Policy Review (https://www.iea.org/reports/colombia-2023)
[62] See Wind Energy: The Facts "Electromagnetic interferences" (https://wind-energy-the-facts.org/)
[63] A wind turbine's hub height is the distance from the ground to the middle of the turbine's rotor. See Wind Turbines: The Bigger, the Better" (https://www.energy.gov/eere/articles/wind-turbines-bigger-better)
[64] IFC (2015 August)

Figure 6.4: Examples of the effects of wind turbines on weather radar, air traffic control, radio, and television

Source: Angulo et al. (2014)



There may be a legal requirement to place aviation warning lights at the top of wind turbines. These may "disturb" the night sky up to 30 km or more away from a wind energy facility, changing a dark rural night sky. Mitigation measures include blinkers (similar to what horses wear when walking alongside a busy road) or radar-activated lights when an aircraft comes in range. However, not all civil aviation authorities will accept such measures.

Public services and infrastructure

Communities near wind farms can be affected by the transfer of oversized and abnormal loads carrying large and heavy wind turbine parts (blades, turbine tower sections, nacelles and transformers). While this will be once and one-way during construction, such transportation can damage existing roads, viaducts, bridges, and road infrastructure (i.e., ditches, drains, culverts, traffic lights, and lamp posts). Permits from transportation authorities and often police or other escorts can be needed. In some instances, road upgrades may also be needed.

Human rights

Local infrastructure and facilities can be improved by the onshore wind companies' corporate responsibility investment programmes. If done right, there are numerous benefits of wind power to local communities including increased empowerment, job creation, infrastructure development and economic diversification. [65] An example of community development benefits from wind power is described in Box 6.5 for the Cookhouse Wind Farm Community Trust (CWFCT) in South Africa.

Box 6.5 Cookhouse Windfarm Community Trust

The Cookhouse Wind Farm Community Trust is a community-owned enterprise with business interests in wind energy, and it operates in the Eastern Cape province of South Africa. It is a channel for community interests through which the community participates and benefits from the Trust's initiatives. Its mandate is to provide broad-based, socioeconomic development and empowerment for the beneficiary communities of Adelaide, Bedford, Cookhouse, and Somerset East.

The trust has programs in agriculture, land and housing, education and development, health care, job creation, marketing and project management, welfare, and humanitarian causes. In 2023, the trust provided some R 4,500,00 in support to 30 schools in the beneficiary area.

[65] Munday *et al.* (2011)

Source: About Us: Cookhouse Wind Farm Community Trust (https://cwfct.co.za/about-us/)

There are significant human rights risks in the supply chains through which raw materials needed for wind farm equipment are sourced. The manufacture of onshore wind turbine components requires rare earths and other minerals. The process of extracting mineral resources for wind turbine manufacture can infringe upon the rights of indigenous and non-indigenous communities including, but not limited to, rights to land, land ownership, natural resources, customary land use and adequate living standards.

6.5 OFFSHORE WIND POWER GENERATION

6.5.1 Offshore installation types

Offshore wind has been in commercial operation in parts of Europe since the early 1990s. In 2021, globally, there was 57 GW of installed offshore wind power capacity.[66]

Offshore wind farms can be located tens of kilometers from the coastline. Construction generally involves foundation structures (e.g., piles or caissons) being installed into the seabed on which fixed wind turbines are mounted. Floating wind farms are also an increasingly more common option in some locations and can offer potential where there were previous technological constraints to deploying fixed wind power structures.

Large, specialized working vessels are used to undertake the foundation works of stationary farms and for the erection of wind turbines as well as to transport project components to offshore sites. Offshore turbines can also be built much taller than those onshore, as there is opportunity to capture energy from higher and more constant winds. The capacity of offshore wind turbines increased from 6 MW in 2019 to 20 MW in 2023 and also a further 25 MW of turbine capacity is in the developing stage.

Typically, offshore wind turbines are connected via submarine inter-array cables to export the electricity generated back to land (i.e., via a submarine alternating current export cable for distances up to 80 km from the coastline and direct current for windfarms further away than about 80 km) where it is fed into the electricity grid.

An intriguing opportunity is to look at converting abandoned offshore oil platforms to house offshore electrolyzers for the purpose of generating green hydrogen from electricity produced from offshore wind farms. [67] More information of the production of green hydrogen is provided in Chapter 11.

[66] GWEC (2022)

[67] See "World's first offshore green hydrogen project on an oil platform gets go-ahead" (https://www.rechargenews.com/energy-transition/worlds-first-offshore-green-hydrogen-project-on-an-oil-platform-gets-go-ahead/2-1-1043998)

Depending on the distance offshore of the wind farm, an offshore substation might also be required in addition to the onshore transmission components such as substations and terrestrial transmission lines.

Offshore wind farms have a high energy output per m^2 and can be built up quickly at gigawatt-scale, so they are increasingly viewed as a preferred option to provide electricity to densely populated coastal areas in a cost-effective manner. Developments in turbine technologies as well as in foundations, installation, access, operation, system integration and, more recently, floating platform technology have made possible the move into deeper waters and farther from shore. This allows selection of sites with greater energy potential and reduced viewshed impacts. Over the last 5–10 years, offshore wind has reached maturity, making it the most advanced technology among offshore renewables.[68] The advent of hydrogen production from floating windfarms may usher in a new era in which hydrogen produced by wind generated electrolyzers becomes the most important, cost-effective, and most environmentally and socially acceptable replacement for fossil fuel energy and the achievement of GHG reduction targets.

The largest windfarm in the world is being developed at Dogger Bank off the coast of England (see Box 6.6).

Box 6.6: Dogger Bank windfarm, England, UK

Dogger Bank offshore wind farm in the United Kingdom (UK) is being developed in three phases—Dogger Bank A, B, and C—located between 130km and 190km from the Northeast coast of England at their nearest points. Collectively, they will become the world's largest offshore wind farm. Each phase will have an installed generation capacity of 1.2 GW. Combined, they will have an installed capacity of 3.6 GW and will be capable of powering up to 6 million homes annually.

The investment in the Dogger Bank C wind farm is estimated to be £3bn ($3.99bn). A specialized Voltaire jack-up installation vessel with a lifting capacity of more than 3,000t was used to deliver the turbines and install them on foundations. The project will occupy an area of approximately 560km² and is expected to generate approximately 6TWh of clean and renewable electricity to be fed into the UK's national power grid. First power is expected in the third quarter (Q3) of 2025, while the wind farm will become fully operational in Q1 2026. Dogger Bank C will have an estimated operational life of approximately 35 years.[69]

6.5.2 Environmental issues associated with offshore wind power development

Table 6.3 summarizes the range of environmental and socioeconomic issues likely to be associated with offshore wind power development. While some issues concerned with construction and operation are the same as for onshore projects, others are unique to the marine environment.

[68] IRENA (2021b)
[69] See "Dogger Bank C Offshore Wind Farm, North Sea, UK" (https://www.power-technology.com/projects/dogger-bank-c-offshore-wind-farm-north-sea-uk/)

Table 6.3: Environmental and socioeconomic issues associated with for offshore wind power development

ISSUE	CONCERN
Environmental	
Protected areas	• Impact (incursion) on marine protected areas (MPAs). • The no-fishing zones that surround offshore wind turbines can function like MPAs by preventing the taking of local marine life.
Habitats and biodiversity	• Changes to benthic and pelagic habitats, e.g., as result of changes in water quality due to sedimentation from construction activities. • Impacts on fauna, e.g., bird strikes on spinning turbines for migrating and local birds (including internationally listed species) (offshore wind speeds tend to be faster and steadier than on land). • Changed food webs. • Some seabird species (e.g., sea ducks and loons) are reluctant to fly or swim near wind turbines, and may thus be displaced from key offshore feeding areas. • Offshore structures may disturb existing habitats and attract new habitat-forming species, such as shellfish, corals, and underwater vegetation. • Biodiversity impacts may also result from associated infrastructure (including underwater cables) and boat-based maintenance traffic (e.g., collisions with marine mammals). • Marine mammals and other marine fauna may be killed by construction or supply vessels. • Direct loss of habitat resulting from clearing for onshore component and fragmentation of habitat from access roads and transmission lines.
Noise and vibrations	• Noise and vibration (hammering) from construction (on seabed) can disrupt biodiversity. Unless adequately mitigated and monitored, underwater noise generated during offshore piling could cause temporary or permanent adverse impacts to the hearing and behaviors of cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals and sea lions). • Operational noise from offshore wind turbines can disrupt the behaviors and physiology of animals and fish and cause physical damage (mortality to damage of hearing tissues and other organs). • Anthropogenic noise can mask detection of biologically important signals used for communication, predator avoidance and prey detection, and can influence behaviors. • Aquatic animals may move out of a noise area, potentially disrupting foraging or breeding. • Sound (pressure) can travel a long distance in the sea and ocean. • Noise from construction traffic and use of machinery during construction of onshore component.
Air quality	• Emissions from vessels involved in construction.
Water quality	• Installation of foundations and sub-surface cables could disturb the marine floor, increase suspended sediments, and decrease water quality, which could affect marine species and commercial or recreational fisheries. • Dredging (e.g., possibly to an extensive amount) could be required depending on the offshore wind turbine generator area's bathymetry, foundation type and working vessel depth requirements. The disturbance and suspension of seabed sediment could have adverse impacts to water quality. • Releasing pollutants (fuels, oils, chemicals, etc.) during construction, operation or decommissioning; and from increased vessel traffic (to generation sites). • Release of contaminants from seabed sediments.
Greenhouse gases (GHG)	• Offshore wind power can reduce GHG emissions where it displaces coal or other fossil fuels as a fuel source.

ISSUE	CONCERN
	• GHG emissions from turbine manufacture, transport to site, maintenance, and decommissioning are low compared to reduction in emissions from equivalent fossil fuel energy.
Waste	• Construction and operation waste as well as waste metals and hazardous materials during decommissioning. • Wind turbine generator blades are made from unrecyclable composite materials and present a problem for disposal in most countries. However, new technology for recycling is emerging. • Failure to incorporate circular economy production and decommissioning elements in wind turbine and fleet design, e.g., turbine and blade lifetime, reuse and recycling standards or requirements.
Seabed erosion	• Installation of offshore structures may result in localized seabed erosion due to changes in water movements.
Mineral extraction	• Extraction of metals and minerals used for wind turbine manufacturing.
Visual and aesthetic impacts	• Turbines, pylons, and transmission lines change the landscape and disrupt the aesthetic value to the local communities. • May detract appeal of area for recreation/tourism.
Marine and ecosystem restoration	• Offshore wind farms have a 30–40-year lifespan after which restoration will be required, unless agreement is reached to repower or upgrade the equipment and extend the wind farm’s operational lifespan.
Socioeconomic	
Human rights	• Mineral mining companies (which supply wind turbine manufacturing companies) are reported to violate the rights of communities (e.g., rights to land, livelihood, ability to undertake traditional cultural practices). • Mineral mining companies are reported to employ forced and child labor.
Employment and labor conditions	• Employment opportunities for construction and operational phases. • Job opportunities generated by new investment in mineral extraction.
Health and safety	• Hazards to beach users during transportation and construction of the wind turbines, or from landfall of electrical transmission cables. • Road closures or disruptions when transporting wind turbine components to site. • Worker safety (e.g., working at heights, electrocution, and fire risk).
Local economy and livelihoods	• Loss of income from marine fishing. • Temporary and long-term loss of access to fishing areas and interference with offshore fishery rights (commonly held by communities or fishery associations). • More cost due to longer boat routes (direct routes to shore blocked by wind farm). • Local communities can gain through benefit-sharing schemes.
Gender and vulnerability	• Impacts on fishers. • Employment opportunities on new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies.
Recreation and tourism	• Interrupted and restricted access to public beaches and swimming areas.
Marine navigation	• Interference with vessel traffic and safety, particularly when located near ports, harbors, or known shipping lanes. • Interference with radar used for shipping navigation. • Impacts to ferry routes.
Other offshore activities	• Impact on existing offshore oil and gas and other mining infrastructure including the transport routes from helicopters. • Impact on existing and future electrical, data, and telephone cables. • Impact on/from military zones. • Impacts on offshore sand extraction sites.

ISSUE	CONCERN
Telecommunications and aviation	• Electromagnetic interference to telecommunications systems. • Potential to affect helicopter safety with direct collision or alteration to flight paths. • Some disruptions to aviation radar may be caused by turbines (e.g., signal distortion).
Public services and infrastructure	• Wind farm companies may fund improved local infrastructure. • Onshore bases will be required to support offshore wind development which could lead to loss of habitat and construction and operational impacts. • Pressure on local infrastructure due to heavy transportation of wind turbine equipment. • Increased pressure on public services, including health centers. • Increased local government tax revenues generated from wind farms.
Migration	• Gender-based violence due to an influx of predominantly male construction workers. • Pressure on pre-existing health services and infrastructure. • Onshore worker camps and accommodation cause social disruption.

Habitats and biodiversity

Some potential risks to habitat and biodiversity have been identified, including those documented by the IFC.[70] These include:

- ***Underwater noise*** impacts during construction (i.e., during piling, dredging, vessel movements) and operations. This can affect the hearing, echolocation, and behavior of fish, birds, cetaceans (whales, porpoises, dolphins), and pinnipeds (seals and walruses).

- ***Seabed (benthic) disturbance*** and new structures may also impact existing habitats and attract new habitat-forming species, such as shellfish, corals, and underwater vegetation[71] to colonize the disturbed areas.

- ***Water quality impacts*** due to sediment transport of cable laying and dredging activities as well as foundation works. This has potential to increase turbidity, which affects coral or seagrass ecosystems by reducing available light.

- ***Potential construction and operation impacts of hydrogen pipelines*** from offshore electrolyzer production platforms (or on an artificial island) to shore may impact benthic fauna and flora.

- ***Working vessels colliding with cetaceans and pinnipeds*** during construction. This can be addressed by keeping a knowledgeable marine mammal spotter on each vessel, raising the awareness of vessel crews about the risks, and implementing a well thought out marine traffic management plan (e.g., with speed limits, using routes that avoid key habitat areas).

- ***Permanent habitat loss*** due to disturbance and barrier effects on certain seabird species (including loons and sea ducks) when they adjust their behaviour to avoid offshore wind farms. In turn, this may limit or alter the way in which they utilize habitats and disrupt migratory paths or their movement between resting and feeding sites.

- ***Noise***. Mitigation measures to minimize the effects of noise during construction are well documented.[72]

- ***Potential behavioral and distributional changes to wildlife*** resulting from construction.

Other risks include:

- Where offshore wind farms have lights, these can attract birds at night.
- Where offshore wind farms are located near seabird colonies or between their colonies and foraging grounds.
- Collisions are potentially more likely under adverse weather conditions at sea with poor visibility.[73] [74]

Bird (seabirds and migrating land birds) and bat collisions with turbine blades are an expected impact of offshore wind farms, although the monitoring of bird or bat fatalities is more challenging than on land. In general, offshore wind farms are likely to have fewer such collisions than those onshore because (i) many potentially affected seabird species tend to fly low over the water surface, below typical rotor-swept area height (with some notable exceptions, such as the Northern Gannet *Morus bassanus* along the Atlantic coasts of North America and Europe) and (ii) the year-round density of birds that are especially vulnerable to wind turbine collisions is usually lower offshore (except in

[70] IFC (2015)
[71] Köller *et al*.,(2006)
[72] e.g., Scottish Natural Heritage (2019); German Federal Agency for Nature Conservation (2013)
[73] Hüppop *et al*. (2006)
[74] Note: it is difficult to detect collisions at sea and difficult to monitor potential collisions, especially in stormy weather (Bennun *et al.* 2021; Pellow 2017, 2019)

coastal migration corridors where large concentrations of migrating birds fly across water).

Offshore wind turbines are considerably taller with longer rotor blades resulting in higher tip speeds and turbulence.

There are similar risks for bats during migration and during offshore foraging of insects at sea, although these are often limited to specific regions and collisions are generally less prevalent than for bats at onshore wind farms.

Offshore wind farms may be located close to coastal habitats that host congregatory and migratory bird or bat species, e.g., river estuaries, wetlands, or islands. They can also be located near or within important regional or global flyways—flight paths used by large numbers of birds on a regular seasonal basis during their migration between their breeding grounds and overwintering quarters.

Wind farms located offshore require less land-take than onshore projects and, therefore, have less use change consequences and associated environmental impacts.

A beneficial aspect of an offshore wind farm is that its structures can provide substrates for the growth of new artificial reefs and habitat for marine life once colonized and established.

Protected areas

Offshore wind farms and their associated infrastructure can have negative impacts on protected areas at sea, by being located within a protected area, by deterring the establishment of new protected areas, or by having an impact on the environment near a protected area.

Impacts on protected areas are generally less than those caused by onshore wind turbines. The onshore components associated with an offshore wind farm typically include a cable landing point (on the coastal shore), terrestrial cables, and, if required, an onshore substation. If these onshore components are accessible by existing roads or cannot connect to existing transmission lines, new access roads and transmission lines may need to be constructed. The onshore footprint of offshore turbines is typically much smaller than that of most other power generation technologies. But there is still a potential risk (albeit of less likelihood/magnitude) of negative impacts on terrestrial protected areas if any of these components are within or close to such areas.

The density of offshore wind turbines, and their potential effects on protected areas can vary. Assumptions made in available literature about state-of-art and prospective capacity densities for European wind farms are in the range 5.0 – 5.4 MW/km.[75] Hence, even a modestly sized 100 MW offshore wind farm could require 20km^2 of offshore area. Such a significant area could potentially encroach on, or deter the establishment of, marine protected areas if offshore wind farms are developed at scale around the globe. The likelihood and significance of such impacts could be greater where fixed bottom offshore wind farms (requiring shallow water depth) are developed near coastlines or islands where there are protected marine areas.

Noise

During construction, noise can arise due to:

- Foundation works, particularly if piling methods (monopiles or jacket foundations) are used.
- Dredging and backfilling activities for cable laying or preparing foundation works.
- Offshore project activities such as vessel movements and equipment operations.

[75] See Interreg (2018) “Capacity Densities of European Offshore Wind Farms” (https://vasab.org/wp-content/uploads/2018/06/BalticLINes_CapacityDensityStudy_June2018-1.pdf)

Piling causes a significant amount of noise and vibration, which can cause temporary or permanent hearing impairment in marine species, including fish, cetaceans, and/or pinnipeds. Guidance developed by the United States National Marine Fisheries Services[76] provides underwater noise thresholds for peak sound pressure levels and weighted cumulative sound exposure levels. It discusses temporary threshold shifts (TTS), permanent threshold shifts (PTS), and onset thresholds for different groups of cetaceans (e.g., low-frequency, mid-frequency, and high-frequency cetaceans).

Breaching such thresholds can be a particular issue if piling occurs near or at known habitats of marine animals, but particularly for cetacean and pinniped species. Unmitigated underwater noise from piling can travel long distances at levels above the TTS or even PTS threshold. This risk is increasingly significant when greater hammer strength is used to install the ever-increasing large foundations for newer and bigger wind turbine generator models.[77] The impacts can be further exacerbated if piling is undertaken during a migration or breeding period, or in locations inhabited by protected species.

Dredging works and vessel movement also generate noise at levels and frequencies that depend on their nature, size, and speed. While noise from these sources is expected to have less impact than piling activities, it tends to be continuous, and the impact may be significant if it occurs simultaneously.

The noise and vibration caused by offshore wind turbines can have ongoing impacts on marine biodiversity. There is a risk that the behaviour and physiology of animals and fish will be impacted. The abilities of many marine species to use sound and vibrations to communicate, avoid predators, and detect prey may be impaired.

Air quality

Offshore (and onshore) wind farms generally have minimal impacts on air quality as they do not produce significant emissions of pollutants during their operation. Air quality impacts are limited to the construction phase, where there is a risk of dust from shore-based vehicular transport. With the limited scope of the onshore components of an offshore wind farm, these air quality impacts are typically unlikely to be significant (except where new ports with access roads, quays, and transmission lines, etc., are required).

Vehicular emissions from both onshore and offshore construction vessels and equipment have the potential to affect local air quality temporarily during construction.

Water quality

Offshore wind farms have the potential to affect marine water quality due to:

- Disturbance of the seabed for the installation of foundations and laying of sub-surface cables.
- Dredging works (including offsite dumping of dredged materials) to prepare an offshore area for foundations and vessel movements.
- Suspension of seabed sediment due to certain foundation construction methods such as use of suction caissons (an inverted bucket that is embedded in the marine sediment).

These activities can all cause the temporary suspension of seabed sediment resulting in the development of a sediment plume. Due to ocean currents and flows, these sediments can become suspended, transported, and deposited to distant areas, and cause impacts such as:

- Degradation of localized marine water quality due to an increase in total suspended solids (TSS) and decreased dissolved oxygen.
- Deposition of sediment and changes to available light for sensitive ecological receptors and areas such as corals, seagrass and coastal habitats (e.g., wetlands).

[76] NOOA (2018)
[77] Bellman *et al*. (2020)

Such impacts can have both direct and indirect consequences for marine life and ecosystems.

The release of pollutants such as fuels and oils from vessels involved in construction and maintenance can also have a negative impact on sea water quality.

Waste

As with onshore wind turbines, offshore wind farm developments generate waste during repowering and during decommissioning. This will be particularly true for turbine blades that come out of service and that will need to be transported to shore for landfilling or recycling.

Seabed erosion

The foundations of offshore wind farms can cause seabed scouring[78] due to a local increase in currents and wave motions which can stir up and suspend seabed particles and transport them away from the structure, creating a pit around the structure.

Apart from affecting the geotechnical stability of the foundations of wind turbine generators (in particular for monopiles), scouring also removes existing marine habitat and prevents new habitat creation.

Visual and aesthetic impacts

Depending on its location, between 0 and 20 km from the shore, a wind farm can alter the character of the natural seascape and visual setting. It may alter how local communities and visitors appreciate the seascape, especially if it is visible from or located near residential areas or tourism sites. Visual impacts associated with both onshore and offshore wind energy projects typically concern the installed and operational turbines themselves (e.g., color, height and the number of turbines).[79] Key factors that determine perceptions of wind farms depend on the proximity of turbines to the viewer and the viewing angles of wind turbines. Seascape visual impacts are largely associated with the siting and layout of wind turbines and related infrastructures, such as meteorological towers, onshore access, transmission line access tracks (if required), and substations.[80]

Tourism activities may also be negatively affected through restrictions on access to public beaches, swimming areas, and coastal recreational areas due to the construction of cable landing points, onshore substations, and transmission lines and easements. Careful design can often be implemented to minimize these effects.

Experience from offshore wind farm development 16-20 km off the Dutch coast showed that visitor use of beaches at Katwijk, Noordwijk and Zandvoort remained unaffected. [81]

Marine and ecosystem restoration

Currently, there is no single standard for the decommissioning and marine restoration of offshore wind farms. Regulatory standards, guidelines, and best practices for offshore wind farm decommissioning are based on existing standards from the maritime conventions and other industries such as oil and gas. Project plans for decommissioning have vague procedures.[82] The unique characteristics of individual sites require exclusive optimal solutions for each project. The basic components that need to be removed consist of wind turbines, foundations and transition pieces, sub-sea cables (export and

[78] van der Tempel *et al*. (2004)
[79] See “wind Energy. Offshore Impacts.” (wind-energy-the-facts.org)
[80] IFC (2015)
[81] E. Zigterman, personal communication (2024)
[82] Topham and McMillan (2016)

inter-array), meteorological masts, offshore substations, and onshore elements as well as any existing scour material. It is important to know what will be done with each of these components before the operations start: if they can be re-used or recycled as a first option, or disposed as final option.

The ecological impact of removing offshore structures at the end of life is unknown and is currently not investigated nor predicted in EIAs. It requires more investigation regarding maintenance of structures in place, especially if they come to provide an artificial habitat for various species.[83]

The lifetime of an offshore wind farm is expected to be 20–25 years. By 2021, only seven offshore wind farms had been decommissioned and only a few countries had experience of executing decommissioning projects.[84]

Marine spatial planning considers how existing windfarm structures can be enhanced to have conservation benefits, and how new developments could provide opportunities for such enhancement alongside site selection. There is evidence to suggest that the presence of windfarms, especially offshore, could in some cases be environmentally beneficial for certain species, such as by providing underwater structures for the development of artificial reefs (benefitting diverse marine life) and substrate habitat for shellfish such as oysters and mussels, and by providing perching areas for cormorants and other seabirds Thus, leaving certain offshore wind farm structures in place to benefit the marine life that has come to use them is an issue to be considered as part of any future decommissioning.

Post decommissioning, there will be a need for ongoing monitoring and management of decommissioned offshore wind sites.

6.5.3 Socioeconomic issues associated with offshore wind power development

Employment and labor conditions

As with onshore wind farms, offshore projects also provide employment opportunities for specialized skills, especially during the construction phase when significant workforces are required. Such opportunities increase during construction but decrease during operation. A study of offshore wind in Denmark found that from 2010 to 2022, the permanent labor requirements for offshore wind farms reduced from 19.0 full-time equivalent (FTE) staff per MW installed to 7.5 FTE MW installed.[85]

With the increase in construction job opportunities, there is a need for employers to manage the associated occupational health and safety (OHS) risks. These are addressed in the discussion of onshore wind energy employment and labor. There are additional risks when working on offshore wind farms—working over water and transport to offshore locations by helicopter or supply vessel.

Local economy and livelihoods

Offshore wind farms affect fishing and other aquatic-based or reliant livelihoods. The presence of offshore wind farms may limit the income of fisherfolk—either directly by prohibiting access around the equipment, or indirectly by temporarily restricting access to fishing areas (e.g., if fish populations are reduced due to the impacts of a wind farm) (Box 6.7). These impacts of offshore wind farms (e.g., creation of artificial reefs, energy landscape impacts) can occur during different project phases (Table 6.4). Offshore wind farms can also have an impact on fisherfolk’s costs (e.g., when detours must be made to get fuel).

[83] Hall *et al*. (2020)
[84] Adedipe and Shafiee (2021)
[85] Danish Shipping, Wind Denmark and Danish Energy (2020)

Box 6.7: Effect of offshore wind farms on fish yields and livelihoods

Offshore wind farms can affect fish populations positively or negatively, ultimately affecting fishing yields. When fish populations or fishing effort are reduced around offshore wind farms, this can have a knock-on effect on fishmongers and other jobs reliant on the fish industry. Reduced catches have direct impacts on food supply and can reduce the income security and well-being of fisherfolk households and have negative indirect economic impacts on the local community.[86]

There is also the potential for offshore wind farms to displace fishing effort. This is a major issue that SEA can consider, particularly with regard to the identification and development of leasing zones for fishing and making leases available for offshore wind development.

Table 6.4: Effects of offshore wind turbines on fisheries
Source: Gill et al. (2020)

	Construction	Operation	Decommissioning
Artificial reef effect		X	(X)
Fisheries exclusion effect	X	X	(X)
Fisheries displacement effect	X	X	(X)
Energy landscape effects*	X	X	X

*Energy landscape includes the sensory and physical energy environment
Brackets represent potential effects

Health and safety

An offshore wind farm can cause negative impacts on onshore community health and safety, particularly when located in an area where there is a high density of shipping movements, fishing vessels, and recreational craft use.[87]

Noise and shadow flicker from offshore wind turbines tends to be limited as they are usually installed far from the coastal communities.[88]

Gender and vulnerability

A recent study found that ethnic minorities and women were underrepresented in the offshore wind farm workforce in the Yorkshire and Humber region of the UK (Box 6.). A similar situation is likely to be found in other countries where the offshore wind industry is newer.

Box 6.8: Jobs in the offshore wind industry in the Yorkshire and Humber Region, United Kingdom

A recent study predicted that the number of jobs available in the Yorkshire and Humber region would increase from 1,500 in 2017 to 9,200 by 2032. At the same time, just 4% of the current workforce is from a Black, Asian, and minority background compared to 8.5% of the available employee pool. Females made up 22% of the workforce in 2017. The prevalence of men employed in the industry makes it important to assess the potential for gender-based violence and risky behavior resulting from an influx of predominantly male construction workers. The study recommended females and those from Black, Asian, and minority ethnic backgrounds should be encouraged into the industry.

Source: Murphy (2018)

[86] Bergström *et al.* (2014)
[87] See "Offshore renewable energy installations: impact on shipping" (https://www.gov.uk/guidance/offshore-renewable-energy-installations-impact-on-shipping)
[88] See Wind Energy: Offshore Impacts (wind-energy-the-facts.org)

There is a range of opportunities for local stakeholders (e.g., local governments, community cooperatives and affected minority groups) to derive benefits from offshore wind projects through skill development and benefit-sharing models.[89]

Marine navigation

The presence of offshore wind farms can present difficulties for marine navigation. They can interrupt marine traffic routes and activities located near ports, harbors, known shipping lanes, mooring locations, and commercial and recreational fishing grounds. If not properly managed, this can lead to marine injuries and casualties including death or loss of property—either at sea or among the onshore population. Wind farm installations can also be at risk of collisions with boats (Box 6.9). The disruption of navigation routes can cause economic loss due to the extra time needed for boats and cargo ships to access ports and can also delay supply chains of both non-consumable and consumable goods.

Box 6.9: Cargo ship collides with Hollandse Kust Zuid Wind Farm, The Netherlands

The Hollandse Kust Zuid wind farm consists of two sites, which are located between 18 and 36km off the Dutch coast, between The Hague and Zandvoort.

On 31 January 2022, a cargo ship and an oil tanker collided, resulting in one of them being left rudderless and later striking a platform foundation of the Hollandse Kust Zuid wind farm—two sites under construction off the Dutch coast. All personnel aboard the cargo ship were evacuated by helicopter. Reports of the accident made no mention of staff working on the foundation at the time of the collision and damage was still being assessed.

Source: Russell (2022)

Aviation and telecommunications

Offshore wind farms can present safety risks for low-flying aircraft, requiring the rerouting of flight paths. They can also cause signal distortion and interfere with aviation and ship radar as well as cause electromagnetic interference to telecommunications and broadcasting systems (Box 6.10).

Box 6.10: United Kingdom's Maritime and Coastguard Agency and offshore wind farms

According to the United Kingdom's Maritime and Coastguard Agency, mariners and organizations require consistent and effective radio communications systems. If they are within close range of an offshore wind farm, they should be able to rely on marine navigation systems as much as if they were in the open sea. However, these systems may be affected by wind turbines. In the UK, to mitigate these risks, the government requires using temporary safety zones during construction, major maintenance and decommissioning. The agency's website indicates that permanent safety zones are not expected to be established around entire wind farm groups, though for single installations this may be considered.

Source: GOV.UK Maritime & Coastguard Agency (www.gov.uk/government/organisations/maritime-and-coastguard-agency)

[89] IFC (2019b)

Public services and infrastructure

As with onshore wind farm projects, offshore wind companies may contribute to improving local public services and infrastructure. The construction, operation, and maintenance (O&M) processes for offshore wind farms may require upgrades to public infrastructure such as roads and ports, which can generally be a net positive impact for those locations. Offshore wind farms can also contribute to increased revenue for local governments through being taxed. Onshore supply bases will also be required to support the offshore construction and operation of wind farms.

Human rights

Typically, as for onshore wind farms, wind turbines (generators, towers, blades, nacelles, gearbox) require metals and minerals that mining companies may extract from countries where human rights are poorly upheld. Wind farm companies need to address this issue through due diligence, examining the activities of their wind turbine and blade suppliers, and imposing requirements on suppliers to eliminate and remedy adverse human rights impacts.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 7

SOLAR POWER

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IAIA
International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 7

SOLAR POWER

7.1 WHY SEA IS IMPORTANT TO SOLAR POWER

An overall rationale for why it is important to use strategic environmental assessment (SEA) to support the energy transition is provided in the preface to the guidance.

SEA can provide critical information to support better decision-making for solar power planning and development, including identifying where there may be implications for policies, plans, and programs (PPPs) to adequately address significant environmental and/or socioeconomic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple solar power schemes/developments whether alone or in combination with other renewable energy technologies (e.g., wind energy).

The SEA process will:

- Identify and focus on key environmental and socioeconomic issues and the concerns of likely affected stakeholders, including local communities, vulnerable groups, and indigenous peoples. Major issues are discussed in detail in Section 7.5 and are summarized in Table 7.2.
- Identify/recommend if there are areas that should be avoided for solar power development ("no-go" areas) because of particularly high risk to the environment, habitats/biodiversity, and/or people/communities.
- Identify what changes or additions are required to PPPs governing solar power development to address these risks.
- Make subsequent project-level Environmental Impact Assessments (EIAs) and Environmental and Social Impact Assessments (ESIAs) more efficient and cheaper by addressing the big picture regarding potential upstream, downstream, and cumulative impacts and identifying the particular issues that individual solar power project EIAs/ESIAs should focus on in more detail. This may also include spatial planning recommendations for optimal siting of solar power projects to minimize these risks and impacts. Such project-level EIAs/ESIAs should identify/recommend mitigation measures to avoid, minimize/reduce negative impacts, compensate, offset, and restore/rehabilitate land at the end of a project, as well as to enhance positive impacts and benefits.
- Engage stakeholders who may be affected by solar power developments (particularly in areas where solar power potential has been identified) to be informed early of proposed or possible policy options or plans, and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for solar development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

7.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE SOLAR POWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for IAIA was unable to identify any guidelines specifically focused on the solar power sub-sector.

The US Department of Energy provides guidance for preparing a programmatic environmental impact statement (PEIS) to assess environmental impacts associated with the development and implementation of agency-specific programs that would facilitate environmentally responsible utility-scale solar energy development in six western states.[1] [2]

A number of guidelines and papers address project-level IA for solar power developments and for large-scale solar energy development proposals.[3]

7.3 SOLAR POWER INSTALLED CAPACITY

In 2022, the world had in excess of 1,053 gigawatts (GW) of installed capacity. By far China had the most capacity (393 GW), followed by India (63 GW), Brazil, Spain, Mexico, and Chile (all <20 GW each).[4] Capacity by region is indicated in Table 7.1.

According to the International Energy Agency (IEA), solar is on track to set records for new global deployments each year after 2022, with an average 125 GW of new capacity expected globally between 2021 and 2025.[5]

Table 7.1: Installed solar power capacity by region, 2021
Source: Our World in Data (2023)

Region	Installed capacity (GW)
Africa	12
Asia	620
Australia	27
Europe	230
Middle East	13
North America	130
South America	33
Oceania	27
Central America & Caribbean	4
World	1,053

Note: The regional totals cannot be summed to derive the World total as parts of some regions (e.g. Oceania) may already have been counted as parts of other regions.

7.4 BACKGROUND TO SOLAR POWER GENERATION

Solar photovoltaic (PV) technologies convert sunlight directly into electricity using photovoltaic cells.

Concentrating solar power (CSP) technologies use a mirror configuration to concentrate the sun's light energy onto a receiver and convert it into heat. The heat can then be used to create steam, which either drives a turbine to produce electrical power or is used directly as a source of power.

Solar PV generation can be:
- Installed on rooftops (distributed solar).
- Integrated into building designs (such as solar parking lots).
- Installed at utility-scale on land (ground-mounted), including on agricultural land (Agri-PV).
- Installed as floating solar (FPV) with PV panels installed on platforms or membranes on a body of fresh water or in a marine environment.[6]

FPV is still considered a niche technology, but it is a growing industry. According to IRENA (2021b), annual growth is expected to be 20% per year until 2024. Market data collected by Solar Power Europe (2023) indicates that total cumulative capacity reached 5.7 GW on a global scale in 2022—a

[1] Arizona, California, Colorado, New Mexico, Nevada and Utah.
[2] For more information, see "Why the Solar PEIS Is Needed" (https://solareis.anl.gov/eis/why/index.cfm).
[3] e.g., Bennun *et al*. (2021) and NSW Government (2017).
[4] Our World in Data (2023)
[5] NSEnergy (2021)
[6] IFC (2012d)

68% increase relative to 2021. FPV projects are being pursued in around 60 countries around the world[7], such as the Da Mi project in Vietnam (see Box 7.1).

Box 7.1: Da Mi floating solar energy project, Vietnam
Source: ADB (2018)

The Da Mi Reservoir is Vietnam's first floating solar farm. The project was connected to the grid in 2019. The project has a total capacity of 47.5 megawatts (MW) peak and power generation of about 70 million kilowatt-hours per year. It comprises 143,940 solar panels on 50 hectares of the reservoir in the Tanh Linh and Ham Thuan Bac districts of Binh Thuan province, approximately 220 kilometers northeast of Ho Chi Minh City. The project life cycle is expected to be 25 years. In 2018, the Asian Development Bank (ADB) approved a $17.6 million loan for the project.

Figure 7.1: Da Mi Floating Solar Energy Project, Vietnam

Photo: Courtesy of ADB

Solar generation can be integrated with thermal or electrical energy storage systems (e.g., batteries, compressed air, green hydrogen, or molten salt, which works as a medium to store solar thermal energy) that can provide power during cloudy periods or the hours of darkness. This ability to store solar energy makes solar power a flexible and dispatchable source—one that can be ramped up or shut down in a relatively short amount of time—of renewable energy. Large solar farms require a substation and connection to the electricity grid via a transmission line. Access roads are also often needed.

A solar farm requires much less maintenance during operation than other renewable energy sources, although the panels require periodic repair and cleaning and vegetation between PV arrays may need to be cut/trimmed. Solar cells and storage batteries have an operational lifespan of approximately 20–30 years.

Recycling of PV panels

A solar farm can create large volumes of waste. While panels and batteries can be recycled, the process is complex, costly, and not yet fully established in many countries, so they are often disposed of in landfills. However, in Europe, significant steps have been taken to regulate recycling (see Box

[7] IRENA (2021a)

7.2). There are compulsory takeback schemes in certain US states, and a number of PV module producer companies also offer takeback schemes.[8]

Box 7.2: Recycling of PV panels
Source: EC (2024)

In Europe, recycling of PV waste was incorporated into the European Union's Waste Electrical and Electronic Equipment (WEEE) Directive in 2012. The Directive established that at least 85% of end-of-life waste must be collected and, from that, 80% must be reused and recycled. The EU Ecodesign rules for PV—expected to be adopted in Q4/2024—will significantly affect the availability of spare parts, the repairability of inverters, and improve the overall sustainability performance and reliability of PV products.

PV modules are currently recycled in existing facilities designed for glass or metal materials, although a few dedicated PV recycling plants have emerged in recent time. Glass and aluminum (materials that comprise 90% of the module´s weight) are typically recovered. The plastic component goes through energy incineration, harnessing energy.

There are several materials, including silver, zinc, tellurium, indium, and gallium, which make up only a small percentage of the module's total weight but hold significant value. Recovery of these materials is the true challenge. Methods are being developed to recover these materials. With an increasing waste stream likely to be produced from PV in the coming years, the recovery of materials of small weight will become more cost-effective, allowing improved purity of existing recovered materials.

Recycling of batteries in the EU is prescribed by the EU Regulation 2023/1542.[9]

As discussed in Section 7.5.1, the waste produced during the operation and decommissioning of CSP can more easily be recycled. The significant quantities of thermal conducting fluid required is a potential hazard and requires disposal.

Materials in solar panels

The two main types of PV technology are crystalline silicon and thin film.

Crystalline silicon modules account for 95% of installed capacity.[10] Production of these modules notably requires silicon, silver, and plastic materials. Small amounts of other materials, such as lead, nickel, zinc, boron, antimony, and germanium are needed (dependent on the concrete module subtype).

The main thin film module types include CdTe (CadmiumTelluride), CIGS (copper-indium-gallium-diselenide-disulphide), and amorphous silicon. CdTe modules are composed of 80-85% glass (by weight); the rest of the composition can contain aluminum, copper, antimony, cadmium, tellurium, and other minerals.[11] CIGS and amorphous silicon are considered niche markets, and their share of global demand is very small at present.

The manufacturing process can involve a number of hazardous materials, including acids and other compounds. Thin film module type CIGS contains gallium arsenide—a key chemical that can absorb relatively more energy in some solar panels—which is toxic.

[8] For more information, see the SEIA National PV Recycling Program (https://www.seia.org/initiatives/seia-national-pv-recycling-program).
[9] See europa.eu for the full regulation details.
[10] Bobba *et al.* (2020)
[11] IEA (2022e)

Examples of solar projects

Box 7.3 provides examples of other solar energy projects in Southeast Asia.

Box 7.3: Examples of solar energy projects in Southeast Asia

Sources: ADB (2013, 2021, 2023, 2023b)

The 240-MW B.Grimm Dau Tieng Solar Power Project occupying 270 hectares of land in the Tay Ninh Province of Vietnam started operation in 2019.

The 73-MW Central Thailand Solar PV farm has been in operation since 2012 (see Figure 7.2).

The 60-MW Rooftop Solar PV project undertaken by Green Yellow Energy in Thailand will see 92 Solar PV systems located on the premises of industrial buildings and facilities.

Figure 7.2: Central Thailand PV: Solar Power Project - Thailand's First Solar Power Facility

Photo: Courtesy of Gerhard Joren/ADB

Another form of solar power generation is through solar evaporation ponds (see Box 7.4).

Box 7.4: Solar evaporation ponds

Sources: Kuchta (2023), BTL Liners (n.d.)

A solar evaporation pond is a saltwater pool that can be used to produce and store thermal energy. Such saltwater ponds form a natural vertical “salinity gradient,” known as a halocline. In these ponds, the bottom is lined with salts, as much as a few meters deep, which are then heated naturally by the sun. Because the salts are heavier than water, they remain at the bottom of the pond, while the cooler top layer of water acts as an insulator of the heat generated below. As long as the upper layer of water remains clear and free of salt, sunlight can penetrate to the bottom of the pond. Solar rays heat the water at the bottom of the pool, making it less dense than the water above it, and a process known as convection occurs naturally.

Salt is added to solar ponds to saturate the lower, warmer water which can reach temperatures up to 900^{o}C. The upper layers of low-salinity water, with much lower ambient temperatures, do not mix readily with the hot, high-salinity water, which is then pumped out to be used in a turbine to generate electricity or as a source of cost-effective thermal energy. The process is relatively simple and has been highly effective in generating electricity in rural areas of developing countries.

Generating electricity from rooftop panels (distributed system) has greater flexibility in size and location than utility-scale systems. However, while rooftop solar can supplement utility-scale solar, it cannot replace it. Nevertheless, rooftop solar provides greater resilience when considering potential hazards to the distribution system related to climate change, such as fires, icing events, or strong wind. Decision makers will need to consider whether utility or distributed scale systems are the right choice in particular locations, or what mix of these two is appropriate. The collective benefits associated with distributed systems may outweigh the impacts and risks of utility-scale power generation.

Over one-third of new solar PV capacity installations worldwide are rooftop attachments. The share of rooftop solar reached a peak in 2018, when 43% of all solar panels deployed that year were fitted on residential and commercial buildings. In Europe, this share is significantly larger, where rooftop solar accounted for 66% of both cumulative and annual installations in 2023.[12] China and the United States are expected to account for the greatest rooftop solar capacity additions in the next few years.[13]

7.5 IMPACTS OF SOLAR ENERGY DEVELOPMENT

During scoping for an SEA, key issues regarding solar power development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) (see Chapter 2, Section 2.5.1), which address these issues and will be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other solar power development applications, solar irradiation profiles, meteorological data, etc.), interviewing key informants, and holding stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing existing solar power development projects.

At the individual project level, these issues will be the focus of an EIA, which should recommend how to manage, avoid, or minimize/reduce potential negative impacts, compensate and offset for them, and restore/rehabilitate land at the end of a project, as well as enhance positive impacts and benefits. This guidance does not aim to present detailed options or opportunities for project-level mitigation, as they are often project-specific. Defining such options is a function of project-level EIAs.

While solar power, like other renewable energy technologies, has the potential to give rise to negative impacts (as indicated in Table 7.2), the replacement of coal and other fossil fuels by solar power and other renewable energy technologies will have the overall effect of reducing many of the negative impacts associated with fossil fuels, particularly those relating to carbon dioxide (CO_2) emissions.

Ideally, before individual solar projects are approved, an SEA of a policy, plan, or program (PPP) for the solar power sub-sector should be completed. This will involve the assessment of multiple projects, schemes, and activities: some directly concerned with the construction and operation of sites and facilities; others linked to associated infrastructure (e.g., transmission lines, access roads). Thus, there is a risk that the impacts of individual solar power developments/projects may become highly significant as they become cumulative. An SEA should focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual solar power applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

[12] SolarPower Europe (2023)
[13] Fernández (2023)

Table 7.2 summarizes the range of possible environmental and socioeconomic issues likely to be associated with solar energy development. In the planning and design of a solar power facility, all these issues should be addressed (particularly during project-level EIA) and measures identified and incorporated to avoid, minimize, mitigate, compensate, and offset them and to restore land when the project ends. In general, mitigation measures are not discussed in this section.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 7.2: Environmental and socioeconomic issues for solar power

ISSUE	COMMENT
Environmental	
Air quality	• Soil disturbance and traffic on dirt roads create dust. • Dust is generated during the construction phase. • Release of soil-carried pathogens and an increase in air particulate matter can contaminate water reservoirs.
Greenhouse gases	• Solar power can reduce GHG emissions where it displaces coal or other fossil fuels as a fuel source.
Noise and vibration	• Noise and vibration are caused by construction traffic and the use of machinery.
Soil erosion	• Construction on vast areas of land can result in soil compaction, alteration of drainage channels, and increased erosion. • Solar panels can contribute to limiting soil erosion (e.g., on degraded land) and improving soil health.
Water use	• Increased water demand for cooling central towers in concentrating solar thermal plants (CSP) and cleaning of photovoltaic (PV) modules can be problematic, particularly in arid areas. • Agri-PV can achieve water savings by installing water collection systems and reusing water for irrigation purposes. • Water usage can be reduced as a result of panel shading.
Water quality	• Potential river or groundwater contamination can happen through leakage of potentially hazardous chemicals used in thermal conducting fluids, semiconductors, and storage batteries.
Land-use change	• Large areas required for developments (usually 1-2 hectares per MW) can mean a loss of productive land, although the land actually occupied by panels and their supporting structures is much smaller than the total solar farm area.[14] • Agri-PV can potentially increase land use productivity by combining energy generation and agricultural production.[15] • Earth movements may be required for site levelling. • Displacement or destruction of existing livelihood activities and physical structures is possible.
Habitats and biodiversity	• Construction of access roads and transmission lines can result in land clearance and loss and/or fragmentation of habitat and present a collision and electrocution risk for bats and birds. • Increased access to remote areas may increase hunting/poaching and introduce invasive alien species. • Associated infrastructure, particularly transmission lines, can result in collision and electrocution. • Habitat below solar panels may be altered due to shade conditions. • Panel shading at agri-PV sites can: protect crops and animals from adverse weather impacts like droughts, direct sunlight, and hail; increase crop yields—up to 60% increase has been recorded in Europe; and improve soil moisture retention, especially in dry regions. [6] • Well-designed and managed solar (PV) farms can increase biodiversity.[16] • Concentrated solar power beams can cause incineration.

[14] The proportion of land occupied by solar PV structures is typically 2.5%. See Bonadio J., Popa A., and Weiskopf V. (2021).
[15] Livestock such as sheep can graze amongst the PV arrays. For more information, see SolarPower Europe's Agrisolar Best Practice Guidelines (https://www.solarpowereurope.org/insights/thematic-reports/agrisolar-best-practice-guidelines-version-2-2) and Fraunhofer Institute for Solar Energy's Agrivoltaics Guidelines (https://www.ise.fraunhofer.de/en/publications/studies/agrivoltaics-opportunities-for-agriculture-and-the-energy-transition.html).
[16] For specific examples, see Helapco's 2016 study "The effects of solar farms on local biodiversity" (https://helapco.gr/wp-content/uploads/Solar_Farms_Biodiversity_Study.pdf), Solar Energy UK's 2019 report "The Natural Capital Value of Solar" (https://solarenergyuk.org/resource/natural-capital/), and BNE's 2020 study "Solar parks – profits for biodiversity" (https://www.bne-online.de/study-solar-parks-profits-for-biodiversity/).

ISSUE	COMMENT
	• Solar plants typically have security perimeter fencing installed, which can cause additional habitat fragmentation, especially for mammals and reptiles (e.g., tortoises), and act as a barrier to movement/migration.
Wastes (hazardous and non-hazardous)	• Broken or end-of-life solar panels containing heavy metals require recycling or disposal to landfills. • Storage batteries contain hazardous substances and heavy metals, and discharges can occur in the event of damage. • The recycling potential for batteries varies across regions of the globe. • Small-scale spills of oils or other substances during construction, maintenance, and operation are possible. • The manufacturing process of PV cells includes several hazardous materials, most of which are used to clean and purify the semiconductor surface. However, the spilling risks are limited.
Mineral extraction	• Over-extraction of minerals used for solar PV panel and battery manufacturing is possible.
Visual and aesthetic impacts	• Solar PV reflection can damage the sight and vision of community members. • Solar infrastructure disrupts the aesthetic view and landscape of the host community.
Land and ecosystem restoration	• Most current solar panels are designed to last for more than 25 years, after which land restoration will be required unless negotiations with landowners result in agreements to repower or upgrade the equipment and extend the solar farm's operational lifespan.
Socioeconomic	
Human rights issues	• Some mineral mining companies (which supply solar PV companies) are reported to violate the rights of communities (e.g., rights to land, livelihood, and ability to undertake traditional cultural practices). • Mineral mining companies are reported to employ forced and child labor. • Some solar companies are accused of exploiting forced labor in the manufacturing of solar panels and equipment.
Local economy and livelihood	• Land acquisition may result in relocation of people and their structures. • New development can increase pressure on the host communities' public services. • Large amounts of land will be acquired, displacing the livelihood activities of affected communities (e.g., rice cultivation). • Displacement can lead to a loss of income from fishing activities, rice cultivation, and other farming activities and from small business and enterprise activities. • Rural communities may lose access to grazing land (used on either a formal or informal basis) for cattle and livestock. • Land and property values often increase within the vicinity of solar farms. • Local communities can gain from benefit-sharing schemes with solar PV companies. • Local access to low-cost electricity can stimulate the local economy and livelihood opportunities.
Employment and labor conditions	• Job opportunities may be provided to the local communities on solar farms (mainly during construction). • Job opportunities may be generated from new investment in mineral extraction.
Cultural heritage	• A loss of cultural, religious, historical, and archaeological sites and properties (e.g., when land appropriated for solar farms is destroyed or damaged due to transmission lines and access roads) is possible. • Limits on access to cultural heritage sites are possible.
Health and safety	• Inhalation of silicon dust during PV cell manufacture can cause health issues. • High-voltage electricity transmission lines from the solar PV farm can cause safety issues for the communities during construction and operation (e.g., electric shocks from touching live cables). • Solar PV reflection can cause glint and glare issues for communities.

ISSUE	COMMENT
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk. • New projects can provide employment opportunities and opportunities for vulnerable groups to acquire new skills and learn new technologies (e.g., solar PV).
Access to water	• Increased demand on clean water. • Communities may experience limited access to clean underground water (i.e., when water is extracted for cleaning panels).
Migration	• New workforce may lead to introduced diseases, inappropriate cultural behavior, etc. • Workforce migration may put pressure on pre-existing health services, infrastructure, equipment, human resources, essential drugs, etc. • Tension between immigrants and workers is possible. • Gender-based violence may increase due to an influx of predominantly male construction workers.
Public services and infrastructure	• Loss or relocation of public services and infrastructure on land acquired for solar farms may be required. • Improvement to infrastructure, including roads and bridges, schools, health centers, and administrative buildings, may occur with community investment by solar companies. • Pressure on public services and infrastructure can increase as a result of immigration. • Heavy vehicles and transportation can damage existing roads and bridges. • Increased vehicular traffic during construction is possible.
Aviation	• In some circumstances, concentrating solar power systems could potentially cause interference with aircraft operations if reflected light beams become misdirected into aircraft pathways.

Note: Some of the above-mentioned construction impacts would apply to multiple renewable energy projects, not just solar.

7.5.1 Environmental issues and impacts

Land use change

Utility-scale, ground-mounted solar PV can require significant areas of land for development of an asset. However, the proportion of solar farmland actually occupied by PV panels and their supporting structures remains limited—about 2.5% of total solar farmland.[17] The amount of land required to satisfy electricity demand in the EU in 2021 remained limited—only 0.26% of all the land in the EU.[18]

A study conducted in the United States in 2013[19] found that:

- A large, fixed-tilt PV plant that generates 1 gigawatt-hour per year requires, on average, 2.8 acres (1.14 hectares) for the solar panels. This means that a solar power plant that provides all the electricity for 1,000 homes would require 32 acres (12.9 hectares) of land.

- Small, single-axis PV systems require, on average, 2.9 acres (1.17 hectares) per annual gigawatt-hour, or 3.8 acres (1.5 hectares) when considering all unused area that falls inside the project boundary.

- Concentrating solar power plants require, on average, 2.7 acres (1.1 hectares) for solar collectors and other equipment per annual gigawatt-hour, or 3.5 acres (1.4 hectares) for all land enclosed within the project boundary.

Solar parks require land for the panel arrays (see Box 7.3).

Box 7.5: Land required for solar panel, Benban Project, Egypt

Source: NS Energy (2018)

The 1,800 MW Benban solar park is one of the largest solar projects in the world. It covers 37 km^2 in Aswan Province in southern Egypt. This project was constructed to reduce Egypt's reliance on fossil fuels and to help the country meet its carbon reduction commitments made as nationally-determined contributions under the Paris Climate Agreement. The project is expected to reduce the nation's carbon dioxide output by around 2 million tons per year.

The solar park has PV panels that vary in size from 1,200 x 600 mm to 2,000 x 1,000 mm. The project acquired land for the control center, water supply pipeline, transmission line, and substations (three substations required 15,000 m^2, and a fourth substation will require an area of 50,000 m^2 for its transformers and switchgear).

Despite the solar park being built in a desert, the scale of the project could lead to many environmental and social impacts, many cumulative (e.g., significant volumes of construction traffic leading to road safety issues, the accumulation of construction wastes, and issues regarding the discharge of wastewater on such a large development). The project also provides considerable employment opportunities for local people.

Floating PV has the benefit of limiting terrestrial land-use change. But there will still be some land-take associated with transmission lines and other project components that need to be located on land. Combining floating PV with other energy-generating projects (e.g., floating PV in combination with hydropower dams, wind, etc.) can minimize the need for additional grid infrastructure and instead

[17] Bonadio *et al*. (2021).
[18] SolarPower Europe (2022). Note: Assumes 2021 values for EU power demand (i.e. not accounting for future electricity demand increase) and assuming 50% of solar capacity is installed on rooftops and 50% on land
[19] Ong *et al*. (2013)

utilize the existing one.[20] The majority of floating PV projects to date have been installed on artificial water sources (e.g., reservoirs), but momentum is picking up for installation of floating PV in the marine environment.

Rooftop-mounted solar PV has the benefit of making use of existing roof space and thus does not require additional land-take. While rooftop solar systems are small in size compared to utility-scale solar ground-mounted applications, they still account for the majority of installed capacity in the EU, with 65.9% in 2023 cumulative installations and 66% annual installations in 2023.

Agricultural lands and grasslands are most often considered for solar farm sites, as they generally have suitable topography and require minimal clearing. These lands may support the livelihoods of local communities in rural areas and industries or may be important for biodiversity, including rare and threatened species. However, certain areas should be avoided for the development of solar farms, including native grassland ecosystems, ridge tops, riparian areas and watercourses, protected areas, and known wildlife corridors within the footprint of a solar power project.[21]

In addition to having a socioeconomic impact, the loss of agricultural land can result in a shortage of local and regional supplies of agricultural products.[22] On the other hand, there is also considerable potential to combine solar farms with agriculture. There are many potential benefits, from using water associated with cleaning panels for agriculture, to solar panels providing shade, and to panels providing mitigation from extreme rain events and limiting soil erosion. A number of agri-PV projects have shown an increase in crop yields, water efficiency, land efficiency, and overall improvements of social and economic aspects of the farms.[23] There is also emerging use of semi-transparent panels that have the potential to improve integration with agriculture.[24] Furthermore, there are good examples of solar farms sharing the land with other uses, such as sheep and fish farming.

The significance of land-use changes following the development of a solar farm depends on the value of the pre-existing land-use. The siting of a solar farm on land with high value for biodiversity or to society would amplify the negative impacts of the development.

Increased mining of raw materials needed for the manufacture of solar PVs will have implications for land-use change, as well. Such impacts are discussed further in the section on mineral extraction.

Habitats and biodiversity

The development of a solar farm (including associated transmission and access infrastructure) will often require the clearing of vegetation. This can cause the removal of habitat for flora and fauna and cause mortality and displacement to other nearby areas during both the construction and operational phases of PV and CSP projects. However, well-designed and managed solar farms can avoid impacts on biodiversity. For example, opportunities for local fauna and flora can be improved by designing the solar farm layout and managing activities around the solar farm to avoid habitats such as nesting and egg laying areas, foraging areas, wintering areas, hedgerows, field margins, meadows, and pollinator habitats. In the case of intensively-managed agricultural areas or degraded areas, restoration as a solar farm offers a significant opportunity.

A recent study showed that 9 out of 10 solar sites resulted in an increase of 14-281% biodiversity net gain. Similar studies showed a significant increase in local flora and fauna, i.e., the presence of endangered insect and butterfly species and other species at risk of extinction, or an increase in reptile and breeding bird population on solar sites.[25]

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[20] SolarPower Europe (n.d.)
[21] Alberta Prairie Conservation Forum (2018)
[22] Farja and Maciejczak (2021)
[23] SolarPower Europe (2023c)
[24] For more information, see the 2022 article by S. Hall for the World Economic Forum (https://www.weforum.org/agenda/2022/07/agrivoltaic-farming-solar-energy/).
[25] See Helapco's 2016 study "The effects of solar farms on local biodiversity" (https://helapco.gr/wp-content/uploads/Solar_Farms_Biodiversity_Study.pdf), Solar Energy UK's 2019 report "The Natural Capital Value of Solar" (https://solarenergyuk.org/resource/natural-capital/), and BNE's 2020 study "Solar parks – profits for biodiversity" (https://www.bne-online.de/study-solar-parks-profits-for-biodiversity/).

Where new access roads pass through forested and ecologically sensitive areas, this can result in increased traffic and road kills and can enable increased human presence, which can further disturb habitats and biodiversity.[26] Solar farms typically have security perimeter fencing installed, which can cause additional habitat fragmentation, especially for mammals and reptiles (e.g., tortoises), and act as a barrier to movement/migration. However, well-designed solar parks can incorporate permeable fences so that mammals and smaller animals can pass through.

There is limited evidence of bird deaths associated with the operation of solar farms, although it has been recorded more frequently at CSP sites (particularly incineration in concentrated solar power beams) than at PV power sites. Most deaths have been associated with collision with structures and transmission lines (including electrocution), with some incidences of incineration.[27] Additionally, there is some anecdotal evidence that birds may mistake the flat surfaces of floating PV panels for water bodies and fly directly into them causing injury.[28]

Solar utilities can also cause habitat degradation due to changes in hydrology, as well as water availability and quality. If care in operation is not taken, pollution by dust, noise, light, vibration, and solid and liquid waste can pose some risks.

Construction, decommissioning, and repowering (i.e., replacing old technology to optimize performance) can lead to dust, waste, noise, and light pollution impacts, but there are few examples of this being a significant issue for solar developments.[29] Most solar power generation technologies do not discharge pollutants into the environment, although accidental release can occur (e.g., conduction fluid). The once-through cooling systems associated with some CSP projects require the discharge of heated water into a receiving water body. This can negatively impact the biodiversity in the waterbody, which may be unable to tolerate warmer conditions.

Where animal species are displaced (i.e., at a solar farm site or along access road and transmission line routes), this can increase pressure on food resources in the areas they relocate to and may displace and out-compete other animals and species. The introduction of alien species, carried to the site by vehicles, construction equipment, and people, can also put pressure on sensitive ecosystems. The fragmentation of biodiverse habitats by solar farms, access roads, and transmission lines can lower the resilience of local populations of species by preventing their free movement and access to food resources. This can ultimately affect the ability of a species to thrive in an area.

The PV array steel structures provide ideal nesting sites for some species of birds. This, in turn, attracts bird predators, such as snakes and other fauna that feed on bird eggs.[30]

The significance of impacts due to solar farm development will depend on the richness and abundance of existing biodiversity at the site and along access road and transmission line routes, including the presence of rare and threatened species. The development of multiple solar projects across a region would amplify the negative effects on habitats and biodiversity, potentially resulting in a significant cumulative loss, even if each individual development only causes limited impacts.

Solar evaporation ponds present a risk to wildlife, livestock, and habitats (e.g., drowning, poisoning, and overflow and contamination of natural waterbodies).

Soil erosion

Soil erosion can occur when land is cleared for a solar farm, access roads, and transmission lines, particularly when there is inappropriate drainage design (i.e., the land is unsealed, allowing water to flow on the land surface and wind to blow soil from exposed bare land). An important consideration for erosion prevention and storm water management is the dripline of the PV arrays, which tends to concentrate water runoff from the panels.

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[26] Bennun et al. (2021)
[27] EC (2020)
[28] Horváth et al. (2009); Huso et al. (2016)
[29] Farmer (1993); McClure et al. (2013)
[30] SolarPower Europe (2022)

Compaction of soil from construction activities (e.g., vehicle movements and civil works) can lead to reduced infiltration, increased runoff, decreased soil bioactivity, and decreased soil organic matter.[31] Soil erosion can lead to sedimentation in nearby water courses and sensitive habitats and to a consequent decline in water quality and loss of biodiversity.

Well-managed, biodiversity-friendly solar farms can help to improve soil health (e.g., switching from the use of pesticides to seasonal grazing, and integrating different restoration measures for degraded soils). Solar panels can help increase carbon stored in soil (by up to 80% where sheep management is integrated with the solar farm[32]), improve soil health, and enhance biodiversity on solar farm sites, which can, in turn, reduce soil erosion.

Water use

The water consumption of PV solar farms is highest during the manufacturing and recycling processes. Water-intensive manufacturing processes include minerals processing, extraction, purification, and chemical etching.[33] Significant amounts of water are also required in the manufacturing of batteries, particularly in the extraction of lithium, which requires 500,000 gallons of water per metric ton of lithium.[34]

A solar farm can have a significant impact on water resources depending on its location, the availability of water, and the technology chosen. Water is required during operation to wash the panels to maintain generation efficiency. The amount of water required depends on the size of the solar farm and the ambient levels of airborne dust. Globally, the cleaning of solar panels is estimated to use more than 10 billion liters (2.64 billion gallons). However, new research is developing a waterless, no-contact, electrostatic repulsion system.[35]

CSP, like all thermal electric plants, requires water for cooling. Water use depends on the plant design, plant location, and the type of cooling system. CSP plants that use wet-recirculating technology with cooling towers withdraw approximately 800 gallons of water per megawatt-hour of electricity produced.[36] An example of such a project is the Qinghai Delingha Concentrated Solar Thermal Power Project in the People's Republic of China, which is expected to generate 199 GWh of electricity every year.[37]

CSP plants with once-through cooling technology have higher levels of water withdrawal but lower total water consumption (because water is not lost as steam). Dry-cooling technology can reduce water use at CSP plants by approximately 90%.[38] However, the trade-offs to these water savings are higher costs and lower efficiencies. In addition, dry-cooling technology is significantly less effective at temperatures above 100^0F.[39]

The demand for water can put pressure on existing local water supplies in areas where water resources are scarce and in sensitive areas, particularly during dry seasons. In arid areas, agri-PV has been reported to reduce water use on the site by as much as 20-30% (especially during long periods of drought or high temperatures)[40] by panel shading and reducing evapotranspiration. Also, incorporating rainwater collection systems in the design of solar farms and reusing water for different purposes such as irrigation or cleaning of panels can improve the efficiency of water use.

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31 DEP (2017)
32 Towner *et al.* (2022); For additional information, see BNE's 2020 study "Solar parks – profits for biodiversity" (https://www.bne-online.de/study-solar-parks-profits-for-biodiversity/).
33 Tawalbeha *et al.* (2021)
34 IER (2020)
35 MIT News (2022)
36 Price (2009)
37 ADB (2022)
38 Price (2009)
39 UCS (2013)
40 SolarPower Europe (2023c)

Where solar panels are installed to cover canals and reservoirs, a secondary benefit is that they keep water cooler and limit evaporation. Floating PV has been shown to reduce evaporation by up to 70%, and also to reduce algal growth.[41]

Additional water savings are possible through installing rainwater collection systems in APV sites.

Wastes (hazardous and non-hazardous)

The PV cell manufacturing process includes hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals include hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride, 1,1,1-trichloroethane, and acetone.[42] The amount and type of chemicals used depends on the type of cell, the amount of cleaning that is needed, and the size of the silicon wafer. Incorrect management of the manufacturing process, including waste management, can lead to the release of hazardous and non-hazardous wastes into the environment.

Most waste generation at a solar farm will occur during the construction phase, with only limited wastes produced during operation from maintenance and ancillary activities (e.g., office wastes). Construction waste streams include:

- Material from packaging
- Building materials
- Scrap metals
- Excess soil material
- Plastic and masonry products
- Vegetation clearing
- Sanitary wastes
- Empty chemical storage containers
- Concrete wash out water.

Solar cells and storage batteries have an operational lifespan of 20–30 years. Solar panels are mostly made of glass, which has low value as a recycled material. The panels also contain small amounts of valuable materials, such as silicon, silver, copper, and tellurium, plus heavy metals (cadmium, lead, etc.) that some governments classify as hazardous waste. In modern PV panel manufacturing facilities, electro deposition and chemical deposition of cadmium is about 90% efficient, and no more than 0.0005% of the cadmium and tellurium used would be lost in the form of very dilute liquid and waste streams.[43]

Panels and batteries can be recycled. However, without a proper policy framework and sufficient economies of scale, the process can be complex and costly. In jurisdictions without an appropriate end-of-life management framework and extended producer responsibility schemes, these products are often disposed to landfills where hazardous contents may leach out and pollute soil and groundwater. Countries are still expected to bolster their policy and regulatory frameworks around PV end-of-life management.[44]

The waste produced during the operation and decommissioning of CSP plants can more easily be recycled as the equipment and infrastructure do not involve complex manufactured parts like photovoltaic cells and storage batteries. However, plants do require significant quantities of thermal conducting fluid (e.g., conduction oil) that is likely to be hazardous to the environment if not managed and disposed of correctly.[45]

A new technology for producing flexible and printable solar cells from perovskite offers a cheaper alternative to the use of silicon cells and could revolutionize the future of solar cell deployment.

[41] SolarPower Europe (2023b)
[42] UCS (2013)
[43] Bonadio *et al.* (2021)
[44] IEA (2016)
[45] Giaconia *et al*. (2021)

However, the technology is not yet developed commercially, and challenges remain regarding cell longevity and the use of lead in production.[46]

Noise and vibration

Solar farms are generally located in areas of low population density, which, in most instances, will limit the number of people impacted by noise and vibration. Wildlife in the surrounding area may be displaced by noise and vibration and/or have their behavioural patterns disturbed. The scope of such impacts will be significantly greater (and possibly temporary) during construction. Solar farms do not emit significant noise nor vibration during operation.

The development of a solar farm will require civil works involving heavy machinery, followed by construction using workers and lifting equipment. The scale and significance of the impacts will depend on the size of the installations, the flatness of the site, the proximity of sensitive receivers, and the duration of construction works. Solar farms are generally relatively quick to construct; therefore, any construction impacts are temporary. The Solar Energy Industries Association in the USA reports that, from initial application to final Right-of-Way grant, the current process for a utility-scale solar project requires between three and five years to complete.[47]

Air quality

The construction phase of solar projects can generate dust due to clearing works, vehicle movements, earthworks, stockpiling, transporting materials, road works, and concrete works. Exhaust emissions will be generated by construction and workers' vehicles and machinery during construction. Air quality impacts (e.g., pollution and dust) during the operation of solar plants will be limited to vehicle movements along access roads and over unsealed land and the aerosolization of dust caused by wind. The power generation process does not release pollutants into the air.

The severity of impacts on air quality will depend on the proximity of sensitive receivers, such as dwellings, to the solar farm site.

Water quality

Where solar farms and associated infrastructure (e.g., access roads and transmission lines) are located near to rivers and lakes, construction work (e.g., excavation and stockpiling of materials and spoil, and land clearing) can cause soil erosion and lead to sedimentation of such water bodies, impairing water quality and damaging aquatic habitats. The greater risk of sedimentation comes from land clearing, as the exposed areas will be subject to erosion by wind and surface water flows, particularly during intense rainstorms.

Hazardous materials involved in construction can include paints, cleaning solvents and acids, concrete products, soil additives for stabilization, and fuels. When used or stored improperly, these chemicals can escape from the construction site and have negative impacts on local water quality. The quantity of hazardous materials is expected to be small, so the scale of impacts will likely be localized.

The operation and management of a PV solar farm does not generally require large quantities of hazardous substances, and the potential for negative impacts on water quality is small. CSP projects use large volumes of thermal fluid, which can pollute a water course if accidentally released. Once-through CSP projects require the continuous discharge of heated water, which, depending on the volume of the discharge and the size of the receiving water body, can have a significant negative impact on water quality and temperature. Discharges can also include antifouling chemicals.

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[46] Bellini (2024).
[47] SEIA (n.d.).

The landscape design of a solar farm, extent of unsealed land, and drainage strategy will influence the likelihood of sedimentation impacts on receiving waterbodies during operation because of windblown dust and surface water flows.

Mineral extraction

A low-carbon future will increase the need for minerals[48] to manufacture clean energy components to support clean energy technologies. The associated infrastructure (e.g., transmission lines), battery storage solutions, and material parts needed to deliver solar projects are also dependent on increased extraction of some minerals.[49] However, a clean energy grid will be significantly less extractive than the current fossil fuel dominated energy system. The amount of minerals needed for future energy systems represents a small fraction of the amount of materials—mainly fossil fuels—consumed by the current energy system. The amount of copper currently in use for the energy system is 21 million tons per year, plus 2.6 million tons of nickel and 0.11 million tons of lithium. As a comparison, current fossil consumption requires around 8 billion tons of coal, 4 billion tons of oil, and 2.6 billion tons of gas annually.[50] Additionally, coal, oil, and gas are combusted to produce energy and cannot be reused, whereas the minerals used in renewable energy infrastructure can be recovered, recycled, and reused.

The solar PV industry will need to compete for resources with other clean energy technologies, as many of the minerals required are cross-cutting across technologies and uses. For example, copper is a key component in both solar and wind for the conduction and connection of electricity. Together, these renewable energy technologies constitute 74.2% of all demand for copper. Other minerals are more concentrated on a single technology. For example, lithium, graphite, and cobalt are mainly associated with energy storage solutions. The recycling and reuse of minerals will play a key role in reducing demand from mining, but increased mined quantities will still be required to meet the future growth in the industry.

Mining for minerals and their processing for use in the solar power industry can result in significant environmental impacts given the activities and scale employed during the extraction and processing stages. The heterogenous distribution of minerals across the globe often means their extraction has direct impacts on sensitive areas if the minerals are in such areas (e.g., impacts on biodiversity, air quality, land use, noise, water usage, waste generation, population, health, labor, and human rights). In general, a low-carbon future will be very mineral-intensive because clean energy technologies need more materials than fossil-fuel-based electricity generation technologies.

The Democratic Republic of Congo is the world leader in cobalt production, which is used for battery production required for energy storage, accounting for more than 70% of global output in 2019. There have been several examples of dangerous occupational safety working conditions, human rights abuses including child labor, and environmental damage associated with Congolese cobalt. This has prompted many major companies who rely on the country's supply chains to form initiatives aimed at promoting higher ethical standards.[51]

Key environmental impacts of mineral mining include:

- Biodiversity impacts, including habitat damage and loss, disturbance and killing of species, competition from alien species, and ecosystem disruption
- Overuse of water supplies and impacts on water quality and groundwater
- Waste generation and pollution
- Reduced air quality for sensitive receivers
- Noise and vibration (including from blasting) impacts on sensitive receivers
- Land-use change
- Landscape and visual amenity degradation.

[48] Minerals in this context also include metals.
[49] World Bank (2020b)
[50] REN21 (2023)
[51] NS Energy (2021)

With the increase in mineral extraction expected to support the expansion of solar power generation and associated battery storage, the cumulative environmental and social impacts (see section on human rights in Section 7.3.2) will continue to rise even if mitigation strategies are implemented.

As mentioned previously, the use of Perovskite-Organic Hybrid Solar Cells sourced from common materials such as lead, iodine, and organic materials offers a lower-cost and less extractive-intense alternative to silicon cells.

Visual and aesthetic impacts

The visual impact of solar installations is an issue that is frequently raised by the public, local communities, and specialist interest groups. Depending on the degree of visual impact, public opinion can strongly oppose the installation of a solar farm and significantly hinder its implementation.

The significance of a visual impact during both operation and construction typically depends on the landscape character and topography of the local area, the size of the installation, the level of screening (e.g., trees), and the number of visual receivers within the zone of influence. As many solar installations are installed in rural areas, their influence on the landscape character can be significant. This is most acute with CSP installations which can involve tall tower structures. Practices like planting trees around the solar plants can help to reduce the visual impacts and better integrate solar farms into local landscapes.

There is a perception that PV solar panels cause glint and glare, which can distract motorists and aircraft and cause eye damage. Solar PV modules are specifically designed to reduce reflection to minimize loss of light and convert it to electricity. Research shows that PV modules exhibit less glare than windows and snow.[52] PV modules have been installed at airports in the United States, including Denver and Oakland.

There is more risk of glint and glare from CSP projects because these use mirrors to concentrate the solar rays. This can pose a potential hazard or distraction for motorists, pilots, and pedestrians.[53] The design and location of a CSP is critical in avoiding this problem.

Land and ecosystem restoration

As discussed above, there are significant risks associated with solar power development with regard to potential environmental harm and degradation (e.g., unnecessary or excessive deforestation when preparing land for solar farms and constructing new access roads and transmission lines; destruction of habitats; loss of biodiversity and ecosystem services; soil erosion; and pollution). This will particularly arise where mitigation measures proposed by an SEA (and subsequent project-level EIAs) are inadequate, ineffective, or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple solar farm developments across landscapes.

From a positive perspective, in general, solar farms constructed on degraded land should enable vegetation and soil carbon to regenerate and at least some local biodiversity to re-establish in areas from which it had previously been lost.

Environmental impacts will usually lead to demand for and need for land and ecosystem restoration (see Chapter 2, Box 2.12). This need will also arise at sites of projects that have come to the end of their useful operational life, usually after 20–30 years.[54] After this time, the project owner will either decommission the site, restore the area to its previous land use, or negotiate with landowners to repower or upgrade the equipment to extend the wind farm’s operational lifespan.

[52] Reach Solar Energy (2018)
[53] Ho and Kolb (2010)
[54] The average lifespan of solar panels is about 25 years.

At a minimum, land/ecological restoration after decommissioning a solar farm should involve the seeding/replanting of disturbed areas. A seed mix of species that were naturally part of the ecosystem/land prior to development of the solar farm should be used.

7.5.2 Socioeconomic issues and impacts

Local economy and livelihoods

The development of solar PV farms may induce large-scale land acquisition that results in economic and physical displacement of the host communities.

This displacement can cause adverse short- and long-term impacts on livelihood activities, affecting income from crop cultivation, small businesses and enterprise activities of the host communities. Rural communities can also lose access to grazing land (used on either a formal or informal basis). In the case of floating solar PV, the acquisition of water space can impact access to fisheries and navigation.

Land acquisition for solar parks and substations can lead to physical and economic displacement that needs to be addressed through resettlement planning. The use of marginal land or land not in high demand for other uses is preferable (e.g., the Benban project in Egypt used desert land that was vacant—see Box 7.5). This means that highly productive agricultural land required for food supplies or land assigned for other important social purposes such as residential areas will not be affected.

Some solar PV park development projects can provide opportunities, including benefit-sharing schemes between the host communities and the solar PV companies (see Boxes 7.6 and 7.9), and can lead to an increase in land and property values within the vicinity of the solar farm.

Box 7.6: Joint investment in a solar farm, Dorset, United Kingdom
Source: Dorset Council (n.d.)

In Dorset, United Kingdom, local communities benefit from joint investment in solar PV farms, often through the local Parish or Town Council. The funding may be through an annual payment over the life of the solar farm or a one-off payment once the solar farm is first commissioned. Solar farm community benefit funds totaling around UK £2m over 20 years have now been offered to twelve Dorset communities. Find more information about Dorset Council's "Low Carbon Dorset" grants and see these community case studies at https://www.lowcarbondorset.org.uk/.

Employment and labor conditions

The construction of solar farms can create jobs for neighboring communities and skilled workers. One review found that the construction of four large-scale solar farms in the US (each 250 MW) created full-time equivalent (FTE) jobs for between 405 and 830 workers per month for a project duration of 2 to 3.5 years.[55] The average annual workforce for operations and maintenance was estimated at 68 (10 general, six engineering, 25 maintenance, 22 operations, and five unskilled). [56] By comparison, it was found that 500 FTE jobs were created for half a year to construct the 25 MW Permacity PV project.

While other countries may not reach the same efficiencies and thus require additional labor, this information helps to show that solar projects have generally short construction phases and small operational workforces. Thus, it can be seen that the difference in job creation between construction and operation should be planned to avoid large scale retrenchment after the close of construction as found in other industries, such as hydropower.

[55] White *et al.* (2010)
[56] CEERT (2010)

IRENA (2022) reports that millions of jobs had already been created by solar PV projects by 2020, with job opportunities having increased significantly compared to other technologies in the renewable energy sector.

While investing in solar PV power brings jobs to local communities, there is a need to manage associated operational health and safety risks.

Concerns regarding the extraction of mineral resources for manufacturing solar PV are discussed in the human rights section.

Cultural heritage

Cultural, religious, and archaeological sites can be destroyed or have access to them be restricted when land is acquired for solar power farms. Box 7.7 cites concerns raised in the media about the impacts of a Maltese solar farm on cultural and archaeological heritage. Measures need to be put in place to manage chance finds during construction, as per other industries that cause site disturbance.

Some cultural heritage features (e.g., historic buildings and graves) can be incorporated into the layout design of a solar farm and protected during construction.[57]

Box 7.7: Impacts of solar farm on cultural heritage and archaeological sites in Malta
Source: Camilleri (2021)

This excerpt is from an article by M.P. Camilleri (2021) in Newsbook Malta: "The effects of a proposed solar farm on the rain catchment system near Ta' Ħaġrat archaeological site is of great concern for Heritage Malta. The national agency for cultural heritage said it feared the proposed solar farm in Triq San Pietru, Mġarr, might negatively affect the site when heavy rainfall causes the road leading to the temples to flood. This is mainly a result of the vast development in Mġarr during the last 50 years. What is mainly worrying Heritage Malta is that the proposed project will prevent the rainwater from penetrating the soil, resulting in runoff flowing into the temples."

Health and safety

The main risks to worker health and safety occur during the construction phase and typically include managing physical, chemical, and biological hazards, particularly dust generated during land clearing and grubbing out vegetation. In addition to working with live power lines and electric and magnetic fields (EMF), work on floating solar farms involves the additional risk of operating over and under water.[58] Weather conditions are a significant factor when working on outdoor solar PV installations and affect the risks to lives and working conditions.

Solar farms can also have negative impacts on community health and safety, such as electric shocks when facilities are unfenced or cables not cased. Depending on the proximity of residential areas and other community activities, the impacts of exposure to glint (momentary flashes of light) and glare (continuous, excessive brightness) from solar PV reflections may need to be modeled, and mitigation measures identified. Glint and glare can affect nearby residents, road users, airplane pilots, and air traffic controllers.[59]

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[57] For more information and examples, see: Roberts, R. (2015, July 18). Listed churches all over England are installing solar panels. The Independent. https://www.independent.co.uk/news/uk/home-news/listed-churches-all-over-england-are-installing-solar-panels-10399129.html
[58] World Bank, ESMAP and Solar Energy Research Institute of Singapore (2018)
[59] DELWP (2022); SolarTechAdvisor (2023)

In some circumstances, CSP systems can cause interference with aircraft operations if reflected light beams become misdirected into aircraft pathways.[60] For instance, light reflection from CSP panels can distract pilots and air traffic controllers and interfere with airport equipment.[61] The adverse impacts on aircraft movements can be due to the proximity between the solar farm and an airport. Some airport companies oppose nearby solar farms. For example, Barrow/Walney Island Airport in the UK objected to a proposed solar farm, citing such concerns. Analysis of solar PV glare has been part of the impact assessment for an installation proposed at the Kuantan Airport in Malaysia.

As previously discussed, solar farms typically have small workforces only in place for short construction periods, so the influx of labor is not a substantial risk.

The impacts—positive and negative—of in-migration induced by the development of solar farms are similar to those that arise for other types of renewable energy.

Gender and vulnerability

Where solar projects have negative impacts that affect livelihoods, women are often disproportionately affected. As solar farms increase in size, they may also impact housing, health and social care services, and sociocultural quality of life (see Box 7.8).

Box 7.8: Gender and other impacts of the NOOR solar plant, Morocco
Source: Terrapon-Pfaff et.al. (2019)

A study of the NOOR solar power plant development in Morocco, North Africa, showed that people living near the plant, especially women, reported decreased abilities to practice livelihood activities such as grazing goats and collecting firewood as construction ramped up. Families who did not profit from employment opportunities at the plant were left more vulnerable to economic shocks.

Construction of the NOOR plant led to an increase in migration to the area of external and foreign workers and students, which changed the social and cultural make-up of the community. It also contributed to an increased population with the potential to put a strain on public infrastructure and services like sanitation, healthcare, and education.

The under-representation of women in the solar energy sub-sector is another issue, and one that is also reflected across all technologies. In 2019, the IEA identified that a growing number of women are recognizing that the sub-sector is a source of well-paid employment with strong opportunities for career advancement. Because solar PV technology requires a workforce for installation, sales, operations, and maintenance, IEA suggested that there is a wide range of opportunities available for women.[62] The share of women working in full-time positions in the solar PV industry is 40%. This is almost double the share in the wind industry (21%) and the oil and gas sector (22%). The solar PV industry also compares well with the 32% share across the entire renewable energy landscape.[63]

Solar power projects can also create opportunities for benefit-sharing among wider community members, local government, and private investors (see Box 7.9) and for female-led business ventures (see Box 7.10).

[60] Solar Energy Development Programmatic EIS Information Center (n.d.)
[61] SolarTechAdvisor (2023)
[62] IRENA (2017)
[63] IRENA (2022c)

Box 7.9: Benefit-sharing from solar farms in the United Kingdom
Source: UK Department of Energy and Climate Change (2014)

Lambeth Council Community Energy Program was part of the UK's Community Energy Initiative to reduce, purchase, manage, and generate energy through collective action. The program was a successful, collaborative partnership involving Repowering London (a community-based organization), Lambeth City Council, and select private local investors. They co-produced three community-owned PV solar projects with a total installed capacity of 132kW through community share offers. Training and work experience was also provided to local young people from some of the poorest social housing estates in the area.

Box 7.10: A female-led solar power company in Thailand
Source: IEA (2019c)

The SPCG Public Company Limited in Thailand is a pioneer company in solar farms and solar roof development. It is headed by a woman. SPCG owns 36 PV solar farm projects that sell electricity to Thailand's distribution grid. The company's businesses include engineering, procurement, and construction for solar farms and solar rooftops, and it manufactures steel or metal roof sheets. In 2017, the company employed more than 1,000 people.

Indigenous communities

Solar energy projects require land or bodies of water that may customarily be owned or used by Indigenous peoples. There is a risk of conflict between communities and project developers if the latter do not secure the free prior and informed consent (FPIC) to projects from Indigenous communities.[64] FPIC is required by various multilateral development banks and other bodies.[65] This issue is addressed in the discussion of Indigenous communities in Chapter 5 (Hydropower).

There are examples from many countries where stand-alone solar power systems are used to provide electricity to Indigenous communities, especially to remote and/or small communities.[66] See Box 7.11.

[64] Free, Prior and Informed Consent (FPIC) is a specific right that pertains to Indigenous peoples and is recognized in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). It allows them to give or withhold consent to a project that may affect them or their territories. Once they have given their consent, they can withdraw it at any stage. Furthermore, FPIC enables them to negotiate the conditions under which the project will be designed, implemented, monitored and evaluated. This is also embedded within the universal right to self-determination.
[65] e.g., by the IFC under its Performance Standard 7 guideline (IFC 2012b), and by the ADB's commitment to Broad Community Support (BCS) under its Safety Policy Statement (2009).
[66] Martire (2020)

Box 7.11: Examples of solar projects serving Indigenous communities

Sources: Natural Resources Canada (2019); Martire (2020)

Canada

There are opportunities for Indigenous peoples in Canada to own or co-own the solar projects on their lands. The largest off-grid solar project in Canada (2.2 MW) is located at Fort Chipewyan. It was projected to cost CDN$4.5 million, create 40 jobs during construction, and replace 650,000 liters of diesel fuel per year, reducing greenhouse gas emissions by 1,743 tons annually. The Indigenous people in this area benefitted from job opportunities during the construction and from cleaner electricity generated.

Figure 7.3: Ft. Chipewyan Solar Farm

Photo: Rob Leavitt, Green Energy Futures (https://www.greenenergyfutures.ca)

Western Australia

Indigenous Business Australia (a government body) is a co-equity investor with an indigenous Noongar (an Aboriginal people in Western Australia) community partner, Bookitja, in a 10 MW solar farm at Northam.

Access to water

During its operational phase, a solar project will require water to wash PV solar panels and maintain their efficiency, or to cool CSP plants. This may be accessed from underground or surface water and may decrease supplies of clean water available to the local community, particularly in dry areas. New cleaning technologies for solar panels, such as the use of electrostatic repulsion, offer the opportunity to substantially reduce water use for this purpose.[67]

Public services and infrastructure

Solar farm projects can have negative impacts on public services and infrastructure. The movement of heavy goods vehicles and the transportation of materials can damage existing roads and bridges and increase traffic congestion in the host communities.

But solar farms may also benefit local communities through investment programs to support local economic development, improve local infrastructure and services, and support social programs to improve community well-being (see Box 7.12). This can be done by project community investment programs as outlined by IFC's community investment handbook.[68]

[67] Engel J. (2022)
[68] IFC (2010)

Box 7.12: Solar company support for community services, India
Source: IFC (2019)

In India, renewable energy company Avaada supports a number of interventions near its solar project sites to improve health outcomes for host communities, including no-cost medical services. Specialized and general awareness camps and regular health check-ups are provided to raise awareness and help local residents lead healthier lives. In addition, Avaada is addressing sanitation challenges in rural India by building toilets and clean drinking water facilities in underserved communities. More information is available at https://avaada.com/sustainability/.

There are many examples of covering infrastructure with solar panels (e.g., parking lots, rail systems, and commercial buildings) to provide shade, help cool urban areas, and provide local power sources. Under a new law in France, car parks with 80 or more spots will need to be equipped with overhead solar power panels.[69] The French national rail service (SNCF) plans to install some 190,000 m^2 of solar panels in 156 stations throughout the country by 2025, and 1.1 million m^2 by 2030, all with the aim to reduce energy consumption by 25%.[70] An intriguing opportunity for solar generation is to place solar panels between railway tracks throughout the rail transport system.

Human rights

Solar PV panels require minerals that are mined in various countries, including in low-income and conflict-affected countries where human rights are not well regulated or enforced. Key social impacts of mineral mining include:

- Child and forced labor (see Box 7.13)
- Forced resettlement, land take, and violence
- Occupational health and safety, including physical and mental health.

Box 7.13: Use of forced labor in the People's Republic of China
Sources: Murphy and Elimä (2021); Ambrose and Jolly (2021); World Bank (2021)

Recently, there has been a media focus on the Uyghur Region in the People's Republic of China, a major producer of solar panels. In 2021, academic researchers in the United Kingdom (UK) found that the region accounted for approximately 45% of the world's solar-grade polysilicon supply. The study identified 11 companies engaged in forced labor transfer, plus another four located in industrial parks, and 90 Chinese and international companies whose supply chains were affected.

In a related article in 2021, *The Guardian* newspaper reported that solar projects commissioned by the Ministry of Defence, the government's Coal Authority, United Utilities, and some of the UK's biggest renewable energy developers were using panels made by Chinese solar companies accused of exploiting forced labor camps in Xinjiang province. The newspaper article suggested that up to 40% of the UK's solar farms had panels manufactured by solar panel companies that used interned Muslim Uyghur community members in polysilicon production. Acknowledging this risk, the World Bank has recently issued guidance on measures to avoid forced labor through solar projects.

The Solar Stewardship Initiative has been launched in Europe to address the above concerns (see Box 7.14).

[69] Balkan Green Energy News (2022); Mossalgue (2022)
[70] Euronews Green (2023)

Box 7.14: The Solar Stewardship Initiative
Source: SolarPower Europe (n.d.)

The Solar Stewardship Initiative (SSI) has been launched by SolarPower Europe and Solar Energy UK. It aims to combine supply chain integrity with enhanced Environmental Social and Governance (ESG) performance, providing a robust ESG assurance and certification scheme. SSI-certification relies on third-party, independent supply chain audits, conducted on the basis of international and sector-specific ESG auditing standards. The SSI does not certify sites complicit in forced labor.

The SSI is governed by various types of stakeholders, including industry representatives and civil society actors who are independent of the solar PV industry. It is supported by more than 60 solar companies covering the whole solar value chain and a significant share of the European (including UK) solar market. This multi-stakeholder initiative is working to further develop a responsible, transparent, and sustainable solar value chain—strengthening confidence in how, where, and by whom solar products are manufactured.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 8

BIOENERGY

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Links to the complete guidance document and to individual chapters are also available.

CHAPTER 8

BIOENERGY

8.1 WHY SEA IS IMPORTANT FOR BIOENERGY

An overall rationale for why it is important to use Strategic Environmental Assessment (SEA) to support the energy transition is provided in the preface to the guidance.

SEA can provide critical information to support better decision-making for bioenergy power planning and development, including identifying where there may be implications for policies, plans, and programs (PPPs) to adequately address significant environmental and/or socioeconomic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple bioenergy power schemes/developments, whether alone or in combination with other renewable energy technologies (e.g., solar, wind energy).

The SEA process will:

- Identify and focus on key environmental and socioeconomic issues and the concerns of likely affected stakeholders, including local communities, marginalized groups and indigenous peoples (issues associated with bioenergy development are discussed in Section 8.5 and summarized in Table 8.2).
- Identify/recommend if there are areas that should be avoided for bioenergy development ("no-go" areas) because of particularly high risk to the environment, habitats/biodiversity, and/or people.
- Identify what changes or additions are required to PPPs governing bioenergy development to address these risks.
- Make subsequent project-level Environmental Impact Assessments (EIAs) and Environmental and Social Impact Assessments (ESIAs) more efficient and cheaper by addressing the big picture regarding potential upstream, downstream, and cumulative impacts and identifying the particular issues that individual bioenergy project EIAs/ESIAs should focus on in more (site-specific) detail. This may also include spatial planning recommendations for optimal siting of bioenergy projects to minimize these risks and impacts.
- Engage stakeholders—including communities, marginalized groups, and Indigenous peoples, which can be particularly affected by bioenergy developments—to be informed early of proposed or possible policy options or plans, and enable them to provide their perspectives and present their concerns as early as possible. This will enable key issues to be identified and verified, help build understanding and support for bioenergy development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

8.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE BIOENERGY SUB-SECTOR

An international survey of existing SEA guidelines conducted for IAIA was able to identify only one specifically focused on the bioenergy sub-sector. The OECD DAC guidelines on SEA and biofuel development[1] cover generic and specific considerations and questions to be addressed at the broad scale in a typical SEA process for biofuel PPP development at a national or sectoral level. Similarly, no EIA guidelines specific to bioenergy have been identified.

In the literature, a range of academic papers and books cover various aspects of the environmental and socioeconomic impacts of biofuels (e.g., solid biofuels[2], biogas[3], commercialization of biofuels production from feedstocks[4] , and bioenergy production based on compiled and published data[5]).

8.3 BIOENERGY INSTALLED CAPACITY

According to International Energy Agency, the annual global demand for biofuels is set to grow by 28% by 2026, reaching 186 billion liters.[6] Table 8.1 shows bioenergy installed capacity by regions in 2022.

Table 8.1: Bioenergy installed capacity in 2022
Source: IRENA (2023)

Region	Installed capacity (MW)
World	148,912
Africa	1,847
Asia	63,370
Central America & Caribbean	3.040
Eurasia	3.330
Europe	41,694
European Union	33,823
Middle East	101
North America	14,960
Oceania	1,105
South America	19,465

8.4 BACKGROUND TO BIOENERGY GENERATION

Bioenergy use falls into two main categories: traditional and modern. Traditional use refers to the combustion of biomass in such forms as wood, animal waste, and traditional charcoal. Modern bioenergy technologies include liquid biofuels produced from bagasse and other plants, bio-refineries, biogas produced through anaerobic digestion of residues, wood pellet heating systems, agricultural waste, and other technologies.

Modern bioenergy[7] is the largest source of renewable energy globally, accounting for 55% of renewable energy and over 6% of global energy supply[8]. Bioenergy accounted for about 10% of total final energy consumption and 1.9% of global power generation in 2015.[9]

Rural households in Africa, Asia, and other parts of the world use a lot of traditional biomass (e.g., wood, dried animal dung, sugar cane bagasse, crop residues) as a principal energy source (i.e., for heating and cooking). However, this chapter focuses on bioenergy sources that could potentially be

[1] OECD DAC (2011)
[2] Christoforou and Fokaides (2019)
[3] Valerio *et al*. (2018)
[4] Arun and Dalai (2020)
[5] Wu *et al*. (2018)
[6] IEA (2021)
[7] Modern bioenergy refers to biomass use alongside modern heating technologies, power generation, and transport fuels, as opposed to traditional wood-burning methods commonly used for heating and cooking in developing countries.
[8] IEA (2022b)
[9] IRENA (n.d.)

used in utility-scale thermal power plants, primarily the conversion of plants (mainly high energy crops grown at large scale) or wood (from forests) to pellets to be combusted in a thermal power plant.

Bioenergy is generated from the combustion of organic matter from bio-based renewable sources such as biofuel, biogas, biomass, and other bio-organic wastes. Biomass supply comes from a variety of feedstocks—wood fuel, forestry residues, charcoal, pellets, purpose-grown crops and residues, municipal and industrial waste (e.g., food, construction waste, paper), biogas, biofuels, etc. Broadly, the supply can be classified into three main sectors: forestry, agriculture, and waste. It can be used in power generation, heating, and transport. To create pellets for combustion (i.e., to drive a steam turbine and create electricity), plant material is harvested, dehydrated in a processing plant, and pressed. This fuel is used instead of, or as well as, coal in power plants.

Bioenergy can also be produced from waste streams, such as wood chips left over from manufacturing processes, or sugar cane biomass left over from the sugar refining process. Using waste products such as these as a biofuel can reduce waste sent to landfill. But they are usually used in combustion plants alongside coal or in small-scale power plants. It is not likely that biofuels sourced from waste streams could supply electricity at a utility scale.

Biomass has been promoted as a carbon-neutral energy, but the UK's The Guardian reports doubts about this view (see Box 8.1).

Box 8.1: Biomass is promoted as a carbon neutral fuel. But is burning wood a step in the wrong direction?

Source: Speare-Cole (2021)

Biomass has been promoted as a carbon-neutral energy source by industry, some countries, and lawmakers on the basis that the emissions released by burning wood can be offset by the carbon dioxide taken up by trees grown to replace those burned. Yet there remain serious doubts among many scientists about its carbon-neutral credentials, especially when wood pellets are made by cutting down whole trees, rather than using waste wood products. It can take as much as a century for trees to grow enough to offset the carbon released.

Burning wood for energy is also inefficient. Biomass has been found to release more carbon dioxide (CO_2) per unit of energy than coal or gas, according to a 2018 study[10] and an open letter to the EU signed by nearly 800 scientists.

This CO_2 is theoretically reabsorbed by new trees, but some scientists suggest relying on biomass could actually end up increasing emissions.

An advantage of bioenergy is that it can provide a controllable and continuous supply of power and use waste products. Biomass and biofuel energy tend to have the lowest energy density compared to other energy sources, but they have the highest land-take of any of the renewable energy technologies. To generate 1 gigawatt-hour (GWh) of electricity, 78 hectares of trees need to be harvested each year (this assumes sustainable harvesting that can be repeated each year).[11]

8.5 IMPACTS OF BIOENERGY DEVELOPMENT

During scoping for an SEA, issues associated with bioenergy development should be identified. They will be used to focus the SEA and to help develop environmental and social quality objectives (ESQOs) (see Chapter 2, Section 2.5.1) that address these issues, to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, other bioenergy development applications, environmental/social profiles,

[10] Sterman *et al* (2018)
[11] Freeing Energy (2020)

sector and inter-sector strategies, donor documents, academic papers), interviewing key informants, and holding stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing other bioenergy development projects.

At the individual project level, these issues will be the focus of an EIA, which should recommend how to manage or mitigate project impacts that might be likely to arise. Implementing a PPP for the bioenergy sub-sector will involve multiple projects, schemes, and activities, including dispersed individual farmers growing bioenergy crops. Activities may include: land clearing, land use change and growing bioenergy crops; construction and operation of sites and facilities; and development/expansion of associated infrastructure (e.g. transmission lines, access roads). Thus, there is a risk that the impacts of individual developments/projects may become highly significant as they become cumulative. An SEA should address the potential for such cumulative impacts and make recommendations for managing and mitigating them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual bioenergy project applications and overarching SEA planning is not synchronized, and SEA may have to "catch-up" to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

Table 8.2 summarizes the range of environmental and socioeconomic issues associated with bioenergy development.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 8.2: Environmental and socioeconomic issues associated with bioenergy power development

ISSUE	COMMENT
Environmental	
Air quality	• Reduction in air emissions through displacement of coal, leading to improved air quality. • Air quality impacts from processing and burning biofuels.
Water quality	• Runoff of biocides used on energy crops.
Water use	• Water consumption of bioenergy crops and conversion of land use can increase demand on water resources.
Greenhouse gases	• Bioenergy can reduce GHG emissions where it displaces coal as a fuel source. • Land clearing for crops can result in release of GHG (e.g., from clearing forests and release from soil). • Biofuels can be carbon neutral in some circumstances but can cause net emissions of GHG in others (i.e. CO_2 from their combustion, although less than from coal).
Land-use change	• Large areas of land required to grow crops that feed into biofuels can displace other land uses, such as food crops and other agricultural practices. • Forest clearance to grow energy crops will lead to habitat loss/degradation, biodiversity loss, and release of carbon stores.
Soil erosion and landslips	• Clearing land can lead to erosion and destabilization of areas, leading to landslips and sedimentation issues. • Can be triggered by an expansion of the area growing fuel crops (particularly corn), residue removal, and land-use change.
Soil quality	• Cropping, overuse of fertilizer, and inappropriate use of pesticides can lead to a reduction in soil nutrients and overall soil quality and result in polluted runoff to surrounding areas. • Soil organic carbon loss due to tillage and harvesting residues.
Loss of biodiversity	• Habitat loss/fragmentation and loss of biodiversity when large areas of land are cleared to grow fuel crops. • Loss of native forests if harvested for wood pellets. • Risk of introducing invasive pests and species. • Energy crops grown as a monoculture can favor some species (often pests) and displace others, leading to loss of native species.
Crop waste products	• If waste products (e.g., sugar cane waste from a sugar mill) are converted to biomass pellets, this can reduce waste in the food chain.
Land and ecosystem restoration	• Forest conversion to grow bioenergy monoculture crops leads to a reduction in biodiversity and resultant ecosystem degradation.
Socioeconomic	
Employment and labor condition	• Employment in the construction and operation phases of bioenergy projects and in associated businesses and activities. • Substandard working conditions. • Worker safety. • Workers have opportunity to learn new skills.
Health and safety	• Increased heavy truck usage to transport biofuels from agricultural areas to processing plants and then to thermal power plants, leading to air pollution, congestion, noise, and safety issues. • Wastes (e.g., contaminated water, particulates from burning biomass materials, etc.) produced by bioenergy projects or plants could cause community health issues, including but not limited to respiratory disease.
Local economy and livelihoods	• Loss of household income from agricultural land acquired by bioenergy companies. • Increased opportunities for small business (e.g., selling energy-related agricultural products to bioenergy projects).

ISSUE	COMMENT
Food security and price	• Less food crops (e.g., corn) available for public sale when purchased by bioenergy companies, driving up the price so that poor people cannot afford to buy food. • Production of energy crops may reduce volume of food crops available and lead to malnutrition in rural areas. • Price of crops grown for energy production likely to increase, presenting an economic opportunity for producers. • Loss of communities' grazing areas when acquired by the bioenergy projects.
Land value	• When land is purchased or acquired by bioenergy companies to grow bioenergy crops, this reduces the amount of agricultural land available for cultivating food crops, and can drive up land prices, making it unaffordable to poor communities. • Increased land conflict over land ownership if land price increases.
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk due to loss of arable land. • Employment opportunities for vulnerable groups within new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies.
Public services and infrastructure	• Loss of and relocation of public services and infrastructure on land acquired for bioenergy projects. • Infrastructure (e.g., roads and bridges, schools, health centers, and administrative buildings) will be improved where there is community investment by bioenergy companies. • Pressure on public services and infrastructure will increase as a result of in-migration. • Heavy vehicles and transportation can damage existing roads and bridges. • Increased vehicle traffic during construction.
Access to water	• Bioenergy projects require large amounts of water (e.g., for irrigating energy crops, steaming, cleaning, etc.), reducing water available to communities.
Indigenous peoples	• Acquisition of large tracts of land for bioenergy projects can affect the use of and cause the loss of Indigenous communities' communal land.

8.5.1 Environmental issues

Air quality and greenhouse gases

Bioenergy can have both positive and negative impacts on air quality. The IEA states that bioenergy can contribute to the mitigation of climate change if it is grown sustainably or comes from waste sources, is efficiently converted to energy products, and is used to displace GHG-intensive fuels.[12] Theoretically, net CO_2 emissions resulting from the direct use of biofuels can be less than from the utilization of fossil fuels.

However, the combustion of biomass also creates atmospheric emissions of carbon dioxide, sulphur dioxide, nitrogen oxide, and particulate matter.[13] The severity of the impact on air quality of such emissions depends on the proximity of the power plant to communities, sensitivity of ecosystems, levels of pollutants released, topography, and climatic conditions. Biomass combustion is generally less polluting than coal with lower emissions of nitrogen oxides and sulfur oxides.[14] Table 8.3 indicates the contribution of different pollutants emitted by a bioenergy plant.

Table 8.3: Air pollution from biomass energy

Source: PPFI (undated)

Emission type	Percentage contribution to combustion emissions
Nitrogen oxides (NO_x)	0.03%
Carbon monoxide (CO)	0.06%
Particulate matter	0.02%
Sulphur dioxide (SO_2)	0.02%
VOCs	0.01%
Hazardous air pollutants	0.00%
Carbon dioxide (CO_2)	99.86%

There are also notable indirect impacts of bioenergy with respect to both increasing and decreasing CO_2 emissions.[15] For example, large-scale land clearing specifically to produce biomass and to enable large-scale expansion of growing energy crops would release stored carbon and result in GHG emissions to the atmosphere. The carbon sink capacity of natural forests could be reduced, as cleared areas may be replaced by energy source crops, which may have less capacity to capture carbon than the replaced forest.[16] The volume of CO_2 emissions from bioenergy production will depend on the types of fuel crops grown and the associated management practices.

If land is to be cleared on a large scale for the growing of biofuel crops, and if this also involves the burning of forests, there will be significant negative impacts on air quality—from smoke, particulate matter, and other pollutants—experienced over large distances. For example, forest fires in Indonesia have had major adverse impacts on air quality, which has also affected neighboring countries such as Singapore and Malaysia.[17] The burning of crop waste products on a large scale can also have significant negative impacts on air quality.

There would also be localized negative impacts on air quality from the growing of bioenergy crops. These include dust emissions (from vehicle movements and agricultural practices, like tilling soil) and vehicle emissions (from the transport of crops or forest wood to the processing facility and then on to the powerplant for combustion).

[12] IEA Bioenergy (2020)
[13] USEPA (2018)
[14] Ren *et al*. (2017)
[15] Wu *et al.* (2018)
[16] World Bank (2010)
[17] Sheldon and Sankaran (2017)

Water quality

The production of crops for biofuels can lead to a decrease in water quality due to:

- Poor agricultural practices that result in fertilizer runoff into waterways, causing algal blooms and nutrient loading in waterways.
- Pesticide runoff from agricultural land, leading to contaminants and biocides entering waterways.
- Land clearing and changes to vegetation cover that result in increased erosion and sedimentation of waterways.
- Spills of fuels and oil from vehicles, agricultural machinery, or machinery used in clearing forests.[18]

The reduced water quality can then cause:

- Health impacts on communities as a result of using polluted water for drinking, cooking, irrigation, washing, and bathing.
- Direct loss of biodiversity and degradation of aquatic ecosystems.

Risks of climate change

The risks to bioenergy production associated with climate change are potentially significant. For instance, droughts, floods, strong winds, and forest fires (due to extended droughts) will affect/disrupt the cultivation of energy feedstocks (i.e., reducing or destroying energy crops), grower incomes and livelihoods, and supply chains to power stations.[19] Power plants may be forced to run at lower utilization rates due to reduced feedstock.

There could also be a higher biomass production and harvest due to an increased growing season and more rainfall. Rainfall quantity could affect the moisture content of the soil or feedstock quality, which, in turn, could result in lower yields and reduced feedstock inputs at the power plant.

Wind velocities can affect the dispersion characteristics of pollutant emissions (i.e., increased winds and wind variations can alter the impact of pollutants on nearby sensitive receptors).

With the increase of CO_2 concentration in the atmosphere, some (potentially less dense) quick-growing varieties of energy crops could out-compete more dense crop species and, over time, reduce the energy content per unit area of land.[20] The energy density of biomass can vary due to variations in photosynthetic interactions driven by CO_2 concentration changes.

Increased droughts may limit cooling water available to power plants.[21] This risk could, at least in part, be offset by growing drought-tolerant biofuel crops. Several promising lignocellulosic crops are emerging that have no food role (e.g., fast-growing trees and grasses) but are well-suited as bioenergy feedstocks, including *Populus, Salix, Arundo, Miscanthus, Panicum* and *Sorghum*.[22]

Water use

The majority of water used in bioenergy production is for the growing of energy crops. These are generally selected for optimal growth, which can mean that they have a high-water demand (i.e., require irrigation). Energy crops consume more water than natural flora and many other food crops.[23] Irrigation water is drawn from either surface water sources or groundwater, which can reduce surface water yields and make groundwater wells unreliable when water sources are over-extracted.

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[18] Wu *et al*. (2018)
[19] Hoover *et al*. (2019)
[20] ADB (2012)
[21] CFR (2019)
[22] Taylor *et al*. (2019)
[23] Berndes *et al*. (2011)

The extraction of underground or surface water may put pressure on existing irrigation infrastructure and reduce fresh water available to host communities and farmers for subsistence crop cultivation, drinking, sanitation, and the support of environmental functioning and services. This is a particularly significant concern when water is scarce, especially during dry seasons. In Brazil, one of the world's largest sugar cane producers, there are well-documented impacts on the availability of freshwater in the Sao Paulo region.[24]

Land use change

Bioenergy production can lead to both direct and indirect changes to land use.

- *Direct land-use changes* relate to changing land use to produce bioenergy crops, including:
    - Changing the types of crops being grown.
    - Converting grazing land to growing biofuel crops.
    - Removing forest or naturally vegetated areas and converting them bioenergy crops.

- *Indirect land-use changes* can occur if bioenergy crops displace food crops, such as when forested areas are cleared to grow food crops. The overall impact would be like what has been experienced in parts of Southeast Asia because of palm oil production (see Box 8.2).[25]

The conversion of land to biofuel production will likely result in the clearing of very large areas of forests and/or habitats with high biodiversity value, resulting in significant habitat and biodiversity losses. This has already occurred where other industries have been promoted, such as with palm oil plantations in Indonesia (see Box 8.2) and the production of other agricultural products.

A review of the literature indicates that there are differences in opinion regarding bioenergy crop production and effects (positive or negative) on biodiversity.

Soil quality, erosion, and landslips

Bioenergy projects usually cause an increase in erosion and sedimentation associated with land clearing for crop production. Clearing can cause a decline in overall soil stability and health and can lead to landslips, sedimentation of waterways, and changes to the amount of water that land can hold, potentially increasing flood or landslip risks. This may also occur when there is poor crop cover, poor agricultural practices, and poor soil conservation on sloping land. Poor soil management can also lead to the loss of nutrients when existing grasslands are converted to biofuel production.

Disturbance to vegetation and soils adjacent to creeks and rivers (e.g., due to tilling soils for fuel crop production) can lead to an increase in erosion and sedimentation in the waterways. If the local geology is unstable, landslips, mudflows, and debris flows can all contribute to watercourse sedimentation.

[24] IATP (2007)
[25] Berndes *et al*. (2011)

Box 8.2: Land use change from palm oil in Indonesia
Sources: Duke University (2019); ICCT (2016); Uryu et al. (2008)

Palm oil plantations in Indonesia claim roughly 50,000 hectares of land per year. The carbon footprint of the palm oil industry has two components: emissions from deforestation, and emissions from the processing of palm oil. Converting forests to palm oil plantations results in the loss of large amounts of carbon from biomass and from the disturbed soil. Studies and estimates indicate that any carbon savings associated with palm oil expansion are far outweighed by the losses. It is estimated to take between 75 and 600 years for the carbon savings of petroleum displacement by palm oil biofuel to balance the carbon lost during the growth and manufacturing of the product.

Forests are usually cleared for palm oil plantation by logging and burning. In Katapang, Indonesia, fire was the cause of 90% of deforestation between 1989 and 2008, while 20% of wildfires across Indonesia can be attributed directly to palm oil plantation practices. Burning has adverse effects on human health, as the subsequent smoke can cause respiratory and cardiovascular disease and even death.

Deforestation through these processes in Indonesia is a leading cause of biodiversity loss. There has been a significant reduction in population densities and species richness for birds, mammals, bees, butterflies, moths, termites, dung beetles, and ants. Additionally, iconic species like the orangutan, found only on Sumatra and Borneo, are rapidly declining due to forest loss. In Riau, Sumatra, Sumatran elephants have declined by up to 84%, from >1000 in 1984 to approximately 210 in 2007. Sumatran tiger populations declined by 70% over a similar timespan. Although these statistics on biodiversity loss in Indonesia are not entirely directly attributable to palm oil plantations, palm production has been found to reduce biodiversity more than other types of crop plantations.

When forests and other natural vegetation are cleared for biofuel production, agrochemicals associated with such cultivation can pollute both land and water, have harmful impacts on terrestrial and aquatic ecosystems, and filter into groundwater.

During large-scale forest clearing, earthmoving activities and road construction can increase erosion, particularly if there is inadequate attention to access road design and drainage. This often happens when temporary, lower cost, and lower quality roads are built.

Increased erosion and sedimentation are common issues for poorly planned and managed agricultural areas.[26] This, in turn, affects water quality and can modify the riverbed composition and geomorphology and cause the degradation or loss of habitats for fish and other aquatic life. An increased sediment load can affect a river a long way downstream and can choke aquatic vegetation and habitats. Very high sediment levels can smother aquatic invertebrates and coat the gills of fish, causing suffocation.

Impacts on the quality of soil due to biofuel crops can degrade soil quality over time, lowering soil nutrient levels or changing soil chemical composition due to the inappropriate use of fertilizers and pesticides.[27] Changes in soil quality can result in:

- Abandonment of areas of land (i.e., once land is degraded, farmers may move to new areas, abandoning farms rather than rehabilitating them).
- Making land unsuitable for future agricultural use (i.e., severe impacts on soil can prevent the land from being used for different agricultural purposes without extensive rehabilitation).
- Additional clearing for more fertile soils (i.e., when farmers are forced to move, they must prepare new areas for growing crops).[28]

[26] Berndes *et al*. (2011)
[27] IFC (2016)
[28] Wu *et al*. (2018)

Loss of habitats and biodiversity

Clearing of land for large-scale biofuel crop production can cause significant loss of habitat and a decrease in biodiversity.[29] Fauna, including protected and threatened species, are displaced when land is cleared (e.g., forests or other natural vegetation), forcing them to seek alternative suitable habitats where available. This has a knock-on effect, as the displaced individuals may then cause increased competition for food resources or out-compete other less dominant species when they relocate.

The building of access roads in a once undeveloped and relatively inaccessible area can also lead to habitat fragmentation, an increase in illegal hunting or poaching of wildlife species, and an increase in illegal harvesting of timber and other forest products. Increased access may lead to further in-migration and conversion of natural habitats to agricultural practices.

The conversion of environmentally sensitive and high-biodiversity-value lands to biofuel cropland can result in associated negative environmental impacts. Apart from loss of biodiversity, it can also result in increased CO_2 emissions from the loss of forests, an increase in weed species, the introduction of alien species, and runoff into waterways impacting aquatic flora and fauna.

Biodiversity can also be affected or killed as a result of using pesticides and herbicides on biofuel crops, which can runoff from fields and enter waterways.

The loss of biodiversity and habitats can disrupt and unbalance the overall function of ecosystems and delivery of ecosystem services.

Crop waste products

If biofuel crop waste product residues (e.g., left over leaf material, roots, and other plant parts after harvesting) are not collected and transported to power plants, or when suitable storage facilities are not available, most farmers will have no option but to openly burn the residues. This has various health risks and can significantly raise levels of air pollution, particularly smoke and particulate matter. Smoke problems are commonplace in Indonesia, India, and other crop-producing developing countries and can have cross-border impacts on neighboring countries. [30] [31]

The burning of crop residues has an impact on soils. When the residues are not reincorporated in the soil, nutrients are lost and cannot benefit the next crop cycle, increasing the requirement to apply fertilizers. Organic matter is also lost, leading to the deterioration of soil structure.

Rice is a common crop in Asia. Once the rice grains are removed from the stalks, the rest of the plant is usually discarded. Demonstration projects in India have started creating a crop residue supply chain so that rice husk waste is collected, stored, and turned into briquettes and pellets, which can replace coal in power plants.[32] There can be an environmental benefit from providing an economic incentive to farmers to stop burning crop waste and increase their incomes.

Land and ecosystem restoration

While bioenergy crops may be grown on existing agricultural land, areas of existing forest may also be cleared to create new land for bioenergy crops. Where these are grown as a monoculture, such conversion can lead to significant biodiversity loss and land degradation as discussed above.
On marginal lands, the establishment of bioenergy crops (e.g., perennial grasses and short-rotation woody crops) offers possibilities for both successful eco-restoration and energy production.
Forest landscape restoration (FLR) is being promoted as a means for reversing land degradation while providing multiple products and services, including bioenergy. FLR using biofuel-friendly trees

[29] IFC (2016)
[30] Bhuvaneshwari et al. (2019)
[31] Sheldon and Sankaran (2017)
[32] FAO (2010)

under climate smart agroforestry practices and utilizing fruits, nuts, and biomass for energy could solve multiple issues by:

- Turning unproductive degraded lands into productive landscapes.
- Preventing further conversion of natural vegetation for other uses.
- Compensating for the high initial investments required for FLR.
- Providing multiple ecosystem services, including climate regulation.[33]

8.5.2 Socioeconomic issues

Employment and labor conditions

Increasingly, the deployment of renewable energy is recognized as an opportunity that helps to diversify a country's skill base and expand industrial development. Bioenergy also offers significant employment opportunities in the emerging renewable energy sector.

IRENA reports that in Southeast Asia, Indonesia, Malaysia, Thailand, and the Philippines have seen increasing employment in the biofuels sub-sector, while a national review in the Philippines indicates that the growing, collecting, and marketing of biomass fuels are handled by the informal sector and are labor-intensive.[34] The same study found that fuelwood and crop residues are a significant source of income and employment, particularly in rural areas. Approximately 700,000 households are involved in commercial biomass gathering and/or production in the Philippines.[35] Similarly, Latin America has approximately two million people working in the renewable energy sector, with biofuels in the lead (Brazil is the leading producer).[36] While employment within the biofuel sub-sector is largely benefiting rural areas of low-income countries, it also boosts employment in higher-income cities like Stockholm, Sweden.[37]

Biofuel crop production, like other agricultural practices, can be associated with the unacceptable use of forced and child labor (see Box 8.3).[38] In 2020, a human rights coalition was working to end forced labor in the palm oil industry[39], which contributes to bioenergy. The ILO reports that, worldwide, 60% of all child laborers in the age group 5 to 17 years work in agriculture, including farming, fishing, aquaculture, forestry, and livestock.[40]

Box 8.3: Child Labor in the sugar cane sector in Asia
Source: ILO (2017)

Child labor in the sugar cane sector is evidenced in three key sectoral studies conducted in the Philippines, India, and Cambodia. In 2016, the United States Department of Labor also reported the issue in Myanmar, Pakistan, and Thailand. The evidence from Asia shows that children working in sugar cane are employed both on smallholder farms as family helpers and on larger commercial plantations.

A survey conducted by the ILO in two sugar-growing regions in Cambodia in 2015 found that the incidence of child labor was more prevalent on smallholder farms than on commercial plantations (64% compared to 26%) and that children on smallholder farms tend to be younger (12 compared to 15 years old, on average). In the Philippines in 2015, it was estimated that over

[33] Baral *et al*. (2022).
[34] IRENA (2017b)
[35] Remedio and Domac (2003)
[36] IRENA (2017b)
[37] Remedio and Domac (2003)
[38] The ILO defines forced labor as situations in which persons are coerced to work through violence or intimidation or by more subtle means such as accumulated debt, retention of identity papers, or threats of denunciation to immigration authorities.
[39] See for instance CGF (2020)
[40] ILO (undated)

13,500 children worked in the sugar cane sector (2.5% of children working in the agricultural sector). Most were thought to be unpaid family workers.

Reports indicate that ethanol production in Brazil (based on sugar growing) is associated with significant labor abuse practices, including child labor, employing children as young as seven years old.[41] Brazil is the main producer of ethanol, with Thailand, the Philippines, and Indonesia also in the top 10 sugar-producing countries.[42]

Among renewable energies, bioenergy is the most labor-intensive sub-sector.[43] Like with other technologies, employment opportunities range from manual labor to engineering. As bioenergy production from agricultural waste increases, there will also be potential to boost employment in the sub-sector, especially managing crop residues and wastes.

Jobs are created all along the bioenergy chain, from the production of biofuels to their transportation, distribution, and marketing. Employment can be direct (i.e., resulting from operation, construction, and production phases) or indirect (i.e., resulting from expenditures related to biomass fuel cycles). The impacts and potential benefits of employment also depend on the country context and type of biofuel used in energy production (see Box 8.4).

Box 8.4: Employment in the biofuels sub-sector in Thailand

Source: Silalertruksa et al. (2012)

A recent study in Thailand found that producing ethanol and biodiesel requires about 17 to 20 workers and 10 times more workers than gasoline and diesel per energy content, respectively. In 2022, approximately 300,000 people were engaged in ethanol production. While there are significant differences in employment characteristics in the agriculture and biofuel processing sectors, direct employment in agriculture contributes to more than 90% of total employment in Thailand.

Local economy and livelihoods

In addition to providing employment, bioenergy projects can impact livelihoods and local economies. They may require large tracts of land to grow energy crops. This may result in land acquisition, leading to the physical and economic displacement and subsequent relocation of people, including Indigenous communities.[44] It may also lead to loss of income, such as from rice cultivation or other farming activities.

A study by the United Nations Food and Agriculture Organization focused on employment and the socioeconomics of bioenergy systems found that, from a macroeconomic perspective, bioenergy contributes to:

- Import substitution with direct and indirect economic effects at the national, regional, and local levels.
- Economic growth through business expansion.
- Mobilizing investments for rural areas.

The study notes that the human resources required to produce biofuels is about five times more than for fossil fuels.

[41] Teixeira and Sherfinski (2021)
[42] ILO (2017)
[43] EUBIA (undated)
[44] Karekezi and Kithyoma (2006)

Increased employment opportunities in the bioenergy sub-sector could help to address adverse social and cohesion trends, such as high unemployment levels, depopulation, and out-migration, which are more prevalent in rural areas. Bioenergy production tends to be in rural locations and may be beneficial there, helping rural areas and indirectly supporting related industries and services.[45]

Food security and prices

Bioenergy projects may cause both positive and negative impacts on food security and prices.[46]

Bioenergy requires a large and continuous supply of energy crops. Where many of these are also food crops (e.g., corn), their cultivation to meet the demand as a biofuel can lead to a reduction in their availability for public sale as a food. The increase in prices can consequently make consumable energy products unaffordable to disadvantaged people and the lower socioeconomic demographic who rely on the crops for food. The production of energy crops may also reduce the volume of food crops available, leading to malnutrition in rural areas.[47] Women, who are often responsible for sourcing family food supplies, may be affected more than men. Bioenergy demand may also increase the price of biofuel products, creating more commercial opportunities for medium-scale producers or wealthy farmers.

Drawing on global data on food prices, food consumption, and land-use change (especially in European countries), research shows that bioenergy projects and the increased use of biofuels causes competition for resources and lowers food crop yields.[48] This is because overall capacity to produce both biomass and food is limited to the amount of available arable land.

A balance is required between food and energy production, especially to meet the demands of the ever-increasing population and to minimize pressure on natural resources and ecosystems. Large-scale biofuel and bioenergy production also increases the demand for arable land, raising the unit cost of food production. It is argued that increased population and demand for food has already led to higher food prices, reducing resource availability (e.g., land for agricultural cultivation) to fulfill everyone's needs.[49] This trend could cause adverse impacts on poor and vulnerable communities.

Indonesia is among the world's largest palm oil and biofuel producers. The country has seen steep increases in food prices and supply shortages from 1990 to 2013[50] and from 2020 to present, including for basic and staple ingredients and commodities. A study of the use of biofuel from agricultural crops for transportation in Indonesia showed that widespread bioenergy generation and the growing of biofuel have the potential to result in food crises if mismanaged.[51] The study also showed that smallholder farmers in Indonesia are more willing to sell their crops to international biofuel companies, largely driven by the higher price and income potential, adding further challenges to food security and sustainable management of resources.

Health and safety

Biofuel production can have negative health and safety impacts. Traffic levels can increase due to the transportation of fertilizers and other crop inputs, and the transport of harvested crops to processing facilities and pellets to powerplants can lead to increased risks of accidents and localized pollution. The increased traffic and operation of machinery can cause congestion and increase noise levels that can disturb local communities and wildlife.

Farm workers will also face health impact risks from using pesticides and fertilizers, which contain hazardous chemicals. Communities can also face health risks due to air emissions from biofuel combustion, the management of waste pesticide containers and packaging, and the pollution of

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[45] GNESD (2011)
[46] FAO (2012)
[47] IFPRI (2008)
[48] Muscat, A. *et al*. (2020)
[49] Hasegawa et al. (2020)
[50] DKP, KP and WFP (2015)
[51] Colbran and Eide (2008)

waterways from runoff of biocides. Such pollution can also put downstream communities and aquatic environments at risk.

For agriculture production, the IFC EHS guidelines[52] identify various OHS issues, including:

- Physical hazards (e.g., overexposure to noise vibration and extreme or adverse weather conditions; use of machinery and vehicles; potentially confined spaces; and exposure to organic dust).
- Risk of fire and explosion from combustible dust.
- Safety when working in silos.
- Biological hazards (e.g., contact with venomous animals).
- Exposure to chemical hazards (e.g., fuels, pesticides, and herbicides).

For community health and safety, the guidelines recognize that changes to land use may affect natural buffer areas and result in increased community vulnerability to manage weather patterns. There may also be exposure to potentially harmful chemicals in post-harvest products and risks of vehicle or machinery injuries on roads and access routes used around local communities.

The operation of bioenergy power plants can cause noxious odors that require managing and mitigation.

Health problems can arise from poorly designed bioenergy plants that produce high levels of specific emissions.[53] When biomass replaces coal in a modern power plant, there can be some reduction of the emission of sulphur dioxide or particles.[54]

Land use and value

Growing crops for biofuel production is land-intensive and can put significant pressure on the land used for conventional agriculture, forest production, and conservation. When existing arable land is converted to biofuel production, competition for land generally increases.

In Thailand, land used for sugar cane and palm oil cultivation is expected to increase significantly by 2026. Promoting sugar cane and palm oil cultivation has been a controversial policy decision due to the increasingly limited yields per area and to the conflict between crop supply and increasing demand for land for biofuel production.[55]

Global analysis of biofuels and land-use change has found that biofuel production will account for approximately 20% of global land-use change between 2006 and 2035. [56] In Southeast Asian countries such as Indonesia and Malaysia, this could translate into the expansion of biofuel production and cultivation of large areas of agricultural land and the clearance of forest land by bioenergy companies, further limiting the ability of communities to purchase and make use of land locally.

In addition, land value is also expected to climb sharply, potentially resulting in land disputes and conflict between stakeholders over licenses to operate.[57] A report in 2021 by the Carbon Disclosure Project highlights the lack of transparency by biofuel producers in Indonesia. It is reported that there is continued illegal use of land and transformation of forests and arable land to biofuel production, infringing the land rights of local communities.[58] The project claims that the Government of Indonesia has committed to allocating over 4 million hectares of land to support biodiesel production by 2025, with a list of Singaporean, Dutch, and Indonesian energy companies.

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[52] IFC (2016)
[53] Stashwick (2016)
[54] Air Quality Expert Group (2017)
[55] Jusakulvijit, *et al*. (2021)
[56] IEA (2022b)
[57] Bruce and Boudreaux (2013)
[58] Jong (2021)

Gender and vulnerability

The transition to bioenergy is a land-intensive process and therefore requires access to and availability of large quantities of arable land. This can lead to heightened vulnerability among communities currently reliant on land access for much-needed subsistence crop cultivation.[59] As with other renewable technologies, there can be asymmetrical impacts on women and vulnerable groups (e.g., persons with disabilities, older people, Indigenous peoples) associated with displacement and access to land benefits.[60]

As affected households become exposed to greater economic pressures and food insecurity, the social risk factors identified in other renewable technologies are heightened, with differential impacts felt by women and vulnerable groups. For example, there are increased financial and domestic burdens on women, a risk of sexual harassment and gender-based violence, and resulting physical and mental health issues experiences by the communities affected. Often women have the main responsibilities for sourcing food and making meals. Changes of land use that affect food availability may change—often increasing—the amount of time they need to spend on these activities.

The potential environmental risks associated with bioenergy (e.g., reduced air quality and impacts on water quality from pesticides usage[61]) may also decrease the resilience of rural communities and individuals to external shocks and hinder their ability to cope with climate change impacts. Women and girls in rural areas may thereby be affected by a double burden of intersecting disadvantages.[62]

In 2019, IRENA conducted a survey of gender in renewables with 1440 global respondents.[63] The participating organizations and individuals rated bioenergy as the second most relevant renewable technology for their work after solar, and among the top three renewable energy types. This technology is therefore ripe with opportunity and has real potential to promote sustainable and inclusive growth for women and vulnerable communities through local employment generation, training, and skills development.

Indigenous communities

Subsistence-based Indigenous peoples rely on the land and natural resources for their livelihoods and cultural practices, such as communal land use.

Bioenergy development projects can require large amounts of land to grow energy crops. The acquisition of land for these projects can cause the loss of Indigenous communities' communal land and traditional use practices.[64] The development of bioenergy projects also has the potential to physically restrict access by Indigenous people to their natural and cultural resources, such as sacred forests, burial grounds, and animistic sites (see Box 8.5).

[59] Remedio and Domac (2003)
[60] Differential impacts of displacement and access to any resulting benefits are explored in greater detail in the Gender and Vulnerability subsection of Chapter 5.
[61] See more in the Bioenergy Research at McGill University (https://www.mcgill.ca/bioenergy/impact).
[62] Rossi and Lambrou (2008)
[63] IRENA (2019)
[64] Zurba and Bullock (2020)

Box 8.5: Impacts of biofuel production on Indigenous people of Guaraní in Mato Grosso do Sul, Brazil
Sources: EJ Atlas (2017); BBC News (2012)

In Brazil, the activities of a multinational energy corporation growing sugar cane for biofuel is alleged to have caused severe negative impacts on the Indigenous Kaoiwá and Guaraní community near Dourados in the southwestern state of Guaraní in Mato Grosso do Sul. The community suffered the use of forced labor, conversion of agricultural lands to monoculture sugar cane farming, and illegal land grabbing, which displaced the community from their ancestral lands, limited access to important cultural resources, and consigned them to small reserves. After two years of protests, the company signed an agreement to forgo buying sugar cane grown on the Indigenous communities' lands.

Public services and infrastructure

A supply-side opportunity associated with local bioenergy production is the potential for the improvement of infrastructure for the local community.

Large biofuel plantations can offer an alternative to subsistence farming for the rural poor and can provide public infrastructure and amenities for employees and their dependents, including housing, water, electricity, roads, and medical care.[65] Road networks are often built to access plantations, as well as additional public infrastructure such as schools and hospitals for employees. Oil palm plantations in Malaysia employ over half a million people, with the provision of infrastructure that Malaysians and foreign workers benefit from and have grown dependent on.[66] The financial support for local communities provided by biomass companies can also be used by local authorities to enhance existing public infrastructure services, such as schools or hospitals.

However, an OECD/IEA publication in 2013 focused on bioenergy project development and biomass supply around the world, especially in Australia, UK, and Norway, identified some negative impacts as a result of improved and new access roads used for the collection and transportation of biomass. These included higher local air pollutant emissions due to increased vehicular traffic (i.e., from exhausts), increased accidents, decreased pedestrian safety, and greater wear and tear of roads themselves.[67]

Infrastructure provision may also not always happen without concrete commitments, and community infrastructure improvements require large sums of upfront investment which can present challenges, particularly in rural low-income locations (see Box 8.6).

Box 8.6: Inadequate infrastructure for biofuel production in rural Myanmar
Source: Cushion et al. (2010)

In 2005, in response to rising energy costs and protests over cuts in diesel subsidies, the government of Myanmar established a project to produce biodiesel from Jatropha, a shrub tree. Various reports estimate that the planting area ranged from 200,000–400,000 hectares, with a planned expansion to 3 million hectares.

Production occurred on large, centrally planned plantations, on military sites, and in rural villages. Farmers with more than 1 acre (0.4 hectares) of land were directed to plant Jatropha on their landholdings and often were required to pay for the seeds. Human rights groups claimed that farmers who refused to plant Jatropha were at risk of being jailed. Other reports suggested that military rulers had confiscated land and used forced labor in some locations. Another

[65] Koh and Wilcove (2007)
[66] Cushion *et al.* (2010)
[67] IEA (2007)

concern was that the required planting of Jatropha crops displaced food production in the poor, rural areas of Myanmar.

The directive was not matched by adequate infrastructure (e.g., collection mechanisms, processing plants, distribution systems) to process the Jatropha crop. As a result, Jatropha seed production did not translate into increased fuel production. In response, on 27 February 2009, a Japanese company, the Bio Energy Development Corp (JBEDC), announced that it would establish a joint venture with a Myanmar private company for biofuel development. The new company, Japan-Myanmar Green Energy, aimed to export 5,000 metric tons of seeds in 2009 and start operating its first oil mill plant in 2010. It also planned to distribute and export Jatropha-derived fuel in addition to its seed. Globally, Jatropha has not met expected yields or investor returns.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 9

GEOTHERMAL POWER

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Links to the complete guidance document and to individual chapters are also available.

CHAPTER 9

GEOTHERMAL POWER

9.1 WHY SEA IS IMPORTANT TO GEOTHERMAL POWER

An overall rationale for why it is important to use Strategic Environmental Assessment (SEA) to support the energy transition is provided in the preface to this guidance.

SEA can provide critical information to support better decision-making for geothermal power planning and development, including identifying where there may be implications for policies, plans, and programs (PPPs) to adequately address significant environmental and/or socioeconomic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple geothermal power schemes/developments, whether alone or in combination with other renewable energy technologies (e.g., solar, wind).

The SEA process will:

- Identify and focus on key environmental and socioeconomic issues and the concerns of likely affected stakeholders, including local communities, marginalized groups and Indigenous peoples. Major issues are discussed in detail in Section 9.5 and summarized in Table 9.3.

- Identify/recommend if there are areas that should be avoided for geothermal energy development ("no-go" areas) because of particularly high risks to the environment, habitats/biodiversity, and/or people.

- Identify what changes or additions are required to PPPs governing geothermal power development to address these risks.

- Make subsequent project-level Environmental Impact Assessments (EIAs) more efficient and cheaper by addressing the big picture and cumulative potential impacts, identifying the particular issues that individual project EIAs should focus on in more (site-specific) detail.

- Engage stakeholders (particularly in areas where geothermal power potential has been identified), including communities, marginalized groups, and Indigenous peoples, which can be particularly affected by geothermal energy developments. SEA enables them to be informed early of proposed or possible policy options or plans and to provide their perspectives and present their concerns as early as possible. This will enable key issues to be identified and verified, help build understanding and support for geothermal energy development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 2 and are therefore are not repeated in this chapter.

9.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE GEOTHERMAL ENERGY SUB-SECTOR

An international survey of existing SEA guidelines conducted for IAIA was unable to identify any that are specifically focused on the geothermal power sub-sector. Several recent guidelines specific to EIA for geothermal energy development projects have been identified in Australia and Europe.[1]

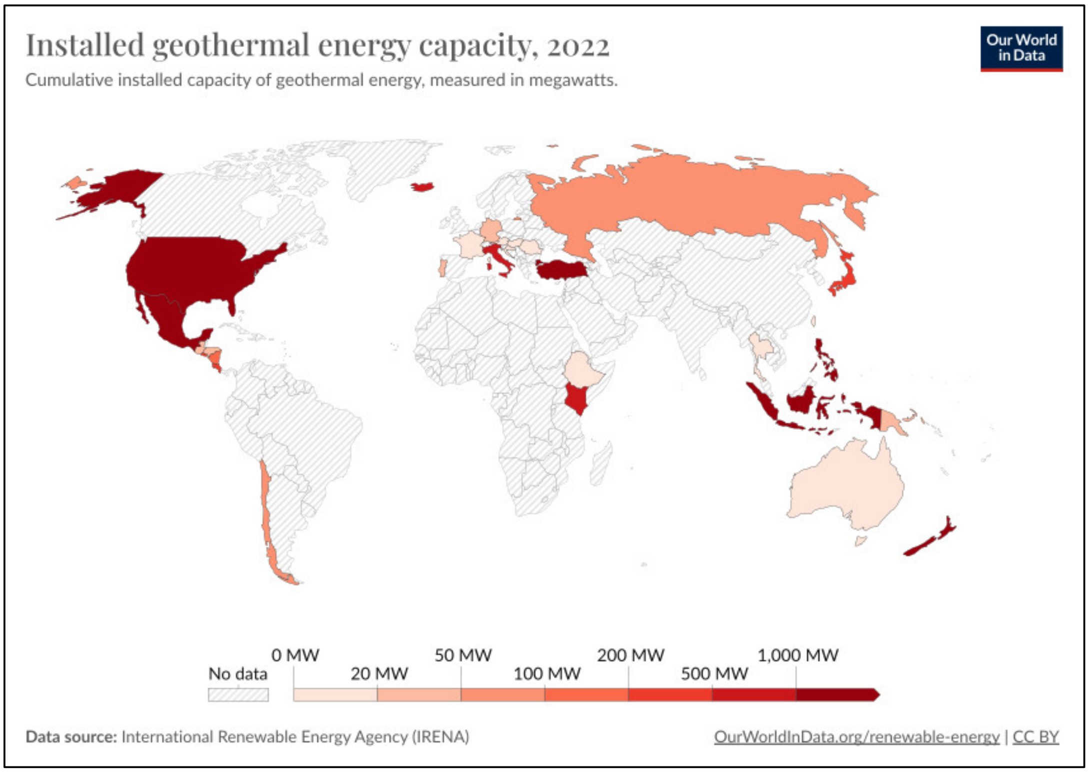
[1] e.g., For Australia, see "Guideline for the Development of Petroleum, Geothermal and Pipeline Environment Plans in e.g., Western Australia" (https://www.dmp.wa.gov.au/Documents/Geological-Survey/Guideline-for-Development-Petroleum-Geotherman-Pipeline-Environment-Plans.pdf). For Europe, see "Proposal for a harmonised procedure on the Environmental Impact Assessment and licensing guidelines for geothermal

Some international agencies have produced guidance on environmental and social issues related to geothermal energy generation,[2] and various sources discuss the environmental impacts of geothermal energy.[3] While not a guideline, the World Bank has completed a rapid environmental and social impact assessment of geothermal energy development in Indonesia which identifies key risks and impacts typically associated with geothermal power development in forest areas.[4]

9.3 GEOTHERMAL ENERGY INSTALLED CAPACITY

The installed capacity of geothermal energy has gradually increased worldwide over the last decade, reaching 14,877 megawatts (MW) in 2022[5] (see Table 9.1). Figure 9.1 shows the global distribution of installed capacity in 2022. The top 10 countries in 2020 are listed in Table 9.2.

Figure 9.1: Installed geothermal energy capacity, 2022
Source: Our World in Data (2023b) based on BP (2021)



development in Europe" (geoenvi.eu/publications/proposal-for-a-harmonised-procedure-on-the-environmental-impact-assessment-and-licensing-guidelines-for-geothermal-development-in-europe/)
[2] e.g., IFC (2007)
[3] e.g., CEI (2019); Energysage (2019); UCS (2013b); Bošnjaković *et al*. (2019)
[4] Meijaard et al. (2019)
[5] Fernández (2024)

Table 9.1: Installed geothermal energy capacity by region, 2022
Source: IRENA (2023)

Region	Installed capacity (MW)
Asia	4,711
North America	3,712
Eurasia	1,765
Europe	1,635
European Union	892
Oceania	1,323
Africa	956
Central America & Caribbean	724
South America	51
World	14,877

Note: These figures cannot be summed, as some areas may have been considered as part of at least two different regions (e.g., components of Oceania may have been included in other regions).

Table 9.2: Top 10 geothermal countries, 2022
Source: IRENA (2023)

Country	Installed capacity (MW)
USA	2.653
Indonesia	2,343
Philippines	1,932
Turkey	1,691
New Zealand	1,273
Mexico	1.059
Kenya	949
Italy	772
Iceland	757
Japan	431
Other	1,017
Total	14,877

9.4 BACKGROUND TO GEOTHERMAL ENERGY GENERATION

Geothermal energy is generated in countries located on or near seismically and volcanically active tectonic plate boundaries. There are four main types of geothermal power plants:

- Dry-steam plants use steam directly from a geothermal reservoir to turn generator turbines.
- Flash-steam plants take high-pressure hot water from deep inside the earth and convert it to steam that drives generator turbines.
- Binary-cycle power plants transfer the heat from geothermal hot water to another liquid.
- A hybrid system.

Geothermal power plants operate by extracting the Earth’s heat in the form of steam or hot water, which, in turn, is used to drive a steam turbine and generate electricity. There are two basic systems: open-loop systems, which can require a large amount of cooling water; and closed-loop systems, which return the water to the underground source.

The geothermal energy is captured through drilling production wells into deep groundwater reservoirs and then extracting and piping the hot water and steam to a power plant where it drives a turbine.

In dry-steam and flash-steam plants, a part of the steam is released to the atmosphere. Wastewater effluents and gases are typically reinjected into the reservoir or its periphery to minimize the potential for groundwater contamination.[6]

[6] IFC (2007)

An example of a geothermal power plant is the 330 MW Sarulla plant geothermal power plant in Sumatra, Indonesia[7] (see Figure 9.2 and Box 9.1).

Figure 9.2: Sarulla Geothermal Plant, Indonesia

Photo: Courtesy of Sarulla Operations Limited

Unlike solar and wind energy, geothermal energy is constantly available. Hence, it provides both baseload power and firming power[8] for when variable renewable energies (e.g., wind or solar) are unavailable.

The environmental and social effects of geothermal energy are dependent on how and where geothermal energy is extracted. Access roads, pipelines, and transmission lines must be constructed, often in areas that have had little or no previous development. Other infrastructure, such as workers camps, may also be required.

During operation, freshwater may be required to cool exhaust gases (before they are passed through amine scrubbers to reclaim the amine solvents) and for cooling towers. Projects may have a wastewater treatment plant located within the production complex. Processed wastewater from exhaust gas washing and reverse osmosis plants and cooling tower wastewater are directed to a wastewater treatment plant prior to discharge to a public sewage system, where this exists.[9] Storm water from handling areas in the production complex needs to be drained through a sedimentation trap drain to an oil and grease separator, after which it might be discharged to natural waterways.[10]

[7] For more information, see Sarulla Operations Ltd (https://www.sarullaoperations.com/company/overview).
[8] Matek and Gawell (2015)
[9] Englande *et al*. (2015)
[10] Meland (2016)

9.5 IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT

During scoping for an SEA, key issues regarding geothermal energy development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs), which address these issues and will be used during the main assessment stage (see Chapter 1, Section 1.5; and Chapter 2, section 2.5.1). The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other geothermal energy development applications, etc.), interviewing key informants, and holding stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing existing geothermal energy development projects.

At the individual project level, these issues will be the focus of an EIA, which should recommend how to manage or mitigate project impacts that might be likely to arise. Ideally, before individual geothermal projects are approved, a PPP for the geothermal energy sub-sector should be completed and be subjected to an SEA. This should assess the risks and impacts of multiple projects, schemes, and activities likely to arise from implementing the PPP—some directly concerned with the construction and operation of sites and facilities, others linked to associated infrastructure (e.g., transmission lines and access roads). Thus, there is a risk that the impacts of individual geothermal energy developments/projects may become highly significant as they become cumulative. An SEA should focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual geothermal energy project applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

Table 9.3 summarizes the range of environmental and socioeconomic issues associated with geothermal energy development.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 9.3: Environmental and socioeconomic issues associated with geothermal energy development

ISSUE	COMMENT
Environmental	
Air quality	• Geothermal power plant emissions are negligible in comparison to fossil fuel-based power plants. • Some small amounts of carbon dioxide are found in plant steam, and site vents can also produce very small levels of hydrogen sulphide emissions. • Well emissions in open-loop systems include sulphur dioxide, hydrogen sulphide, carbon dioxide, ammonia, methane, and boron. • Some geothermal plants also produce small amounts of mercury emissions, which must be mitigated using mercury filter technology. Scrubbers can reduce air emissions, but they produce a watery sludge composed of the captured materials, including sulphur, vanadium, silica compounds, chlorides, arsenic, mercury, nickel, and other heavy metals. This toxic sludge often must be disposed of at hazardous waste sites.
Greenhouse gases	• Geothermal energy can reduce GHG emissions where it displaces coal as a fuel source.
Noise	• Noise from well exploration (e.g., installation, testing), construction machinery and vehicles, and maintenance activities during operation.
Soil erosion	• From clearing of vegetation and construction of access roads.
Water quality	• Chemical pollution of surface water and groundwaters. Hot water pumped from underground reservoirs often contains high levels of sulphur, salt, and other minerals, which can affect local water quality if not a closed-loop system (i.e., water is pumped directly back to geothermal reservoir after it has been used for heat or electricity production). Surface water used by geothermal plants is normally returned to the original source (e.g., a river) with some increase in heat. • Fluids used during drilling activities may be water- or oil-based and may contain chemical additives. Cuttings from oil-based mud may have high oil-related contaminants in effluent. • Rejected water from geothermal separators may contain heavy metals. • Well blowouts can result in the release of toxic drilling additives and fluids, as well as hydrogen sulphide from underground. • Pipeline failures can result in the surface release of geothermal fluids and steam containing heavy metals, acids, mineral deposits, and other pollutants.
Water use	• Geothermal plants can require between 1,700 and 4,000 gallons of water per MW-hour. • Open-loop systems can require a large amount of water (with over exploitation of available resources); closed-loop systems return the water to the underground source.
Habitats and biodiversity	• Land clearing for well pads, pipelines, and access roads. • Fragmentation of habitat from access roads, pipelines, and transmission lines. • Increased poaching and hunting due to increased access to areas and introduction of workforce into an area. • Risks to birds/bats from collision with overhead power lines.
Protected areas	• Geothermal sites may be close to or within protected areas. • Many geothermal sites are in remote and sensitive ecological areas. • Improved access, roads, and transmission lines increase vulnerability of protected areas.
Waste	• Geothermal power plants produce a relatively minimal amount of waste, but there is potential for leaching of silica compounds, chlorides, arsenic, mercury, vanadium, nickel, and other heavy metals, which may be classified as hazardous.

ISSUE	COMMENT
Earthquake risk	• Hydrothermal plants are sited on geological "hot spots," which tend to have higher levels of earthquake risk.
Visual and aesthetic value	• The visual amenity of the landscape will change. This may reduce appeal of the area to tourists, but may create opportunities for industrial tourism (e.g., visits to facility).
Land and ecosystem restoration	• The average lifespan for geothermal power plant is 20-25 years for the indoor components and 50 years of more for the ground loop. If and when decommissioning takes place, restoration of the site to its former status/condition will be required.
Socioeconomic	
Local economy and livelihoods	• Relocation of people and their structures. • Increased pressure on the host communities' public services. • People displaced from their economic activities, such as crop cultivation. • Loss of income from fishing activities, crop cultivation, and other farming activities; damage to crops from discharges. • Loss of income from small business and enterprise activities due to acquisition of land by energy companies. • Conflict between communities and geothermal energy companies over land ownership. • Negative impact on Indigenous communities and their traditional or customary land and resources. • Benefits to local economy from jobs created (see section on employment and labor conditions).
Employment and labor conditions	• Employment in the construction and operation phases of projects and associated businesses and activities. • Substandard working conditions. • Worker safety. • Workers have the opportunity to learn new skills.
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk. • Gender-based violence and human trafficking resulting from an influx of predominantly male construction workers. • Employment opportunities within new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies.
Cultural heritage	• Loss of religious, historical, and archaeological sites and properties. • Cultural heritage may be destroyed or damaged due to transmission lines, pipelines, and access roads. • Limited access to cultural heritage sites.
Health and safety	• Nearby communities may be exposed to air pollution, including hydrogen sulphide gas. • General hazards for local communities may include contact with hot components, equipment failures, and presence of active or abandoned wells. • Short-term disruptions, such as traffic, road, influx of population, noise, vibration, odor, and steam.
Public services and infrastructure	• Infrastructure (e.g., roads, bridges, schools, health centers, and administrative buildings) may be improved due to community investment by geothermal energy companies. • Pressure on public services and infrastructure will increase as a result of in-migration. • Heavy vehicles and transportation can damage existing roads and bridges. • Increased vehicle traffic during construction.

9.5.1 Environmental issues

Habitats and biodiversity [11]

The location of geothermal power projects is predominantly selected based on geological conditions that are suitable for the highest yield of geothermal energy. Such locations may occur in natural habitats (which can sometimes be critical habitats), such as the dense forests of Sumatra in Indonesia. Alternatively, they could be within modified habitats, such as plantations or rice fields, which may still harbor significant biodiversity value. It is common that forests and vegetation need to be cleared by heavy machinery to allow for the construction of the required infrastructure, such as well pads, power plants, cooling towers, pipes and pipelines, access roads, transmission lines, and other associated facilities.

Clearing results in direct loss of habitat and displaces fauna—which can include protected and threatened species—that depend on it. Animals are forced to seek alternative suitable habitats in other areas of the forest, if available. This can have a knock-on effect, as the displaced individuals may cause an increase in competition for resources or out-compete other less dominant species in such areas. There can also be road kills due to collisions with construction vehicles on access roads.

Significant long-term impacts on biodiversity typically arise from the development of access roads and transmission line easements due to habitat fragmentation. This occurs when an area of habitat that was originally “whole” before the development becomes divided into multiple areas due to partitioning. For fauna species, fragmentation creates a barrier effect by limiting or preventing their movements to areas of the habitat that they would have previously accessed for food, shelter, or breeding grounds. Arboreal species (i.e., species that almost exclusively move in the tree canopy), small mammals, and slow-moving species are particularly vulnerable to habitat fragmentation.

In the long term, once forests have been permanently fragmented, the gene pool of both flora and fauna species tends to be less diverse and more vulnerable to unpredictable and chance events, such as lightning strikes and floods. The creation of access roads through a forest also introduces an “edge effect,” where micro-climates become permanently modified and plant species struggle to survive when exposed to an increased amount of sunlight. Access roads also increase the risk of introducing invasive species.

Access roads constructed through a once undeveloped and relatively inaccessible area can also lead to an increase in illegal hunting or trade and poaching of wildlife, as well as an increase in illegal harvesting of timber and other forest products.

Wildlife can also be displaced from their habitat near a geothermal development due to construction noise (e.g., vehicles and drill rigs) and noise from operations (e.g., vehicles and plant).[12] Similarly, floodlights at a geothermal power plant site can also cause the displacement of wildlife species that are not able to tolerate such changes in their environment. It can force them to seek other habitats, potentially displacing less-dominant species and increasing competition for resources and shelter.

Sulphur emissions from geothermal plants can hinder the growth of vegetation around the site.

Once a geothermal well pad has been established, it is usually tested for its viability and yield. More often than not, some well pads will be unviable, and more drilling than initially planned will be required. In some cases, a well pad is decommissioned or abandoned altogether. Typically, the original planned footprint of a geothermal power project will be subject to change and may increase in area with greater loss of habitat than originally envisaged.

The development of multiple geothermal projects across a region would amplify the negative effects on habitats and biodiversity, potentially resulting in a significant cumulative displacement or loss of biodiversity, even though the impacts of the individual projects may be limited.

[11] Ng *et al.* (2021)
[12] ADB (2017)

The loss of biodiversity and habitat, or the alteration of the ways in which species can utilize the habitat, can disrupt and unbalance the overall function of the original ecosystem and can result in additional loss of some species and ecosystem services.[13]

These issues need to be assessed and mitigation measures identified (see Box 9.1).

Box 9.1: Risks to habitats and biodiversity at Sarulla geothermal power plant, Indonesia

Source: ADB (2019); ADB (2020)

The Sarulla Geothermal Project in Indonesia (Figure 9.2) was developed in an area of high biodiversity value. It was found to pose several risks to high value habitats and biodiversity, including:

- Loss of connectivity between habitats due to the creation of access roads through them.
- Mortality of fauna species from collisions with vehicles.
- Increase in hunting or poaching of threatened species.
- Clearing of habitat for project components, including well pads.

A Critical Habitat Assessment and Biodiversity Action Plan (BAP) was developed for the project to mitigate the risks. The BAP recommended actions to be undertaken by the project company, including designing road crossings for primates, raising community and workforce awareness about the value of the habitats and species in the area, and implementing speed limits to avoid collisions with fauna species.

Protected areas

There is a risk that geothermal developments could be in or near protected areas such as national parks when there is a drive to make the most of the available geothermal resource. In some areas, it is difficult to avoid encroaching on protected areas to create wells for a development, construct an access road, or construct a transmission line to export the energy to the electricity grid. The terrain on fault lines is generally steep, and, in some instances, the only feasible access route to get to the geothermal resource may be to traverse a portion of a protected area. Similarly, in some instances, routing a transmission line through a portion of a protected area may be the most cost-effective or only feasible technological solution open to a development’s design.

Encroachment into protected areas results in direct habitat loss and fragmentation of habitat (see previous section). However, the impacts can be even more significant, as protected areas are intended for conservation purposes. As such, they may host a range of protected flora and fauna species that may not exist in significant numbers elsewhere, and these species may be particularly sensitive to disturbance and human presence. Thus, encroachment into protected areas can lead to a loss of high-value biodiversity. This is particularly true if these habitats are also critical habitats.

A geothermal energy development may inadvertently increase access to protected areas, even if the development or its associated infrastructure is not actually located within the protected area. This can lead to degradation of the protected area by enabling illegal take of wood or other resources from the protected area as well as increasing the opportunity for illegal poaching.

Air quality

In closed-loop geothermal energy systems, gases removed from a well are not released to the atmosphere but are injected back into the ground after giving up their heat, so air emissions are

[13] IFC (2012d); ADB (2019 and 2020)

minimal. In contrast, open-loop systems emit hydrogen sulphide (H_2S), carbon dioxide (CO_2), ammonia, methane, and boron.[14]

Once in the atmosphere, H_2S changes into sulphur dioxide (SO_2), which can have a strong odor when emitted in high concentrations. This contributes to the formation of small acidic particulates that can be absorbed by the bloodstream and cause heart and lung disease. At high enough levels (1,000 parts per million by volume), SO_2 can cause death.[15] SO_2 also causes acid rain, which damages crops, forests, and soils, and acidifies lakes and streams. However, SO_2 emissions from geothermal plants are approximately 30 times lower per MW-hour than from coal-fired power plants (CFPPs) and in some cases can be null.[16]

Emissions of H_2S from geothermal power plants can cause odor annoyances among members of the exposed public, some of whom can detect this gas at concentrations as low as 0.002 parts per million by volume.[17]

Some geothermal plants also emit small amounts of mercury, which must be mitigated using mercury filter technology such as "scrubbers" or air filters. This is generally due to the nature of the local environment (i.e., thermal waters can naturally contain mercury and arsenic). For instance, a study in West Java showed that thermal waters can naturally contain up to 2.6 ppm arsenic and 6.5 ppb mercury, and the surface hydrothermal alteration can contribute up to 50 ppm arsenic and 800 ppb mercury.

However, geothermal power plant emissions are negligible compared to those of fossil fuel combustion-based power plants or bioenergy. For example, geothermal power plants emit approximately 1% of the sulphur oxide (SO_x) and nitrogen oxide (NO_x) and 5% of the CO_2 emissions of a coal-fired thermal power plant of similar power generation capacity.[18]

Scrubbers can reduce air emissions of mercury, but they produce a watery sludge composed of the captured materials, including sulphur, vanadium, silica compounds, chlorides, arsenic, mercury, nickel, and other heavy metals. This toxic sludge must be disposed at hazardous waste sites.

Local air quality can also be affected during construction due to emissions from construction vehicles and by the creation of dust. Occupational exposure to geothermal gases (mainly hydrogen sulphide) may occur during non-routine release of geothermal fluids (e.g., due to pipeline failures) and maintenance work in confined spaces, such as pipelines, turbines, and condensers. The significance of the H_2S hazard may vary depending on the location and geological formation particular to the facility.

Water quality

Closed-loop geothermal systems have few impacts on water quality, as most of the extracted water is returned to the underground source via a second well, resulting in little or no discharges to the environment. However, in open-loop systems, there can be risks associated with the discharge of geothermal water to receiving water bodies. Such water (i.e., brine) extracted from underground reservoirs often contains high levels of sulphur, salt, and other minerals that can negatively affect water quality of the water body or waterway that it is discharged to and/or if there is runoff downstream. In turn, this can lead to a deterioration, alteration, or even loss of aquatic habitat, as well as effects on downstream users of the water. There have also been instances when steam emissions from the geothermal energy process have corroded building roofs and damaged habitats and crops of nearby communities.[19] [20]

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[14] Kagel *et al.* (2005)
[15] Layton *et al.* (1981)
[16] UCS (2013b)
[17] Layton *et al.* (1981)
[18] Duffield and Sass (2003)
[19] UCS (2013b)
[20] Treece (2021)

Under both open- and closed-loop systems, there are risks that construction and operation activities will have a negative impact on water quality because of soil erosion and subsequent sedimentation of waterways (see section on soil erosion) or may result in accidental hazardous waste discharges (see next section).

Accidental spills of contaminants and geothermal fluids can occur during the drilling and construction stages, which can have a negative impact on surface water quality.[21]

If not well managed, polluted runoff from well pads and ponds, especially during rainy season floods, can also affect water quality.

Waste

The biggest source of solid waste on a geothermal project is the earthen drill cuttings material (e.g., soil, rock, mud) extracted during the drilling process. This material is temporarily stored in drill pits, (e.g., mud from the drilling process is stored in temporary mud pits).[22] The material then needs to be transported to a landfill if an option for reuse is not available.

Other construction waste streams would include:

- Material from packaging
- Building materials
- Scrap metals
- Excess soil material
- Plastic and masonry products
- Cleared vegetation
- Sanitary wastes
- Empty chemical storage containers
- Concrete wash out water.

These wastes can pose a risk to water and soil quality and put pressure on landfills if not managed appropriately.

Water use

Closed-loop systems recapture the steam of the geothermal water after it has driven the steam turbine, condense it back to water via a cooling process, and then return the water to the ground via a second well. This means that almost all the water is returned to the underground source. Nevertheless, there are some water losses (approximately 2%) from evaporation and "blow down."[23] However, in the less common open-loop systems, the geothermal water is not returned to the source. Some is lost as steam through the cooling process, but the remainder is condensed and transferred to large-scale cooling ponds and subsequently discharged (e.g., to a marine or freshwater environment).

In the drilling stage of geothermal power plants, high volumes of surface water are required and are usually taken from nearby rivers or lakes, if accessible. In some regions of the world (e.g., Southeast Asia), there is often sufficient surface water availability in the wet season but not in the summer dry season.[24] In drier areas of the world, the high demand for water may put pressure on available water resources.

Like thermal power plants, open-loop geothermal plants also require a source of cooling water that is separate to the geothermal resource. This water could come from either a freshwater or groundwater

[21] World Bank (2017)
[22] ADB (2019)
[23] Blow down refers to a process where some water from the cooling system is purposely released, and new cooling water is added to the system to avoid a build-up of corrosion-causing minerals such as salts in the cooling system.
[24] Alamsyah *et al*. (2020)

source and typically would draw approximately 9,000 liters per MW-hour.[25] Depending on the availability of water resources in an area, this can lead to excess demand on local water resources, which reduces freshwater available to local communities and for livestock and crops. This can be a particular problem for communities in the dry season.

The condensate from the steam cycle is used in the cooling system. Approximately 70% of the water is evaporated by the cooling tower.[25] Alternatively, air-cooled condensers may be used. These use large-scale fans to generate a flow of cool air to condense the steam to water. Such condensers do not require a water source to operate, but they create noise (see section on noise).

Soil erosion

Soil erosion can occur when land is cleared for geothermal project components, pipelines, access roads, and transmission lines. Large volumes of soil can be excavated for leveling well pads and creating access roads.[26] This removal of vegetation, particularly roots, decreases soil stability.

In regions where high rainfall is common, this can cause exposed soils to wash away, leading to sedimentation of nearby waterways. This can reduce water quality and result in the alteration or loss of habitat for aquatic species. Soil erosion can also lead to localized landslips, a health and safety risk for communities (see section on health and safety).

Noise and vibration

The development of a geothermal energy facility involves several construction and commissioning phases that may produce adverse levels of noise and vibration:

- Steam field development involves drilling geothermal wells, which produces noise and vibration from drilling and well-testing activities, mud pumps, compressors, hydraulic pumps, and generators.
- Purging geothermal wells to remove debris involves a vertical discharge, generating a very high noise level. However, this typically lasts only a few hours. Few mitigation options are available, apart from shielding the well outlet and scheduling the activity in periods with a lower risk of intrusion (such as during a weekday).
- General construction noise and vibration impacts come from construction of the power plant, support infrastructure, and site office buildings. The equipment transported to the site can be very large, causing temporary nuisance noise and vibration in the communities through which it is transported.
- During operation of a facility, the main sources of noise will likely include high flow steam pipelines, traps installed in supply lines, steam vents, well maintenance, and electricity generation plants.

Earthquake risk

Geothermal plants are in seismically active areas where earthquakes are likely to occur. In general, geothermal projects themselves are not considered to generate any significant seismic risk. However, there have been some examples of geothermal projects inducing micro-seismic events (by drilling in rock creating “shearing” or fractures) at a localized level that may be perceptible by and impact nearby communities (see Box 9.2).[27] This risk is subject to ongoing research.

[25] USDE (2006)
[26] World Bank (2017)
[27] USDE (2007)

Box 9.2: Earthquake in Switzerland caused by a geothermal system
Source: Choi (2009)

In 2006, a geothermal system in Switzerland caused a magnitude 3.4 earthquake in Basel, an area prone to natural earthquakes. No expert assessment had been conducted of how much the seismicity induced by the project would connect with the natural seismicity under the Basel area.

A court case seeking compensation for property damage was brought against the head of the company, Geothermal Explorer, which subsequently shut down the system.

Visual impacts

In some cases, for safety reasons, a geothermal project will undertake a ground flare to dispose of methane gas should the operation of engines be disrupted. Best practice is to use an enclosed ground flare. Flares would normally only be of short duration. Providing suitable technology choices are made, impacts on air quality are not expected to be significant. However, the visual amenity of the landscape will change. This may reduce the appeal of the area to tourists and local populations and could, depending on location, impact property prices.

The development of a geothermal energy project and its associated pipelines can cause negative visual and spatial effects on the landscape (e.g., by altering vegetation and wildlife habitat).[28] In some countries, geothermal energy is located in protected areas, where the construction of the power plants, access road, transmission lines, and other facilities tends to change the natural visual landscape and, ultimately, can undermine the attractiveness of the area for tourism. [29] [30]

However, geothermal resources often coincide with natural hot springs, presenting opportunities to develop tourism. Iceland is a prime example.

Land and ecosystem restoration

As discussed above, there are significant risks associated with geothermal power development with regard to potential environmental harm and degradation (e.g., unnecessary or excessive deforestation when preparing land for geothermal plant sites and constructing new access roads, pipelines, and transmission lines; destruction of habitats and loss of biodiversity and ecosystem services; soil erosion and pollution). This will particularly arise where mitigation measures proposed by an SEA (and by subsequent project-level EIAs) are inadequate, ineffective, or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple geothermal power developments across landscapes.

Environmental impacts will usually lead to demand for, and need for, land and ecosystem restoration (see Chapter 2, Section 2.6.6), particularly at sites of projects that have come to the end of their useful operational life. The average lifespan for a geothermal power plant is 20–25 years for the indoor components, and 50 years of more for the ground loop. If and when decommissioning takes place, restoration of the site to its former status/condition will be required. At a minimum, this should involve revegetation of the plant area to its original state, including replanting and reseeding using a mix species that were naturally part of the ecosystem/land prior to development of the geothermal power project.

[28] Manzella *et al*. (2018).
[29] Nepal has over 100 facilities within protected areas, while India has 74 under development in important conservation zones. Read more in this 2020 BBC News article (https://www.bbc.co.uk/news/science-environment-52023881).
[30] Soltani *et al.* (2021)

9.5.2 Socioeconomic issues

Local economy and livelihoods

As with many other renewable energy developments, geothermal energy projects provide opportunities for local communities, as well as a range of risks and possible impacts, such as those associated with access to land for drill rigs, well pads, access roads, pipelines, transmission lines, and other associated facilities.

The acquisition of land can create physical and economic displacement. The average area of land required for geothermal projects is smaller than for most other types of renewable energy (see Box 9.3). The most land-intensive stage is the construction of well pads, power plants, and associated infrastructure. The building of access roads and storage facilities during earlier drilling stages may also cause short-term disturbances to the livelihood activities of affected communities and open up areas with natural resources which previously were less accessible.

Box 9.3: Land required for geothermal energy projects

Source: Geothermal Technologies Office (undated); ADB (2019b)

Geothermal projects have a small footprint. The US Geothermal Technologies Office estimates that an entire geothermal field uses 1-8 acres (0.4–3.2 hectares) per megawatt (MW) compared to 19 acres (7.7 hectares) per MW for coal power plants.

The Asian Development Bank-financed 110MW Dieng (2) geothermal expansion project in Java, Indonesia, estimated the need for about 30.8 hectares in total in various locations, mainly for the new pipelines and access road but also for the power plant and five well pads. According to the project’s resettlement plan, the project will require 30.8 hectares for five well pads and the power plant site. As the site is in a fertile and intensively farmed area (Figure 9.3), the acquisition of land for the project will directly impact the livelihoods of 106 persons (29 households) and indirectly affect four lease coordinators (21 persons), particularly smallholders, tenants\, and sharecroppers in the area.

Figure 9.3: Location of Dieng geothermal expansion project in Java, Indonesia

Image: Courtesy of ADB (2019b)

Because well pads generally have a small footprint, and associated infrastructure is linear or underground, careful siting and design can often help avoid or minimize physical displacement.

Land acquisition for geothermal exploration and exploitation is different to other renewable energy projects. An area for exploration may be acquired, but exploration—usually involving the drilling of several wells—may not actually confirm the presence of the resource (geothermal energy) or it may not be economically worth exploiting. By comparison, modeling of wind and solar energy to determine sufficient yield can be undertaken through desktop work. The specific location of geothermal resources can therefore lead to more potential for disputes within communities over land ownership and sometimes over land compensation arrangements. Disputes about land ownership can cause community tension.

Conversely, geothermal projects can be built in harmony with other land uses and deliver livelihood benefits (see Box 9.4).

Box 9.4: Livelihood benefits from geothermal energy

Source: Geothermal Technologies Office (Undated)

The website of the US Geothermal Technologies Office mentions 15 geothermal plants that are producing more than 400MW in one of the most productive agricultural areas, where land around the geothermal infrastructure is used for livestock grazing and agriculture and is adjacent to a national wildlife refuge. See more at https://www.energy.gov/eere/geothermal/geothermal-technologies-office.

Other than the adverse impacts, geothermal projects can induce local business opportunities. As with other renewable technologies, local communities could provide services for the geothermal companies and contractors, such as accommodation for workers, retailing, and other services. In 2000, the Gunung Salak geothermal project in Indonesia, located in the middle of a protected forest, won a prestigious environmental award for its well-planned community development program and responsible environmental management.[31] In Iceland, the geothermal sub-sector provides a multitude of stakeholder benefits, such as participation in decision-making, job creation, and infrastructure upgrades, along with sustainable energy development. But there are trade-offs between pursuing an economically efficient energy system and nature conservation.[32] Iceland has been able to stimulate new unforeseen industries alongside geothermal plants (see Box 9.5).

Box 9.5: New industries connected to geothermal energy in Iceland

Source: McMahon (2016)

Iceland has leveraged geothermal energy production to stimulate new industries, including data storage, greenhouse agriculture, and ecotourism. Prior to recent volcanic eruptions, visitors to Iceland were drawn to the famous Blue Lagoon geothermal spa located in a lava field near Gridavik.

Engineers have begun to design power plants to accommodate tourists and have established geothermal-powered greenhouses where local farmers produce tomatoes, cucumbers, and other crops that once had to be imported.

[31] Slamat and Moelyono (2000)
[32] Cook *et al*. (2022)

Occupational health and safety

As with other types of renewable energy projects, geothermal energy presents occupational risks and hazards, including:[33]

- Hazards from working in a confined space, where entry by workers and the potential for accidents may vary among geothermal facilities depending on design, on-site equipment, and the presence of groundwater or geothermal fluids.
- Exposure to geothermal gases, mainly hydrogen sulphide, during the non-routine release of geothermal fluids (e.g., well blowout and pipeline failures) and during maintenance work in confined spaces like pipelines, turbines, and condensers.
- Exposure to heat during construction activities and the operation and maintenance of pipes, wells, and related hot equipment.

In the case of large-scale geothermal plants, many projects will be subject to the environmental and social safeguards of multilateral development banks (MDBs) and to the environmental and social risk management guidelines and procedures of MDB standards and the Equator Principles. These may provide a higher standard of (and oversight of) labor and occupational health and safety management procedures than the prevailing national standard.

Community health and safety

Geothermal projects bring health and safety issues for local communities. These can be induced by the exploration, construction, and operational phases of a project. During the construction phase, communities close to the project infrastructure sites will be exposed to short-term nuisances, such as increased truck and vehicle movements, noise, vibration, dust, odor, and influx of skilled workers. Geothermal wastewater and gaseous emissions typically contain hydrogen sulphide and other non-condensable gases and may contain mercury, which can be emitted during geothermal well drilling and testing processes.[34] These emissions are typically not significant, though this is dependent on the concentration of gases and the proximity of wells to sensitive receptors. Nearby communities may be exposed to air pollution, including hydrogen sulphide gas, which has an odor and can be toxic.[35] Geothermal wells need to have cement casings to prevent pollution of groundwater.

The health risks to communities include exposure to air pollution (e.g., hydrogen sulphide gas), infrastructure safety issues, and impacts on water resources.[36] Without proper management, the release of wastewater from the plants can cause adverse impacts on community health (e.g., skin and respiratory diseases), sanitation, and noxious odors.

Noise from gas engines, drilling, construction vehicles, and power plant operation can cause disturbance and damage to local communities and property (e.g., noise and traffic congestion can affect community tourism and homestays) and nearby infrastructure.

Gender and vulnerability

One of the social risk factors associated with geothermal energy development is the degradation of water quality and supply (discussed in Section 9.3.1). This may have a disproportionate impact on women and girls, where they tend to be the primary collectors of water for household use, and may increase “time poverty” [37] if longer travel to clean water sources is required. Other risks are associated with potential land acquisition and displacement, plus resettlement planning and compensation procedures for geothermal projects. In addition, the development of geothermal

[33] IFC (2007)
[34] Finster (2015)
[35] Bastaffa *et al*. (2019)
[36] IFC (2007)
[37] Time poverty is the experience or feeling of having too much to do and not enough time to do it.

projects may cause potential damage to, or restrict access to, areas of spiritual and cultural significance.[38] This can have disproportionate impacts on women and vulnerable groups, particularly those from Indigenous communities, and sometimes more so than other renewable energy technologies (see section on Indigenous communities).

Other risks include the potential for an increase in gender-based violence (GBV) against women, plus sexual harassment, exploitation, and abuse, resulting from an influx of predominantly male construction workers[39] and other male presence, such as private security forces or the military (see Box 9.6). Concerns around an increased risk of GBV during renewable energy projects have also been discussed in other technologies (see discussion of gender and vulnerability in Chapters 5 and 6).

Box 9.6: Community opposition to the Chevron Geothermal Project, Philippines
Source: World Bank (2019)

In Kalinga, Philippines, Indigenous women in Western Uma blocked the development of a Chevron geothermal energy project, causing the company to abandon the site. The women's grievances included disregard for cultural beliefs linked to the resource, loss of tiger grass (an important cash crop for women), fear of gender-based violence (GBV) from an anticipated increase in military presence to protect assets at the project site, and unequal compensation and benefits for women, including scholarships and employment opportunities.

Furthermore, women who pursue professional careers in geothermal energy often face several barriers, such as social expectations about their roles and abilities and a lack of an inclusive workplace environment.[40] As with other technologies, factors such as a skills gap among women due to their limited access to and uptake of education and training in STEM subjects[41] (see discussion of gender and vulnerability in Chapter 5) can also limit their employment opportunities in the geothermal industry.

Indigenous communities

Geothermal development may have a negative impact on Indigenous communities and land under traditional or customary use. Geothermal plants are often located near volcanoes or hot water—sites that frequently have cultural, sacred, and spiritual value for local communities of Indigenous people. The healing properties of the warm and sulphur-rich water are often the subject of community lore.

Potential geothermal energy development sites tend to be located in remote areas where Indigenous communities often reside
Chapters. They may be disproportionately affected by land acquisition and by opening up access to the natural areas and resources they depend on. Novel approaches to co-developing equitable communication models between Indigenous peoples and geothermal developers have been proposed in Alberta, Canada.[42] It is intended to allow for a more appropriate, community-centered approach to consultation, honoring Indigenous rights to free, prior, and informed consent as per the United Nations Declaration on the Rights of Indigenous Peoples and treaties signed with the Government of Canada.

Chapters addressing other types of renewable energy have highlighted the potential for local Indigenous communities near renewable energy projects to benefit from employment opportunities with the project, during construction and/or operations. There is a risk that such employment

[38] World Bank (2019)
[39] World Bank (2019)
[40] World Bank (2019)
[41] Science, technology, engineering, and mathematics.
[42] Giang, et al. 2021

opportunities will not be accessible to local Indigenous people (e.g. because they may lack qualifications or required skills and experience).

In British Columbia, Canada, the Clarke Lake Geothermal Development Project is a CAD $40.5 million, wholly-owned and Indigenous-led project that will provide jobs and economic opportunities for local community members and provide capacity building and training to workers to help them transition into the renewable energy sector. Waste heat may also be sold to nearby timber and greenhouse industries.[43] Other Indigenous-owned geothermal projects are also scheduled for development in the Pacific Ocean "Ring of Fire".[44]

Cultural heritage

New geothermal developments can take place in or near sites that are protected or prized for cultural significance or aesthetic aspects, threatening or compromising the physical or visual status of sites.[45] Such risks may be more pronounced among Indigenous communities who frequent geothermal sites for the sacred and healing properties they are believed to have. Such sites may also be in, or contain, fragile or protected ecosystems with endangered species.[46]

Research carried out at Olkaria geothermal fields in Kenya found that the development of geothermal projects led to a reduction in family size. This was linked to the gradual loss of community land to the project, which greatly impacted the preservation of local cultural heritage sites. Also, the local community complained about foreign cultural attitudes penetrating their culture and causing cultural conflicts because of the interaction with outsiders.[47] The preservation of cultural sites can help to increase their potential to attract tourism.

Employment and labor conditions

Geothermal energy development has the potential to offer some employment during both the construction and operations phases, providing the local community with the opportunity to acquire new skills. For instance, the ESIA for the 35 MW Casita geothermal project in Nicaragua estimated that the exploration phase (intended to be 2.5 years) would create 100 jobs for site preparation and 100 for drilling.[48] Specialist skills are required for drilling. Skills gained in fossil fuel industries are transferable to geothermal development (e.g., drilling experts and construction-related roles). Figure 9.4 shows that, in 2021, there were almost 200,000 jobs in the geothermal energy sub-sector, significantly fewer than in the other renewable energy sectors discussed elsewhere in this guidance.

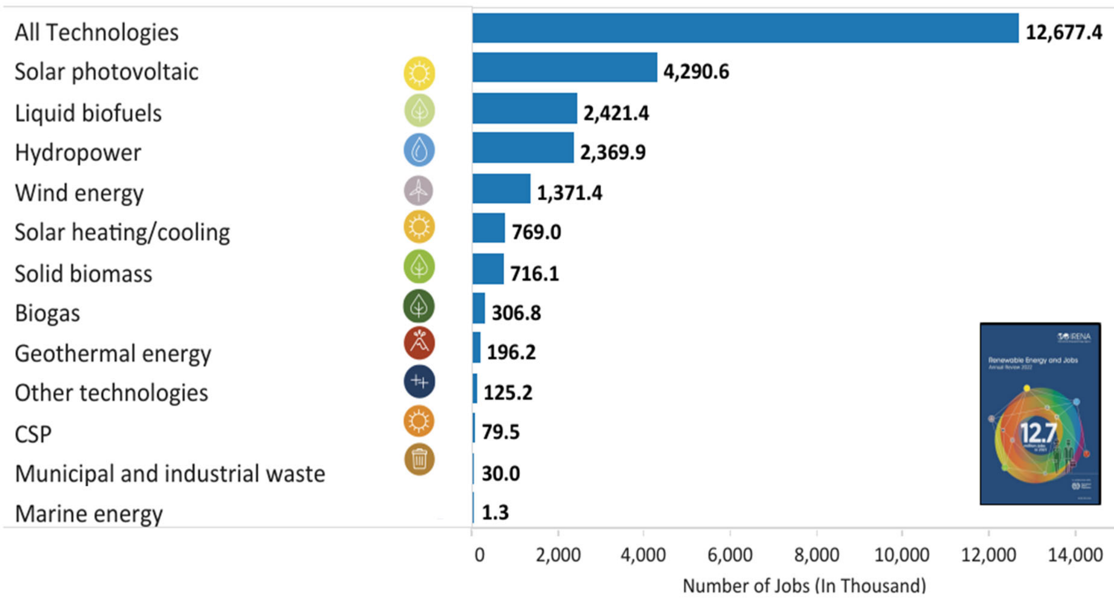
Public services and infrastructure

As for other renewable energy types, geothermal energy projects can bring both opportunities and risks for public services and infrastructure under the remit of local public authorities. Heavy construction vehicles and transportation may damage existing roads or buildings adjacent to roads, especially bridges. Normally, energy projects will contribute to the development, improvement, upkeep, and access to overall community facilities and services in an area. This may be because the project simply requires certain infrastructure and will put this in place, or, alternately, will do so through its wider corporate social responsibility (CSR) programs. The potential for community investment has been discussed previously for other renewable energy technologies.

Geothermal energy could create alternative employment opportunities for those who may have lost jobs or are at risk of unemployment due to the transition away from non-renewable energy.

[43] Natural Resources Canada (2021)
[44] For more information, see the 2021 Forbes article "Asia's Ring Of Fire Is A Hot Spot For Net Zero Energy" (https://www.forbes.com/sites/mitsubishiheavyindustries/2021/11/15/asias-ring-of-fire-is-a-hot-spot-for-net-zero-energy/).
[45] The World Bank (2019b)
[46] World Bank (2019)
[47] Kabeyi and Olanweraju (2022)
[48] World Bank (2017)

Figure 9.4: Renewable energy employment by technology in 2021
Source: IRENA (2022d)



Source IRENA and ILO (2022), Renewable energy and jobs: Annual review 2022, International Renewable Energy Agency, Abu Dhabi and Internationa Labour Organization, Geneva. Data are principally for 2021, with some dates for 2020 and a few instances in which only earlier information is available. The data for hydropower include direct employment only and for other technologies include both direct and indirect employment whereve possible. 'Other Technologies' include jobs not broken down by individual renewable energy technologies.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 10

TIDAL POWER

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Links to the complete guidance document and to individual chapters are also available.

CHAPTER 10

TIDAL POWER

10.1 WHY SEA IS IMPORTANT TO THE TIDAL POWER

An overall rationale for why it is important to use strategic environmental assessment (SEA) to support the energy transition is provided in the preface to the guidance.

SEA can provide critical information to support better decision-making for tidal energy planning and development, including identifying where there may be implications for a PPP to adequately address significant environmental and/or socioeconomic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple tidal energy schemes/developments, whether alone or in combination with other renewable energy technologies or developments.

The SEA process will:

- Identify and focus on key environmental and socioeconomic issues and the concerns of likely-affected stakeholders, including local communities, marginalized groups, and Indigenous peoples. Major issues are discussed in detail in Section 10.5 and are summarized in Table 10.2.
- Identify/recommend if there are areas that should be avoided for tidal energy development ("no-go" areas) because of particularly high risk to the environment, habitats/biodiversity and/or people.
- Identify what changes or additions are required to PPPs governing tidal energy development to address these risks.
- Make subsequent project-level EIAs more efficient and cheaper: by addressing the big picture, and upstream, downstream and cumulative potential impacts, as well as identifying the issues that individual project EIAs should focus on in more (site-specific) detail. This may also include spatial planning recommendations for optimal siting of tidal energy projects to minimize risks and impacts.
- Engage stakeholders (particularly in areas where tidal energy potential has been identified) including communities, marginalized groups, and Indigenous Peoples which can be particularly affected by tidal energy developments.
- Early flagging to stakeholders of proposed or possible policy options or plans, enabling them to provide their perspectives and present their concerns as soon as possible. This will enable key issues to be identified and verified, help build understanding, and support for tidal energy development and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

10.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE TIDAL ENERGY SUB-SECTOR

An international survey of existing SEA guidelines conducted for IAIA was unable to identify any that are specifically focused on the tidal energy sub-sector. Similarly, there appear to be very few guidelines specific to EIA for tidal energy development projects. One example is from the UK[1]. Various sources discuss the environmental impacts of tidal energy.[2]

10.3 TIDAL ENERGY INSTALLED CAPACITY

Compared to other renewable energy technologies, tidal energy is still in early development. In 2022, global installed marine/tidal energy capacity was 524 MW. The main producing regions were Asia (dominated by South Korea) and Europe (dominated by France and the UK) (Table 10.1).

Table 10.1: Marine (tidal) energy installed capacity, 2022
Source: IRENA (2023)

Region	Installed capacity (MW)
Asia	260
South Korea	*256*
China	*5*
Eurasia	2
Russia	*2*
Europe	241
France	*211*
UK	*22*
European Union	218
North America	21
Canada	*21*
USA	*No data*
Oceania	0
South America	0
World	524

10.4 BACKGROUND TO TIDAL ENERGY GENERATION

Tidal power is a form of energy generation that utilizes either the tide or marine currents to generate electricity. It can be split into two subsets: tidal stream (see 10.4.1) and tidal range (see 10.4.2). Although not yet widely used, tidal energy has the potential for future electricity generation. Tides are more predictable than the wind or the sun, and therefore can provide a more consistent source of energy.

Historically, tide mills have been used both in Europe and on the Atlantic coast of North America to capture energy generated by tidal range. The incoming water was contained in large storage ponds, and as the tide receded, it turned waterwheels that used the mechanical power to mill grain. The earliest occurrences date from the Middle Ages, or even earlier from Roman times. The process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe in the 19th century.

Tidal energy is still not widely used and has had limited commercial rollout to date, partly due to:

- High costs of development (tidal energy can be almost 10 times more expensive than other renewable technologies) and the technical challenges created by the harsh nature of the marine environment and the sensitivities of estuarine areas (for tidal range projects);
- Limited availability of sites with sufficiently high tidal ranges or flow velocities;
- The potential environmental impacts and the site-specific topographical changes likely required to locate and establish tidal range schemes in environments sensitive to change.

However, recent technological developments and improvements, both in design (e.g., dynamic tidal power, tidal lagoons) and turbine technology (e.g., new axial turbines, cross flow turbines), are helping to address some of these issues, suggesting that the total availability of tidal power may be

[1] Environment Agency (2011)
[2] e.g., Choose Clean Power (2022); Burrows *et al*. (2009)

much higher than previously assumed and that economic and environmental costs may be lowered to more economically competitive levels. Globally, there has been a tenfold increase in tidal energy production in the past decade.[3]

The world's first large-scale tidal power plant was France's Rance Tidal Power Station, which became operational in 1966. It was the largest tidal power station in terms of output until the Sihwa Lake Tidal Power Station opened in South Korea in August 2011. The Sihwa Lake station uses sea wall defense barriers complete with 10 turbines generating 254 MW.

Tidal power can be split into two subsets: tidal stream (Section 10.4.1) and tidal range (Section 10.4.2).

10.4.1 Tidal stream power generation

Tidal stream power generation utilizes the flow of currents through a turbine. This is akin to wind turbines and converts kinetic energy in the water into electricity.

Tidal stream infrastructure requires placement of turbines in areas where there are high velocity marine currents. Turbines can be located individually or in an array configuration and can be either suspended on the sea surface or fixed to the seabed. Electricity is transported to an onshore substation via an undersea cable and then exported to the electricity grid.

Different tidal stream designs include two- or three-bladed horizontal-axis turbines, vertical axis turbines and tidal kites.[4]

Some examples of tidal stream projects are provided in Box 10.1.

10.4.2 Tidal range power generation

Tidal range energy generation uses a form of barrage to impound the water at high tide, so that at low tide a difference in head is created and used to drive a turbine. This is a "reaction" type turbine that converts pressure into electricity and is based on low head hydropower technology. It is possible to generate electricity on both the ebb and flood tides.

Tidal range turbines are placed at estuarine or coastal locations and require a barrage with a low-sitting profile. There are two types of tidal range arrangements:

- A barrage arrangement is typically located across an estuary and impounds water in the estuary;
- A lagoon arrangement is a form of barrage that encloses a body of water, either connected to the coastline or placed entirely out to sea.

In both cases, turbines are in a linear powerhouse arrangement forming part of the barrage body.

Tidal range infrastructure with barrages that incorporate turbines usually consist of:

- Embankments, constructed where there are gaps along an estuary, and to enable access;
- Barrage structure;
- Turbines, located along the barrage structure;
- Openings, fitted with control gates to enable flow at a particular time; and
- Locks - one or more to enable boat traffic (if required).

Box 10.2 provides examples of existing barrage projects. No lagoon-type projects have been taken beyond the planning stage anywhere in the world. Therefore, a lot of currently unknown risks and factors need to be expected in these environments. Planning for the Tidal Lagoon Swansea Bay in southwest Wales (the Blue Eden project) is well advanced and will be the world's first purpose-built

[3] Largue (2020)

[4] ETIP Ocean, Strategic Research & Innovation Agenda, 2020. Read the full agenda here: https://www.etipocean.eu/wp-content/uploads/2020/06/ETIP-Ocean-SRIA.pdf

tidal energy lagoon. The generating station will have a capacity of 320 MW. To deliver the project, a U-shaped 9.5 km long seawall is required, encompassing 11.5 km^2 of the seabed, foreshore, and intertidal area of Swansea Bay. Subject to final planning consent, work on the project site was scheduled to begin by early 2023.[5]

Box 10.1: Examples of Tidal Stream Projects
Source: OES (n.d.)

(A) Current projects

The MeyGen tidal energy project is located at an offshore site between Scotland's northernmost coast and the island of Stroma. Here, multiple turbines installed on sub-surface gravity turbine support structures operate in a high flow and medium water depth environment. When fully developed, it will be the world's largest tidal energy project with the option to develop a tidal stream project of up to 398MW.

Orbital Marine Power's O2 turbine went into operation in July 2021 in the waters off Orkney in Scotland. The floating 74-meter-long turbine is anchored in the Fall of Warness, where a subsea cable connects the offshore unit to the local onshore electricity network.

(B) Emerging tidal stream projects in Southeast Asia

Zambales, Sorsogon, Northern Samar, and Surigao del Norte provinces, Philippines. Multiple sites are at pre-development and development contract stage for projects with the capacity to generate between 5–10 megawatts (MW). These projects are being undertaken by several different companies.[6]

Larantuka Strait, Indonesia. Nova Innovation's FLITE (Feasibility of Larantuka and Indonesian Tidal Energy) project is currently underway. It will deliver a feasibility study for Larantuka Strait which lies between the islands of Flores and Adonara and has one of the strongest tidal currents in Indonesia.

Larantuka and Boleng Straits, Indonesia. In early 2022, the UK-based energy developer SBS International Limited signed a memorandum of understanding with state-owned Indonesia Power for the development of tidal energy projects for both the Larantuha and Boleng Straits.

Box 10.2: Examples of barrage projects

(A) Operational Projects

Sihwa Lake, Gyenggi Province, South Korea. Construction of the 12.7km tidal barrier in 1994 at Sihwa Lake (c. 20 km SW of Seoul) subsequently became an opportunity to commission a 260 MW capacity tidal power project in 2010.

La Rance Tidal Power Station, France is located on the estuary of the Rance River, in Brittany. It was the world's first tidal power station, opening in November 1966. The Rance Barrage is 750 m long and 13 m high, enabling a peak capacity of 240 MW to be generated by its 24 turbines.

Bay of Fundy, Annapolis Royal, Nova Scotia, Canada. This is the only barrage project in North America. The Annapolis tidal plant was commissioned in 1984 and had a generating capacity of 20

[5] For more information, see: https://tethys.pnnl.gov/project-sites/swansea-bay-tidal-lagoon-sbtl
[6] For more information, see: https://www.doe.gov.ph/sites/default/files/pdf/renewable_energy/awarded_ocean_2020-12-31.pdf?withshield=3

MW using a single 7.6m diameter turbine. It was decommissioned in 2019 due to equipment failure that was considered uneconomical to repair.

Each of these sites used traditional hydropower technology adapted for marine conditions. Due to the wide head range associated with the tides, these projects cannot fully exploit the potential energy available due to the limitations in operation ranges and poor efficiency at extremes of operation. A report by Sidgwick and Macrae (2016) suggested that recent developments in variable speed converter and turbine technology at the time made it possible to generate efficiently across a much wider range of heads.[7]

(B) Emerging Barrage Projects

***River Wyre, Fleetwood, England*.** The project is at the mouth of the River Wyre, requiring a 600 m barrage between Fleetwood and Knott End on the Lancashire Coast. Natural Energy Wyre (NEW) has been planning a project that seeks to generate 160 MW, providing electricity for an estimated 50,000 homes.

***Derby, Western Australia, Australia*.** Tidal Energy Australia is the proponent securing approvals for the Derby Tidal Energy Project. The project proposes to generate 40 MW of electricity, with potential to supply enough to power 10,000 to 15,000 homes.

10.5 IMPACTS OF TIDAL ENERGY DEVELOPMENT

During scoping for a SEA, key issues regarding tidal energy development should be identified. They will be used to focus the SEA on the most critical issues and to help develop environmental and social quality objectives (ESQOs) (see Chapter 2, Section 2.5.1) – that address these issues - to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other tidal energy development applications, interviews with key informants and during stakeholder consultations at national to local levels. Many of the issues will be well known from implementing other tidal energy development projects.

At the individual project-level, these issues will be the focus of an EIA which should recommend how to manage or mitigate individual project impacts associated with these issues that might be likely to arise. Ideally, before individual tidal energy projects are approved, an SEA of a policy, plan, or program (PPP) for the tidal sub-sector should be completed. This will involve the assessment of multiple likely projects, schemes and activities, some directly concerned with the construction and operation of sites and facilities; and others linked to associated infrastructure (e.g., cables). Thus, there is a risk that the impacts of individual developments/projects may become highly significant as they become cumulative. An SEA should address the potential for such cumulative impacts and make recommendations for mitigating or managing them. This may include recommending thresholds for specific factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual tidal energy applications and overarching SEA planning is not synchronized, and SEA may have to "catch-up" to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed. This is far from ideal in diluting the potential benefit to be gained from an SEA being completed earlier in the process.

Tables 10.2 and 10.3 summarize the range of key environmental and socioeconomic issues associated with tidal stream and tidal range developments, respectively.

[7] An example of using this technology is the New Bong Escape Hydropower Project in Pakistan. This is a low head 84MW hydropower scheme located on Bong Canal/Jhelum River basin in Azad Kashmir. Construction commenced in 2009 with commissioning in 2013, It generates power through four 21 MW low head high efficiency Kaplan turbines.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 10.2: Environmental and socioeconomic issues associated with tidal stream power generation

ISSUE	COMMENT
Environmental	
Air quality	• Emissions from vehicles, barges, dust (during construction) • Onshore dust following soil disturbance and from vehicle traffic to coastal access point site and for onshore component.
Water quality	• Build-up of physical and chemical contaminants due to reduced flushing rates. • For tidal range projects that include barrage infrastructure, the amount of natural vertical mixing of sea water will be reduced due to reduced tidal flows; and there will be less re-suspension of particulate matter, leading to decreased light penetration; and reduced saline penetration within the basin leading to freshening, i.e., more brackish water. • In areas of increased flows, there may be potential re-suspension of contaminated sediments with net reduction in water quality. • Toxic paints, lubricants and antifouling coatings used on offshore tidal infrastructure can affect sea water and sediment quality.
Greenhouse gases	• Tidal energy can reduce GHG emissions where it displaces coal as a fuel source.
Loss of habitats and biodiversity	• Tidal stream infrastructure can have negative impacts on biodiversity, including disturbance and displacement, collision, entanglement and introduction of nonnative species, and can also modify or create new habitats.
Noise	• Noise from construction traffic and use of machinery during construction of onshore component. • Sound (pressure) can travel a long distance in the sea and ocean. • Underwater sound from turbines may cause behavioral disturbance, as well as acoustic masking[8] and barrier effects, which may result in habitat exclusion by marine species sensitive to noise. • Anthropogenic noise can mask detection of biologically important signals used for communication, predator avoidance and prey detection, and can influence behaviors.
Land or marine use change	• Change in access to tidal areas. • Potential impact on localized fisheries.
Visual and aesthetic impacts	• Tidal infrastructure may impact on the aesthetic view and landscape of the host community. •
Marine and ecosystem restoration	• Tidal energy systems are inherently age-resistant and have long lifespans. The average estimate for most tidal systems is 75-100 years of working use. After this, some components might be decommissioned, and restoration of the local marine ecosystem will be required. Other structures might be left *in situ* to conserve changed (since prior to construction) ecosystems that are likely to become established.
Socioeconomic	
Local economy and livelihoods	• Diminished income of fisherfolk due to restrictions on access to mudflats. • Disruption to fisherfolks' pier and landing areas and potential damage to fishing gear from contact with turbines or associated equipment. • Possible impact on recreation and tourism (may deter or possibly attract tourists). • Temporary disruption or permanent loss of port, commercial, and recreational shipping activities.

[8] Pine et al., 2019

ISSUE	COMMENT
	• Price of adjacent land and housing near the project area may decrease. • Displacement of people when land acquired for access roads and transmission lines. • Tidal stream development also offers new job opportunities to local communities.
Gender and vulnerability	• Vulnerable groups (e.g., the poor, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk where coastal communities are dependent on fishing. • Employment opportunities within new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies.
Cultural heritage	• Destroyed or damaged, or limited access, due to transmission lines and access roads.
Employment and labor conditions	• Employment in the construction and operation phases of projects. • Employment in relation to activities associated with projects and supply chains. • Substandard working conditions. • Worker safety. • Opportunities for workers to acquire or learn new skills. • Worker influx during construction phase.
Health and safety	• Electricity transmission lines from the tidal power plants may be a safety issue for nearby communities during construction and operation (e.g., electric shocks from touching live cables).
Public services and infrastructure	• Infrastructure (e.g., roads and bridges, schools, health centers and administrative buildings) may be improved due to community investment by tidal power companies. • Pressure on public services and infrastructure may increase due to immigration. • Heavy vehicles and transportation can damage existing roads and bridges. • Increased vehicle traffic during construction.

Table 10.3: Environmental and socioeconomic issues associated with tidal range power generation

ISSUE	COMMENT
Environmental	
Physical changes (e.g. to estuaries and river channels) (Tidal range only)	• Modified tidal and residual flows - scouring around structures. • Reduced vertical mixing, leading to an increase in density stratification. • Reduced levels of suspended particulate matter, leading to increased light penetration. • Reduced saline penetration within the basin leading to freshening (i.e. more brackish water).
Air quality	• Emissions from vehicles, barges, dust (during construction).
Water quality	• Build-up of physical and chemical contaminants due to reduced flushing rates. • For tidal range projects that include barrage infrastructure, the amount of natural vertical mixing of sea water will be reduced due to the reduced tidal flows; and there will be less re-suspension of particulate matter, leading to decreased light penetration; and reduced saline penetration within the basin leading to freshening, i.e., more brackish water. • In areas of increased flows, there may be potential re-suspension of contaminated sediments - with net reduction in water quality. • Toxic paints, lubricants and antifouling coatings used on offshore tidal infrastructure can affect sea water and sediment quality.
Greenhouse gases	• Tidal energy can reduce GHG emissions where it displaces coal as a fuel source.
Impaired land drainage	• Impaired drainage due to an increase in average water level inside the basin, could lead to a decrease in ground water flows.
Loss of habitats and biodiversity	• Especially in intertidal mudflats and salt marshes which are important for some species of birds and can be nationally and internationally protected areas. • Benthic habitats may change due to bottom stress from modified waves and currents. • Migratory fish may be impeded, although fish passes can be constructed. • Fish and marine mammals may suffer damage by collision with the barrage and turbines. • Some estuaries may provide nurseries for breeding fish and conditions for these may no longer be suitable. • An increase in primary productivity may enhance the population of filter feeders.
Noise	• A problem during both construction and operation. • Changes to ambient noise in aquatic environments can affect many types of aquatic life including marine mammals, fish, and birds, changing their responsiveness to other stimuli, masking, temporary threshold suppression and injury, as well as interfering with communication, echolocation for navigation, spawning, and shoaling behavior.
Land or marine use change	• Coastal land used for agricultural grazing or crops may be lost or gained depending on project proposals. • Change in access to tidal areas. • Potential to impact localized fisheries.
Visual and aesthetic impacts	• Tidal range infrastructure may impact on the aesthetic view and landscape of the host community.
Marine and ecosystem restoration	• Tidal energy systems are inherently age resistant and have long lifespans. The average estimate for most tidal systems is 75-100 years of working use. After this, some components might be decommissioned, and restoration of the local marine ecosystem will be required. Other structures might be left in situ to conserve changed (since prior to construction) ecosystems that are likely to become established.

ISSUE	COMMENT
Socioeconomic	
Local economy and livelihoods	• Diminished income of fisherfolk due to restrictions on access to mudflats. • Restricted or denied access for shellfish gatherers. • Disruption to fisherfolks' pier and landing areas and potential damage to fishing gear from contact with turbines and associated equipment. • Possible impact on recreation and tourism (may deter or possibly attract tourists). • Temporary disruption or permanent loss of port, commercial and recreational shipping activities. • The price of land and housing near the project area may decrease. • Displacement of people when land acquired for access roads and transmission lines.
Gender and vulnerability	• Vulnerable groups (e.g., the poor, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk where coastal communities are dependent on fishing. • Employment opportunities within new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies.
Cultural heritage	• Loss of religious, historical and archaeological sites and properties. • Destroyed or damaged due to transmission lines and access roads. • Limited access to cultural heritage sites.
Employment and labor conditions	• Employment in the construction and operation phases of projects. • Employment in relation to activities associated with projects. • Substandard working conditions. • Worker safety. • Opportunities for workers to acquire or learn new skills. • Worker influx during construction phase.
Health and safety	• Noise from the tidal structures can disturb beach users or nearby communities. • Electricity transmission lines from the tidal power plants may be a safety issue for nearby communities during construction and operation (e.g., electric shocks from touching live cables).
Transportation	• Marine transport and navigation may be disrupted but a barrage also gives potential for road and rail crossings. • Access to shoreline may be impeded.
Public services and infrastructure	• Infrastructure (e.g., roads and bridges, schools, health centers and administrative buildings) may be improved due to community investment by tidal power companies. • Pressure on public services and infrastructure may increase due to f immigration. • Heavy vehicles and transportation can damage existing roads and bridges. • Increased vehicle traffic during construction.

10.5.1 Environmental issues

Physical changes to estuaries, river channels, terrestrial, and benthic environments

Benthic habitats (those on the sea or ocean floor) can be altered, or instead can be created, by offshore tidal stream infrastructure. They are modified due to direct disturbance (e.g., seabed clearance) caused by new infrastructure introduced for surface turbines, to house sub-surface alternatives, or to deliver power back to the shore via cables.[9] Depending on the sensitivity of the local environment, structures can cause changes to bathymetry, including tidal flows, waves and currents which can have negative impacts on marine and estuarine habitats, flora, and fauna.

By retaining sea water for part of the tidal cycle, there will inevitably be some changes to tidal range in an estuary basin and its channels. The tidal and residual flows will be modified, possibly leading to some local scouring around the new structures (specifically in the outflow regions of the turbines and sluices) and siltation in the basin. An increase in average water level inside the basin would lead to a decrease in ground water flows which may have impacts on land drainage.[10] The extent of these effects will be dependent upon how the barrage structure is operated and will be specific to each site and each local environment.

All types of tidal power infrastructure also have the potential to have negative impacts on terrestrial environments. Where sites with strong tidal flows are in locations that do not already have access to the power transmission network, clearing of vegetation will be required for transformers and transmission lines, and for access roads to enable construction and maintenance. This can lead to the fragmentation or loss of habitats and biodiversity, and disturbance or relocation of fauna (see discussion in section on habitats and biodiversity in Chapter 9 (Section 9.3.1) for further information as the effects are similar).

A key principle of SEA is to address the cumulative impacts of multiple projects, schemes and developments that may arise when a PPP is implemented. Assessing cumulative impacts for tidal projects will be difficult. At present, there are only a handful of commercially operating tidal power plants worldwide. However, many new projects have been proposed, or are in development, with the potential environmental and social impacts of these not yet fully understood. So, given the lack of existing experience of the impacts of tidal power schemes, a precautionary approach to impact assessment is warranted. But there will be cumulative impacts arising from the combination of developing tidal power schemes and other renewable energy projects (e.g., from the construction of transmission lines), as well as from projects in other sectors and from other land uses in an estuary.

Air quality

During operation, tidal power does not typically have significant impacts on air quality. There will be impacts to air quality during construction, e.g., emissions from machinery and vehicles (trucks, workers' vehicles, generators, etc.) and dust from land clearing to construct terrestrial infrastructure (barrages – in the case of tidal range developments, access roads, substations, and transmission lines). The severity of such impacts will depend on the proximity of sensitive receivers. Once operational, the quality of the air around tidal power infrastructure will likely return to pre-construction levels since there will be only a small number of vehicle movements and few sources of dust.

Water quality

Modified flow rates or changes in mixing and settlement of particulate matter caused by tidal power turbine infrastructure (for both tidal stream and tidal range) have the potential to change water quality and sediments. This includes build-up and mixing (both physical and chemical) of contaminants in areas where flows are increased. Contaminated sediments can also become re-suspended and reduce water quality. This impact, coupled with increased turbidity, has the potential to affect the health of marine and estuarine life in the local area.

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[9] Orbital Marine Power (2021)
[10] Wolf *et al.* (2009)

Toxic paints, lubricants and antifouling coatings used on offshore tidal infrastructure can also contribute to reducing sea water and sediment quality. Depending on the tidal energy technology, hazardous chemicals could be accidentally released to the marine environment during equipment installation, operation, maintenance and removal. This can occur due to an unplanned acute release of fluids and contaminants, or a spill of large amounts of lubricants, hydraulic fluids, vessel fuel or other petroleum-based products and gradual releases of toxic contaminants over time from antifouling coatings used on tidal devices.

Further complications could result if the contaminants bioaccumulate in the food chain, potentially affecting public health if the aquatic organisms are consumed by humans.[11]

For tidal range projects that include barrage infrastructure, the amount of natural vertical mixing of sea water will be decreased due to the reduced tidal flows; and there will be less re-suspension of particulate matter, leading to increased light penetration. The reduction in mixing will also lead to an increase in density stratification. There will be reduced saline penetration within the basin, leading to freshening (i.e., more brackish water). There may be a build-up of contaminants (both physical and chemical) due to the reduced flushing rates. In areas of increased flows, there may be potential for the re-suspension of contaminated sediments which could cause a net reduction in sea water quality. An abundance of nutrients combined with increased light penetration may cause increased primary production, potentially leading to eutrophication.[12] The extent of these effects will be dependent upon the how the barrage structure is operated and will be specific to the local environment.

Habitats and biodiversity

Estuarine and lagoon environments are important habitats for invertebrates, fish and some species of birds and marine mammals, and all are susceptible to local environmental change. The uniqueness, and often remoteness, of these sites is recognized. They are often listed as nationally and internationally protected areas.

Tidal power infrastructure can lead to localized environmental changes that occur due to housing, installing and operating the turbines. These changes are most notable with tidal range projects where water regimes (flow and depth) are affected by infrastructure installation and operating methodologies. They can result in a direct loss of habitat and biodiversity (including birdlife), particularly in estuaries and lagoons with intertidal mudflats and salt-marsh habitats that are susceptible to change. These habitats are often nurseries for breeding fish and are particularly vulnerable to the changes that would occur during construction and operation. As a result, the introduction of new infrastructure has the potential to impact on local fisheries, resulting in a reduction of local fish populations and diversity in the area and reduced access for migratory bird species. Intertidal mudflat habitats are also susceptible to change because of altered tidal flows.

Tidal barrages can impede migratory fish paths and breeding cycles. However, depending on the species of fish, the risk can be mitigated to some extent by fish ladders or passage structures.

There is some understanding of the interaction between marine wildlife and tidal turbines and the potential for collision.[13] There is a low risk of marine animals colliding with underwater turbines constructed for offshore tidal steam projects. There have been only rare and isolated instances of such collisions with tidal range infrastructure involving barrages. The Annapolis Tidal Station (operating from 1984 to 2019 in the Bay of Fundy in Canada) saw two incidents involving humpback whales. In the last decade, there have been advances in methods to prevent fish and marine life mortality when passing through turbines, and deterrent devices for marine mammals are available for new infrastructure.[14]

[11] Polagye *et al*. (2010)
[12] Wolf *et al*. (2009)
[13] Carlson *et al*. (2013)
[14] Neill *et al*. (2018)

Tidal stream infrastructure can have negative impacts on biodiversity, including disturbance and displacement, collision and entanglement and introduction of non-native species, and can also modify or create new habitats.[15]

Electromagnetic fields (EMF) associated with tidal power generators and underwater power cables can affect aquatic wildlife in the near-field of the device, array or cable,[16] although the effects may be location-specific. The EMFs can be potentially sensed by fish and evoke avoidance or attraction behaviours. Some species of fish, such as sturgeon and eels, appear to be particularly sensitive to EMF, and others, such as salmon, do not appear to be as sensitive. Sharks, skates, rays, ratfishes, and other elasmobranchs can detect faint electric fields.[17]

The effects of tidal power infrastructure (including cables) on fish behaviour are not clear. *In situ* studies of EMF effects are challenging to conduct and, often, inconclusive.

Surface structures in estuaries and at sea that require lighting for safety and navigation have the potential to affect seabirds and aquatic species, including fish.

Noise

Various activities and processes, both natural and human made, combine to form the sound profile (ambient noise) at and below the surface in estuaries, lagoons and the open sea. Changes to ambient noise in aquatic environments can affect many types of aquatic life, primarily invertebrates and fish, but also marine mammals.

Tidal power noise sources that change existing ambient noise vary during construction and operation. The nature of these impacts will vary according to the receiving environment (whether onshore - estuaries and lagoons; or offshore - marine) and to the sensitivities of the species living on land, in intertidal areas and in the water near the tidal infrastructure.

For fish and marine mammals in particular, the observed effects of changes in ambient noise include changes in their responsiveness to other stimuli, masking temporary threshold suppression and injury, as well as interfering with communication between members of particular species, echolocation for navigation, spawning and shoaling behavior.[18]

Short-term changes to ambient noise occur during construction for both tidal stream (during installation of rock anchors and cables) and tidal range (during barrage construction). Temporary increases in vehicle traffic, construction equipment, vessel engines, propellers, drilling and piling contributes to the changes in noise levels.[19]

Noise from the operation of machinery and turbines housed in sub-surface structures has potential to change the ambient underwater noise (sound pressure and particle motion) for extended durations over a longer term, and this can affect marine life.

Land and marine use change

All tidal power infrastructure has the potential to change land and marine uses, both at the site of the infrastructure and along the transmission lines and access roads. Some coastal land used for agriculture and/or livestock grazing may be lost or, potentially, gained with land reclamation for infrastructure. Shellfish fisheries relying on the intertidal zone (e.g., cockles and mussels) are most susceptible to being affected by changes in water volumes. If these changes are significant, these livelihoods, and those of similar fisheries reliant on the existing intertidal environment, may be affected if there is a change (including restriction) in access for local communities.

[15] Hooper and Austen (2013)
[16] Bochert and Zettler (2006)
[17] Öhman *et al*. (2007)
[18] Michel *et al*. (2007)
[19] Gill *et al.* (2005)

The development of shore-based infrastructure can cause a change in land use (and loss of livelihood for some people) and may lead to conflicts over land use and access to areas and resources, making co-location problematic or impossible.

There have been advances in the industry over the last 10–15 years in structure, design and turbine technology that minimize the footprint extent of projects, and evolution will be ongoing as the technology develops further.

Tidal area habitats are often nurseries for breeding fish and the introduction of new tidal range infrastructure can cause a reduction of local fish stocks. This has the potential to make fishing in the local area unviable, or force fisher-folk to turn to other uses of marine and estuarine environments.

If existing access to the power network is not available for either tidal stream or tidal range infrastructure, then there will be land clearing for onshore transformers, transmission lines, substations and access roads. This may change local access to agricultural land and conservation areas along these linear routes.

Visual and aesthetic issues

The visual and aesthetic impacts of tidal power projects will depend on location. Both tidal stream and tidal range power infrastructure can result in changes to the visual appearance and aesthetics of the receiving local environment. These changes can occur at the site of the infrastructure, particularly for tidal range infrastructure and along onshore transmission lines. Subject to the local tidal environment and siting methodology, tidal stream projects are often less visible and have less aesthetic impact.

The character of an area and the landscape may be drastically changed if a tidal barrage (for tidal range sites) is constructed, but there may be pros and cons. Some people may find the visual intrusion of tidal power schemes objectionable and feel they undermine the scenic appeal of coastal areas, particularly barrage schemes. But others find tidal schemes of considerable interest.[20] The change in the speed and rise of tides resulting from tidal power schemes can be dramatic, particularly in estuarine areas, detracting markedly from the aesthetics of more inland areas of estuaries.[21]

Generally, a tidal lagoon has a surface barrier marking the area. Control centers may be built into the water or on the land.

Marine and ecosystem restoration

As discussed above, there are significant risks associated with tidal power development with regard to potential environmental harm and degradation, e.g. loss of habitats and biodiversity and ecosystem services, coastal land and marine use change, unnecessary or excessive deforestation when constructing new on-shore access roads and transmission lines. This will particularly arise where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple tidal power developments across areas of sea in combination with other coastal development projects and activities.

The need and nature for land/marine and ecosystem restoration is discussed in Chapter 2 in Box 2.12. For most renewable energy developments, this need will also arise at sites of projects that have come to the end of their useful operational life. However, tidal energy systems are inherently age resistant and have long lifespans. The average estimate for most tidal systems is 75-100 years of working use. After this, some components (e.g., turbines and housings) might be decommissioned (see Box 10.2) and restoration of the local marine ecosystem will be required. Other structures (e.g., barrage walls) might be left in situ to conserve changed (since prior to construction) ecosystems that are likely to have become established.

%

[20] Tidalpower (n.d.)
[21] Tidalpower (n.d.)

Box 10.2: Decommissioning of Strangford Lough tidal turbine, Northern Ireland

Work started in 2016 to remove a tidal energy turbine installed in Strangford Lough, County Down, Northern Ireland, after it had served its research and development purpose. The SeaGen turbine was lowered into place in 2008 and generated electricity from tidal currents. Two horizontal axis turbines were anchored to the seabed and driven by the powerful currents resulting from the tide moving in and out. The topsides and crossbeam were taken out in August 2018, while the remaining tower and subsea structure were removed thereafter. SeaGen's foundation structure was taken to a dry-dock in Swansea from where all recyclable materials were recycled (mainly steel) and the concrete sections were then ground down as far as possible.[22]

An EIA for the decommissioning was undertaken. It recommended mitigation for various potential environmental impacts:

- Short-term and temporary impacts upon benthic communities in Strangford Lough via loss or damage of seabed habitat through use of moored barge or jack-up vessel;
- No adverse effect on site integrity of Strangford Lough SAC and less than 0.01% will experience short-term temporary impacts via loss or damage of designated seabed habitat through use of a moored barge or jack-up vessel;
- Short-term and temporary impacts upon fish, including basking shark, pinnipeds and cetaceans, due to noise disturbance through use of diamond wire cutting tools or abrasive water jets;
- Impacts on all other receptors were considered to be negligible;
- No cumulative impacts with commercial fisheries, shipping and the Minesto tidal device were expected; and
- Decommissioning of the SeaGen device was not predicted to result in any medium- to long-term environmental impacts.

The EIA concluded that that, following mitigation, there would be no major adverse residual impacts either from the project alone or cumulatively with other projects on any environmental receptors within Strangford Lough.[23]

10.5.2 Socioeconomic issues

Local economy and livelihoods

As indicated in section 10.3, there are few existing tidal power projects and so there is little direct evidence yet of their impacts on local communities. The most significant livelihood impacts from tidal energy are related to fishing and transportation.

Pollution from vessel discharges and accidental leakage of contaminants caused by tidal power projects can have a negative impact on fishing and shellfish collection. It is reported that fish stocks in the oceans of Southeast Asia are already declining rapidly following a major expansion of regional fisheries, putting the livelihoods of up to 100 million people at risk.[24] Any additional potential impacts from tidal power development on local fisheries needs careful consideration and management.

The rapid increase in fishing in Southeast Asia has been stimulated by increased demand for and consumption of fish due to population growth and has been accompanied by the adoption of modern fishing and aquaculture technologies, burgeoning domestic and international markets, flexible and rapidly adapting fish-supply chains, and investments in fish processing. The ability of fishing communities to access fisheries resources is critical to being able to sustain their livelihoods. Where

[22] For more information, see: https://www.rechargenews.com/technology/pioneering-seagen-tidal-power-turbine-decommissioned/2-1-644606?zephr_sso_ott=WxFhK1
[23] Read the full report here: https://tethys.pnnl.gov/publications/decommissioning-seagen-tidal-turbine-strangford-lough-northern-ireland-environmental
[24] Williams (2007)

the fish resources are depleted, larger operators continue to prosper while small-scale fishers seem to do poorly.[25]

The potential effects of tidal energy generation projects on marine fish and shellfish populations (i.e., not farmed under aquaculture), which in turn could impact the livelihoods of fishermen, include:

- Release of fluid waste/contaminants;
- Light pollution;
- Excess noise and vibration;
- Increase in suspended sediments;
- Loss of spawning/nursery grounds;
- Removal/alteration of habitats;
- Barriers to fish movement; and
- Electromagnetic fields.

These effects can occur to varying degrees throughout the life cycle of a tidal power project. There could be associated impacts on shellfish gatherers if access to shellfish production areas is restricted or denied. Similarly, there could be a disruption to fisherfolks' pier, mooring and landing sites. There may be some short-term disruption to fishing activity during device deployment and recovery operations. However, due to the small amount of ocean energy devices, the impact from this on fishing would generally be negligible.[26] In the long term, there could be habitat changes that could create new economic activities such as new fisheries.

The supply chain supporting the development of tidal and wave energy production provides energy devices and subsystems, foundations and mooring systems, cables, installation ports and vessels (both small and large).[27] Expanded supply chains may provide opportunities for increased turbine production and provision of other materials. If countries are to develop tidal lagoons on a large scale, this would stimulate supply chain development. Depending on the scale, individual projects may lead to the creation of dedicated manufacturing facilities to produce turbine generator sets or other components.

The prices of land and housing near new large infrastructure may change, but for tidal projects this impact is expected to be negligible. As with all energy projects, associated infrastructure could entail some physical and or economic displacement where land needs to be acquired for access roads and transmission lines. Some tidal projects contribute to local economic development through tourism (Box 10.3).

Box 10.3: Positive impacts of tidal energy projects on tourism and employment in the United Kingdom and France

Source: TidalLagoon (n.d.)

It is suggested that 100,000 tourist visitors per year could be attracted by the proposed Swansea tidal lagoon project (320 megawatt installed capacity), which could generate new indirect employment opportunities, with associated training. The project would involve constructing a breakwater to enclose 11.5 km^2 of sea and create 2,232 construction and manufacturing jobs.

The Rance power station in France has a tidal barrage and has become a significant tourist attraction, with 70,000 visitors a year. The improvement of roads and associated infrastructure along the coastal area facilitate the access of tourists to where the tidal projects are located. In addition, some of the visitors are interested in visiting the site to understand how tidal energy is generated. There is potential for many types of renewable energy to be more open to developing programs for such spin-off economic benefits.

[25] Bene (2003)
[26] Tethys. Galway Bay Test Site. https://tethys.pnnl.gov/project-sites/galway-bay-test-site
[27] Hundleby *et al.* (2015)

Employment and labor conditions

With little existing expertise globally in tidal energy project implementation, local expertise is unlikely to be available at new project sites. As the case of Tidal Lagoon Power in Wales, UK, suggests (see Box 10.3), tidal energy projects can provide opportunities for training, both in terms of income-generating activities per se and for upskilling workers and increasing their chances of better paid employment going forward.

Health and safety

Renewable UK[28] has produced a health and safety guide for mitigating and avoiding operational health and safety (OHS) risks associated with wind and tidal power.[29]. It identifies the risks of working near water, noting that the construction of tidal projects involves large numbers of people and vessels, working in small groups, in multiple locations. It may include vessels and offshore structures and working on a remote site for an extended period. These activities present OHS risks for the workers and marine navigation. The guide also identifies the need to address issues such as:

- Providing clear policies defining weather limits supported by effective forecasting;
- Safe practices for working over water;
- Safe practices for line handling when towing;
- Effective diver competency standards; and
- Proper equipment for recompression (when diving).

The main community health and safety risk relates to collisions and navigational safety.[30] As with other renewables, there will be a range of community and OHS issues during construction.

Indigenous communities

Tidal energy projects could have negative impacts on Indigenous communities whose lives and livelihoods are primarily marine based, e.g., in Australia and the islands and coastal area throughout Indonesia and the Philippines. Indonesia has a particularly large number of Indigenous communities. Such communities may claim traditional or customary ownership or use of coastal regions for their cultural traditions which could require free, prior, and informed consent (FPIC) for tidal power development. FPIC is a requirement under "lenders" (e.g., MDBs) safeguard standards to obtain financing and before a project can proceed. The UN Declaration on the Rights of Indigenous Peoples (UNDRIP)[31] recognizes the rights of indigenous peoples in marine environments. As tidal energy projects scale up in future, the need for inclusive consultation and engagement of Indigenous peoples will gain further importance.

Gender and vulnerability

The is little analysis in the literature of the impacts of tidal energy on women or vulnerable groups. As with other renewable technologies, tidal projects need to identify and manage any risks and negative impacts on women and vulnerable groups that may arise. Discussions of gender and vulnerability in sections on hydropower and offshore wind indicate that impacts could include exposure to risks of sexual exploitation and abuse and sexual harassment due to worker influx, pressures on social amenities from the temporary presence of construction workers from outside the local area, and disruption to travel routes.

As noted in the previous section, tidal projects can have adverse impacts on remote and/or indigenous communities in coastal areas, including potential displacement of and disruption to marine-based livelihoods. Without sufficient planning and consultation - that includes women and vulnerable groups, there is a risk that projects will be rejected by the affected community. The

[28] A membership organization involved in wind and marine renewables
[29] Renewable UK (2014)
[30] Howell and Drake (2012)
[31] See United Nations Declaration of Rights of Indigenous Peoples: www.un.org

involvement of communities in decision-making processes can ensure that any benefits derived from the project are shared equitably among community members, local governments, project developers and other private sector investors, e.g., through benefit-sharing schemes and favorable project contract mechanisms that allow for training and the scaling-up of renewable technologies in local communities.

Cultural heritage

Many communities have an intimate cultural relationship with local aquatic and coastal environments. Land/sea acquisition for project development may affect cultural heritage sites in coastal zones, including areas with potential shipwrecks and other marine archaeological sites. It may restrict local communities' and Indigenous Peoples' access to sites of cultural and spiritual significance.

Some tidal energy projects are tourist attractions (Box 10.3). In addition to informing tourists about the technology, visitors can be made aware of local culture. In Nova Scotia, Canada, a "visitors" center is attached to the Fundy Ocean Research Center for Energy (FORCE). The approximately 3,000-square foot facility houses interpretive exhibits, interactive displays, a small theatre/community room, as well as space for on-site meetings and research work.[32]

Transportation

In general, shipping lanes and navigation requirements will have to be considered during the planning and design of tidal energy projects. The installation of facilities on rivers may require the installation of locks to facilitate shipping up and down rivers. Tidal projects may disrupt access to ports, sailing routes, navigation aids, and transportation routes in estuarine areas. Modifications may affect sea conditions, bathymetry, fishing grounds and fishing activities[33] which then influence the need for riverine transportation.

Public services and infrastructure

As with other large projects, tidal power projects can be expected to provide on-site health services during the construction phase. Construction will require the use of heavy machinery and transportation of large parts which may require changes to roads and bridges (e.g., improvements, widening), or repair work if there is damage. Increased vehicle traffic during construction may have a negative impact on existing settlements, causing accidents and air, noise, and dust pollution. It may also restrict people's movement since terrestrial access to coastal communities can be limited to the landward side. Boats and vessels are needed to support installation, and their presence may affect coastal access by others.

Tidal project developers may provide financial support to improve local public facilities and infrastructure, such as schools, roads, clinics, transportation services, etc. This support is mostly included in the developers' social and environmental management plans or their CSR or investment. For instance, Tidal Lagoon power (in the UK) built access roads that the public can use to access coastal areas.

[32] For more information, see: https://fundyforce.ca./
[33] Read more about the project site here: https://tethys.pnnl.gov/project-sites/galway-bay-test-site

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 11

GREEN HYDROGEN AND AMMONIA

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International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 11

GREEN HYDROGEN AND AMMONIA

Put simply, ***green hydrogen*** is produced by splitting water into hydrogen and oxygen using renewable energy. ***Green ammonia*** is made from green hydrogen, with the process powered by renewable energy as well. The production of green hydrogen and ammonia has both positive and negative environmental and social impacts.

Green hydrogen (see Table 11.1) is seen as a major carrier of GHG-free energy in the global transition to sustainable energy and net zero emissions. Momentum is growing to rapidly expand green hydrogen production to meet IPCCC GHG reduction targets. It is emerging as an option for storing energy (see also Chapter 13 for other energy storage options) from renewables with hydrogen-based fuels potentially being transported over long distances, from regions with abundant energy resources to energy-hungry areas thousands of kilometers away.

Green ammonia, in liquid form, sourced from green hydrogen, is considered along with green hydrogen because of its current and potential role in transporting hydrogen over long distances, offering a number of advantages as a safer fuel transport medium. Ammonia is also a valued agricultural and industrial product.

Green hydrogen featured in a number of emissions reduction pledges at the UN Climate Conference, COP26, as a means to decarbonize heavy industry and its applicability as a fuel for long-haul freight, shipping, and aviation. Governments and industry have both acknowledged green hydrogen as an important pillar of a net zero economy.[1]

The "Green Hydrogen Catapult," a United Nations initiative to bring down the cost of green hydrogen, announced that it is almost doubling its goal for green electrolyzers from 25 GW, set in 2020, to 45 GW by 2027. The European Commission has adopted a set of legislative proposals to decarbonize the EU gas market and to ensure energy security for all European citizens by facilitating the uptake of renewable and low-carbon gases, including hydrogen. The United Arab Emirates' new hydrogen strategy aims to hold a quarter of the global low-carbon hydrogen market by 2030, and, recently, Japan announced that it will invest $3.4 billion from its green innovation fund to accelerate research and development and promotion of hydrogen use over the next 10 years.[2]

It is predicted that green or low-carbon hydrogen will become cost-competitive by 2040, given increased scale and lower costs of renewables, along with higher costs for producing brown, gray, and blue hydrogen.[3] White hydrogen is naturally occurring hydrogen found within the earth's crust.[4]

The production of green ammonia is promoted as an additional option in the transition to net zero carbon dioxide emissions. Its uses in this regard include:

- ***Energy storage*** – ammonia is easily stored in bulk as a liquid at modest pressures (10-15 bar) or refrigerated to -33°C. This makes it an ideal chemical store for renewable energy. There is an existing distribution network in which ammonia is stored in large, refrigerated tanks and transported around the world by pipes, road tankers, and ships.

- ***Zero-carbon fuel*** – ammonia can be burned in an engine or used in a fuel cell to produce electricity. The maritime industry is examining the potential of ammonia to replace fuel oil in marine engines. However, combustion of ammonia can release harmful nitrogen and nitrous oxides, and these emissions must be eliminated before this can be adopted as a viable replacement fuel.

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[1] World Economic Forum (2024)
[2] Obayashi, Y. (2021)
[3] Wood Mackenzie (2020); IRENA (2020b)
[4] Hawkinson, K. (2023)

- ***Hydrogen carrier*** – there are applications where hydrogen gas is used (e.g., in PEM[5] fuel cells). However, hydrogen is difficult and expensive to store in bulk (needing cryogenic tanks or high-pressure cylinders). As a liquid, ammonia is easier and cheaper to store and transport, and it can be “cracked” and purified to give hydrogen gas when required. However, there are significant conversion losses in the transformation process.

11.1 EXISTING STRATEGIC ENVIRONMENTAL ASSESSMENT GUIDANCE/GUIDELINES FOR THE PRODUCTUION OF GREEN HYDROGEN AND AMMONIA

An international survey of existing strategic environmental assessment (SEA) guidelines conducted for the International Association for Impact Assessment was unable to identify any guidelines specifically focused on infrastructure associated with the production of green hydrogen or ammonia.

11.2 TECHNOLOGIES FOR THE PRODUCTION OF GREEN HYDROGEN AND AMMONIA

Power-to-X, also known as P2X or PtX, refers to a bundle of pathways for the conversion, storage, and reconversion of electric power, especially that generated by renewable energy. It is an “umbrella” term, where X can be heat or chemicals including hydrogen, syngas, synthetic fuels, and many more.[6]

Hydrogen can be produced using various technologies and various terms are in use reflecting the technology used, e.g., brown, gray, blue, and green (Table 11.1), and sometimes even pink, yellow, white, or turquoise.

Table 11.1: Main types of hydrogen

Hydrogen type	Manufacturing process
Brown hydrogen	• Created through coal gasification.
Gray hydrogen	• Produced from natural gas but generates carbon dioxide waste. Producing and piping natural gas is a major source of climate-warming methane leaks.
Blue hydrogen	• Captures and stores the carbon dioxide produced in the creation of brown or grey hydrogen.
Green hydrogen	• Involves the use of an electrolyzer — a device that uses electricity and water and has an anode and a cathode separated by an electrolyte (see Box 11.1). Heat is generated as by-product of the process. The process is energy intensive and, where possible, that energy is derived from renewables. There are no greenhouse gas emissions, unlike other methods that use natural gas and steam. Electrolysis can also help to balance the electricity grid by adjusting the demand for electricity. • A new generation of polymer electrolyte membrane (PEM) electrolyzers are being developed and used that are more efficient and less material-intensive compared to the more mature alkaline electrolyzers.

[5] Polymer electrolyte membrane, or proton-exchange membrane, is a semipermeable membrane generally made from ionomers and designed to conduct protons while acting as an electronic insulator and reactant barrier, e.g., to oxygen and hydrogen gas
[6] Gong, J., English, N. J., Pant, D., Patzke, G. R., Protti, S. and Zhang, T. (2021)

11.2.1 Green hydrogen

Initiatives potentially included in the green hydrogen value chain are very diverse and may include, for example:

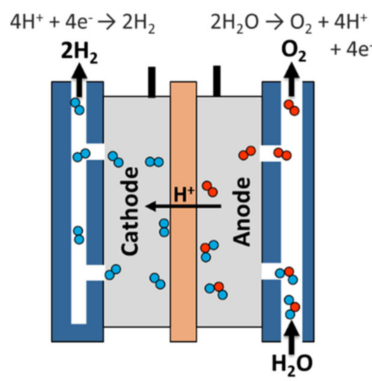
- Greenfield integrated developments, potentially including renewables farms, transmission lines, electrolyzers, conversion units to ammonia/methanol, and shipping facilities;
- Large- or medium-size brownfield developments in existing industrial areas, most often where green hydrogen (and eventually the by-product, oxygen) is utilized in existing units for power generation or steel or ammonia/fertilizer production;
- Medium-/small-size projects or distributed projects to produce hydrogen for mobility; and
- Projects that include hydrogen transmission pipelines or distribution systems.

The role of electrolysis[7] in green hydrogen production

Electrolysis is an especially appealing option for the production of hydrogen from renewable energy sources such as wind and solar. The process of splitting water into hydrogen and oxygen in an electrolyzer is shown in Figure 11.1.

Figure 11.1: The Electrolysis Process

Source: Energy.gov (n.d.-a)



Three types of electrolyzers are available:

- Alkaline electrolyzers where the electrolyte is a liquid alkaline solution of sodium or potassium;
- Polymer electrolyte membrane electrolyzers where the electrolyte is a solid specialty plastic material; and
- Solid oxide electrolyzers where the electrolyte is a solid ceramic material.

The differing levels of the electrolysis process are shown in Box 11.1 and Figure 11.2.

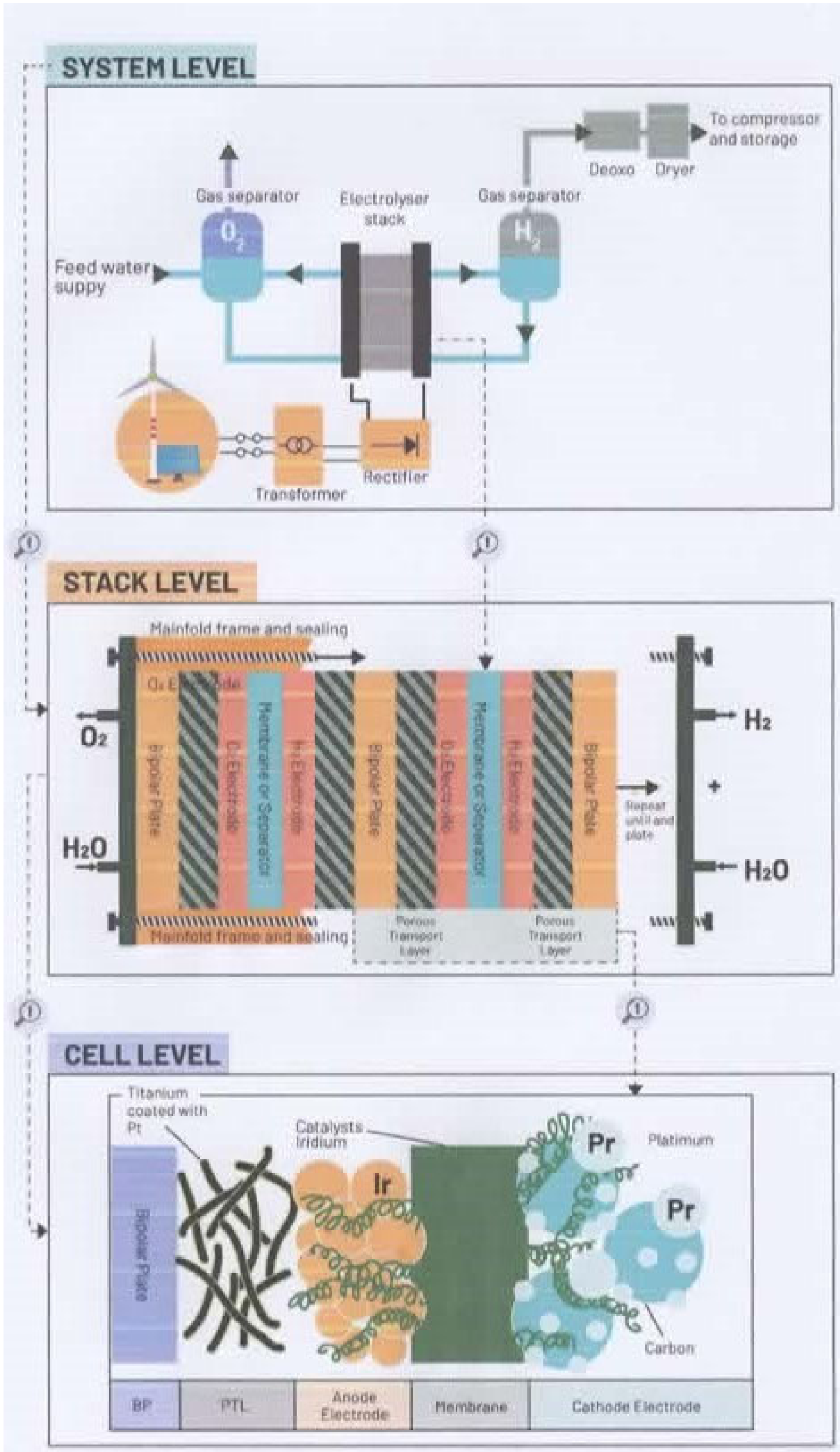
[7] Energy.gov (n.d.-b)

Box 11.1: Electrolyzer levels

An electrolyzer consists of three different levels (see Figure 11.2):

- ***The cell*** is the core of the electrolyzer where the electrochemical process occurs. At the electrode, water is split into oxygen and hydrogen, with ions (typically H+ or OH-) crossing through a liquid or solid membrane electrolyte. The membrane or diaphragm between both electrodes is also responsible for keeping the produced gases (i.e., hydrogen and oxygen) separate and avoiding their mixture.
- ***The stack*** includes multiple cells connected in series and related frames (providing mechanical support) and ancillary items.
- ***The system*** (or balance of plants) goes beyond the stack to include equipment for processing hydrogen, treating water supplied to the electrolyzer, and auxiliary activities.

Figure 11.2: The green hydrogen process
(Source: Signoria and Barlettani, 2023)



11.2.2 Ammonia

About 70% of ammonia is used for fertilizers, while the remainder is used for various industrial applications such as plastics, explosives, and synthetic fibers.[8]

The process of making most of the ammonia consumed in the world is currently not a “green” process. It is most commonly made from methane, water and air, using steam methane reforming (SMR) (to produce the hydrogen), and the Haber-Bosch process.[9] Approximately 90% of the carbon dioxide produced is from the SMR process. This process consumes a large amount of energy and produces around 1.8% of global carbon dioxide emissions.[10]

One way of making green ammonia is by using hydrogen from water electrolysis and nitrogen separated from the air. These are then fed into the Haber-Bosch process, all powered by sustainable electricity.

11.3 GLOBAL PRODUCTION OF HYDROGEN AND AMMONIA, AND STORAGE

11.3.1 Hydrogen

Global hydrogen use reached 95 Mt in 2022, a nearly 3% increase from 2021. Use has grown in all major consuming regions, with the exception of Europe.[11] Both greenfield and brownfield initiatives are under development, with different implications in terms of their potential environmental and social aspects. Huge greenfield developments may change the socioeconomic characteristics of a vast area, while other projects, such as those related to initiatives for distributed hydrogen production for mobility, have a completely different socioeconomic pattern.[11]

The Global Hydrogen Review (2023) is an ongoing annual publication by the International Energy Agency to track progress in hydrogen production and demand, as well as in other critical areas such as policy, regulation, investments, innovation, and infrastructure development. Key points of the review are set out in Box 11.2.

Box 11.2: Key points from the Global Hydrogen Review, 2023[12]

Low-emission hydrogen production can grow massively by 2030, but cost challenges are hampering deployment

- The number of announced projects for low-emission hydrogen production is rapidly expanding.
- After a slow start, China has taken the lead on electrolyser deployment.
- Equipment and financial costs are increasing, putting projects at risk and reducing the impact of government support for deployment.
- Governments have started to make funding available to support the first large-scale projects, but slow implementation of support schemes is delaying investment decisions.
- Electrolyser manufacturers have announced ambitious expansion plans.

Efforts to stimulate low-emission hydrogen demand are lagging behind what is needed to meet climate ambitions

- Hydrogen demand reached a historical high in 2022, but it remains concentrated in traditional applications.

[8] IEA (n.d.)
[9] The process converts atmospheric nitrogen (N_2) to ammonia (NH_3) by a reaction with hydrogen (H_2) using a metal catalyst under high temperatures and pressures.
[10] Gong, J., English, N. J., Pant, D., Patzke, G. R., Protti, S. and Zhang, T. (2021)
[11] Signoria and Barlettani (2023)
[12] IEA (2023-b)

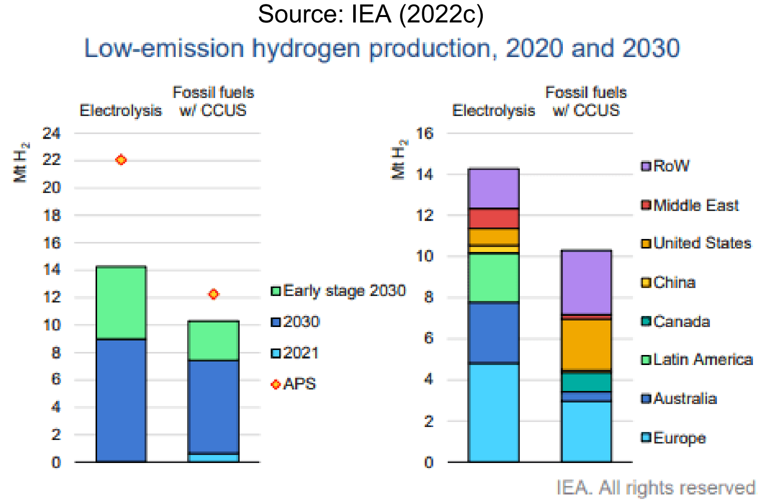
- Measures to stimulate low-emission hydrogen use have only recently started to attract policy attention and are still not sufficient to meet climate ambitions.
- The private sector has started moving to adopt low-emission hydrogen through off-take agreements, but efforts remain at very small scale.
- International cooperation initiatives can help to aggregate demand for low-emission hydrogen, but demand signals from these initiatives are unclear.
- Scaling up low-emission hydrogen use is also key to enabling the nascent hydrogen trade.

Transforming momentum around hydrogen into deployment remains a struggle

- Political momentum behind low-emission hydrogen remains strong, but deployment is not taking off.
- Regulation and certification remain key barriers to adoption, but strong international cooperation can be crucial to finding solutions.
- Governments need stronger policy action on multiple fronts to tap into the opportunity that low-emission hydrogen offers.

Figure 11.3 shows low-emission hydrogen production data for 2020 and a projection for 2030.

Figure 11.3: Low-emission hydrogen production, 2020 and 2030
Source: IEA (2022c)



Notes: RoW = rest of world; APS = Announced Pledges Scenario. In the left figure, the blue columns for 2020 and 2030 refer to projects at advanced planning stages. The right figure includes both projects at advanced planning and early planning stages. Only projects with a disclosed start year for operation are included.
Source: IEA, Hydrogen Projects Database (2022).

11.3.1 Ammonia

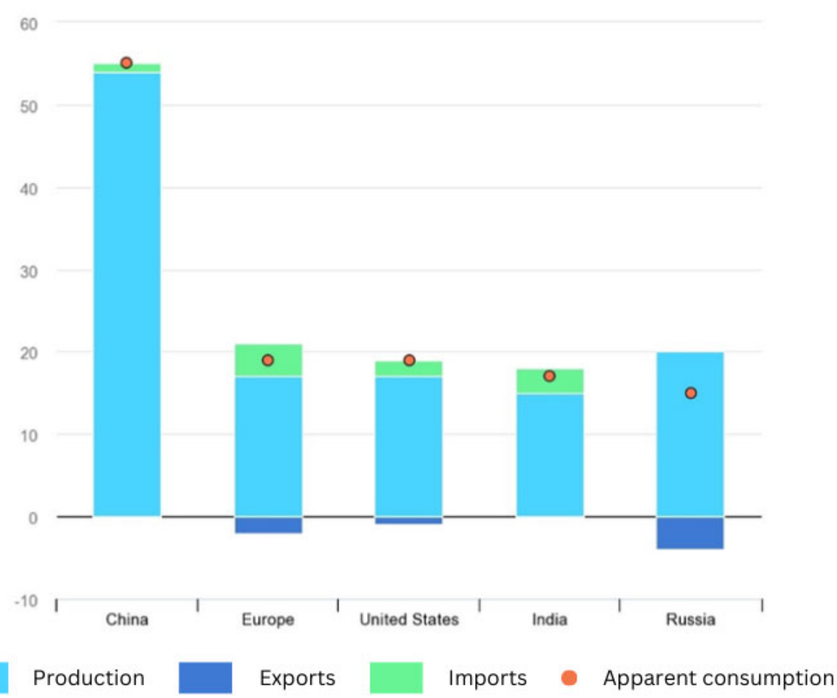
The biggest producer of ammonia in 2022 was China, followed by Russia and the USA (see Table 11.2). Almost all of this production is from natural gas sources.

Production, consumption, and trade statistics for ammonia for 2022 are shown in Figure 11.4.

Table 11.2: Ammonia production worldwide in 2022, by country
Source: Statista (2024)

Country	**Production** (1000 metric tonnes)		**Country**	**Production** (1000 metric tonnes)
China	42,000		Qatar	3,300
Russia	16,000		Algeria	2,600
USA	13,000		Poland	2,100
Other countries	13,000		Germany	2,000
India	12,000		Netherlands	2,000
Indonesia	6,000		Ukraine	2,000
Saudi Arabia	4,300		Oman	1,700
Trinidad & Tobago	4,200		Australia	1,700
Egypt	4,000		Malaysia	1,400
Iran	4,000		Viet Nam	1,200
Canada	3,800		Nigeria	1,100
Pakistan	3,400		Uzbekistan	1,100

Figure 11.4: Production, consumption and trade of ammonia in selected countries and regions, 2020
Source: IEA (2022d)



According to IEA, existing and announced projects totaling nearly 8 Mt of near-zero-emission ammonia production capacity are scheduled to come online by 2030, equivalent to 3% of total capacity in 2020.[13]

It is reported that, in 2026, South Africa will start operations at a large green ammonia plant at Mandela Bay in the Eastern Cape at a cost of USD $4.6 billion and creating at least 20,000 jobs.[14] It will be powered by a nearby solar farm extending over thousands of hectares and will get its water—

[13] IEA (n.d.)
[14] Prisco, J. (2022)

of which vast amounts are needed to make ammonia—from a local table salt factory that desalinates seawater. The NEOM Green Hydrogen Company of Saudi Arabia is building the world's largest green hydrogen plant to produce green ammonia at scale in 2026. The project has a total value of USD $8.4 billion and will integrate 4 GW of solar and wind energy to produce 600 tons of green ammonia by the end of 2026. An exclusive 30-year off-take agreement of all the produced green ammonia has been secured.[15]

Many large hydrogen and ammonia projects are being delayed due to challenges in their commercial viability.

11.3.2 Storage of hydrogen

Hydrogen can be stored in steel or composite tanks or in underground geological formations. Tanks of various sizes and pressures are already used in the industry. Underground storage is possible in different types of reservoirs, but the most feasible are salt caverns, which are also used for natural gas storage. Underground storage is more suited to large volumes and long timeframes (weeks to seasons).

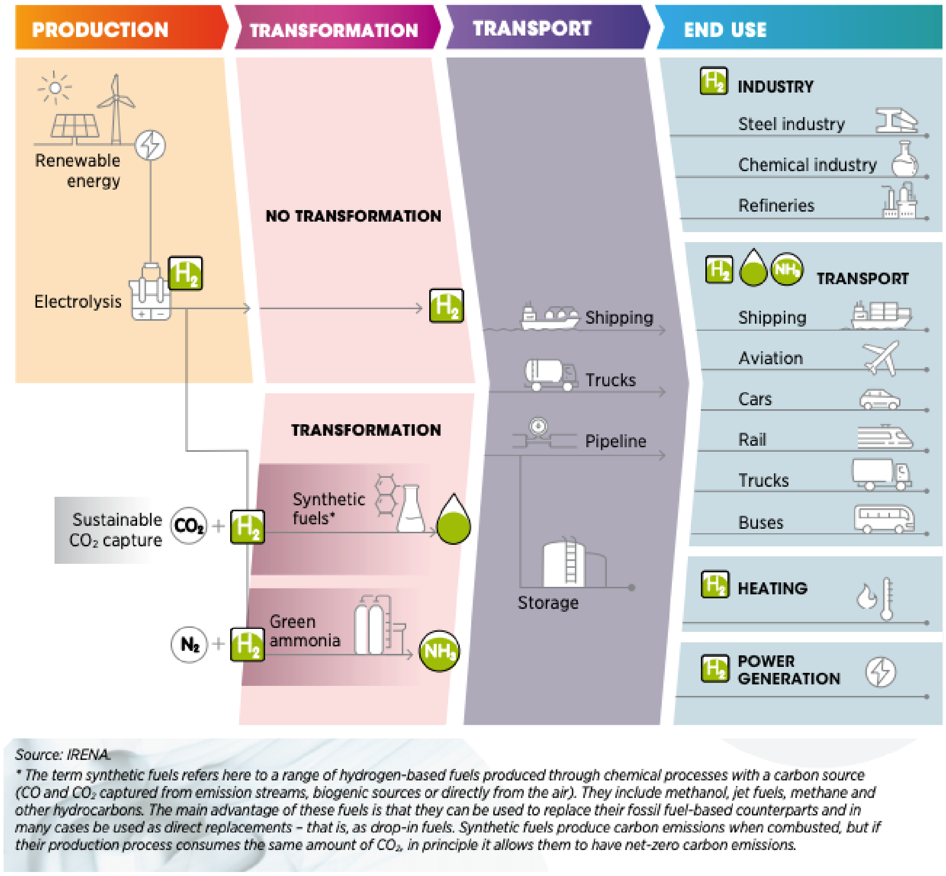
However, storing hydrogen is not easy, and leakage may occur. It is "corrosive," and, due to its small molecule size, it is more prone to leakage. Hydrogen affects the electrochemical kinetics of the metal, which subsequently lead to pitting and accelerate the rate of intergranular corrosion. The interaction of hydrogen and stress can significantly escalate the stress corrosion cracking susceptibility of steel, especially in the welded joints.[16]

Hydrogen leakage is thus an important consideration in the context of climate change. Though hydrogen molecules do not directly trap heat, they have an indirect global warming effect by extending the lifetime of other GHGs. Certain GHGs (e.g., methane and ozone) are gradually neutralized by reacting with hydroxide radicals (OH) in the atmosphere. When hydrogen gas is released to the atmosphere, it reacts with OH radicals, depleting atmospheric OH levels and delaying the neutralization of GHGs. This effectively increases the lifetime of these GHGs in the atmosphere. A recent study modeled continuous emissions of hydrogen and estimated that, over a 10-year period, hydrogen has an approximately 100 times stronger warming effect than carbon dioxide (CO_2).[17]

The relationships between green hydrogen production, conversion and end uses are shown in Figure 11.5.

[15] NEOM (2023)
[16] Li, W. et al. (2021)
[17] Fan, Z. et al. (2022)

Figure 11.5: Green hydrogen production, conversion, and end uses across the energy system
Source: IRENA (2020)



11.4 ENVIRONMENTAL AND SOCIOECONOMIC ISSUES ASSOCIATED WITH PRODUCING GREEN HYDROGEN AND AMMONIA

The production of green hydrogen and, in turn, green ammonia, is based on the use of large amounts of electricity derived from renewable sources. Most often it is assumed that this will come from wind and solar power. The environmental and socioeconomic impacts of wind and solar power are discussed elsewhere in Chapters 6 and 7, respectively. But the generation, storage, and transport of green hydrogen and ammonia will also result in direct and indirect environmental and socioeconomic impacts (Table 11.3). The environmental impacts of other forms of hydrogen are not discussed.

Table 11.3. Environmental and socioeconomic risks associated with green hydrogen and ammonia

Source: Hurwitz et al. (2023); Signoria and Barlettani (2023)

Issue	Green hydrogen	Green ammonia
Environmental		
Transport-related issues	• Transportation of hydrogen and ammonia by trucks or ships (including to homeowners) adds emissions of pollutants	
Water	• Large amounts of water are needed to produce hydrogen (approximately 9 L per 1 kg of hydrogen). This has the potential to make water (a critical requirement in production) scarce, especially to local communities and particularly where it is already limited, exacerbating **water shortages, causing conflicts with food production,** and threatening lives and livelihoods. • The use of deionized water produced by desalination plants may reduce freshwater demand, but it generates a need to **discharge brine** into water sources and soils (see Box 14.3). This increases the salinity and density of the receiving water, which may lead to higher water stratification and reduced oxygen exchange in the water column. Desalination also requires significant amounts of energy, which will have to be generated by renewable sources. • Offshore wind hydrogen production using electrolysers also affects ocean salinity with potential adverse impacts on pelagic and other marine species and ocean currents. Electrolysers and desalination systems also require significant amounts of energy, which will have to be generated by renewable sources. • **Eutrophication** due to phosphate enrichment if polyphosphates and organic cleaning solutions are added to the brine (if desalination occurs). • **Discoloration of receiving waters** due to high concentration of ferric substances, also with high-suspended solids and turbidity. • Increased salinity can **impact the composition and distribution of biota**. • **Biodiversity can be affected** by impacts to water resources (whether freshwater or seawater) receiving brine discharge from desalination plants, particularly if dilution (e.g., using a diffuser) is inadequate.	Ammonia and methanol generate waste, and production often involves the use of catalysts and other ***chemicals that can be toxic or harmful to the environment***, potentially contaminating water sources and soils during production and transportation if not handled properly. In cases of continuous discharge or leaks into water bodies, this may represent an immediate danger to aquatic life, with subsequent impacts on the livelihood of communities depending on it.
Land use/land cover change	• Large amounts of land are required for associated wind or solar energy generation. This could lead to the ***conversion of natural habitats or agricultural land***, which could have negative impacts on biodiversity, ecosystem services, and food security. • Such changes can lead to ***deforestation, land degradation and habitat fragmentation***, invasive alien species, overexploitation, hydrological changes, nutrient loading, and pollution. • This may involve the ***loss of natural buffer areas*** such as wetlands, mangroves, and upland forests that mitigate the effects of natural hazards such as flooding,	

Issue	Green hydrogen	Green ammonia
	landslides, and fire; these may result in increased vulnerability and community safety-related and health-related risks and impacts. • Production plants and associated infrastructure (e.g., transport pipelines, transmission lines, port facilities, access roads) will also involve land use change with similar impacts. This will also result in increased human access to less developed areas. • The presence of hydrogen-related infrastructure may also cause visual and aesthetic impacts.	
Waste	• ***General waste, sludge, and wastewater*** from (fresh) water purification for electrolysis requires careful management to avoid pollution of water courses and groundwater. The quantity of sludge will depend on the level of contaminants originally present in the raw water, and on the purity of water required by the specific electrolysis process adopted. • ***Electric and electronic waste and hazardous substances*** as a result of the decommissioning of electrolyzers and plants. • Risk of abandonment of the facilities at the end of their lives (probably 20-30 years).	
Pollution	• ***Emissions from trucks*** during construction phase.	
Socioeconomic		
Transport accidents	Risk of ***accidents*** on roads and at start/end sites.	
Occupational health and safety	• Hydrogen is ***highly flammable***. If not handled properly, it can pose a significant risk to workers' safety during production, transportation, and storage (explosions and fires). • The production process involves the operation of complex and potentially dangerous ***high-pressure equipment*** (containers and pipelines) and the handling of ***hazardous chemical***s, which can lead to accidents and injuries. • Workers may also be exposed to ***intense electromagnetic fields*** within the electrolyser building, to ***toxins*** (including methanol and ammonia) in conversion and storage units, and to ***cold surfaces*** in cryogenic storage units.	
Labor risks and working conditions	• Risk of ***poor/unacceptable working conditions*** (including lack of training or protective equipment) at production sites and associated infrastructure. • Catalyzers involves the use of rare earth elements such as iridium, which can present ***labor risks in the primary supply chain*** if not sourced responsibly, including the risk of ***forced and child labor***.	
Influx of workers	An influx of workers, both unskilled and skilled, is likely, particularly during the construction phase. Impacts include: • ***Induced pressure on land, natural resources, and availability and price of goods and services*** at the local level as the influx of newcomers in the area will likely increase demand for food, fuel, housing, and land. Such pressure may exert the greatest impact on the most vulnerable in the location, as well as on those communities whose livelihoods are highly or even exclusively resource-based, in particular those depending on subsistence agriculture. • An influx of labor from outside may stretch beyond capacity the local level's **social service infrastructure** due to increased demand in housing services, schools, and health care, as well as generating additional pressure on waste management, sanitation, water, power, and transportation services. • Labor influx may cause communities to experience **significant boosts to the local economy** associated with the start of projects, followed by **sharp declines** once construction works have concluded.	

Issue	Green hydrogen	Green ammonia
	• External worker influx may pose ***threats to the health and safety of local communities***, provoking higher rates of violence, injuries, alcohol and drug consumption, and communicable diseases (including sexually transmitted diseases) in the local population. • ***Conflicts*** between local community members and workers from outside the community may arise with respect to employment opportunities, wages, and demand and pressure on natural resources. • A large influx of external male workers may lead to an increase in ***gender-based violence.***	
Job opportunities	• Potential for significant ***new jobs,*** but this will need to be balanced by the requirements of training workers in new renewable energy technologies.	
Associated livelihood opportunities	• Potential for ***new livelihoods*** servicing production plants and associated infrastructure (e.g., shops, stalls). • Potential to return electricity and desalinated water to communities in areas where water and electricity access are problematic.	
Improved local services	• Potential for developers to invest in/provide ***new and improved local services*** (e.g., schools, clinics, bus services).	
Cultural heritage	• There is a risk that ***cultural, religious, and archaeological sites*** may be disturbed or destroyed as a result of developing hydrogen production sites or associated infrastructure, or access to such sites may be restricted or denied.	
Land rights	• There are risks that acquisition of land for plants and associated infrastructure will undermine, restrict, or limit ***local community rights to access*** particular areas of cultural or livelihood importance; this may lead to ownership conflicts, particularly as regards agricultural lands.	
Gender issues	• There is a potential that ***gender inequalities*** may arise during the construction and operation of plants and associated infrastructure. These can interact with other inequalities (e.g., socioeconomic, ethnic, racial, disability) and exacerbate barriers to accessing project benefits, limit the ability to deal with negative project impacts, and create other vulnerabilities. • ***Women may be discriminated*** against or subjected to sexual harassment or abuse in the workplace due to gender and/or sexual identity and orientation. • Land fragmentation and land take may ***affect women disproportionately***, also taking into consideration that land acquisition processes occur within a framework of inequalities rooted in all dimensions of land rights, i.e., ownership, management, transfer, and economic rights, in particular those associated with agricultural lands. • A large influx of external male workers may lead to an increase of ***gender-based violence*** against women and young girls, particularly in socioeconomic settings where there is an existing gender differentiation in terms of power and norms. • If green hydrogen/ammonia developments induce additional water stress, women (particularly in Indigenous communities) will likely bear a ***disproportionate impact of lack of access to safe water*** for drinking, sanitation, and other purposes. Without safe access at home and/or in work and study places, it is significantly harder for women and girls to lead safe, productive, and healthy lives. • Alongside other disadvantaged groups and minorities, women risk being ***left out of and/or underrepresented*** within consultation processes and activities of stakeholder engagement. Conversely, this may also provide opportunities for women-owned and operated renewable energy companies.[18]	
Indigenous communities	• *Indigenous Peoples may be particularly and disproportionately affected by many of the above socioeconomic issues. However, opportunities may arise for development of Indigenous-owned companies producing green hydrogen and ammonia.*	
Economic	• New green hydrogen and ammonia development will provide an economic boost to a country and to the local economy.	

Many of the socioeconomic impacts above are not exclusive to green hydrogen projects but typically arise in the construction phase of large infrastructure projects.

[18] WRISE (2024) For more information, see: wrisenergy.org

Box 11.3: Options for managing brine from desalination for hydrogen production
Source: Signoria and Barlettani (2023)

- Deep well injection;
- Evaporation ponds;
- Discharge into surface water bodies;
- Disposal into municipal sewers;
- Concentration into solid salts (e.g., salt harvesting and on-site generation of sodium hypochlorite);
- Irrigation of plants tolerant to high salinity;
- Reusing the brine;
- Zero liquid discharge;
- Aquaculture;
- Application in soils.

Potential impact can be minimized and regulated by treatment and recycling technologies, by limiting concentration values of brine at the discharge point, as well as by imposing concentration values within a prescribed circular mixing zone in coastal waters via outfall design.

The increase in salinity or temperature, or the reduction in dissolved oxygen, in the water bodies receiving brine discharge from electrolyzers or cooling systems can be modeled with available software tools.[19] The selection of the most appropriate models will depend on various factors:

- Complexity of shoreline topography;
- Presence of streams within receiving bodies;
- Possibility of water recirculation (for example, within bays with strong tidal streams), with pollutant accumulation;
- Sensitivity of local ecosystems to average and/or peak pollutant concentrations;
- Discharge geometry (along the shoreline, under water level, single or multiple discharge, etc.);
- Distance to discharge point at which the respect of a limit is requested (point of compliance).

[19] The US Environmental Protection Agency (EPA) maintains and updates a specific page (currently available at https://www.epa.gov/hydrowq/surface-water-models-assess-exposures) with a list of commercial software and freeware tools, with recommendations for their use in different situations.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 12

RETIREMENT OF COAL-FIRED POWER PLANTS, AND ASSOCIATED COAL MINE AND SUPPLY CHAIN CLOSURES

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Updated October 2024
Version 1

IAIA
International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 12

RETIREMENT OF COAL-FIRED POWER PLANTS AND ASSOCIATED COAL MINE AND SUPPLY CHAIN CLOSURES

12.1 WHY IS STRATEGIC ENVIRONMENTAL ASSESSMENT IMPORTANT TO COAL-FIRED POWER PLANT RETIRMENT AND COAL MINE CLOSURE

An overall rationale for why it is important to use strategic environmental assessment (SEA) to support the energy transition is provided in the preface to this guidance.

SEA can provide critical information to support better decision-making for the early retirement of coal-fired power plants (CFPPs) and the closure of associated coal mines and supply chains as part of the energy transition. In particular, it should identify where there might be significant environmental and/or socioeconomic risks and potential impacts that need to be addressed. This information can be particularly important as regards identifying and assessing the scale and significance of the possible cumulative impacts of multiple retirements of CFPPs and coal mines and on supply chains.

The guidance provided in this chapter differs from that in previous chapters, as the focus here is closing facilities rather than opening new renewable energy facilities or expanding existing operations. Closure can result in a loss of jobs that will ripple through regional communities, triggering a complex array of impacts but also a suite of opportunities. Planning for such changes is made complicated by the significant role that coal can play in national and regional economies and the potential volatility in the domestic and export coal markets due to shifts in national policy and in geopolitical relations. This brings high levels of uncertainty about timing and potential government reinvestment in affected communities. This is particularly true where there may be regional discrepancies in economic development.

The SEA process will:

- Identify and focus on ***key environmental and socioeconomic issues*** and the concerns of likely affected stakeholders, including work forces and local communities. Major issues are discussed in detail in sections 11.5 and 11.6 and are summarized in Tables 11.7 and 11.10.

- ***Make EIAs*** for individual CFPP retirement and coal mine and supply chain closure (where required) ***more efficient and cheaper*** by addressing the big picture and cumulative potential impacts, identifying the particular issues that individual EIAs should focus on in more (site-specific) detail.

- ***Engage stakeholders early***, including work forces, trade unions, and local communities, which can be particularly affected by such retirements or closures, and enable them to provide their perspectives and present their concerns as early as possible. This will enable key issues to be identified and verified, help build understanding and support for the energy transition, and avoid future misunderstandings, economic shocks, and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted principles and standards of good practice (see Chapter 1, Section 1.4). They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

12.2 EXISTING SEA GUIDANCE/GUIDELINES FOR RETIREMENT OF COAL-FIRED POWER STATIONS AND CLOSURES OF COAL MINE AND SUPPLY CHAIN

An international survey of existing SEA guidelines conducted for the International Association for Impact Assessment was unable to identify any that are specifically focused on the retirement of coal fired power stations or associated coal mines. Similarly, no such specific EIA guidelines have been identified, although there are some for coal mining and many for mining in general[1], and many other sources discussing the impacts of coal mining[2] and coal plants in operation.[3] There are also publications focusing on managing the social impacts of mine closure.[4] Environmental, health, and safety guidelines for thermal power plants are available from the World Bank Group.[5]

12.3 COAL-FIRED POWER STATIONS: INSTALLED CAPACITY

The world's coal-fired power capacity grew 2% during 2023, its highest annual increase since 2016, with China driving two-thirds of new additions, and decommissioning delays and a small increase seen for the first time since 2019 in the rest of the world.[6] China has the highest installed capacity of coal power plants in the world. As of July 2022, it operated 1,118 coal plants with a combined capacity of 1,074.1 GW.[7] This was more than four times the operational capacity of coal plants in the United States, which ranked third (Table 12.1).

Table 12.1: Countries with largest installed capacity of coal power plants worldwide (July 2022)

Source: Statista (2024c)

Country	Installed capacity (GW)
China	1,074.06
India	233.13
USA	217.89
Japan	50.61
South Africa	44.11
Indonesia	40.86
Russia	40.05
South Korea	38.11
Germany	37.50
Poland	30.18

According to the Global Coal Mine Tracker (GCMT)[8], in April 2023, there were 7,990 operating coal mines worldwide. China had by far the largest number (3.803), followed by India (783), Indonesia (642), and the USA (550) (Table 12.2).

[1] e.g., EPA Australia (1995); MNREC (2018)
[2] e.g., Chadwick et al. (1986)
[3] Bartan *et al.* (2017)
[4] e.g., Stanley *et al.* (2018)
[5] IFC (2008a)
[6] Global Energy Monitor et al. (2024a)
[7] Statista (2024d)
[8] The Global Coal Mine Tracker is a worldwide dataset of coal mines and proposed projects.
The most recent update, published in July 2022, includes operating mines producing 1 million tons per year or more, with smaller mines included at discretion. The tracker also includes proposed coal mines and mine expansions with a designed capacity of 1 million tons per year or more (The tracker is available at https://globalenergymonitor.org/).

Table 12.2: Number of operating coal mines in top 20 countries
Source: Global Energy Monitor (2024b)

Country	No. operating mines
TOTAL	*8,064*
China	3,881
India	866
Indonesia	589
Australia	575
United States	466
Russia	447
South Africa	279
Germany	116
Kazakhstan	102
Poland	100
Türkiye	88
Vietnam	54
Canada	52
Mongolia	51
Colombia	49
Serbia	48
Czech Republic	36
Bulgaria	34
Ukraine	28
Romania	21

12.4 BACKGROUND TO COAL ENERGY GENERATION

Retirement of CFPPs comprises two phases: shut down, when operational impacts cease, and decommissioning, the series of activities required (often by regulations) to remove hazards and potentially to redevelop the site. Decommissioning will typically be expected to comprise a mixture of repurposing, demolition, removal of demolition and waste material from site, land remediation, and redevelopment. In the context of the Energy Transition,[9] both phases are likely to take many years to complete.

CFPPs generate electricity through a series of energy conversion stages: coal is burned in boilers to convert water to high-pressure steam, which is then used to drive a steam turbine to generate electricity. Figure 12.1 shows a generalized schematic diagram for a thermal power plant and the associated operations required to run a plant.

High-temperature, high-pressure steam is generated in the combustion plant (boiler), which then enters the steam turbine. At the other end of the steam turbine is the condenser, which is kept at a low temperature and pressure using a cooling agent, usually water. Through the steam condensing process, that cooling water is warmed. If the cooling system is an open or a once-through system, this warm water is released back to the source water body (such as a river, lake, or marine environment). In a closed system, the warm water is cooled by recirculation through cooling towers, lakes, or ponds, where the heat is released into the air through evaporation and/or sensible heat transfer (e.g., conduction to adjacent soil or air) before being used in the cooling process again. If a recirculating cooling system is used, only a relatively small amount of make-up water is required to offset the evaporative losses and cooling tower blowdown, which must be discharged periodically to control the buildup of solids. A recirculating system uses about one-twentieth the water of a once-through system.[10]

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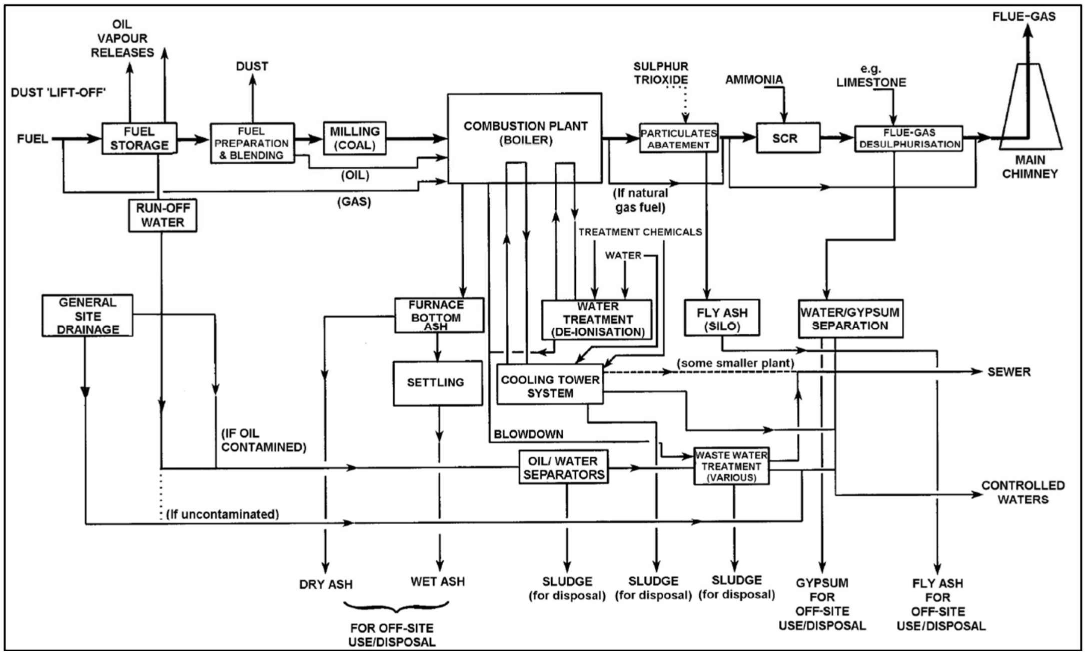
[9] Energy transition is the change in the composition or structure of primary energy supply, from fossil-based systems to renewable energy sources and electrification. It affects the energy sector and other sectors that produce energy-related emissions, such as transportation and industry.
[10] IFC (2008b)

Figure 12.1: Generalized flow diagram of a thermal power plant (coal, gas, oil) and associated operations
Source: IFC (2008b)



In many countries, CFPP sites are located on the coast and use coastal sea water for cooling in once-through cooling systems.[11]

Coal-fired steam generation systems generally use pulverized or crushed coal. Several types of coal-fired steam generators are in use and are generally classified based on the characteristics of the coal fed to the burners and the mode of burning the coal. The coal can be transported to the powerplant by rail, barge, or truck,[12] although the majority of the CFFPs use sea-going barges to deliver coal to the plants.

The burned coal releases carbon dioxide and an array of other chemicals, and it leaves ash. To give a rough sense of scale, each ton of coal produces 2-3 tons of carbon dioxide and provides about 300 kg of solid ash. For each gigawatt of electricity in capacity, a power station would use about 2-3 million tons of coal per year, therefore being responsible for 1 million tons of ash and 10 million tons of carbon dioxide each year. These outputs are detailed in the next section.

12.5 ENVIRONMENTAL ISSUES OF OPERATIONAL COAL FIRED POWER PLANTS

It is recognized that the energy transition from coal to renewable energy sources will take some time, perhaps decades. In developing countries and economies, this process could take longer—conceivably to 2050 and beyond. Therefore, in the discussion of environmental and social issues associated with coal-fired power plants (CFPPs), it is important to consider both operational as well as decommissioning and retirement phases, as CFPP-related risks and impacts may continue to occur for many years to come.

[11] Suarez and Myllyvirta (2020)
[12] IFC (2008b)

Greenhouse gases

The burning of coal in CFPPs emits greenhouse gases (GHG)—predominately carbon dioxide (CO_2) with relatively minor amounts of nitrous oxide (N_2O)—to the atmosphere, contributing significantly to climate change impacts. The volume of emissions from CFPPs is a function of the efficiency of the energy conversion of the plant and the fuel type (coal or lignite).

Table 12.3 shows the range of emission performances for a range of CFPP types.

Table 12.3: Typical carbon dioxide emissions performance of new thermal power plants
Source: IFC (2008a)

Fuel	Efficiency	CO_2 (gCO_2 / kWh – Gross)
Efficiency (% Net, HHV)		
Coal (*1, *2)	Ultra-Supercritical (*1): 37.6 – 42.7 Supercritical: 35.9-38.3 (*1) 39.1 (w/o CCS) (*2) 24.9 (with CCS) (*2) Subcritical: 33.1-35.9 (*1) 36.8 (w/o CCS) (*2) 24.9 (with CCS) (*2) IGCC: 39.2-41.8 (*1) 38.2–41.1 (w/o CCS) (*2) 31.7–32.5 (with CCS) (*2)	 676-795 756-836 763 95 807-907 808 102 654-719 640 – 662 68 – 86
Gas (*2)	Advanced CCGT (*2): 50.8 (w/o CCS) 43.7 (with CCS)	 355 39
Efficiency (% Net, LHV)		
Coal (*3)	42 (Ultra-Supercritical) 40 (Supercritical) 30 – 38 (Subcritical) 46 (IGCC) 38 (IGCC+CCS)	811 851 896-1,050 760 134
Coal and Lignite (*4, *7)	(*4) 43-47 (Coal-PC) >41(Coal-FBC) 42-45 (Lignite-PC) >40 (Lignite-FBC)	(*6) 725-792 (Net) <831 (Net) 808-866 (Net) <909 (Net)
Gas (*4, *7)	(*4) 36–40 (Simple Cycle GT) 38-45 (Gas Engine) 40-42 (Boiler) 54-58 (CCGT)	(*6) 505-561 (Net) 531-449 (Net) 481-505 (Net) 348-374 (Net)
Oil (*4, *7)	(*4) 40 – 45 (HFO/LFO Reciprocating Engine)	(*6) 449-505 (Net)
Efficiency (% Gross, LHV)		
Coal (*5, *7)	(*5) 47 (Ultra-supercritical) 44 (Supercritical) 41-42 (Subcritical) 47-48 (IGCC)	(*6) 725 774 811-831 710-725
Oil (*5, *7)	(*5) 43 (Reciprocating Engine) 41 (Boiler)	(*6) 648 680
Gas (*5)	(*5) 34 (Simple Cycle GT) 51 (CCGT)	(*6) 594 396

Source: (*1) US EPA 2006, (*2) US DOE/NETL 2007, (*3) World Bank, April 2006, (*4) European Commission 2006, (*5) World Bank Group, Sep 2006, (*6) World Bank Group estimates

CGT = combined cycle gas turbine, CCS = carbon capture and storage,
FBC = fluidized-bed combustion,
GT = gas turbine,
IGCC = integrated coal gasification combine-cycle,
PC = pulverized coal.

Air quality

When coal burns, the chemical bonds holding its carbon atoms in place are broken, releasing energy. However, other chemical reactions also occur, many of which emit toxic airborne pollutants and heavy metals into the environment.

This air pollution includes sulfur dioxide (SO_2) produced when the sulfur in coal reacts with oxygen. In turn, the SO_2 combines with other molecules in the atmosphere (including water vapor) to form small, acidic particulates that can penetrate human and animal lungs. These particulates are the ashy gray substance in coal smoke that is linked with respiratory and pulmonary illnesses such as chronic bronchitis, aggravated asthma, lung disease, cardiovascular effects such as heart attacks, and premature death. It can also cause smog and haze and the formation of acid rain, which damages crops and terrestrial and aquatic ecosystems.

Nitrogen oxides (NO_x) are visible as smog and irritate lung tissue, exacerbate asthma, and make people more susceptible to chronic respiratory diseases such as pneumonia and influenza.

Mercury and other toxic heavy metals result from coal combustion and can damage neurological, digestive, and immune systems, and is a serious threat to child development.[13]

Most of these emissions can be reduced by the installation of pollution control equipment (scrubbers) at the CFPPs, although many plants do not have adequate controls installed or are not monitored or maintained in line with national standards or good international industry practice (GIIP). Table 12.4 shows the emission standards in place in various countries.

Table 12.4: Emission limits for existing coal fired power plants

Source: CREA (n.d.)

Unit: mg/m3, except Hg as µg/m3, dry STP 6% oxygen.

Jurisdiction	$S0_2$	NOx	PM	Hg
EU, from 2023, hard coal	130	150	8	4
EU, from 2023, lignite	130	175	8	7
China, from 2020	35	50	10	30
EU, from 2015	200	200	20	-
USA	640	6740	23	1.6
China, all plants	200	100	30	30
South Korea	286	308	36	-
Japan	200	376	46	-
India, units installed after 2003*	200	600	50	30
Turkey	400	200	50	-
South Africa*	680	1020	68	-
India, units installed before 2003*	200	300	100	30
Indonesia	589	589	107	-
Philippines	1607	1607	214	-
Vietnam	500	1000	400	-

*Limits are technically in force but the regulator has delayed or failed to require compliance

Note: The table simplifies the complexity of regulation by only showing the emission limits applying to large (varyingly, >50MW to >500MW) plants. It also does not cover all exemptions either to individual plants or specific categories of plants which exist in many countries. The values are converted to 6% reference oxygen content, the most common basis used e.g., in the EU and China.

Southeast Asian coal emissions were estimated to have caused 19,880 (range 11,400−28,400) excess deaths per year in 2017.[14] Pollution from the current Philippines operating fleet of CFPPs is estimated to have led to 630 deaths in 2019, as well as 1,300 new cases of child asthma, 149,000

[13] UCS (2019)
[14] UCS (2019)

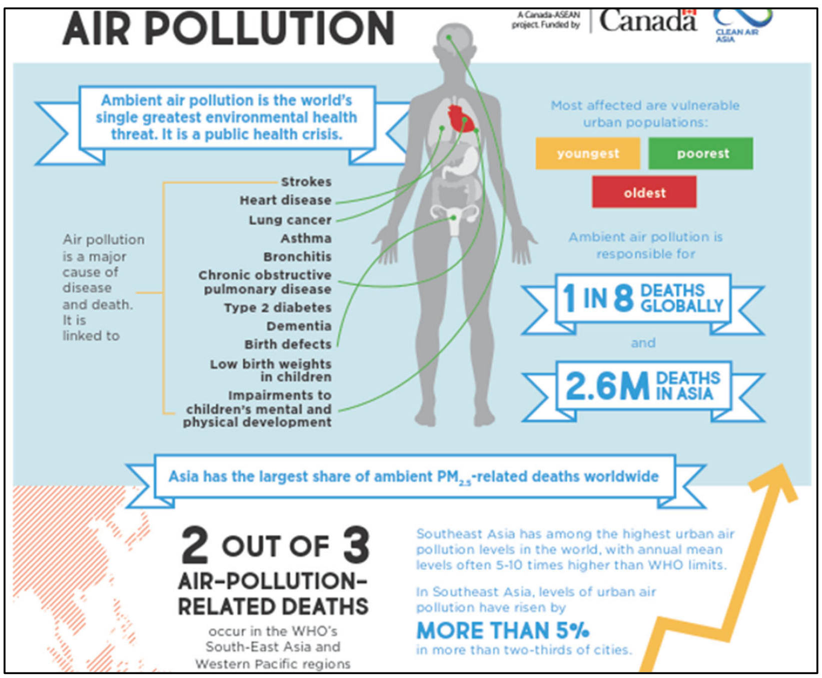
days of work absence (sick leave), and 240 pre-term births.[15] Studies show that children exposed to CFPP emissions face the highest risks, resulting in significant adverse effects on pediatric neurodevelopment, birth weight, and pediatric respiratory morbidity.[16]

The quantum of pollutant emissions from CFPPs, their installed air pollution control devices, as well as population density, topography, and meteorology, play key roles in determining exposure risks.[17] In general, communities living nearest to CFPPs, or those with the highest exposures, face as much as five times the risk compared with those residing farther away.[18] Depending on the specific pollutants and the dominant meteorological and other atmospheric conditions, hazardous air pollutants from CFPPs can travel from 8 to 48 km from the stack unless they are deposited on the ground, chemically transformed, or removed from the air.[19]

Where CFPPs are present, they contribute to ambient air pollution together with burning of other fossil fuels.

Globally, air pollution accounted for an estimated 6.67 million premature deaths in 2019 and, on average, reduces life expectancy by 1 year and 8 months (Figure 12.3), with almost 70% of the burden of air pollution-related mortality borne by Asia.[20]

Figure 12.3: Ambient air pollution
Source: Clean Air Asia (n.d.)



Water quality

Local coastal water quality can be impacted by both contaminants and increases in temperature (referred to as “thermal plume”) and from the operations of CFPPs.

[15] CREA (2020)
[16] Amster & Levy (2019)
[17] Clean Air Asia (2020)
[18] Munawer (2017)
[19] Clean Air Asia (2020)
[20] Tong et al. (2021)

Mercury is one of the key contaminants resulting from the combustion of coal in CFPPs (Table 12.5), accounting for about 13% of global mercury emissions. Mercury is one of the most toxic elements in nature and a threat to wildlife because it accumulates and magnifies to unsafe levels in aquatic food chains (Box 12.1). Exposure to mercury in humans, even in small amounts, may cause serious health problems to the nervous, digestive, respiratory, and immune systems, and is a threat to the development of the child in utero and early in life.[21] After mercury is emitted into the atmosphere from the stacks of CFPPs, it settles onto both water bodies and land. It is persistent in sediments but can become bioavailable and mobilize through the food chain.

Table 12.5: Quantities of mercury emitted to air from anthropogenic sources in 2015, by different sectors (main sources)
Source: UNEP (2019)

Sector	Mercury emissions (range) tons	Sector % of total
Artisanal and small-scale gold mining	838 (675-1000)	37.70
Stationary combustion of coal (power plants)	292 (255-346)	13.10
Cement production (raw material and fuel, excluding coal)	233 (117-782)	10.50
Non-ferrous metal production (primary Al, Cu, Pb, Zn)	228 (154-338)	10.30
Waste (other waste)	147 (120-223)	6.60
Stationary combustion of coal (industrial)	126 (106-146)	5.67
Large-scale gold production	84.5 (72.3 - 97.4)	3.80
World total	*2220 (2000-2820)*	*100.00*

Box 12.1: Mercury contamination of water case study, Thailand
Source: Prachatai (2013)

Mercury concentrations were found to be above safe levels in fish tissue and hair samples taken from residents near a coal-fired power plant and a paper and pulp mill in Prachinburi's—the largest industrial area in eastern Thailand. The study concluded that the possible sources ranged from fly ash from the coal-fired power plants, coal dust from outdoor coal storage piles, ash deposits (which are spread over eucalyptus plantations in the area), as well as the possible leak of mercury-contaminated wastewater from a nearby paper and pulp mill to a public canal.

Research has shown that Asia releases a large amount of anthropogenic mercury.[22] While increased burning of coal in Asia has been known to exacerbate mercury emissions and air pollution, the research estimates that Asia could produce up to 1,770 metric tons of mercury emissions per year—more than double the mercury emissions previously estimated.[23]

Effluents from CFPPs include thermal discharges from the heated water emanating from the cooling systems. In some countries, where CFPPs are in coastal areas, once-through cooling systems are used that require large quantities of water that is usually drawn from the sea. Subsequently, it may be discharged at elevated temperatures with increased brine levels and chemical contaminants (e.g., biocides, chlorine, or other additives, if used). Such discharges may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life.[24] Thermal pollution is the disturbance of water quality by elevated temperatures that cannot dissipate in a natural way and can result in significant degradation of aquatic ecosystems (Box 12.2).

[21] World Health Organization (2024)
[22] MIT News (2015)
[23] World Economic Forum (2015)
[24] IFC (2008a)

Box 12.2: Thermal water pollution in Romania

A fleet of coal-fired power plants is situated along the Jiu River in Romania. They use large volumes of water from the river for their once-through cooling systems. Here, the higher temperature of the water returned to the river was found to have a significant thermal pollution impact to the downstream aquatic ecosystems in the river.

Solid waste

CFPPs generate large volumes of solid waste due to the relatively high percentage of ash in coal. This so-called bottom ash remains in the CFPP boiler bed after the coal has been combusted.

The coal combustion wastes (CCW) include fly ash (carried in the exhaust gases), bottom ash, boiler slag, and sludge. Fluidized-bed combustion (FBC) boilers generate fly ash and bottom ash, known as bed ash. Fly ash removed from exhaust gases makes up 60%–85% of the coal ash residue in pulverized-coal boilers and 20% in stoker boilers. Bottom ash includes slag and particles that are coarser and heavier than fly ash. Low-volume solid wastes from CFPPs include coal mill rejects and/or pyrites, cooling tower sludge, wastewater treatment sludge, and water treatment sludge.

The high volume of CCW waste is typically disposed of in landfills or surface impoundments or, increasingly, may be used for a variety of beneficial purposes, such as a component of concrete manufacturing. The use of ash to replace Portland cement in concrete mixes is lauded for its contribution to reducing the significant greenhouse gas emissions created in producing cement and to divert this waste from landfills. Some countries have a very high utilization of this ash, such as India[25], where the reuse rate is over 90%. Other countries, such as Australia, are struggling to boost the use of coal combustion ash. That is attributed to the cement market being dominated by a small number of large corporate players who have been portrayed as reluctant to “rock the boat” in a buoyant market made possible by plentiful resources and extensive government investment in infrastructure that uses concrete.[26]

Low-volume wastes may also be disposed of in landfills but are more frequently disposed of in surface impoundments, sometimes at the CFPP site itself. Many CFPP owners manage their waste streams through relationships with third parties, such as jointly owned waste management companies. The third parties are often landowners in the vicinity of the plant. Hazardous materials stored and used at coal-fired combustion facilities include solid, liquid, and gaseous waste-based fuels; air, water, and wastewater treatment chemicals; and equipment and facility maintenance chemicals (e.g., paint, certain types of lubricants, and cleaners).

Surface impoundments storing coal ash can fail if the integrity of the containment is compromised. This can lead to very large spills to adjacent land and potentially to water bodies, with the potential to contaminate several hundred hectares due to the volumes of waste. The failure of a surface impoundment cell at a CFPP in Kingston, Texas, led to approximately 4.1 million m^3 of coal ash being released over an area extending approximately 120 ha outside of the fly ash dewatering and storage areas of the plant and eventually spilling into the Emory River channel.

Inadequate management of coal ash is a known issue in some countries. Due to high rainfall events and the dense population of coastal areas where the majority of CFPPs are located, solid waste storage is considered a significant environmental issue. The ash can leach heavy metals, including lead, arsenic, and mercury, into nearby water sources.

[25] Central Electricity Authority, Civil Design Division (2022)
[26] Rifkind, W. (2024)

Health and safety

CFPPs are large-scale industrial facilities with a complex series of operations that have major hazards associated with materials, plants and processes. This can lead to high numbers of workplace fatalities and injuries. The following health and safety impacts are of particular concern to workers:[27]

- ***Non-ionizing radiation***: CFPP workers may have a higher exposure to electric and magnetic fields (EMF) than the public due to working in proximity to electric power generators, equipment, and connecting high-voltage transmission lines;
- ***Heat***: occupational exposure to heat occurs during operation and maintenance of combustion units, pipes, and related high-temperature equipment;
- ***Noise:*** noise sources in combustion facilities include: the turbine generators and auxiliaries; boilers and auxiliaries, such as pulverizers; diesel engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers;
- ***Confined spaces***: specific areas for confined space entry may include coal ash containers, condensers, and cooling water towers;
- ***Electrical hazards***: energized equipment and power lines can pose electrical hazards for workers at thermal power plants;
- ***Fire and explosion hazards***: CFPPs store, transfer, and use large quantities of fuels; therefore, careful handling is necessary to mitigate fire and explosion risks. Fire and explosion hazards increase as the particle size of coal is reduced. Particle sizes of coal that can fuel a propagating explosion occur within thermal dryers, cyclones, baghouses, pulverized-fuel systems, grinding mills, and other process or conveyance equipment and at storage yards, where there is a need for regular monitoring, water sprinkling, and limitation of coal pile height;
- ***Chemical hazards***: CFPPs utilize hazardous materials, including ammonia for NOx control systems, chlorine gas for treatment of cooling tower and boiler water, and chemicals used for laboratory analyses, some of which may be classified as ozone depleting substances;
- ***Dust***: generated in handling solid fuels, additives, and solid wastes (e.g., ash). Dust may contain silica (associated with silicosis), arsenic (with skin and lung cancer), coal dust (with black lung), and other potentially harmful substances;
- ***Operational health and safety***: compared with other energy production methods, coal is significantly more dangerous than renewables and biomass as a source of energy. This is both with respect to power plants reliant on coal and the mining processes to fuel that process.[28]

Historically, coal has seen the greatest number of severe accidents (leading to fatalities). Examples of major incidents include:

- 21 people were killed in an explosion at a coal-fired power plant in the city of Dangyang in Hubei Province, People's Republic of China (2016).
- An explosion at a newly commissioned unit of CFPPs in northern India killed 43 people, while about 80 were injured in one of the nation's worst industrial disasters in recent years (2017).
- Six people were injured in a dust explosion and fire at a CFPP in Turkey's Canakkale province (2018).
- A man died in an explosion at the Yallourn Power Station, Victoria, Australia (2018).

Coal (including brown coal) is responsible for over half of all deaths worldwide for all energy sources (Table 12.6).

[27] IFC (2008a) Annex A
[28] Markandya and Wilkinson (2007)

Table 12.6: Mortality rate from accidents and air pollution per unit of electricity worldwide, by energy source *(death per thousand TWh)*
Source: Statista (2024b)

Energy source	Deaths (per thousand TWh)
Brown coal	32.72
Coal	24.62
Oil	18.43
Biomass	4.63
Natural gas	2.82
Hydro	1.30
Wind	0.04
Nuclear	0.03
Solar	0.02

12.6 ISSUES ASSOCIATED WITH THE RETIREMENT OF COAL-FIRED POWER PLANTS

Table 12.7 summarizes the range of environmental and socioeconomic issues associated with the retirement of CFPPs.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 12.7: Environmental and socioeconomic issues associated with retiring CFPPs

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
Environmental	
Reduction in greenhouse gas emissions (GHG)	• Early retirement of CFPPs will reduce GHG emissions unless they are replaced by a larger capacity of power stations (i.e., for a larger population) running on natural gas or burning municipal waste.
Improved air quality	• Reduction in certain emissions to air due to early retirement of CFPPs (sulfur dioxides [SO_2], nitrogen oxides [NO_x], mercury, particulates), unless they are replaced by power stations that burn waste ineffectively, which can lead to emissions of chemicals and heavy metals.
Improved localized water quality	• No longer discharging cooling water to water bodies (eliminating thermal pollution), and elimination of mercury emissions contaminating water.
Water use	• Retiring CFPPs reduces water demand unless they are replaced with power stations that also have significant water demands, such as facilities that generate hydrogen and then use it in fuel cells.
Generation of waste	• Decommissioning of power plants leads to large amounts of waste, including hazardous waste that requires disposal, including asbestos in building materials and use for insultation. • There may be issues concerning regional cumulative impacts connected to handling and disposing of toxic waste. • Failure of unremediated surface impoundments containing waste ash, slag, and sludge. Early retirement will stop waste production but will require a waste management plan and disposal at appropriate facilities.
Land and water contamination	• Decommissioning may require remediation of contaminated land (particularly with heavy metals and hazardous materials) and disposal of contaminants. • It may not be possible to reclaim CFPP sites to a pre-existing condition. A decommissioning plan will be required, which should also prescribe safe and acceptable end-land uses. • There may be associated contamination of groundwater and surface water.
Land and ecosystem restoration	• CFPPs tend to occupy a small footprint, and many are located in or near urban centers. After decommissioning, site restoration will be required. However, some plants or sites may be repurposed should conditions for the installation of renewable energy facilities or other desired facilities be favorable. • Large power stations often feed electricity into high-voltage lines for transmission over distances up to hundreds of kilometers. In some instances, decommissioning of the power station can lead to decommissioning of the power lines, which can enable “re-wilding” of power line corridors, reversing certain effects of ecosystem fragmentation.
Socioeconomic	
Legacy socioeconomic issues (crosscutting)	• Outstanding legacy socioeconomic issues (e.g., lack of compensation for land and property loss, lost livelihoods and income, impacts on cultural practices involving the land, such as hunting and sacred sites, and historical marginalization of certain groups dating back to colonial times) linked to stand-alone mines and impacts specifically linked to individual CFPPs that have not been handled or mitigated before retirement.
Regional economy	• Early retirement of CFPPs will impact national and international coal supply chains and associated business activities (shortage of coal supplies in countries, job losses, transport, etc.). • Job losses result in the loss of employment income and loss of income tax revenues; closures of related businesses mean a loss of local tax revenue.

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
	• Reduced reliability and security of electricity supply leading to disruption at major economic hubs and centers; possible closure of large facility electricity consumers, e.g., aluminum smelter. • Raised electricity tariffs leading to an increase in commodity and food prices. • Indirect losses through supply chains (transport) may affect the regional economy. • Reduced interest in investing in the region due to loss of an “anchor tenant,” its electric power, and the skilled workforce in its supply chain.
Employment and labor conditions	• Loss of jobs (direct and indirect) in CFPPs may require retrenchment plans. • Job loss may lead to increased pressure on national welfare and social protection. • Alternative employment options can represent underemployment in terms of hours, income, and skill sets, which can lead to early departure from the workforce. • Long-term opportunities for employment, improved labor standards, and working conditions in CFPPs and supply chains during the retirement period. • Retraining and skill development will be required to take advantage of opportunities in renewable energy technology.
Health and safety	• Reduced air and noise pollution and dust will lead to improved public health. • Community health services may deteriorate as support to health facilities and services from CFPPs and associated businesses is reduced or lost. • Hazardous waste and contaminated land may lead to contamination of groundwater supplies, food crops, and local fisheries. • Closure and decommissioning may result in a risk of worker exposure to hazardous materials.
Local economy and livelihoods	• Reduced livelihood opportunities in the host communities (less demand for food stalls, accommodation, reduced business for small retailers). • Increased households’ indebtedness and vulnerability to income losses related to individuals and businesses unable to repay their loans. • Reduced revenues from renting properties and values of properties as a result of outmigration. • Disrupted belief in aspects of capitalist, growth-oriented economy as it has “failed” locally; green, no-growth alternatives explored. • Rehabilitation and redevelopment of CFPP sites will create income-generation activities.
Gender and vulnerability	• Women and vulnerable groups, such as the poor, persons with disabilities, children, the elderly, and Indigenous communities, may be disadvantaged and at particular risk. • Incomes will be lost following closure, and competition for jobs in other sectors may well increase. • Increased competition from former male workers in CFPPs may arise in women-dominated industries (such as manufacturing and garment industries) following closure. • Increased domestic and gender-based violence due to loss of income and resultant stress in the household. • Increase pressure on state welfare systems. • Opportunities for women and vulnerable groups to acquire new skills and learn new renewable energy technologies. • Opportunities for vulnerable groups to engage in the decision-making process and in inclusive dialogue for CFPP retirement.
Migration and loss of local skills	• Migrants attracted to work in CFPPs and associated businesses will leave the communities. • Local skilled workers and skilled migrants from CFPPs will leave communities. • Increased vulnerability of abandoned household members whose income depends on skilled migrants. • Opportunities for local workers to reskill for new opportunities in renewable energy replacement.

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
Public services and infrastructure	• The early retirement of CFPPs may affect public services and infrastructure directly supported by the CFPPs (e.g., health clinics, education facilities, roads, bus services, and other transportation); and through reduced tax revenues due to less local government revenues generated from imposing taxes on CFPPs and associated businesses. • Reduced pressure on public services and infrastructure as a result of outmigration. • Potential loss of sponsorship funding for social infrastructure such as libraries, town halls, parks, and meeting spaces. • Potential loss of support and membership for religious organizations and charities and reduced levels of volunteering.
Social cohesion and engagement	• Weakened community cohesion resulting from outmigration of community members. • Risk of internal conflict due to increased stress as income lost. • Opportunities for the communities to engage in the decision-making processes. • Reduced tension between CFPPs and communities, non-government organizations (NGOs), and activists due to reclamation and rehabilitation of industrial sites formally occupied by CFPPs.

Decommissioning activities vary widely. They range from:

- A plant being abandoned with little advanced notice to workers, the surrounding community, and authorities, and minimal works undertaken by the site operator or owner once operations cease;

to

- A carefully planned redevelopment or decommissioning plan being prepared and communicated to stakeholders years ahead of shutdown, site remediation being undertaken, and future land-use opportunities realized.

Evidence suggests that there are a variety of benefits to repurposing and ensuring appropriate remediation of coal-fired power plants. A report by the World Bank[29] asserts that the direct benefits of repurposing such facilities in developing countries outweigh the costs of decommissioning. Such benefits may include land reutilization, equipment reuse (substations, generators, turbines), land remediation, and transmission and interconnection benefits. Beyond direct cost, benefits from decommissioning and repurposing plants provides social and grid stability benefits.

There is a wide range of technology options available for repurposing of CFPP sites (Table 12.8), e.g., solar PV (located on surface impoundments), concentrated solar power, biomass, battery energy storage systems, offshore wind, and synchronous condensers. The options selected require careful consideration of multiple factors, including generation requirements for renewable energy, requirements of the power systems, and location and decommissioning needs. Repurposing allows for retaining part of the workforce for an upcoming repurposing project at the same site. This retention would partly ameliorate the socioeconomic impact of potential layoffs. The repurposed plant would also continue to support local economies and the surrounding communities by providing jobs and enabling economic activities and their well-being in the long run.[30]

Table 12.8: Repurposed coal-fired power plant sites and their end use
Source: World Bank (2021a)

Plant name	Location	Country	End use	Status
Nanticoke	Ontario	Canada	Solar	Completed
Prosper Haniel	North Rhine Westphalia	Germany	Pumped storage, salt thermal storage	Completed
Drax	North Yorkshire	UK	Biomass	Completed
Beckjord	Ohio	USA	Battery storage	Completed
Eastlake	Ohio	USA	Synchronous condenser	Completed
Widows Creek	Alabama	USA	Data centre	Completed
Mount Tom	Massachusetts	USA	Solar & battery storage	Completed
Redbank	New South Wales	Australia	Solar, biomass	Proposed
Liddell	New South Wales	Australia	Renewable energy, battery storage, gas demand response	Proposed
Guru Nanak Dev	Punjab	India	Solar	Proposed
Breyton	New England	USA	Offshore wind	Proposed

One controversial repurposing technology, proposed by Japan, is to use ammonia as a fuel with coal for co-fired power generation. But there are concerns about this technology. It may be more costly as most ammonia today is produced from fossil fuels, and emissions of nitrous oxide from the combustion process may result in a global warming potential significantly larger than gas-fired power plants.[31] Japan is also investing in converting coal to hydrogen through gasification, supported by carbon capture and storage.[32]

[29] World Bank (2021)
[30] World Bank (2021)
[31] BloombergNEF (2022)
[32] Hydrogen Energy Supply Chain (HESC) Project (2023)

Conversely, poorly planned shutdowns and abandoned CFPPs leave a significant legacy of environmental and social impacts, which are discussed in the following sections.

12.6.1 Environmental issues associated with retiring coal-fired power plants

Greenhouse gases

A major benefit of the closure of CFPPs will be the elimination of associated GHG emissions. But benefit will not be immediate as the retirement of CFPPs may be prolonged, and there will still be relatively minor short-term GHG emissions from vehicles and mobile plants used during decommissioning activities.

Air quality

The closure of CFPPs will result in the elimination of all stack emissions arising from the burning of coal. Air quality impacts from dust related to decommissioning activities will vary depending on how these activities are planned and executed. If the decommissioning of sites is not undertaken according to national and good international practice, coal ash dust from storage at CFPP sites may be an ongoing issue for local communities living in proximity (see also section below on land contamination).

Water quality

The closure of CFPPs will result in ending: (i) direct thermal emissions from the discharge of cooling waters to source water bodies; (ii) indirect impacts from contaminated dust in air emissions settling into water bodies in the vicinity of the plants; and (iii) groundwater contamination from ponds and leaks.[33]

Water quality impacts related to decommissioning activities will vary depending on how these activities are planned and executed. If the decommissioning of sites is not undertaken according to national and good international industry practice (GIIP), coal ash waste may contaminate nearby water bodies, leading to ongoing issues for local communities living in proximity (see also section below on land contamination).

Solid waste

The closure of CFPPs will stop large volumes of waste (e.g., coal ash) being generated from operations, providing a long-term benefit. However, existing fly ash stored in surface impoundments is potentially a significant environmental issue if adequate provisions are not included in the CFPP decommissioning scope of work.

Ownership of surface impoundments is frequently shared between the CFPP and other parties. If waste is left in unremediated impoundments, there will be a significant environmental risk and liability issue, deterring redevelopment of land by future owners (see also section below on land contamination).

The decommissioning phase of CFPPs will generate potentially large volumes of new waste types, both hazardous and non-hazardous, particularly if a CFPP site is demolished rather than repurposed. Waste from CFPPs can potentially have a cumulative impact. Where existing local landfills have limited capacity, they will be constrained to handle additional waste from decommissioning CFPPs, and there will be a risk of illegal dumping.

Land contamination

[33] Union of Concerned Scientists (2017)

Coal ash generated by CFPPs can contain heavy metal contaminants such as mercury, cadmium, and arsenic. As described in the preceding section, this material is stored in either landfill, or surface impoundments. Without proper management of ash ponds, the contaminants can be released to pollute soil, groundwater, drinking water, and waterways (see Box 12.3).[34]

Box 12.3: Coal ash pollution in Indonesia

Source: Apriando (2018) and Bersihkan Indonesia (2021)

The PT Indominico Mandiri coal company operates a large thermal coal surface CFPP and mine near the Bontang city, East Kalimantan, Borneo, Indonesia. The mine covers an area of 251 km^2. There have been serious issues concerning coal ash pollution. During 2012-2013, the mine illegally piled ash near the paving block production site. In 2015, the locally community filed a report to the Ministry of Environment and Forestry (MoEF). The company then obtained a temporary permit for storage of hazardous waste and the MoEF found 3,950 tons illegally piled outside the ash facility. In 2016, a renewed permit was issued requiring a 44 x 60m ash shelter located 300m from the nearest residence. In December 2017, the Tenggaron District Court criminally sanctioned PT IMM and imposed a fine of IDR 2 billion (about US$ 130,000).

The PT Barat Rayon coal mine obtained permits for final disposal of coal ash from its coal-fired power plants. Nonetheless, between 2005 and 2015, the company illegally dumped 252,000 tons of coal ash into Rawa Kalimati, a wetland connected to the Citarum River. The local Department of Environment found out in 2011 and forced the company to sign an agreement to improve its coal ash management practices. Later, a criminal investigation revealed that, despite its permit, the company had never operated a landfill facility or managed its coal ash properly. The court document estimated that the illegal disposal might have saved the company up to IDR 27.72 billion (about US$1.8 million). In 2016, Purwakarta District Court issued am IDR 1.5 billion fine (about US$100,000) and required the company to clean up the waste it dumped in the wetland. However, the clean-up did not include remediation of the water that had been contaminated with various carcinogenic and toxic substances.

Additional hazardous materials stored and used at CFPPs include solid and liquid fuels, chemicals used for treating air, water, and wastewater, and chemicals used for equipment and facility maintenance (e.g., paints, lubricants, and cleaners). If there is poor practice in the storage and use of such hazardous materials during operations, or if they are not removed from the site and properly disposed, there is a risk that they may contaminate soil and groundwater at the site. The decommissioning of CFPPs should include site assessment and remediation plans covering potential contaminated land issues to avoid leaving a legacy of contamination issues that will have long-term impacts on local communities and ecosystems. The plans should include all related facilities to the CFPPs, including ponds, storage, and waste disposal sites. Final suitable end-land uses for the site should be determined.

Land use and ecological restoration

CFPPs tend to occupy a small footprint, and many are located in or near urban centers. After decommissioning, site restoration will be required. However, many plants and sites are likely to be repurposed. Before this is done, the CFPP sites will need to be decommissioned, decontaminated, and reclaimed. Any outstanding environmental and social legacy issues should be remedied. This should also include the assignment of financial responsibilities for all associated liabilities.

[34] US EPA (n.d.)

12.6.2 Socioeconomic issues associated with retiring coal-fired power plants

The impacts of CFPP retirement depend on the type of facility. The latter include stand-alone CFPPs (with coal supplied from elsewhere) and mine-mouth CFPPs where coal is supplied on-site. Regardless of the impacts from supply chains, stand-alone CFPPs tend to create less complicated adverse impacts compared to mine-mouth CFPPs. Socioeconomic impacts can be contingent upon the age of the CFPPs as well as the project company's corporate reputation and relationship with the communities.

A range of "true costs" are associated with the extraction and use of coal.[35] These range from the costs of health effects to atmospheric pollution. Consideration of externalities such as those related to water, air pollution, land use, and others can maximize environmental conservation, protect human health, and contribute to long-term stability.[36] Additionally, companies may require (depending on regulatory requirements) a significant reserve fund for decommissioning costs at a time when plant revenues may be decreasing due to closure.

Country, regional, and global economy

At the country and regional levels, specific economic structures and their complex interactions with the energy system vary greatly.[37] Energy transition can bring substantial regional economy benefits and contribute to a country's gross domestic product (GDP). Retiring or closing CFPPs have been reviewed positively in terms of tackling the climate crisis and the need to divest from fossil fuels in the energy supply mix in regions where coal is an anchor industry. However, these costs may be too high for some national governments to assume, and will require external funding from international lenders or other funding sources to finance the retirement, decommissioning, and associated legacy costs.[38]

There are arguments that national politics, income from tax revenues, and investment in infrastructure can cause a national economy to be "locked in" to coal-fired power generation. These conceptual "blinkers" among decision-makers in government and industry can make it difficult to explore alternatives and plan closures with sufficient lead time. The latter is necessary to meaningfully engage and, where necessary, support key stakeholder groups. Such a failure to engage with stakeholders, in turn, can result in a costly and inefficient closure process with long-term negative effects.

More specifically, the retirement of CFPPs is likely to pose challenges for local and national economies that have developed a dependency on CFPPs and for the industry's supply chains (e.g., Box 12.4). The closure of CFPPs may also cause import and export and trade imbalances between countries and regions.

Box 12.4: Potential economic impacts of retiring CFPPs in Indonesia

Domestically, the Indonesian electricity sector is dominated by CFFPs. In 2021, they contributed at least 5.5% to the total GDP.[39] The potential impacts of retiring CFPPs includes regional job losses, losses for associated business activities along the coal supply chains, a rise in electricity tariffs, and increasing commodity and food prices. State revenues, from both corporate and salary taxes, could be reduced and thus decrease public funding and budgets for specific regions and provinces which host many CFPPs. The reduction of electricity supply without replacement sources being available may also adversely affect the operation of major economic hubs or centres, including shopping malls and factories, which consume more electricity than other industries. At least four million enterprises in Indonesia rely on the state electricity company

[35] True cost economics is most often applied to the production of commodities and represents the difference between the market price of a commodity and the total societal cost of that commodity, such as how it may negatively affect the environment or public health (negative externalities). See more about true costs at https://truecostsinitiative.org/mission-vision/truecosts/
[36] Roth and Lawrence (2004); Schmidt et al. (2015)
[37] IRENA (2020b)
[38] Mafira, T. (2023)
[39] Badan Pusat Statistik (2010)

(PLN).[40] Without proper mitigation measures, the effort to retire CFPPs would cause adverse impacts on the national economy and intra-country trade (both energy and non-energy) in Southeast Asia.

However, the impact of retiring CFPPs is heavily dependent on the share of coal in each market's electricity mix, the availability of sources to replace coal, and the growth rate of the electricity demand.[41] Retiring CFPPs might increase the price of electricity (even making it unaffordable for some people), exacerbate ongoing energy supply shortages, and make it difficult to meet the ever-increasing demand for electricity that is a consequence of population growth. Without policies addressing long-term impacts in place, the rapid transition from CFPPs to renewable energy could introduce long-term issues for energy supply. Government policies need to consider which energy source(s) might replace coal in the short, medium, and long term.[42]

Local economy and livelihoods

In localities where the economy and livelihoods of host communities are highly dependent on the operation of CFPPs, their retirement will have both direct and indirect socio-cultural and commercial consequences and could lead to socioeconomic deprivation for decades.[43] According to the International Energy Agency, the closure of CFPPs can have adverse socioeconomic consequences and unintended distributional effects due to their highly focused value chains.[44] In most parts of the world, CFPPs can act as an anchor industry for the local area and for the livelihoods and economic development of surrounding communities. In some cases, employment at these facilities may be multigenerational, which can lead to them becoming part of the local culture and identity, which, in turn, influences how residents envision their future options.

As the CFPPs are set to retire, the associated business activities (e.g., food stalls, accommodation and renting services, retailers, small enterprises, food services, and transportation and social services) can be disrupted due to outmigration. This was the case in communities dominated by CFPPs in Scotland[45] and the US (in the 1970s).[46] Income from the related businesses will be reduced, increasing households' indebtedness and vulnerability to poverty, as well as reducing tax revenues due to local governments, which are meant to provide support services. However, there are opportunities when the CFPPs and the adjacent areas are rehabilitated and redeveloped as recreational areas or as precincts for other uses, with new income-generating opportunities from the installation of replacement renewable energy sources.

Legacy of socioeconomic issues (cross-cutting)

Currently operating CFPPs could have been established several years or even decades before environmental and social regulations were introduced and enforced. Those CFPPs might not meet regulatory requirements, such as addressing and managing impacts (usually these would be identified by environmental and social impact assessments) and mitigating the adverse impacts of developing and operating the power plants. Where there has been no regulatory monitoring and external audits, some of the outstanding issues (e.g., regarding workers and communities' rights, socioeconomic and environmental legacy concerns, availability of functioning grievance mechanisms) may not have been addressed. Even if they have been addressed in some way, this is not likely to have been in line with good international industrial practices, typified by the IFC Performance Standards[47] and the World Bank Group environmental health and safety guidelines.[48]

[40] Badan Pusat Statistik (n.d.)
[41] IEA (2021b)
[42] GRICCE (2019)
[43] Financial Times (2018)
[44] IEA (2021b)
[45] IME (2016)
[46] Baldwin et al. (1977)
[47] See: www.ifc.org
[48] See: https://documents.worldbank.org/

Coal-fired electricity generation is an industry that has long been associated with a range of human rights and environmental issues arising during the different phases of projects, including construction, operation, and decommissioning.[49] Disengagement from CFPPs can severely impact workers, families, and local communities that host CFPPs. Such local communities, dependent on CFPPs, may have little or no access to safety nets and social protection. Some companies do not sign everyone up to social protection schemes systematically. Some countries have relatively new social protection legislation (e.g., Philippines[50] and Indonesia[51]).

Where there are outstanding inequalities and disparities resulting from poor attention to and management of socioeconomic issues linked to CFPPs that have not been dealt with or mitigated[52], the retirement of such CFPPs could exacerbate those problems.[53]

Experience from the rest of the world, especially in Colombia[54], illustrates this problem when stand-alone and mine-mouth CFPPs have been closed, leaving behind unresolved issues including human rights violations in host communities. In Indonesia, since 2016, the communities in Winong village have blamed the Cilacap plant and its Jakarta-based operator for polluting their air and depleting the water table. The company did not deal with such issues until early 2019.[55]

Employment and labor conditions

The transition to low-carbon economies based on accessing renewable energy will change the occupational and skills patterns in the energy sector, with both job losses and gains.[56] The transition can create jobs in the renewable energy sector, but it will also reduce jobs in the non-renewable energy sector. In aggregate, there will be displacement and substitution of jobs from one sector to the other, but the full extent to which there will be a direct transfer of workers from non-renewable to renewable energy generation is uncertain. As shown in Table 12.9, the energy transition is predicted to increase job opportunities globally by 0.18% in 2030 and by 0.15% in 2050, respectively.

Table 12.9: Impacts on general employment as result of energy transition (global)
Source: IRENA (2020b)

Employment (thousands)	2030	2050
Employment: Planned Energy Scenarios (PES)	4,051,588	4,238,092
Employment: Transformed Energy Scenarios (TES)	4,058,720	4,244,626
Employment changes: TES V PES	7,132	6,534
Employment changes (%) TES v PES	0.18%	0.15%

In addition to losing employment (when CFPPs are retired) and wages (which would have been spent in the local economy), not all workers will have the skills or experience required to work in the renewable sector. The location of renewable energy development may, in some cases, be at or close to CFPP retirement sites. In other cases, they may be in other parts of the country, changing the geography of job opportunities with implications for settlement patterns.

The scale of job losses will vary from one plant to another, depending on the plant's megawatt capacity and the nature of its ownership, as the employees of large firms with renewable investments will be more likely to secure internal transfers. The larger the capacity of CFPPs, the more potential for job losses, but also the more likely that the plant will be owned by a large firm able to offer

[49] The case of Colombia suggests these legacy issues. See Wilde-Ramsing et al. (2021) and Haigh (2015)
[50] Valencia (2017) and World Bank (2012)
[51] ILO (n.d.-b)
[52] e.g., lack of compensation for land and property loss, lost livelihoods and income, infringement of rights to land and associated conflict, unmet commitments for livelihood restoration entitlements, unaddressed legacy issues, and health monitoring that is deemed to be inadequate.
[53] Wilde-Ramsing et al. (2021)
[54] Wilde-Ramsing et al. (2021)
[55] Darmawan (2019)
[56] IRENA (2020b)

redeployment options. It is evident that significant job losses are resulting from the global trend to replace CFPPs with renewable energy, a result of international pledges to reduce carbon emissions (under the Paris Agreement).[57] For example, in Poland, the employment rate in the sector declined rapidly from 1990 to mid-2015.[58] Indonesia's electricity and gas sector employed at least 0.284 million workers in 2021[59], excluding jobs associated with the electricity infrastructure. If a number of CFPPs in Indonesia were to be closed around the same time without a proper mitigation plan, a very large number of direct jobs could be lost.

In many developed countries, trade unions have secured better than average wages and conditions for the employees of CFPPs, as well as generous redundancy provisions that soften the impact of job loss.[60] Unions in such locations have identified the poorer employment conditions being offered in the renewables sector as an impediment to the direct transfer of workers to that sector and to the pace of the transition in general.[61]

Conversely, in countries where national regulatory enforcement is weak, CFPPs might have invoked substandard labor management. For instance, in Mexico between 2012 and 2013, it was found that some CFPPs illegally employed minors.[62] In China, researchers reported that from 2017 to 2019, workers in CFPPs worked in hazardous, unsafe, and unhealthy environments.[63] In jurisdictions mandating strong labor regulation in the emerging renewables sector, the closure of CFPPs might abolish substandard labor and working conditions and labor exploitation. Governments as well as lenders and financial institutions could require that labor and working conditions in CFPPs be improved before financing the decommissioning of such assets.

In countries where governments have not established or mandated transition measures, where the responsibility for managing change therefore falls to exiting firms, the injustices and equity implications for the affected workers and for households adapting to different energy sources and prices may not be adequately redressed.[64]

Therefore, it is important that, as part of the closure of CFPPs, opportunities are created for worker retraining and reskilling, ideally prior to CFPP closure, for jobs that maximize each worker's skill utilization and earnings potential (whether in the renewable energy or other sectors), and that measures are taken to guarantee worker compensation and support for unemployed former CFPP workers, including through adequate relocation assistance.[65]

Health and safety

The closure of CFPPs will end on-site occupational hazards described in the sub-section on health and safety in Section 12.4.1, with a consequent elimination of severe accidents and fatalities to workers on-site. There will be limited short-term health and safety issues for those workers involved in decommissioning activities. However, these are unlikely to be significant if the process is well-planned and delivered.

The decommissioning phase of CFPPs, if not undertaken to good international industry practice (GIIP), may leave hazardous waste on and below the site (as described in the sub-sections above on solid waste and land/water contamination), which could contaminate drinking water, food, and local fisheries and cause long-term health impacts. Workers involved in decommissioning activities should be provided with protective equipment to minimize their risk of exposure to site contaminants. Surrounding communities should also be informed of potential health risks from decommissioning and the measures taken to address them.

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[57] An international treaty on climate change adopted in 2015 (see: https://www.un.org/en/climatechange/paris-agreement)
[58] Baran et al. (2018)
[59] Badan Pusat Statistik (2022)
[60] Snell (2018) and Weller (2024)
[61] ACTU (2023)
[62] Jamasmie, C. (2013)
[63] Wang et al. (2021)
[64] Piggot et al. (2019)
[65] Weller, 2024

The World Bank's Environmental, Health, and Safety (EHS) Guidelines provide standard requirements for coal processing power plants.[66] They outline key health and safety risks and management of health issues related to air emissions, wastewater, solid and hazardous materials and wastes, and noise, as well as issues concerning occupational and community health and safety in the life cycle of coal mines. The IFC Performance Standard (PS) 2 also highlights key labor and working conditions requirements that CFPPs should comply with.[67] These include the International Labor Organization (ILO) labor conventions[68] for, among other issues, rights of workers, forced labor, and child labor. The Guidelines and PS can be adopted by private investors and companies for activities that are not financed by the IFC or World Bank and in situations where national regulatory requirements are lower than international standards.

If closure and the remediation of land are not planned carefully, there is a risk of community exposure to hazardous waste, contaminated land, and open ponds, leading to disease, contaminant-related legacies, and possible food insecurity. This was experienced in the US when a coal power plant that operated for 40 years was reported to have left behind 9.6 million tons of toxic waste.[69]

The closure of CFPPs is both a leading requirement for addressing the climate change narrative and for the public health of local communities proximate to where they operate. CFPPs produce sulfur dioxide ($S0_2$), nitrogen oxides (NOx), mercury, and invisible particulate matter (known as PM_{10} or $PM_{2.5}$), which are all harmful pollutants and can contribute to chronic health conditions such as asthma and lung diseases. Children and elderly groups are particularly vulnerable to health impacts, and therefore may disproportionately benefit in the long term from the closure of CFPPs.[70]

A Government of Canada website for the Powering Past Coal Alliance[71] indicates that there are massive health care issues (see sub-section on air quality in section 12.5) and economic costs due to lost worker productivity. It also states that a recent analysis found that more than 800,000 people around the world die each year from the pollution generated by burning coal. A phase out of coal will mean real improvements in air quality and the health of both humans and ecosystems.

As mentioned in the section on public services and infrastructure, the closure of the CFPPs may reduce financial support to community health systems and facilities provided by their operating companies, possibly through their corporate social responsibility funding ending. Noise pollution and dust from CFPPs are common community complaints. Some communities may therefore welcome the ending of such impacts as a result of CFPP early retirement.[72]

Migration and loss of local skills

CFPPs should normally invest in developing local skills and capacities to support their functioning. However, migrant workers from other places are also often employed, bringing their skills to the host communities. Some of these migrant workers will have settled permanently in communities around CFPPs, adding to their social capital. As CFPPs are retired, skilled local and migrant workers may leave host communities to seek employment elsewhere and in other sectors. In the UK, depending on the plant's size, a coal power station typically employs around 100–500 workers directly, with a similar number of people employed on a contractual basis. In the US, in 1997, a 300-MW CFPP would typically employ 54 people in operation and maintenance on an ongoing basis.[73] These employment numbers may not be as large compared to other industrial sectors, but they need to be evaluated at each individual plant level.

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[66] IFC (2007b)
[67] IFC (2012c)
[68] ILO Conventions include: ILO Convention 87 on Freedom of Association and Protection of the Right to Organize, ILO Convention 98 on the Right to Organize and Collective Bargaining, ILO Convention 29 on Forced Labor, ILO Convention 105 on the Abolition of Forced Labor, ILO Convention 138 on Minimum Age (of Employment), ILO Convention 182 on the Worst Forms of Child Labor, ILO Convention 100 on Equal Remuneration, ILO Convention 111 on Discrimination (Employment and Occupation), UN Convention on the Rights of the Child, Article 32.1, UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families.
[69] Global Energy Monitor (n.d.-b)
[70] World Bank (2018b)
[71] Government of Canada (n.d.)
[72] Kravchenko and Lyerly (2018)
[73] Global Energy Monitor (n.d.-a)

Migrant workers and local workers trained by the CFPPs could leave their families behind or move with their families for long-term employment in other places. Social networks, skills concentration, and demands for vocational know-how would be affected by such migration.

Retraining opportunities in replacement renewable energy sources may arise from efforts to retire CFPPs. Lenders and national regulatory institutions/bodies (such as ministries responsible for manpower or labor and employment) could require the CFPPs to compensate the workers affected by the closures and to offer a reskilling and upskilling program to equip them for job opportunities in renewable energy and other sectors. A well-developed and implemented retrenchment plan can support such transitions.

Indigenous communities[74]

Indigenous communities[75] may be more vulnerable to the adverse impacts associated with retirement of CFFPs, e.g., through loss of identity, culture, and natural resource-based livelihoods, as well as exposure to impoverishment and diseases.[76] In many countries, CFPPs are located in semi-urban and coastal areas and in remote areas where Indigenous communities reside. There are documented instances of Indigenous communities resisting CFPP establishment (e.g., in West Papua, Indonesia[77]) or being required to give up land for CFPPs in exchange for jobs, associated business activities, and community development.

The experience of Indigenous peoples in the southwestern US provides useful lessons regarding CFPP closures. The Native American peoples' lands of this region are home to large coal reserves, coal mining, and coal plants. Many Native American reserves are in remote territories with high rates of unemployment and poverty. According to IEEFA[78], the residing Indigenous population is disproportionately impacted by environmental and health hazards associated with the coal industry. To date, communities including the Navajo Nation and Hopi Tribe have seen the loss of hundreds of high-paying power plant and mining jobs and millions of dollars in revenue. This followed the closure, in 2019, of the Navajo Generating Station near Page and the Kayenta coal mine that supplied it since the 1970s.

In the face of CFFP closures, Indigenous communities risk losing access to ancestral land (due to redevelopment of the CFPP sites) that may play an integral role in their way of life, providing subsistence and income, plus a spiritual, sacred landscape that contributes to individual and collective identities.

CFFP closure can also provide several benefits for Indigenous communities. The transition to cleaner energy sources can end or offset negative environmental and health conditions. Often, geographic isolation and historical dispossession of ancestral lands make energy access among Indigenous groups particularly difficult, encouraging the use of highly polluting biomass and biofuels. The closure of CFPPs and coal mines and a move toward clean energy may help to undo long-standing trends that trap Indigenous peoples in an unsustainable and damaging cycle of energy inequality (Box 12.5).[79]

[74] The United Nations describes Indigenous Peoples as inheritors and practitioners of unique cultures and ways of relating to people and the environment.
[75] See definition in Annex 19.
[76] IFC (2012b)
[77] Asia Pacific Solidarity Network *(*2020)
[78] IEEFA (2021)
[79] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (2018)

Box 12.5: Delivering clean energy to Navajo tribal lands, USA

In the Southern United States, Navajo Power, a majority Indigenous-owned Public Benefit Corporation, is developing utility-scale clean energy projects on Tribal lands. Navajo Power's mission is to develop more than $3 billion of clean energy infrastructure in Tribal communities by 2030. Over the next decade, Navajo Power aims to deliver billions of clean energy infrastructure assets to power major markets across the U.S., with emphasis on the Southwest. A subset of this work includes bringing electricity to Navajo Nation households, where 15,000 families lack access to electricity. Navajo Power has launched a separate company, Navajo Power Home, to focus on this work of bringing power to Navajo families directly.[80] The W.K. Kellogg Foundation has $3 million program-related investment in support of Navajo Power.[81]

Gender and vulnerability

CFPP closures may have gender-specific impacts. Gender often intersects with age, disability, income, race and/or class, and Indigenous status to compound social inequalities. In the context of Southeast Asia, vulnerability to the transition away from coal is ever more pervasive in rural areas, especially when women and girls (particularly Indigenous women) are disproportionately impacted due to their relative isolation and more entrenched traditional gender roles[82]. These impacts can take the form of:

- Greater gender inequality in workforce demographics and wage equality;
- Increased social and health access and personal safety issues for women and girls;
- Education and health disadvantages that are acutely gendered;
- Where land is customarily owned by women, post-closure land distribution or withholding of customary land by the state as part of energy transitions can snatch these rights from women and thus further diminish their economic, social, and cultural status.

While CFPP closure may result in direct job losses for both men and women, women are likely to bear the increased burden of social care and domestic responsibilities and can be forced to take on more (often insecure and exploitative) paid work to support families, shouldering what is known as the "triple burden."[83] Loss of livelihoods among male workers can prompt a shift in traditional gender roles at the household and societal level, heightening instances of intra-household tension, sexual and gender-based violence, and psychological distress. In pursuit of more secure economic opportunities, male workers impacted by closure may look to migrate out of affected communities and/or gain entry to so-called women-dominated sectors (i.e., garment factories), increasing competition that will seek only to heighten existing gendered disparities within the workforce.

Closure of a CFPP that predominantly employs men, particularly when the men are from other communities, can lead to greater fears of women over their safety where they live. Where the work environment in the CFPP is strongly hierarchical or marginalizes staff from certain backgrounds, closure can reduce tensions within households by reducing instances of "oppressed group behavior," where employees who feel oppressed take out their workplace frustrations on family members.

Public services and infrastructure

The early retirement of CFPPs may also affect public services and infrastructure such as transportation, health, and education facilities. Other forms of social infrastructure might lose sponsorship, e.g., libraries, town halls, parks, and meeting spaces, as well as social and sporting facilities and religious buildings (e.g., churches and mosques). Retirement will reduce dust, air, and noise pollution, leading to improved public health. However, overall community health may deteriorate as support from CFPPs and associated businesses is reduced or eliminated (including through lost tax revenue generation to local authorities) for health facilities and other services (e.g., education

[80] Moriarty, A. T. M. (2024)
[81] Mission Investors Exchange (n.d.)
[82] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (2018)
[83] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (2018)

facilities, roads, bus services, and other transportation). Local communities reliant on CFPP may also lose charitable contributions.

- Local community members impacted by a plant's closing are often most in need of the services of local charities, but the charities themselves may lose a major source of contributions based on money donated by both the plant and the plant's wage-earning employees and the employees' contributions of time.[84]
- However, pressure on the public services and infrastructure could also be reduced as a result of outmigration of workers and their families.
- Local communities are often tied to the local services provided by CFPPs (Box 12.6), and so will be impacted when education or health facilities are downsized or stagnate following CFPP closure.

Box 12.6: Community dependence on coal-fired power plants and coal mines in Betul District, Madhya Pradesh, India

Source: Gupta, R. (2021)

Betul District in Madhya Pradesh, India experienced a boom in business and public infrastructure in the 1960s with the development of both coal-fired power plants and coal mines. Housing and community facilities grew, including schools, hospitals, roads, and banks. The coal industry also financed schools and medical services. It set up schools primarily for the children of its regular employees. There was a hospital only accessible to employees and dependents of the Satpura Thermal Power Station, while the rest of the community traveled to the district hospital at Betul. The communities became reliant on the facilities financed by the coal industry. Indeed, communities emerged as power plants were developed as their socioeconomic centers.

In countries that supply coal to many neighboring countries (e.g., Indonesia), the closing of CFPPs can create more complex and serious problems than in developed countries.[85]

Community cohesion and engagement

In some cases, the existence of CFPPs has been a long-standing issue of contention for local communities, often raising tensions between community members, activists, environmental NGOs, and the CFPP companies and government. In the Philippines, the anti-coal power plant movement has been growing significantly.[86] Filipino environmental NGOs such as Greenpeace, as well as trade unions, have actively advocated against new CFPPs. In Central Java, Indonesia, communities have staged protests against long-running air pollution problems caused by ash from a CFPP.[87]

Stakeholder dialogue and citizen engagement (including with community representatives, CSO, and trade union representatives) can provide meaningful mechanisms for addressing the concerns of coal industry workers and for wider community members dependent on CFPP activity.

CFPP closure can have a negative impact on community cohesion and increase the risk of conflict within affected communities between groups of people who lose their jobs and incomes earlier compared to those who lose them later and between groups of people who adapt more quickly and those who adapt more slowly. Being non-discriminatory regarding who loses jobs and when can help prevent conflict among worker groups, which may manifest further into the community.

[84] McCarter and English (2016)
[85] Resosudarmo et al. (2009)
[86] Asia Sentinel (2016)
[87] Darmawan (2019)

12.7 ENVIRONMENTAL AND SOCIOECONOMIC ISSUES ASSOCIATED WITH CLOSING COAL MINES

The previous section discusses environmental and social risks and impact associated with the operation and closure/decommissioning of coal-fired power plants. This section continues this discussion but for the closure of associated coal mines and supply chains. Table 12.10 summarizes the range of environmental and socioeconomic issues associated with closing coal mines.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 12.10: Environmental and socioeconomic issues associated with coal mine closure

ISSUE	COMMENT
Environmental	
GHG emissions	• Reduction in GHG emissions from stopping operating plant and pit and shaft closure reducing methane emissions from coal seams. • Uncontrolled mine abandonment may leave a legacy of methane leaks from open shafts, boreholes, fissures, and pits.
Water quality	• Improved water quality following stopping dewatering (pumping water from mine) and land disturbance (tailings, dams, etc.)/sediment runoff. • Conversely, uncontrolled mine abandonment can leave a legacy of contamination on-site (e.g., old heaps, chemicals, etc.), which can contaminate downstream rivers, surface water bodies, and groundwater, or can lead to impacts on downstream salinity, which can be an issue in agricultural areas as salinity can affect crop productivity by reducing the availability of soil water to plants. • Spills and leaks (from vehicles and their cargoes) during the closing of mine sites can pollute groundwater and surface water. • Alternative facilities built on a reclaimed mine site (e.g., a manufacturing plant to take advantage of the ready access to high-capacity power lines and rail lines) might generate their own water quality impacts, such as effluent.
Water use	• Closing coal mines reduces water demand for use at the coal mine. • Options to turn open pit mines into lakes for water supply can lead to concerns about the cleanliness and safety of the water, since surface flows (potentially contaminated) will accumulate in the pit. Pit lakes present a large surface area, leading to high rates of evaporation in sunnier areas (such as Australia).
Noise	• Long-term elimination of mine noise following closure/decommissioning. • Short-term impacts on local communities from vehicles on-site and using local roads during decommissioning. • Alternative uses for a mine site can create noise on site or via truck traffic.
Contaminated land and groundwater	• Discharges from abandoned mines as a consequence of groundwater rebound (commonly acidic), which may contain high concentrations of heavy metals. • Contamination of land and groundwater from abandoned mines due to undisposed chemicals, hazardous materials, mine dumps, and tailings.
Air quality	• Stopping operations will reduce emissions of dust and particulate matter, NOx and SOx, but mine decommissioning activities may cause a short-term increase in such emissions. • Fires may occur with uncontrolled mine abandonment and in situ coal burning, leading to increases in particulates.
Waste	• Redundant infrastructure, equipment, and hazardous substances can contaminate soil groundwater and surface water. • Improper disposal of potentially toxic overburden can cause land and water contamination.
Land-use change	• Impacts related to future development. Sites that have managed decommissioning and carried out land-use planning can provide significant ecological benefits through revegetation and reinstatement of ecosystems, services, and habitats. • Conversely, abandoned mine sites may render the site as a liability.
Land degradation	• Slumpage and geotechnical instability from the collapse of underground works may make the site unsuitable for other uses and pose a public safety risk. • Failure of mine walls, tailings dams and stockpiles. • Soil erosion on un-reinstated, de-vegetated slopes. • Waterlogging caused by artificial land contours and drainage patterns. • Underground fires lead to ground slumpage and instability.
Land and ecosystem restoration	• Developing and operating coal mines involves changes in land use and usually has a negative effect on local ecosystem functions, such as nutrient cycling and carbon sequestration. When a mine is closed, it is important to rejuvenate mine-degraded land and restore ecosystem

ISSUE	COMMENT
	functioning similar to that of undisturbed sites. Restoration to original land uses may not be possible, and final land uses should be decided well in advance as part of closure and decommissioning planning.
Socioeconomic	
Legacy socioeconomic issues	• Outstanding socioeconomic issues of coal mines and mine mouth CFPPs that have not been dealt with or mitigated before closure. • Particular issues relate to the negative effects on Indigenous peoples and traditional societies of Western-style industrialization since colonization.
Regional economy	• Early retirement of CFPPs will impact national and international coal supply chains. • Increased coal price. • Reduced imports and exports, leading to imbalance in national economies. • Infringement of international trade agreements on coal supply. • Increased electricity and fuel prices, impacting commodity and food prices. • Coal may be exported to other countries resulting in carbon leakage. • Opportunities to diversify the economy that do not rely on coal. • Impacts on coal supply transport such as truckers, shipping fleets, etc.
Illegal mining	• Increased illegal mining as investment in managed and regulated coal mines is reduced. • Reduced government capacity to enforce regulations as resources at the local and national level are focused on other aspects of the energy transition.
Employment and labor conditions	• Loss of jobs (direct and indirect employment) in coal mines. • Long-term opportunities for employment and improved labor standards and working conditions in CFPPs and supply chains during the retirement period. • Increased pressure on national welfare and social protection systems.
Health and safety	• Reduced occupational hazards and fatalities resulting from coal mining. • Reduced chronic health impacts associated with coal mining, particularly underground. • Improved health due to reduction of air and noise pollution and dust. • Mine abandonment without remediation of geotechnical risks (filling/capping mine shafts, fencing-off, etc.) leading to community safety risks. • Hazardous waste and contaminated land, and mine pits left without remediation, leading to adverse impacts on community health, including children's high exposure. • Reduced traffic incidence.
Local economy and livelihoods	• Decreased livelihood opportunities in the host communities. • Increased households' indebtedness and vulnerability to income loss and poverty. • Reduced revenues from renting properties and values of properties as a result of outmigration. • Reduced investment in a region by outsiders as it is seen as unattractive due to closures. • Potential economic opportunities induced by the rehabilitation and redevelopment of coal mines and pits will create income-generation activities.
Gender and vulnerability	• Women and vulnerable groups (e.g., the poor, persons with disabilities, children, the elderly, and Indigenous communities) may be disadvantaged and at particular risk. • Increased domestic and gender-based violence due to loss of income. • Increased competition from former male mine workers may arise in women-dominated industries (such as manufacturing and garment industries) following closure.

ISSUE	COMMENT
	• Opportunities for women and vulnerable groups to acquire new skills and learn technologies. • Opportunities for vulnerable groups to engage in the decision-making process and in inclusive dialogue for coal mine closure.
Migration	• Local skilled workers and migrants attracted to work in mines and associated businesses will leave the communities. • Increased vulnerability of abandoned household members whose income depends on skilled migrants. • Opportunities for local workers to re-skill for new opportunities such as replacement renewable energy industries.
Public services and infrastructure	• CFPP/mine closure may affect the public services and infrastructure supported by mining companies (e.g., health clinics, education facilities, roads, bus services, and other transportation). • Decreased local government tax revenues from CFPPs and associated businesses. • Reduced pressure on public services and infrastructure as a result of outmigration. • Increased pressure on public services when empty housing is rented by the government to house families in need from other regions. • Potential loss of sponsorship funding for social infrastructure such as libraries, town halls, parks, and meeting spaces. • Potential loss of support and membership for religious organizations and reduced levels of volunteering.
Community cohesion and engagement	• Weakened community cohesion due to outmigration. • Risk of internal conflict due to increased stress as result of lost income. • Opportunities for communities to engage in the decision-making processes about mine closure. • Reduced tension between the communities, NGOs, activists, and mining companies; tension can increase if they are unable to agree on overcoming past distrust and future steps, and this may be influenced by how stakeholders and authorities deal with change and transition.

12.7.1 Environmental issues associated with coal mine closure

Coal mine closures will occur as part of the transition away from fossil fuels toward cleaner energy. They will have a range of environmental and social risks and opportunities, as described below.

Until recently, it was not common for governments to require mine decommissioning and closure. So, there are many mines that have been closed poorly or abandoned and left derelict, or in some cases, without ownership (orphan mines), creating legacy issues for governments and communities.

There is a risk that coal mines no longer supplying retired coal-fired power plants may continue coal production, selling to other markets and resulting in carbon leakage elsewhere.

Greenhouse gas emissions and air quality

Coal mining and mine closure have the potential to release coal bed methane through disturbance of the coal rock strata. Methane is released from underground mining activity through ventilation systems and degasification. Although surface mines release less methane than underground mines, the sheer volume of coal mined in surface mines allows for large volumes of methane to be released. Abandoned and closed mines release methane from diffuse vents, boreholes, and fissures in the ground. Methane is a GHG with high global warming potential and can cause explosions leading to fires.

The release of methane from a mine will depend on the coal formation and the closure process, so it is difficult to quantify. Closing coal mines will have the benefit of reducing the amount of methane that would have been emitted if the coal mine had continued to operate. However, there is also a risk that in closing the operating plant, the open pit and mine shafts may continue to leak methane from the disturbed coal seam. There is potential to capture and use the methane from some larger mines. However, the small and irregular quantities of methane production from some mines make this unviable. The volume of methane from abandoned mines around the world, although not quantified, is expected to be very high. Although the decrease in coal production would decrease methane release, it does not stop methane release altogether. Therefore, there is a need to manage methane from closed mines.

Fires may occur in abandoned mines where the methane and/or coal ignite. Such fires cause the release of airborne pollutants, which can impact the health of residents in nearby communities and cause a reduction in localized air quality. Particulate matter can also enter waterways, leading to a reduction in water quality.

Closing a coal mine and subsequent rehabilitation activities at the mine site may result in a temporary increase in trucks and machinery at the site that will cause localized air emissions from vehicle exhausts and the creation of dust. There can also be dust from the significant amounts of waste spoil on site and particulate matter arising from still existing coal storage piles.

Mine closure can also lead to longer-term improvements in air quality around mining sites as a result of ceasing operational activities and due to site rehabilitation (e.g., through revegetation), which will reduce the amount of particulate matter released to the local environment and avoid polluting waterways.

Water quality

Water management is one of the main environmental issues associated with an operational mine. It remains an ongoing concern when a mine is closed and there is a need to address issues such as dewatering (pumping out water) of pits and mine shafts, coal washing, runoff, groundwater contamination, and any water diversions that caused environmental impacts during operation. Many of these issues can be resolved and properly managed through effective site closure planning. In some cases, there will be a need for ongoing management and monitoring of water in pits and mineshafts.

Potential water quality impacts caused by mismanaged mining operations include acid mine drainage, algal blooms, and heavy metal pollution. These can impact nearby waterways, rendering the water unfit for human consumption and irrigation and impacting aquatic ecology. During mine closure, a specific water management plan should be developed and measures implemented to prevent such potential impacts and to ensure that stockpiles, pits, and other disturbed areas are rehabilitated and revegetated to reduce the potential for contaminated runoff.

Acid mine drainage issues associated with coal are commonplace around the world, often as a result of dam failure at abandoned mines (Box 12.7). Impacts from a number of smaller abandoned mines may also have an impact.

Box 12.7: Residual problems of closed coal Mines: the case of the Sewanee coal seam in East Tennessee, United States
Source: Frankenberg Veal (2012)

In the Sewanee Coal Seam in East Tennessee in the United States, there are 300 abandoned coal mines. The seam is surrounded by high levels of pyrite, an iron sulfide, that, when exposed to water and air, creates acid mine drainage. Although these mines are no longer operational, due to this chemistry, there is no known method of preventing acid mine drainage runoff. It is highly toxic to humans, flora, and fauna, and has polluted the waterways and had impacts on communities. Although the water is being treated, the runoff still impacts aquatic flora and fauna and downstream users of this waterway.

Subsidence during operation or closure can have an impact on streams and result in other environmental consequences. Fracturing of rockbars and dilution and cracking of bedrock can reduce the flow and water levels of streams. Subsidence may also result in soil erosion or scouring of waterways, increasing turbidity, changing water quality, impacting aquatic flora and fauna. These risks should be addressed through a plan for landform management and site rehabilitation.

Not only can coal mining have an impact on the quality of water, but in some locations, it may have an impact on surface and groundwater quantities and runoff (e.g., by blocking or diverting water courses). The reduction in volume of available water may affect nearby communities, farming, and aquatic environments. Closing of a coal mine provides an opportunity to enable surface waters to go back into water courses and groundwater systems for use by communities and to improve environmental flows.

Noise

Closure of coal mines will reduce the level of noise experienced by communities as equipment used for mining operations will cease operating (e.g., haulage equipment, truck movements, cutting and drilling machines, blasting, crushing, conveyors, fans, and loaders, etc.). However, there may be a temporary increase in noise impacts when a mine site is being rehabilitated when trucks and machinery, such as excavators, will be required to operate.

A reduction in noise can be accompanied by a reduction in vibration and reduced use of lighting at night, reduced smells from vehicle exhaust, reduced traffic, and declines in other annoyances, which are sometimes referred to by environmental toxicologists as “non-chemical stressors.” Assessments of such stressors indicate that certain types of persistent, penetrating, and/or unwelcome noise have been associated with increases in stress. In turn, this can lead to health impacts such as increased prevalence of cardiovascular disease. So, the cessation of coal mine operations and the associated noise can have a ripple effect, reducing health impacts.

Contaminated land and groundwater

If there is inadequate water management at abandoned or closed mines, this can result in significant pollution and contamination of surface water or seeping into groundwater due to the discharge of mine water containing heavy metals and other pollutants.[88] Such pollutants can be carried by rivers away from the immediate mine site and impact communities many kilometers away from the mine, polluting water used for drinking and growing food.

With the closure of a coal mine, there is the opportunity for groundwater recharge, and this can have both positive and negative impacts. Reducing the use of water in the mining process reduces demand on the groundwater in the vicinity of the mine and allows the groundwater source to be replenished. However, both land and groundwater can become contaminated if there are undisposed or untreated chemicals or hazardous material abandoned in the mine on closure.

The land on which mining operations occur can become highly contaminated during mining activities due to accidents and/or the careless use and storage of chemicals, fuels, and hazardous materials (e.g., sulfuric acid, nitric acid, solvents, fuels, oils, and heavy metals).

Remediation of the land upon closure of a mine is vital to ensure that the land can be utilized for other uses post-mining, e.g., for agriculture, grazing, or residential estates.

Untreated land and water contamination—and long-term exposure to contaminants—can lead to health impacts for people and animals. Contamination can also have an impact on soil fertility, affecting the future use of the area. However, remediating mine sites to mitigate the risks of contamination is a costly exercise, and there is a risk that mining operators may simply abandon sites, leading to legacy impacts.

Waste

Waste from coal mine closure also needs to be managed appropriately. It includes redundant infrastructure, overburden, equipment, and hazardous substances no longer required for mining that have the potential to contaminate soil, groundwater, and surface water.

Overburden (also called spoil or waste) is the soil and rock removed to access the coal. Open pit coal mining produces large volumes of overburden that may contain heavy metals, acid-producing rock, and sulfur.[89] Overburden should be managed from the commencement of a mining operation (i.e., the vegetation should be removed and the topsoil taken away and stockpiled separately to the overburden).

During mine closure, the environmental impact can be reduced through engineered surface water and groundwater controls, removal of overburden, reinstatement of the topsoil layer, and revegetation. During closure, the movement of the overburden has the potential to expose rocks containing sulfur (a source of acid generation) and toxic metals, which may leak into the environment and impact soils, waterways, and groundwater. This, in turn, can impact downstream environments and lead to ecological degradation. Intake of toxic metals by humans and animals can have severe health impacts, which may not show for many years.

The disposal of potential toxic overburden to areas of the mine site where contamination can be contained is recommended in areas where management on-site and rehabilitation cannot occur. Management of toxic overburden volumes within mine sites, rehabilitation, or proper disposal of surplus wastes (subject to risk, if permitted) is often a legal requirement. Planning, measures, and actions to manage overburden are routinely documented in mine site closure plans.

Land degradation

Land degradation is a key concern for coal mines due to activities such as land clearing, pit formation, underground shafts, subsidence, and erosion. It can lead to the loss of terrestrial habitats, and the loss of aquatic and terrestrial biodiversity, and reduced water quality. A key requirement in the successful rehabilitation of land post mine closure is to ensure that native vegetation is established over the site to stabilize the land and reduce erosion. Mine closure plans seek to restore water flow and quality to pre-mining levels and to create topography/landform and drainage systems that are

[88] Johnston et al. (2008)
[89] E.g., rocks containing iron sulfide minerals, such as pyrite

consistent with the surrounding areas. This also aims to allow habitats to establish and biodiversity to return to previously cleared areas.

Mine closure plans are routinely prepared in consultation with the relevant government agencies and in accordance with the relevant rehabilitation and mine closure guidelines for the local state and/or country. Mandated minimum durations for monitoring and evaluation are often required and are often varied by way of extension when site risks and the receiving environment are more sensitive.

The content of each mine closure plan reflects the land use being reinstated. For example, for rehabilitation to be successful for agriculture, drainage, revegetation, soil establishment, and erosion control will be required to support this type of land use (e.g., Box 12.8).

Box 1.8: Rehabilitation of Canyon Mine, New South Wales, Australia

Source: Whitehaven Coal Limited (2009)

Canyon Mine in New South Wales, Australia, was an open-cut coal mine and was extensively rehabilitated to pastureland after closure in 2009 due to exhaustion of the resource. Rehabilitation included reshaping of the final void and overburden emplacements, topsoil placement, installation of water management control measures, establishment of a cover crop, planting of tube stock, and monitoring and maintenance of rehabilitated areas. The land continues to rehabilitate to pre-mining vegetation communities, including pastoral, woodland, and forest. As part of the closure plan and original development approval, a water management plan documented the quarterly water monitoring data results over the 5 years post-closure (i.e., October 2010 to October 2015). At this site, largely due to the absence of contaminated materials, the results were positive, with only one discharge point requiring subsequent monitoring every 6 months for a further 2 years.

Land use change

Land-use changes following mine closure require careful consideration and coordination to ensure that lands are repurposed and environmental impacts are minimized and mitigated. As described above, soils and landforms need to be rehabilitated to pre-mine conditions if the former land use is to be reinstated. If the land use is to change, the extent of remediation needs to be sufficient to enable that end land use to occur. It is important for land to be rehabilitated to meet future use options in consultation with local communities.

In North America, former mines have been converted into wildlife centers and education and research facilities, creating job opportunities in tourism and conservation (Box 12.9). Future land use may not be as complex as a wildlife center and rehabilitation may simply be for agriculture or grazing, or it may also make way for other industries and opportunities for new roads and water infrastructure.

Box 12.9: Rehabilitation former coal mines: some examples

Source: Braun (2023)

The former East Germany was a coal mining powerhouse, but the industry collapsed after the fall of the Berlin Wall. Soon after, 25 open-pit lignite mines in the Lusatia region were transformed into recreational lakes. Spanning the states of Brandenburg and Saxony, water was fed into the former mines from several major rivers, including the Spree and Black Elster. Some 30,000 animal and plant species have since been drawn to the region, leading to an increase in biodiversity. Lake Geierswalde and Lake Partwitz, in particular, have since become holiday hot spots.

In West Virginia, USA, the Appalachian Botanical Company is growing lavender in the poor soils of former strip coal mines. The drought-tolerant herb is processed to produce a fragrant oil for cosmetic and culinary products. Lavender rejuvenation is labor-intensive and provides jobs for coal industry workers made redundant amid the energy transition.

Discussions and planning for land use change can also have impacts on communities. Decision-making processes that are inclusive (i.e., where marginalization is reduced and where government and industry are seen to be listening and to be trustworthy both in providing information and in following through) can boost a community's sense of meaningful engagement in and ownership of decision-making. This can lead to more positive social and economic outcomes following mine closure.

Mine reclamation, and land and ecosystem restoration

As discussed in the preceding sections, developing and operating coal mines involves changes in land use and usually has an adverse effect on local ecosystem functions such as nutrient cycling and carbon sequestration. When a mine is closed, it is important to rejuvenate mine-degraded land and restore ecosystem functioning similar to that of undisturbed sites.

The planning of mine reclamation/restoration activities should occur prior to a mine being permitted or started. It can help restore the lost carbon sink by promoting plant growth and enriching the mine spoil, which helps sequester atmospheric carbon. The most common techniques for mine restoration include afforestation, agriculture, and grassland development. This may result in a land condition not necessarily the same as surrounding lands.

Mine reclamation creates useful landscapes that meet a variety of goals, ranging from the restoration of productive ecosystems to the creation of industrial and municipal resources and the development of alternative land uses (including solar farms). The operator should restore the land to its approximate original contour (AOC) or leave the land graded and suitable for a "higher and better" post-mining land use (PMLU) that has been approved as part of the original mining permit application. Exceptions are provided when a community or surface owner is in need of flat or gently rolling terrain. Acceptable post-mining land uses include commercial, residential, recreational, agricultural, or public facility improvements.

Establishing a long-term sustainable ecosystem at a closed coal mine site will depend on the adaptations of species to newly formed site conditions. The main element of the reconstructed terrestrial ecosystem is reclaimed mine soils, which are characterized by large spatial variability and consequently changeable habitat conditions. Thus, soil reconstruction and revegetation require ecological engineering tools and knowledge about species selection and their adaptation to post-mining sites. Larger landscape-scale reclamation requirements, such as the restoration of wildlife movement corridors, should also be considered with the preparation of site closure plans.

12.7.2 Socioeconomic issues associated with closing coal mines

Country, regional, and global economies

Coal mining is an important contributor to many national economies (Box 12.10). The closure of coal mines will affect the coal supply chain at both national and international levels, resulting in increased coal prices and reduced imports and exports. According to an analysis of the global socioeconomic and economic impacts of coal retirement, "a*n increase in imports, or reduction in exports* [of coal]*, has a negative impact on GDP, while a decrease in imports or increase in exports has the reverse effect*."[90]

Closing coal mines is a politically and socially complex issue due to the involvement of multiple stakeholders, including governments (particularly energy ministries), local economic development agencies (where they exist), investment associations, companies, NGOs, and local communities. The phasing out of coal mines requires early planning, due diligence, and active and inclusive dialogue with affected stakeholders.

In Indonesia, closures of mine activities are already known to create complex and severe problems, especially since the local economy in many of the country's mining areas and the local governments

[90] IRENA (2020b)

lack capacity. The sudden closure of coal mines can initially hit the local and regional economy adversely. Mass redundancies, reductions in economic output, and, in more extreme cases, economic crisis, can fuel deprivation, extreme inflation, and social unrest (Box 12.11).

Box 12.10: Coal mining and economies
Source: FutureCoal (n.d.)

"Coal makes a significant economic contribution to our societies, and economies, particularly at a local level. Coal mining is still a contributor to many economies, especially in developing countries. Around seven million people worldwide work in coal mining, processing and delivery.[91]

Much of the coal industry in developing countries is export oriented and is a major source of foreign hard currency. Emerging economies continue to see coal as a good option for future development, but the contribution of coal is not limited to developing nations, as advanced economies benefit significantly from coal industry operations, both directly and indirectly.

In Queensland, Australia, 20,000 people were employed by the coal industry creating A$20 billion of income (2018 figures). Coal exports raised A$1 billion in royalties, providing a significant source of necessary funding for public services. Whilst in Europe, despite the significant reduction in coal production in recent years, the coal market in Germany and Poland still supports over 160,000 jobs in the form of direct and indirect employment."

Indonesia is the second-largest coal exporter in Asia and the Pacific. In 2021, coal mining contributed 8.9% to the Indonesian GDP.[92] The closure of coal mines will affect Indonesian economic growth. Between 1992–2009, Indonesia earned at least $9.3 billion in taxes from coal mine extraction.[93] The Philippines imports coal from Indonesia, Australia, the PRC and Viet Nam. Annually, the Philippines imports coal to supply its CFPPs—about 12-15 million tons of oil equivalent. Change in coal supply in Indonesia would affect international trade patterns and importing and exporting countries' economies.

The volume of export and import of coal—and associated monetary flows—are affected by geopolitics. So, coal represents not just an important revenue stream for certain countries but also a source of potential economic instability. For example, China (PRC) dramatically reduced its purchases of Australian coal and other commodities, as the Chinese government cited its unhappiness with Australian commentary on human rights in China and the Australian government's support for Taiwan. Further tension is due to the two countries acting as rivals in providing support for island nations in the Asia Pacific, such as Samoa.

Box 12.11: Mine closure conflicts in Indonesia
Source: Resosudarmo B., Resosudarmo I.A.P., Sarosa W., and Subiman, N. (2009)

In Indonesia, since the 2000s, the closure of coal mines has resulted in substantial and ongoing tensions between communities, conservationists, mining companies, the Ministry of Environment and Forestry, and the Ministry of Energy and Mineral Resources. Local people receive only limited revenues while mining operators make high profits from coal extraction. When the mineral supply is depleted, mining operators abandon the area with limited alternative revenue options for local communities.

Mining operators, the government, and local communities have debated how to address this issue and the extent of environmental reclamation required prior to the closure of the mining operation. PT Kelian Equatorial Mining (KEM), one of the few mining companies in Indonesia, closed its operation in 2004. KEM had tried to implement its corporate social responsibility programs well in advance of its closure and had taken an integrated social and environmental approach to the mine closure process. Nevertheless, conflicts occurred as compensation, environmental

[91] Floyd, D. (2022)
[92] Badan Pusat Statistik (2010)
[93] Asia Pacific Solidarity Network (2020, April 27)

mitigation, and employment opportunities could not be established in an appropriate and timely manner.

Local economy and livelihoods

As with the retirement of CFPPs, the risks associated with coal mine closures also include negative impacts on livelihoods, employment, and the well-being of local skilled workers, migrant workers, and associated businesses within the existing coal supply chains. The loss of income from jobs in coal mining would substantially reduce income flows, affecting the economy of host communities Box12.12). It would affect retail, accommodation services, food services, other dependent sectors, and social and emergency services. There is clear evidence that decades after coal mines have been shut down, many coal-dependent regions continue to lag socially and economically.[94] For instance, as workers leave communities, the price of properties and land can decline, and local government tax revenue can also decrease. It cannot be expected that renewable energy technologies will replace these revenue losses in a timely manner. Careful planning is needed when considering the shift to cleaner energy generation. Unfortunately, in many cases, planning often lacks foresight, detail, and input from a range of affected parties.

Box 12.12: Local economy and community dependence on coal mines
Source: World Bank (2003) and Della Bosca H. and Gillespie J. (2018)

Shanxi Province in the north of the People's Republic of China provides an example of an economy dependent on the coal industry. Recent declines in the coal market and the government's environmental commitments resulted in closures of coal mines in Shanxi in the early 2000s. These closures have hit the province with reduced revenues for the state-owned enterprises and tax revenue reductions for the local government.[95]

Countries in Eastern Europe such as Poland, Ukraine, and Romania had programs to restructure their coal sectors in the 1990s. These programs resulted in the mass closure of mines, which were often located in communities where the coal sector was a dominant source of income and economic development. Mining enterprises not only mined coal, but they also provided houses and socioeconomic benefits to the workers, their communities, and towns. Communities throughout Romania, Ukraine, and Poland faced further social problems after mine closure, e.g., increased substance abuse, prostitution, and child abandonment.

Evidence from Australia shows that the emotional dimension of the mining sector and community utilities associated with the coal sector can be characterized as their "cultural asset" and identity. Towns hosting coal mines are usually coal industry-driven, without many alternatives to sustain economic and social make-up. Additionally, there are a number of communities in Australia where coal mine workers are engaged on a fly-in/fly-out or drive-in/drive-out basis. So, the affected communities are both where the mines are located and sometimes at a great distance away where the coal miners live in the weeks when they are not rostered on to work. Similar dynamics would occur in other countries where workers are temporary migrants to the mining region.

However, the rehabilitation of coal mining sites can create income-generation opportunities. For example, in Nord-Pas-de-Calais in northern France, former coal mines were rehabilitated to provide playgrounds, museums, hiking trails, cycling routes, and artificial ski slopes, etc.[96] Open mine pits can also be redeveloped as reservoirs or pumped-storage hydroelectricity projects, as in the state of North-Rhine Westphalia, Western Germany.[97] Such repurposing creates economic activities for the local communities.

[94] World Bank (2018b)
[95] ADB (2006)
[96] National Geographic (2022)
[97] Agerholm (2017)

Many coal-dependent economies lack the incentives and resources needed to protect workers and their communities. A study of 1,000 coal mine closures from around the world between 1981 and 2009 found that 75% of them were unplanned.[98]

Legacy of socioeconomic issues

As with the retirement of CFPPs, closing coal mines could exacerbate prolonged unresolved (i.e., not mitigated previously by coal mine companies) socioeconomic and related environmental impacts, including outstanding land conflicts, land degradation and contamination, lack of compensation payments for land and property loss, lost livelihoods and income, and exacerbation of historical cultural and economic marginalization. Such issues could be induced by the lack of enforcement of national regulations, inadequate impact assessments, and mitigation measures not following good international industrial practices (e.g., the IFC performance standards).[99] An assessment report found that, in the Cesar department in the north of Colombia, "*there is no evidence that any activities by either* [mining] *company mitigated the impacts to any degree. The high degree of severity of the forced displacements continued unmitigated well into the mining companies' timespan of operations, and those impacts remain fully unmitigated and remediated to this day*."[100]

Such legacy issues can also be found in the Southeast Asian mining sector. Sumatra (Indonesia's second most coal-rich region) is both blessed and cursed by coal. At the beginning of 2022, the government revoked more than 2,000 mining business licenses (including 1,776 mineral licenses and 302 coal licenses) because of failures to comply with requirements under national laws. The government plans to transfer the areas covered by the licenses to local entities and potential investors.[101]

Health and safety

The closure of coal mines can provide opportunities for reducing the health and associated safety risks to communities (e.g., chronic health impacts associated with coal mining, particularly underground) and for improving local water and air quality. Mine closure and land reclamation requirements should be embedded in the overall mine planning and permitting process from the outset. Good practice examples are available from the Ukraine, Poland, and Romania where dedicated coal mine closure companies effectively manage the efficient and safe physical closure of mines.

A priority for mine closure needs to be the health and safety of people and communities during the closure and rehabilitation phases, both within and adjacent to the mine site. Compliance with safety standards is important to protect infrastructure and prevent hazardous events and incidents from occurring.

Health and safety risks arise when a mine is not properly decommissioned. Problems can include land instability, subsidence, or potential land and water contamination from tailings dams and mine spoil areas. These risks, in conjunction with inadequate monitoring and water management, can lead to water logging, soil slumpage, slope failure, and contamination within and adjacent to the closed mine site.

The closure of coal mines can benefit the health and safety of local communities. Mine closures often help improve air quality and eliminate or reduce dust at the mine site, which are two key public health issues associated with coal mines.

In addition, closure eliminates fatalities resulting from road accidents involving heavy vehicles transporting coal (Box 12.13).

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[98] Strambo et al. (2019)
[99] To read the full standards, see www.ifc.org.
[100] Wilde-Ramsing et al. (2021)
[101] Zuhal (2022)

Box 12.13: Road accidents involving coal trucks in Sumatra, Indonesia
Source: Saputra M.B. (2022)

It is reported that in Sumatra in 2022, thousands of overloaded coal trucks used the main roads each day, infuriating local communities. The trucks caused traffic congestion for kilometers, and those living along the main road had no option but to breathe in dust and thick diesel fumes every day. Coal truck drivers, some of them reckless, inexperienced, and unlicensed, regularly caused traffic accidents with dozens of fatalities. During 2017–2019, more than 30 residents were killed, and, in 2021 alone, the number of deaths reached 34.

Large industrial facilities, such as mines, are often serviced by improved roads to urban centers and employ staff who are relatively well paid. They can thus attract prostitution and drug dealing. So, closure can lead to improvements in reproductive health, household gender relations, physical health, and mental health.

However, the departure of a large industrial employer can lead to fewer resources being put into reducing mosquito populations (leading to possible outbreaks of malaria) or ensuring health in the community through immunization programs.

There may also be risks of public health issues if hazardous waste is left behind in coal mine areas. Mine abandonment without remediation (filling/capping mine shafts, fencing off, etc.) and the absence of long-term monitoring will create safety risks. For instance, animal and child drownings have been reported at abandoned mines in Australia and in Indonesia's Borneo region (Box 12.14).

Box 12.14: Lack of post-closure remediation in abandoned coal mines in Borneo
Source: Apriando and Esterman (2017)

Indonesian law requires mining companies to fill in their mine pits as part of closure and prohibits mining within 500m of houses. But these regulations are not followed. It is reported that the owners of hundreds of abandoned coal mine pits in Borneo failed to undertake post-closure remediation, and, in some cases, local governments did not fully ensure that owners complied with regulations. In East Kalimantan, 632 water-filled mine pits have been identified, with the true number estimated as being many more.

As a result, the surrounding communities are at risk of short- and long-term environmental and health risks. Between 2011 and 2016, 27 persons, mostly children and adolescents, died in 18 abandoned mine pits in East Kalimantan, most by drowning. These pits are also an environmental hazard, with the water found to be highly acidic and containing high levels of heavy metals, including manganese, zinc, and iron. Many of these pits provide water to nearby communities for irrigation and drinking.

In Indonesia, mining companies are required to have reclamation guarantee funds set aside for mine pit closure. Only 96 of the commercial mining license holders registered in the East Kalimantan Office of Mining and Energy have deposited post-mining guarantee funds meant to restore environmental and social conditions at the mine site. As a result, hundreds of abandoned mine pits remain in East Kalimantan, posing environmental, health, and safety risks to adjacent communities.

Closed mine sites are one of the most significant pollution risks in many countries, including the UK. It is important from a public health perspective to have mitigation measures in place when decommissioning. If not planned for or mitigated, heavy metals and other pollutants may be discharged into the water. According to environmental and coal authorities in the UK, some mines are filling up with groundwater and may discharge the liquid in the future, posing large-scale health and safety risks. Legislation and policy in the UK, including the Environmental Permitting Regulations (2010), National Planning Policies, and the EU Mining Waste Directive (Directive 2006/21/EC) aim to protect human health. Other countries, including those in the Southeast Asia region, may lack such national regulations or may have less robust requirements that focus on health and safety when mine sites are closed. It is important that these public health and safety concerns and issues are fully addressed and included as part of mine closure plans.

Illegal mining

In countries where regulatory enforcement is weak due to inadequate institutional support, coal mining may be carried out by artisanal, illegal, and unlicensed companies or individuals. Such illegal mines are reported in many low-income countries, both small- and large-scale,[102] [103] and can have significant consequences (Box 12.15).

Box 12.15: The consequences of illegal coal mining in Indonesia

Source: Cronin and Pandya (2009); Resosudarmo et al (2009b); Saputra (2022); and Wijaya (2020)

Following the Asian financial crisis[104] and unemployment in Indonesia, illegal coal mining activities significantly increased from 1998 onwards. Further expansion of such illegal mining was also fuelled by the decentralization of the coal sector aimed at boosting the economy and energy supply. Lenient sanctions and corruption in granting mining permits resulted in inconsistencies in mining regulation and policies, which led to local resistance to the government.[105] The Government of Indonesia used to tackle only symptomatic cases of illegal mining activity. This selected attention led to illegal and complex networks of coal mining operations increasingly funded and backed by foreign investors to avoid tax and other regulatory commitments. As a result, businesses in neighboring countries and overseas used Indonesia's illegal mining sector without having to internalize and address deep socioeconomic and environmental externalities and repercussions.[106] Although illegal mining temporarily supported local and regional economic development, it also resulted in long-term and deep inter-communal conflict and social unrest. For example, in the Pongkor region (West Java), the opportunities to engage in illegal mining led to the development of rebel groups and increased fighting over mining territories.

Large companies' mining operations and extraction activities in the region resulted in continued violence and an increase in sex workers, child labor, and fatal occupational accidents.[107]

In Indonesia, workers were killed at illegal mining sites due to improper health and safety measures (Figure 12.11). In 2006, illegal mining sites in Kalimantan were found to involve child labor, with about 10% of workers reported as being under 17 years old. In Sumatra, non-transparent coal mining concessions increased rapidly from 750 in 2001 to 10,900 in 2022. Over 1,000 of these mining permits were revoked by President Joko Widodo because the mining had harmed both the social fabric and environment of the communities. Such situations could worsen when the state's budget allocation for managing the coal mining resources diminishes as the need for coal for coal-fired power plants gradually declines.

[102] Soelistijo (2011) and Nasir et al. (2022).
[103] MCSA (n.d.)
[104] A sequence of currency devaluations and other events that began in the summer of 1997 and spread through many Asian markets.
[105] Resosudarmo et al. (2009b)
[106] Resosudarmo et al. (2009b)
[107] Resosudarmo et al. (2009b)

Coal mine closure can increase pressure on the capacity of local and central governments to manage the remaining coal resources. For many reasons, government capacity may be limited by insufficient public budget allocations by the central government. In such situations, opportunistic mining (individuals or entities) may find loopholes to extract coal illegally.

Employment and labor conditions

Phasing out coal mining is a complex process and will affect local workers. This impact is particularly true for regions highly dependent on coal-related activities. It is expected that the direct decline in coal-related jobs seen over the past decade will continue, largely driven by the environmental agreements and transformation into alternative renewable energy resources, but also by increases in automation in developed settings and more efficient mechanization in less developed countries.

According to the International Energy Agency (IEA), by 2030, 30% fewer people are expected to work in coal-related sectors compared to 2019. Almost a third of this decline is expected in coal mining. According to the World Bank, the closure of coal mines can exacerbate the existing socioeconomic and employment impacts given the geographic isolation, disparity in wages, and the distinct culture of coal mining towns. These factors are expected to pose further challenges to the recovery efforts regarding employment and labor conditions.[108]

Employment in coal mines varies from one site to another due to the size and accessibility of the coal deposit. However, coal mining sites tend to employ more workers than CFPPs. The closure of coal mines tends to create significant adverse job loss impacts. In Poland, efforts to close coal mines reduced jobs drastically from around 390,000 in 1989 to about 150,000 workers in 1999.

According to the Indonesian Bureau of Statistics, the mining and extraction industry employed 1,443,422 Indonesians in August 2021. If the coal mines close, many workers will be affected. As such, community protests and closures can be expected in areas neighboring mines. This will be particularly important when announcing how the energy transition will occur in areas facing coal mine closure or CFPP retirement.

Coal mine work is characterized by the International Labor Organisation (ILO) as difficult, dangerous, and rarely associated with good labor relations.[109] There is plenty of evidence of coal mines operating without proper health and safety standard. In Sumatra, up to 34 residents were killed by road accidents caused by a coal mine transportation truck.[110]

The process of closing mines, as with retiring CFPPs, could reduce or eliminate the use of forced labor and child labor. Facilities with substandard working conditions can be addressed by introducing or changing existing laws to make such practices illegal and by ensuring systems are in place to enforce laws and regulations. Lending and financing institutions (e.g., the MDBs) could make such practices unacceptable through imposing lending requirements for safeguard implementation.

There are opportunities that some or all workers who lose jobs in coal mines could be retrained and upskilled for job placement programs and to pursue employment opportunities in renewable energy projects or other sectors. However, evidence from job placement programs in the UK and Canada (both coal-exiting economies) shows that opportunities for former miners were largely limited to part-time and short-term positions, which did not replace the long-term security and benefits provided by full-time coal mining jobs. Part-time workers generally receive low wages, have limited advancement opportunities and unpredictable working hours, lack pension contributions, and face undesirable working and living conditions, all limiting their career prospects.[111]

Indigenous communities

When coal mines close, adjacent Indigenous communities face similar issues to those highlighted during CFPP retirement (see Section 12.6.2). However, when coal mines are to shut down, the

[108] World Bank (2018b)
[109] ILO (2004)
[110] Saputra (2022)
[111] Aassve et al. (2006)

Indigenous communities can face both challenges and opportunities. Challenges include difficulties asserting their rights to reclaim natural resources, cultural sites and places to practice cultural traditions, and their ability to participate in redevelopment projects.[112] Indigenous communities, or specific groups within them, are often already considered to be vulnerable. Where Indigenous communities rely on coal mines for their livelihoods, the closure of such mines can increase their vulnerability and force them further into poverty.

Energy transition involving coal mine closure can cause unintended and complex social challenges, which are recognized in some circles to be nearly universally overlooked in policy-making. Many cases of coal mine closure in the southwestern regions of the US demonstrate these challenges. As mentioned in Section 12.6.2, there are many Native American peoples' lands in the US with large coal reserves exploited by mining. Indigenous communities occupying these lands are therefore disproportionately impacted as host communities. In the face of mine closures, Indigenous communities will need to be involved with governments and mining companies in determining how they want the land fully reclaimed, considering that their past, current, and future identity are closely aligned with the physical, cultural, and spiritual representation of the land.[113]

There are also benefits to Indigenous communities from coal mine closure, not least a transition to cleaner energy sources that can offset negative environmental and health conditions. Closure may create an opportunity for such communities to reclaim land and natural resources and revive their customary land-use practices and culture, as in East Kalimantan, Indonesia.[114] The benefits of closures can increase as recognition of the rights and titles of Indigenous peoples increases and as policies and practices are implemented to help redress historical injustices. In other words, a changing political context in the mining sector means that closures today and in the near future can offer benefits that would have been less likely than closures 20 or 50 years ago.

Gender and vulnerability

As with CFPP retirement, the social risks and issues associated with mine closure, particularly those related to employment, livelihoods and well-being, are felt differently by women and men, challenging and changing gender roles, relations, and identities (Box 12.6). Mine closure can compound social inequalities faced by women and the most vulnerable, particularly those from protected groups such as Indigenous peoples.

Box 12.16: Gender difference in employment in coal mines in Kalimantan, Indonesia

Source: Lahiri-Dutt (2012)

For the Indigenous Peoples of Kalimantan in Indonesia, coal extraction predominantly offers income for men of the region, while women search for more precarious (and possibly informal) work. The coal industry here serves to solidify gendered divisions of labor, with the closure of the industry likely to expose such vulnerabilities further.

The risks and issues associated with gender and vulnerable groups highlighted in Section 12.5.2 subsection on gender and vulnerability apply equally to coal mine closure and include:

- Greater financial and domestic burdens placed on women resulting from sudden job losses;
- A shift in traditional gender roles that heightens instances of intra-household tension, harassment, sexual and gender-based violence, and psychological distress.
- Opportunities for a positive shift in gender relationships within households and in communities assisted by government or industry interventions in the rare cases when closure processes are well planned and carefully executed.

[112] IFC (2012b)
[113] University of New Mexico (2017)
[114] The Asia Foundation (2016)

Migration

Mine closure can cause unintended and complex social challenges, such as migration. This is almost universally overlooked in policy-making.[115] Outmigration of the mining labor force (particularly skilled workers) can lead to significant demographic change. Evidence shows that extended outmigration can also put a strain on local businesses, tax revenues, and the associated delivery of public services, as experienced in Yorkshire and Wales, UK.[116]

Depending on the size of the coal mine, outmigration can be small or large. In most cases, the closure of coal mines can cause large-scale outmigration, especially from mining areas that operate for years or decades. Over time, skilled workers become a significant local resource for the communities in the mining area, and their departure creates a skills vacuum. Similarly, those who had settled in the mining areas to work in small businesses associated with the mining activities may leave for other opportunities.

This outward migration can take families from the coal mine area, which can reduce the strength of “social capital” and community support networks, which, in turn, were providing trade and staffing for small businesses in the local economy. Outward migration can also imply that one family income earner travels in search of employment while the rest of the family stays behind. This can lead to tensions within a household and can weaken support within the family for the primary caregiver in the household, the children, and the elderly.

Employment opportunities may arise when coal mines are closed early. These could be created by the requirements of financing organizations that coal mine companies compensate workers affected by mine closure. Such requirements could also include mining companies providing a program for reskilling and upskilling workers so that they can pursue job opportunities in renewable energy and other sectors. However, such reskilling will not occur quickly and must be adequately planned for.

Public services and infrastructure

As for the early retirement of CFPPs, the closure of coal mines can affect public services and infrastructure such as transportation and health and education facilities in areas where the mining companies are present and where they have large corporate responsibility budgets. The ability of local governments to spend tax revenues on maintaining public facilities may also be reduced.

Indonesia is Southeast Asia’s largest exporter of coal, supplying many neighboring countries. In the coming years, it could face the same experience as Yorkshire and South Wales in the UK, where mine closures created social tensions due to the loss of community services such as hospitals and schools. Local communities are often dependent on services provided or financed by mines (e.g., literacy and health and education services). Problems arise when these cease or are no longer funded as a casualty of mine closure.[117] In Southeast Asia, especially in the Philippines and Indonesia, the closing of mine activities, which can provide a greater proportion of a region’s cash flow, can create more complex problems than in higher-income countries.

The existence of mining projects in Indonesia has often been regarded as a catalyst for accelerating the development of infrastructure and increasing community well-being in many areas. This is particularly true for many districts (Kabupaten) where local governments generally lack the capacity to provide public services.[118]

Section 12.4.2 discusses how communities may become dependent on public services and infrastructure provided and/or financed by CFPPs and coal mines (e.g., in Betul District, Madhya Pradesh, India[119], see Box 12.7). However, the lack of financial support from mining companies could be offset by the reduced pressure on public services and infrastructure due to outmigration, and even

[115] Mayer (2021)
[116] Merrill and Kitson (2017)
[117] Merrill and Kitson (2017)
[118] Resosudarmo et al. (2009b)
[119] Gupta R. (2021)

by the reduction of heavy vehicle movements, which would then require less public expenditure on road infrastructure repair and rehabilitation.

Community cohesion and engagement

The social risk posed by rapid coal mine closures, compounded by the variations in coal mine ownership, points to the important leadership and communication roles required of governments to plan and prepare for such closures. Those planning coal mine closure must consider how best to mitigate impacts on people and communities.

Avoidance of conflict and protests is a critical measure of success in coal mine closure programs, as successfully demonstrated by several coal sector reform programs in Poland and Romania (Box12.17).

Box 12.17: Engagement with coal mine workers and communities over mine closure

Source: Gupta (2021) and World Bank (2018b)

Extensive dialogue channels were established with trade unions in Poland, facilitating a mechanism for reform acceptance and implementation, supported by the continued engagement by government and industry with mine workers.

In Romania, community representatives were involved in capacity-building and identifying direct employment opportunities as part of the coal mine decommissioning process and in discussions on the repurposing of infrastructure and other assets, which helped to guide expectations, making them more realistic. This engagement with mine workers and community representatives not only contributed to the acceptance of mine closures but also contributed greatly to the design of social and labor support measures for workers, their families, and communities.

In Ukraine and the United Kingdom, there was a lack of significant stakeholder engagement with regard to the closure of coal-fired power plants and mines. In Ukraine, reforms were blocked. In the United Kingdom, reforms were achieved, but there were protracted conflicts with unions and mine workers over a two-decade period after 1984.

Such outcomes can be the result of other aspects of the national political context, issues with the national or global economy (such as the Global Financial Crisis), and the level of domestic corruption.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 13

INFRASTRUCTURE ASSOCIATED WITH RENEWABLE ENERGY DEVELOPMENT, AND SUPPLY CHAINS

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Links to the complete guidance document and to individual chapters are also available.

CHAPTER 13

INFRASTRUCTURE ASSOCIATED WITH RENEWABLE ENERGY DEVELOPMENT AND SUPPLY CHAINS

This chapter focuses on infrastructure that is associated with the energy transition, particularly new infrastructure required to support the development of renewable energy, such as transmission lines (trunk lines, new connections), sub-stations, access roads, and the development of smart grids with energy storage systems and facilities. The chapters in this guidance concerned with types of renewable energy (Chapters 5-11) all highlight that the construction of transmission lines, substations, and access roads is among the main causes of environmental and social impacts.

New transmission lines will be required to connect new renewable energy facilities to the national grid (where there is one) or to end-users, and the impacts of these should be assessed as part of a strategic environmental assessment (SEA) for any renewable energy plan, policy, or program (PPP) and subsequently for project-level EIAs. But equally, where renewable energy development is likely to require developing a new grid (or elements of a grid) or major upgrading of an existing national energy grid, it would be prudent to conduct a bespoke SEA of such a development or upgrading.

13.1 EXISTING SEA GUIDANCE/GUIDELINES FOR INFRASTRUCTURE ASSOCIATED WITH THE ENERGY TRANSITION

An international survey of existing SEA guidelines conducted for the International Association for Impact Assessment was unable to identify any guidelines specifically focused on infrastructure specifically associated with the energy transition and specifically with the development of renewable energy. However, many EIA and some SEA guidelines refer to the general impacts of roads, transmission lines, substations and ports, harbors, and terminals.

Roads

The Mekong River Commission has produced guidelines for the integrated planning and design of economically sound and environmentally friendly roads in the Mekong River floodplains.[1]

Transmission lines and sub-stations

EIA and SEA guidelines for transmission lines and sub-stations have been published for several countries: Germany, Southern Africa, Surinam, Canada, and the USA.[2] The International Finance Corporation's *Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution* are a very useful reference document with general and industry-specific examples of good international industry practice.[3] Some recent academic papers have discussed the concrete benefits that SEA may deliver to private companies, e.g., where it is applied in Scotland in relation to regional electricity transmission planning in a tiered system.[4]

Ports, harbors, and terminals

With regard to the energy transition, ports, harbors and terminals are likely to be developed or upgraded/expanded mainly in connection with exporting green hydrogen and ammonia. The International Finance Corporation's *Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals* provide a useful reference source with general and industry specific examples of good international industry practice.[5]

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[1] MRC (2011
[2] Bundesnetzagentur (2021) EnvSC (1999); Bundesnetzagentur (2021) MRC (2011); NIMOS (2005); USAID/CCAD/EPA (2011a, b, c);
[3] IFC (2007c)
[4] Marshall and Fischer (2006)
[5] IFC (2017)

13.2 TYPES OF TRANSMISSION LINES AND POWER GRIDS

A transmission line is the long conductor (either overground supported by pylons or underground/submarine) with a special design (bundled) to carry bulk amounts of generated power at very high voltage from one station to another as per variation of the voltage level. Design must take account of key factors, including voltage drop, transmission efficiency, line loss, etc. These values are affected by line parameters (resistance (R), inductance (L) and capacitance (C)[6]) of the transmission line. There are three types of transmission line length (Table 13.1). These different types of power lines have various types of posts or pylons, distance between them, and right-of-way width, which create various environmental and social impacts.

Table 13.1: Lengths categories of transmission lines
Source: Electrical4U (2024)

Type of transmission line	Features
Short line distribution	• A length less than 80km (50 miles) • Voltage level less than 69 kV (low voltage) • Capacitance effect is negligible • Only resistance and inductance are taken in calculation; capacitance is neglected
Medium line (transmission)	• A length more than 80 km (50 miles) but less than 250 km (150 miles) • Operational voltage level is from 69 kV to approximately 133/168 kV (medium voltage) • Capacitance effect is present • Distributed capacitance form is used for calculation purpose
Long line (transmission)	• A length more than 250 km (150 miles) • Voltage level is above 133/168 kV to 735 kV (high voltage) • Line constants are considered as distributed over the length of the line

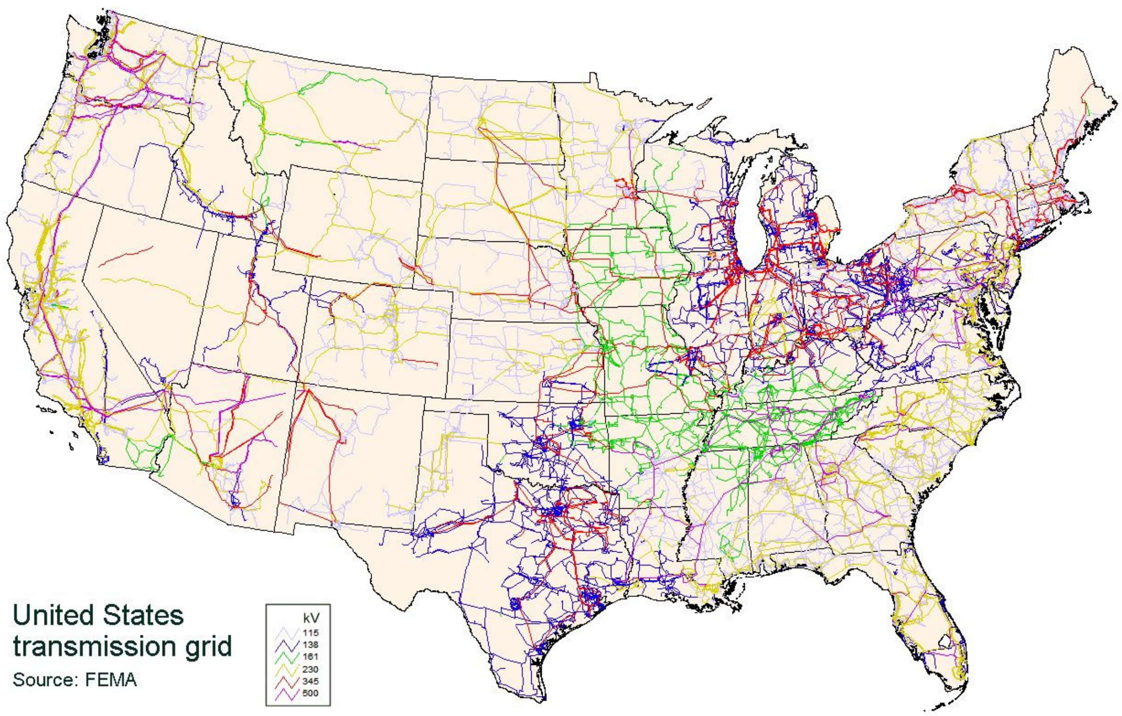
The electric power system consists of production, transmission, distribution, and consumers. A ***power grid*** is a country's network of transmission and delivery, conducting electricity from power plants to homes and businesses across a country (e.g., Figures 13.1 (USA)). It includes energy utility companies and energy suppliers and the infrastructure to generate and distribute power. The grid may be a single national network or several regional grids that may be interconnected within the country or with neighboring countries.

A grid ensures best practice use of energy resources, provides greater power supply capacity, and makes the power system operations more economical and reliable. The generating stations (power plants) are interconnected to reduce the reserve generation capacity, known as a spinning reserve, in each area.

A ***smart grid*** (including new smart grids) is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Grids coordinate the needs and capabilities of all generators, grid operators, end users, and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience, flexibility, and stability.

[6] A transmission line is modeled with a resistance (R) and inductance (L) in series with a capacitance (C) and conductance (G) in parallel. The resistance and conductance contribute to the loss in a transmission line.

Figure 13.1: USA power grid
Source: Federal Emergency Management Agency (FEMA) (n.d.)



Despite some recovery from the economic disruption caused by the Covid-19 pandemic, investment in smart grids needs to more than double through 2030 to get on track with the Net Zero Emissions by 2050 Scenario, especially in emerging markets and developing economies.[7]

According to analysis of available data[8], the total length of transmission circuits worldwide is estimated at 4.7 million kilometers, and the length of distribution grids is between 88 and 104 million km. China accounts for 41% of the expansion of global transmission grids and 32% of the expansion of distribution grids since 1980. In 2017, China's electricity grids were approximately as large as the grids of all western industrialized countries combined. The globally installed capacity of transformers is estimated between 36 and 45 teravolt-amperes, with transmission and distribution transformers accounting for above 40% each, and generator step-up transformers for the rest.

In 2023, worldwide, there were 7 million circuit km[9] of power transmission lines and 110 million km of power distribution lines.[10] As a "rule of thumb," each TWH of electricity used globally is supported by 225 km of power transmission lines (interquartile range of 175-275 km per TWH pa). Another "rule of thumb" is that each TWH pa of electricity used is supported by almost 4,000 km of distribution lines. The cut-off between transmission and distribution is a little bit blurry, but, generally, 100kV and greater lines can be considered as transmission lines and <70kV lines as distribution lines. Globally,

[7] Drtil, M., Pastore, A., Evangelopoulou, S. (2023)
[8] Kalt *et al*. (2021)
[9] *What are circuit kilometers?* One "network kilometer" of power transmission lines may carry one circuit kilometer, two circuit kilometers or sometimes (rarely) three circuit kilometers, suspended from the same towers. In turn, each circuit kilometer may contain two large conductors (e.g., a high voltage direct current, HVDC), three conductors (3-phase AC) or sometimes (rarely) six conductors where the 3-phase AC is disaggregated to promote transmission efficiency. This makes the length of a transmission line a somewhat debatable concept.
[10] Thundersaid Energy (n.d.)

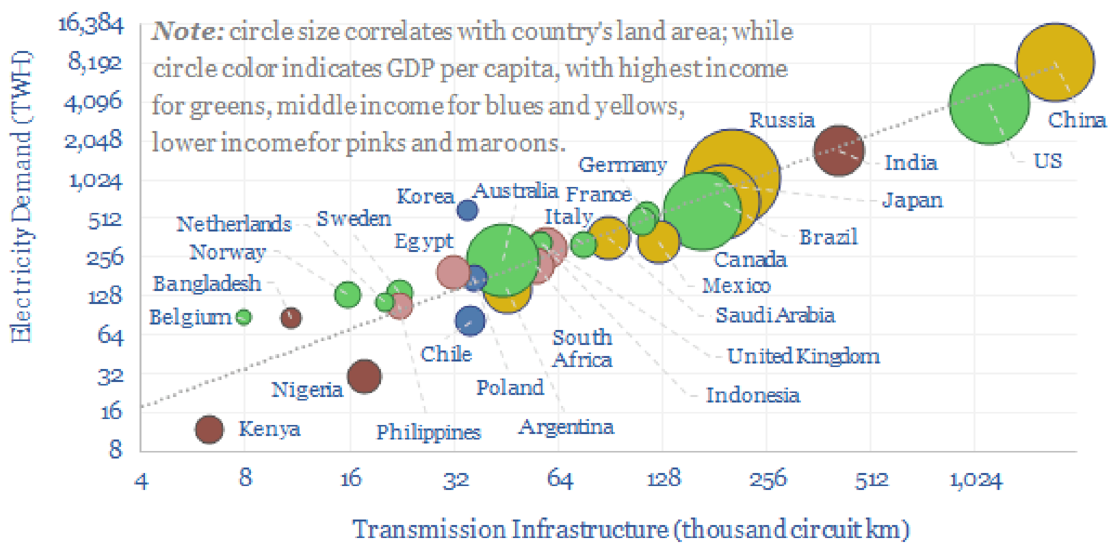
on average, countries have 16 km of distribution lines per km of transmission lines.[11] Generally, large, developed countries tend to have a higher share of large-scale transmission due to greater availability of financing for larger and more efficient grid infrastructure. Countries tend to have longer power transmission networks per unit of delivered electricity when (a) population density is lower, (b) GDP per capita is lower, and (c) average voltages of the transmission system are lower.

Using the above rules of thumb, Thunder Said Energy (a research consultancy for energy technologies) estimates that each 1 GW of new, utility-scale renewables might warrant constructing or upgrading around 500 km of transmission lines and 8,000 km of distribution infrastructure. However, the requirements will clearly vary case by case and depend on regional backlogs. A far-offshore wind project clearly has different network impacts from rooftop solar.[12]

Figure 13.2 shows power transmission and distribution km by country across 30 key countries, which comprise 80% of global electricity use.

Figure 13.2: Transmission infrastructure and electricity demand for a range of countries

Source: Thundersaid Energy (n.d.)



To achieve the energy transition, most electricity transmission systems around the world will need massive expansion, upgrades, shifts in technology used, and accommodation to the type of electricity that is transmitted, such as high voltage dc. Investments in the types of transmission systems taking place now may limit future options. There may be issues for projects to connect to electricity grids (so that they are on-grid or grid-tied) that are designed for larger utility-scale projects. Also, the potential for grid connections between countries could have huge benefits (financial, environmental, social) if done properly. There are already examples of essentially “stranded” renewable energy projects that cannot get their energy to markets due to grid constraints. After 20 years of effort, the USA has only recently finalized the first decision on a grid expansion.

For the timely implementation of the energy transition, it is necessary to strengthen the existing transmission network for the transfer of large amounts of electricity from areas of renewable energy sources to areas where this energy will be consumed or stored locally in another form of energy. For the efficient integration of renewable sources into the power grid, it is necessary to consider the connection line to the existing grid as a functional part of this source. The impacts of the renewable energy source and the connecting transmission line must be assessed together in a national or international context.

[11] Thundersaid Energy (n.d.)
[12] Thundersaid Energy (n.d.)

13.3 SUBSTATIONS

The transmission of electricity requires substations (electrical transformer stations) to increase the voltage at the outlet of the generation equipment or to gradually lower it throughout its transmission to consumption centers. Substation sizes vary depending on their voltage, and some can occupy large areas. They include a control building, transformers, and different electrical equipment.

A variety of substation types are in use, e.g., step-up or step-down (of voltage); transformer, switching, and converter; high and extra and ultra-high voltage; grid and town; indoor and outdoor.[13]

13.4 ACCESS ROADS

All renewable energy developments are likely to require access roads (including bridges), particularly in the preparatory stage, e.g., to bring in equipment (e.g., drilling rigs for geological investigation of selected sites, earth-moving equipment, and construction materials), to transport labor to sites, and for maintenance purposes. In an inhabited area, existing roads may be capable of being used but may require upgrading (e.g., to accommodate wide or heavy loads). But there may be a need to extend the existing road network. In many cases, new renewable energy facilities may be located in remote areas, requiring the construction of new access roads. Such roads may require to be constructed across difficult terrain (e.g., mountainous land), and it may not be possible to avoid traversing sensitive and protected areas.

There are no internationally agreed specifications for such access roads. But they certainly can lead to serious environmental and socioeconomic impacts (discussed in Section 13.6) which need to be mitigated and managed. But it must also be recognized that access roads can also bring benefits to local populations and communities.

Some authorities (national or local) may set out specifications for such access roads (e.g., national standard specifications in South Africa[14], and specifications set by county councils in the UK[15]) setting out requirements covering, for example, design issues, management of materials (e.g., for blasting), safety, fences and barriers, drainage, earthworks, surfacing, footways, traffic signs, lighting, etc.).

13.4 ENERGY STORAGE FACILITIES

An electric power grid operates based on a delicate balance between supply (generation) and demand (consumer use). One way to achieve this balance is to store electricity during periods of relatively high production and low demand, then release it back to the electric power grid during periods of lower production or higher demand. In some cases, storage may provide economic reliability and environmental benefits. Depending on the extent to which it is deployed, electricity storage can help the utility grid to operate more efficiently, reduce the likelihood of drops in voltage in the electrical power supply system (brownouts) during peak demand, and allow for more renewable resources to be built and used.

The need for storage is a particular concern with regard to solar and wind power. In the past, nuclear, thermal, and hydroelectric power plants were operated and output adjusted to meet fluctuating consumer demand for electricity, and there was no need for energy storage. When the electric grid has all the energy it needs at a given time, but it’s a sunny or windy day and solar and wind energy systems are still generating electricity, it makes sense to store the surplus. Then, when the sun has set and the wind isn’t blowing, that stored surplus energy can be discharged to continue supporting power needs.

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[13] How Engineering Works (2017)
[14] Department of Transport for the Republic of South Africa (2020)
[15] Leicestershire County Council (2019)

Energy can be stored in a variety of ways, including:

- ***Hydroelectric complex with reservoir***. When solar and wind energy are generating electricity, water can be maintained in the reservoir for a period when the sun is not shining or there is no wind. It is a very efficient combination.
- ***Pumped hydroelectric*** (currently the most widely used technology with significant additional potential in several regions) Electricity is used to pump water up to a reservoir. When water is released from the reservoir, it flows down through a turbine to generate electricity.
- ***Compressed air*****.** Electricity is used to compress air at up to 1,000 pounds per square inch and store it, often in underground caverns. When electricity demand is high, pressurized air is released to generate electricity through an expansion turbine generator.
- ***Flywheels*****.** Electricity is used to accelerate a flywheel (a type of rotor), through which the energy is conserved as kinetic rotational energy. When the energy is needed, the spinning force of the flywheel is used to turn a generator. Some flywheels use magnetic bearings, operate in a vacuum to reduce drag, and can attain rotational speeds up to 60,000 revolutions per minute.
- ***Batteries*****.** Batteries are the most scalable type of grid-scale storage, and the market has seen strong growth in recent years. Similar to common rechargeable batteries, very large batteries can store electricity until it is needed. These systems can use lithium ion, lead acid, lithium iron, or other battery technologies (see Box 13.1).
- ***Thermal energy storage*****.** Electricity can be used to produce thermal energy, which can be stored until it is needed. For example, electricity can be used to produce chilled water or ice during times of low demand and later used for cooling during periods of peak electricity consumption.
- ***Others***: In addition to these technologies, new technologies are currently under development, such as flow batteries, supercapacitors, superconducting magnetic energy storage, molten salt[16] and hydrogen (discussed separately in Chapter 14).

Box 13.1: Batteries

The most common type of battery used in grid energy storage systems are lithium-ion batteries. Lithium-ion batteries include five components:

- an anode (typically graphite coated onto aluminum foil);
- a cathode (either nickel-magnesium-cobalt or nickel-cobalt-aluminum; lithium-iron-phosphate; and blended onto copper foil);
- a separate barrier between the anode and cathode;
- an electrolyte solution to transport lithium ions; and
- current collectors made of copper and aluminum that connect the battery to wires.

In some countries (e.g., USA), instead of batteries, fossil fuel-powered “peaker plants” are often used to supply energy during high-demand periods. Despite being used infrequently, these plants are inefficient and highly polluting and contribute greatly to carbon emissions.

The USA is predicted to have deployed 20.5 GwH of energy storage capacity between 2013 and 2023, followed by China (10 GwH) and Japan (8.3 GwH) (see Table 13.2).

[16] Bauer, T., Odenthal, C., Bonk, A. (2021)

Table 3.2: Projected energy storage deployment between 2013 and 2023
Source: Statista (2024b)

Country	Projected capacity (GwH)
USA	20.5
China	10
Japan	8.3
Australia	6.6
Germany	4.3
UK	2.6
India	2
South Korea	1.5
Canada	1.3
Rest of World	8.1

According to the U.S. Department of Energy, the USA had more than 25 gigawatts of electrical energy storage capacity as of March 2018. Of that total, 94% was in the form of pumped hydroelectric storage, and most of the latter capacity was installed in the 1970s. The 6% of other storage capacity was in the form of battery, thermal storage, compressed air and flywheel.[17]

13.5 PORTS, HARBORS, AND TERMINALS

The energy transition will involve reducing (and ideally eliminating) our dependence on fossil fuels as energy sources. Coal, oil, and gas need to be transported from where they are extracted to where they are consumed (within countries or internationally) by road, rail, sea, and pipelines. Where fossil fuels are exported or imported by sea, this involves ports, harbors, and terminals. Sometimes these are dedicated stand-alone facilities, e.g., Richard Bay coal terminal in South Africa (Box 13.2); in other cases, they are part of general ports that handle a wide range of other cargo.

Regarding fossil fuels, this guidance focuses only on retiring coal-fired power plants, the closure of associated coal mines, and the cessation of use of ports, harbors, and terminals for coal transport.

Box 13.2: Richards Bay Coal Terminal, South Africa
Source: Mozambique Resources Post (2015)

Richards Bay Coal Terminal (RBCT) in South Africa is one of the leading coal export terminals in the world. RBCT was established in 1976 with an original capacity of 12 million tons per annum (Mt/a). It has since expanded to an advanced 24-hour operation with a design capacity of 91 Mt/a, and handles coal from 65 collieries and brought by rail. RBCT is positioned at one of the world's deep seaports and handles large volumes of coal and vessels. The 276-ha site is currently 2.2 km long, has 6 berths and 4 ship loaders, with a stockyard capacity of 8.2 Mt. It is currently visited by more than 900 vessels per year.

[17] US EPA (2024)

13.6 IMPACTS OF TRANSMISSION LINES AND ACCESS ROADS

The environmental and socioeconomic impacts of both transmission lines and access roads are discussed in detail for different types of renewable energy development in chapters 5 (hydropower), 6 (wind), 7 (solar), 8 (bioenergy), 9 (geothermal) and 10 (tidal).

13.6.1 Environmental and socioeconomic issues and impacts of transmission lines and access roads

Tables 13.3 and 13.4 summarize, respectively, the main environmental and socioeconomic issues and impacts associated with transmission lines and substations, while Tables 13.5 and 13.6 summarize the main issues and impacts associated with access roads.

Table 13.3: Environmental issues and impacts associated with transmission lines and substations

Issue	Impacts
Land clearing/ deforestation	• Soil erosion; • Landslips; • Sedimentation of rivers; • Loss of and fragmentation of habitats (including wetlands), and loss of biodiversity (including endangered fauna and flora); • Loss of ecosystem services (terrestrial and aquatic).
Biodiversity	• Fragmentation of habitats caused by single and multiple linear disturbances. Often transmission lines may be placed together in a corridor; • Increased access to protected areas; • Poaching and wildlife trafficking
Quarries and borrow-pits	• Digging for rock/gravel can release pollutants and other harmful substances into the surrounding environment (particularly surface and ground water); • Land degradation and loss of vegetation; • Noise from blasting and crushing; • Dust; • Waste from unwanted materials; • Lack of restoration to prevailing conditions,
Marine habitat disturbance	• Seabed and marine habitat disturbance/scouring and water quality impacts (when constructing underwater cable foundations associated with offshore wind).
Wildlife deaths	• Bird and bat collisions with power lines and electrocutions; • Increased access leading to poaching.
Waste	• Waste soil and rock (spoil) from excavation/routing works and leveling transmission pylon sites; • PCB may remain in some old transformers at substations or may have been disposed of on site.
Noise	• Noise (during road and line construction) and underwater noise, and due to vessel movement in case of off-shore wind; • Noise during substation operation; • Vibration and dust during construction.
Visual & aesthetic impacts	• Impacts on landscape.
Herbicide use	• Impacts of herbicides used to control vegetation on right-of-way or in substation area.
Accidental oil spills	• From transformers in substations.
Fires	• Wildfires can result from downed lines, vegetation contact, conductor slap, downed lines, repetitive faults, and equipment failures.

Table 13.4: Socioeconomic issues and impacts associated with transmission lines

Issue	Impacts
Land use	• Limitations/restrictions on land use along easement routes and beneath transmission lines (e.g., restrictions on agriculture, tree planting or constructing buildings). For Indigenous Peoples, this can include impeded access to spiritual, cultural, and economic relationships with their land.
Fishing	• Effects on fishing (e.g., reduced yields/catches) and other aquatic-based activities or reliant livelihoods (for offshore wind transmission cables).
Health and safety	• Health and safety issues related to high overhead voltage cables during construction of lines or underground/underwater cables; and due to roads, quarries and borrow-pits (accidents due to increased presence of vehicles – particularly during construction, and operation of equipment); • Health effects associated with electromagnetic fields (EMF).
Jobs	• Job opportunities for local people; • Opportunity for vulnerable groups and Indigenous communities to acquire new skills through working on transmission line construction and tower building; • There may be gender gaps with women where they are under-represented.
Labor rights	• Infringement of labor rights during transmission line construction, mainly where there is a demand to undertake excessive overtime and successive days of work without sufficient rest.

Tensions and conflicts	• Tensions can arise when transmission lines are built, particularly since the electricity generated is not distributed locally (hydropower projects are typically permitted as generating facilities and are not allowed to distribute electricity to local communities);
	• Conflicts between the workforce and the local population and exposure to anti-social behavior;
	• Conflicts within the local population can arise for a range of reasons, often relating to issues of inequity, including, for example:
	  ○ compensation measures (which may arise from a lack of clarity on cut-off dates);
	  ○ eligibility criteria or entitlement provisions (e.g., duration);
	  ○ access to and extent of training and support; and
	  ○ access to and extent of project benefits.
	• There is a risk of conflict between communities and project developers if the latter do not secure the free prior and informed consent (FPIC) to projects and their associated transmission lines from Indigenous communities.

Community cohesion and engagement	• Impacts to or loss of community resources (e.g., gardens, land, forest, fisheries) and community assets (e.g., community meeting areas, culturally significant features).
Land acquisition risks	• Associated with acquiring land for substations and transmission lines.
Cultural	• Cultural, religious, and archaeological sites can be destroyed, or access to them restricted when land is acquired.

Table 13.5: Environmental issues and impacts associated with roads

Issue	Impacts
Land clearing/ deforestation	• Soil erosion; • Landslips; • Sedimentation of rivers • Loss of and fragmentation of habitats (including wetlands), and loss of biodiversity (including endangered fauna and flora); • Loss of services (terrestrial and aquatic).
Biodiversity	• Fragmentation of habitats caused by the road corridor. Often transmission lines and roads occur together in the same corridor; • Increased access to protected areas; • Poaching and wildlife trafficking.
Quarries and borrow-pits	• Digging for rock or gravel can also release pollutants or other harmful substances into the surrounding environment (particularly surface and ground water); • Land degradation and loss of vegetation; • Noise from blasting and crushing; • Dust; • Waste from unwanted materials; • Lack of restoration to prevailing conditions.
Wildlife deaths	• Collisions with vehicles; • Increased access leading to poaching.
Waste	• Waste soil and rock (spoil) from excavation/routing works and leveling transmission pylon sites.
Noise	• Noise (during road and line construction and including underwater) and due to vessel movement in case of off-shore wind; • Noise during sub-station operation; • Vibration and dust during construction.
Visual and aesthetic impacts	• Impacts on landscape.
Herbicide use	• Impacts of herbicides used to control vegetation on the road right-of-way.
Accidental oil and other spills	• During construction and also during operations.

Table 13.6: Socioeconomic issues and impacts associated with access roads

Issue	Impacts
Land use	• Limitations/restrictions on land use along road corridors (e.g., restrictions on agriculture, tree planting or constructing buildings). For indigenous peoples, this can include impeded access to spiritual, cultural, and economic relationships with their land.
Health and safety	• Health and safety issues related to road construction.
In-migration	• Roads can open up previously inaccessible areas to local and remoter populations. This may create a pressure on natural resources and affect the livelihoods of Indigenous communities.
Jobs	• Job opportunities for local people; • Opportunity for vulnerable groups and Indigenous communities to acquire new skills through working on road building; • There may be gender gaps with women where they are under-represented.
Labor rights	• Infringement of labor rights during transmission line and road construction, mainly where there is a demand to undertake excessive overtime and successive days of work without sufficient rest.

Issue	Impacts

Tensions and conflicts	• Conflicts between the workforce and the local population and exposure to anti-social behavior;
	• Conflicts within the local population can arise for a range of reasons, often relating to issues of inequity, including, for example:
	  o compensation measures (which may arise from a lack of clarity on cut-off dates);
	  o eligibility criteria or entitlement provisions (e.g., duration);
	  o access to and extent of training and support; and
	  o access to and extent of project benefits.
	• There is a risk of conflict between communities and project developers if the latter do not secure the free prior and informed consent (FPIC) on road projects from Indigenous communities.

Community cohesion and engagement	• Impacts to or loss of community resources (e.g., gardens, land, forest) and community assets (e.g., community meeting areas, culturally significant features).
Land acquisition risks	• Associated with acquiring land for roads.
Cultural	• Cultural, religious, and archaeological sites can be destroyed or access to them restricted when land is acquired for roads.

Box 13.1 discusses some of the challenges associated with transmission lines in Nepal.

Box 13.1: Challenges of constructing transmission lines in Nepal and the case of the New Butwal – Lamahi 400 kV transmission line

Source: Mathema, A. (n.d.)

Transition lines are prioritized. The Government of Nepal (GoN) has prioritized the construction of transmission lines to "evacuate" or transport electricity generated by hydropower projects across the country. Environmental requirements for transmission line projects have been eased. The Environmental Protection Regulations 2020 now require only an Initial Environmental Examination (IEE) rather than a full EIA for all sizes and scales of transmission lines.

Land acquisition (for Rights of Way, RoW) across private land is a major challenge. Electricity Rules require both vertical and horizontal clearance beneath and adjacent to conductor wires to ensure safety and smooth operation of transmission lines. A right-of-way (RoW) is negotiated with the landowner that imposes restrictions on the use of land (e.g., on the height of vegetation and buildings that can be constructed) and offers compensation (typically 15-25% of the land's value) to landowners. The restrictions significantly depress the value of the land, and financial institutions will not accept such land as collateral, further limiting its financial potential. As a result, many landowners are reluctant to have the transmission line pass through their land, and transmission line projects have faced strong resistance from the public, significantly delaying construction and leading to uncertainties in the overall energy infrastructure development. Land is purchased from landowners for towers and substations.

Routing transmission lines through forest areas. This alternative has given rise to a new set of concerns and trade-offs, particularly related to the environment, the integrity of forest ecosystem (through land clearing), and the loss of habitats and biodiversity, as exemplified by the proposed New Butwal – Landhi 400 kV transmission line (see below). Many animal species rely on forested areas for shelter, food, and breeding, and their displacement and habitat fragmentation due to the transmission line can disturb the delicate ecological balance.

The proposed 400 kV New Butwal – Lamahi transmission line project in Lumbini Province, Nepal

This 160km transmission line is estimated to require the clearing of about 180,000 trees along its corridor. Nearly 97% of the transmission line alignment passes through the forests on the foothills of the Churiya Hill range. Traditionally, transmission line projects in Nepal clear the vegetation along the RoW to comply with the Electricity Rule 1003 and to ensure the safe and efficient operation of the transmission line while minimizing potential hazards (e.g., fire) and disruption caused by encroachments or incompatible constructions.

The project intends to minimize impacts on the forest by avoiding removal of ground vegetation, as well as to minimize the clearance or trimming of trees (to only those above 20m) by increasing the height of the towers to 90m. Forest sampling showed that 20% out of the 180,000 trees along the transmission line corridor are taller than 20m and will require either removal or trimming.

The project also aims to minimize vegetation removal for tower construction and stringing operations. Drones will be used for stringing. Vegetation clearance will be limited to a 200m stretch of the RoW at every 4 km, requiring 40 clearance sites, which will cover a combined area of 36.8 ha. Taking all factors into account, including trees above 20m, construction work, stringing, and substation sites, the total number of trees expected to be removed along the corridor will be approximately 45,000 (25% of all trees). Most of the trees to be preserved are Sal, a protected species. This approach will also minimize disturbance to forest habitats and the delicate, erosion-prone geology of the Churiya hill range.

It is estimated that the proposed taller towers and using advanced construction technology will increase project costs by 40%, making it one of the most expensive transmission line projects. This significant increase in expenses may not be feasible for the GoN.

13.7 IMPACTS OF ELECTRICITY STORAGE

Storing electricity can provide indirect benefits. For example, electricity storage can be used to help integrate more renewable energy into the electricity grid. Electricity storage can also help generation facilities to operate at optimal levels and reduce use of less efficient generating units that would otherwise run only at peak times. Furthermore, the added capacity provided by electricity storage can delay or avoid the need to build additional power plants, transmission and distribution infrastructure, or access roads, which have associated environmental impacts.

The potential negative impacts of electricity storage will depend on the type and efficiency of storage technology. For example, batteries use raw materials such as lithium and lead, which can present environmental hazards if they are not disposed of or recycled properly. In addition, some electricity is wasted during the storage process. Plus, demand for these rare metals in batteries is leading to a boom in their mining and the associated environmental impacts associated with such mining.

From a social perspective, mining for rare metals is often associated with violations of the human rights of communities (e.g., rights to land and livelihood), the ability to undertake traditional cultural practices, and forced and child labor. Furthermore, the rapid increase in demand for rare earths and the associated boom in mining is also leading to protests and conflicts between mining companies and host communities, e.g., over lithium extraction from salt flats in the Atacama Desert in Argentina.[18]

[18] Global China Unit (2024)

13.8 IMPACTS OF PORTS, HARBORS, AND TERMINALS ASSOCIATED WITH THE ENERGY TRANSITION

With regard to the energy transition, new ports, harbors, and terminals are likely to be developed or existing ones upgraded/expanded mainly in connection with exporting green hydrogen and ammonia. Liquid natural gas (LNG) terminals are also being built for the transport of natural gas as a transition fuel for electricity generation, away from coal and diesel. But, as pressure and commitments increase to retire coal-fired coal plants and as associated coal mines are closed, existing coal terminals are likely to be closed, possibly repurposed (e.g., to export green hydrogen). Also, they may have potential to be converted to other purposes (e.g., as leisure marinas or industrial tourism sites). Such issues are discussed in the IFC EHS Guidelines for Ports, Harbors, and Terminals.[19]

There are two main types of environmental and social impacts associated with ports and harbors that may affect the port area itself and/or the surrounding area: those arising from construction when developing or upgrading/expanding facilities; and those linked to operating the facilities.

Environmental impacts can include:

- Local air and water pollution (e.g., spillages and discharges from ships);
- Noise from ship engines and machinery used to load/unload cargo and from vehicles/trains delivering to the port;
- Underwater noise and vibration and blasting during construction;
- Dredging required to deepen access to the port and disposal of dredged materials;
- Biodiversity impacts on sensitive marine and terrestrial habitats (e.g., mangroves, seagrass, coral) and protected areas such as important bird areas (IBAs);
- Water quality impacts;
- Hydrology impacts and changes to coastal geomorphology and sedimentation dynamics;
- Waste management (ballast water, slops, wastewater, hazardous materials);
- Air pollution, such as exhausts of greenhouse gases and particles, CO_2, NO_x, and SO_2 from the ship's main and auxiliary engines, and from trains/vehicles;
- Traffic congestion in and around the port and feeder roads;
- Widespread contamination of sediments;
- Vulnerability to climate change impacts such as increased storms and sea level rise;
- Health and safety impacts during construction and operations;
- Impacts at sea due to:
    - Ships' wash;
    - Collisions between vessels and marine animals;
    - Noise from ships engines and propellors;
    - Marine accidents;
    - Anchoring and mooring.

From a social perspective, ports, harbors, and terminals can support and benefit local, regional, and national economies through their role in creating jobs and transporting goods. Their operators/owners can also partner with communities to offer workforce development programs, protect the environment, and provide coordination for land use planning to incorporate community amenities.

However, ports can also create potential challenges for near-port communities who are disproportionately impacted by port operations and related transportation systems. Construction may involve an influx of workers from elsewhere, which carries with it the potential for conflict with local communities. In addition, while ports are major economic engines for local, regional, and national economies, these economic benefits may not be equitably distributed. The near-port communities may not receive a fair share of the economic benefits that flow to the region or national economy.

Ports may also require the acquisition of land, often from nearby communities, and this must be done in a fair and equitable manner consistent with best international practices (e.g., IFC Performance

[19] IFC (2017)

Standard 5 on land acquisition and involuntary resettlement [20]). Ports can also cause conflicts with local fishing communities regarding access and landing points. Transport congestion can arise during port construction and persist throughout the life of the port.

Ports can also impact important terrestrial and marine areas important to indigenous peoples and their use of those lands. In recognition of indigenous rights and the need for respect, cooperation, partnership, and the need for establishing meaningful dialogue for better informed port decisions, the Government of Canada is amending the Canada Marine Act to recognize indigenous groups alongside port users and communities and to establish new advisory bodies and governance mechanisms to assure environmental and social sustainability of port infrastructure and operations.[21]

Where existing coal ports, harbors, and terminals are closed, this may offer opportunities to restore sites to their former ecological status. Or they may be repurposed for other commercial use or for leisure/tourism.

Closure will inevitably have impacts on the local or regional economy and on jobs and livelihoods. Repurposing may offer new economic and job opportunities, but different skills are likely to be required. In practice, port closures related to coal transport and coal mining are still in their infancy, and many new initiatives are under development to reinvent ports to become “ports of the future” and energy hubs for green hydrogen and ammonia.[22]

13.9 SUPPLY CHAINS

A supply chain is a complex logistics system that consists of facilities that convert raw materials into finished products and distribute them to end consumers or end customers. The elements of a supply chain include producers, vendors, warehouses, transportation companies, distribution centers, and retailers.

All forms of renewable energy development (including their associated infrastructure) will have their associated supply chains, which provide a wide array of equipment, materials, and services. These may include, for example, plant components, construction vehicles and fuels, construction materials (i.e., steel, sand, gravel, and cement), and machinery. Suppliers may vary from large companies to small- and medium-sized enterprises (SMEs).

At a local level, the closure of a coal-fired power plant (CFPP) or coal mine could lead to the closure of many SMEs that have been established to service the CFPP or mine or its workforce (e.g., local engineering companies, shops, food stores, local bus and taxi services, coal trucks, and barges), which will mean loss of jobs and livelihoods.

On the other hand, the rapid global expansion of new renewable energy projects will stimulate demand for materials and equipment and foster opportunities for service providers and SMEs, which will lead to an expansion of job and livelihood prospects.

One of the most contentious aspects of renewable energy development is that, combined with the transition to electric vehicle manufacturing and the expanding use of cell phones, it is driving a massive increase in the demand for metals and rare minerals (e.g., lithium, copper, cadmium, aluminum, antimony, and tellurium), most particular for the construction of wind turbines and solar panels.

A serious concern is that some mining companies are known to practice forced labor, employ children, use unsafe working conditions, and violate rights of communities (e.g., rights to land, livelihoods, ability to undertake traditional cultural practices). In some instances, this has led to

[20] Read full Performance Standard 5 here: https://www.ifc.org/en/insights-reports/2012/ifc-performance-standard-5
[21] Government of Canada (2022)
[22] Vandermeiren, J. (2022)

conflicts between mining companies and host communities.[23] Mines have also caused damage to ecosystems and created unsafe working conditions.

An OECD briefing note titled "*Responsible is Reliable*" [24] addresses critical issues related to business, human rights, and due diligence in the context of the global transition to renewable energy and electrification. The briefing identifies the following challenges and risks associated with their supply chain:

- *Geopolitical risks*: Transition minerals are not equally distributed globally, leading to concentration in a few countries. For example, the Democratic Republic of the Congo supplies 70% of cobalt, and China dominates the supply of several other minerals. This geopolitical concentration poses risks to the reliability of supply;

- *Conflict-affected and high-risk areas*: Many of these minerals are located in conflict-affected or high-risk regions where issues like corruption, security concerns, and human rights violations are prevalent. Over 70% of cobalt, graphite, and rare earth element resources are in countries perceived as corrupt;

- *Environmental and ethical concerns*: The extraction of transition minerals often has negative environmental and social impacts, including human rights abuses and environmental degradation. The report draws on the over 500 allegations of human rights abuses related to these minerals between 2010 and 2022 and registered in the 2022 Transition Minerals Tracker by the Business and Human Rights Resource Center[25];

- *Market dynamics*: The rapidly growing demand for transition minerals, combined with limited investments in mining capacity, raises concerns about potential supply-demand mismatches and price volatility.

A study by the University of Technology, Sydney[26], links the projected mineral demand at a global scale, the potential to offset demand through recycling, supply risks, and potential environmental and human rights impacts.

13.9.1 Supply chains and the circular economy

The circular economy is a framework of three principles, driven by design: eliminating waste and pollution, keeping products and materials in use, and regenerating natural systems. It is a regenerative approach to manufacturing, taking it away from the traditional, linear, wasteful, "take-make-dispose" approach. The circular economy thus emphasizes instead the sharing, leasing, reusing, part harvesting and remanufacturing, repairing, refurbishing, and recycling of existing materials and products for as long as possible. It encourages manufacturers to design products and business models with durability, repairability, and recyclability in mind. Applying circular economy principles can reduce dependency on scarce resources and component suppliers and build adaptable and resilient supply chains. For manufacturers, this means controlling the management, use, and recovery of materials and components and ensuring that parts and materials within their control never unintentionally exit their sphere of influence. By retaining control over the lifecycle of products, materials, and components, manufacturers can prevent resource loss, ensure efficient reuse, enable capitalization of circular practices, and reduce their environmental and social impact.[27]

The circular economy approach decouples economic growth from resource consumption, fostering a more sustainable and resilient supply chain.[28]

[23] Global China Unit (2024)
[24] OECD (2023)
[25] Business & Human Rights Resource Center (n.d.)
[26] Dominish E., Florin N. and Teske S. (2019)
[27] Hvid Jensen, H. (2024)
[28] Ibid

From a renewable energy perspective, this means recycling and reusing all components, such as wind turbine blades, solar panels, wiring, etc., and keeping these materials and components out of landfills, particularly in those countries where recycling facilities do not exist. Applying circular economy principles can make a vital contribution to the energy transition in three important ways[29]:

- Recycling can conserve critical minerals, reducing dependence on mining if implemented at scale. It can also help recover critical minerals from e-waste, which can be used in manufacturing components of renewable energy technology;

- Using of low-carbon, recycled materials means that there are fewer carbon emissions;

- Designing circular systems that take a life cycle approach involving recycling and reuse of materials from product design through to the end of product life, maximizing product efficiency across the entire lifecycle of usage.

In practice, an SEA will not be able to analyze and assess in any detail the risks and opportunities associated with the wide range of supply chains associated with the array of renewable energy developments likely to arise when implementing renewable energy PPPs. But an SEA should at least identify that such risks need to be recognized and make appropriate recommendations, e.g., that project developers should purchase wind turbines, solar panels, and batteries, etc. from manufacturers and suppliers that commit to responsible sourcing and oblige manufacturers to adopt a circular economy life cycle approach involving recycling, repurposing, and reuse. It will encourage more mines to engage in responsible practices and sustainability certification throughout the entire mine lifecycle.

[29] Pennington, J. (2022)

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 14

GUIDANCE FOR INSTITUTIONS

Compiled by:
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Version 1

International Association for Impact Assessment

Links to the complete guidance document and to individual chapters are also available.

CHAPTER 14

GUIDANCE FOR INSTITUTIONS

This chapter provides guidance and suggestions for those government institutions and other organizations likely to commission or undertake strategic environmental assessments (SEAs) for national energy plans, or PPPs, particularly as part of the transition away from generating power from fossil fuels to the use of renewable energy sources.

Usually, it will be national government departments (particularly those responsible for energy) that will commission or undertake such SEAs. But funding agencies (particularly multilateral development banks, or MDBs) may also carry out or fund SEAs to comply with their safeguard policies when providing financial support for national energy transition plans and programs.

Planning and delivering the energy transition will involve multiple government ministries and agencies and require the involvement of private sector energy companies and investors, as well as stakeholders and the public. This makes it a complex process with a wide array of participants with different political and economic interests, each of which has their own agendas, policies, and responsibilities. An SEA will have to navigate potentially challenging “institutional waters.” This makes it very important to establish a Steering Committee (or equivalent body) to oversee the SEA process (see below). It can act as a high-level platform or space to build support and involvement in the SEA, agree on its focus, and discuss concerns (which may be divergent) about energy transition. The Steering Committee should be established at the earliest point possible in the SEA process. Ideally, it should be chaired by the lead institutional responsible for the SEA.

One of the most important tasks of the Steering Committee is to clarify how the SEA will contribute to the decision-making process. This will inform how the PPP will be assessed and govern how it will be approved, who will be responsible for this process, and what will be the scope for considering alternatives. Building on this, the Steering Committee should ensure that the SEA feeds into this process and provides deliverables that will be carried forward by the responsible decision-makers and agencies that will implement the PPP.

14.1 A SIMPLE INTRODUCTION TO SEA

Chapter 1 provides a background to SEA and Chapter 2 sets out the key stages, tasks, and approaches. The information in these chapters and the rest of this guidance is likely to be of particular relevance and utility to SEA practitioners and reviewers. For non-technical people working in government as policy-makers and planners, who may have to be involved in commissioning an SEA for a policy, plan, or program, or may find themselves involved in an SEA process, Box 14.1 provides a short guide to SEA.

Box 14.1: A short guide to SEA

Strategic environmental assessment is now in use around the world and is a formal requirement in over 100 countries. The following is a summary of key questions that arise at the onset of SEA.

What is SEA and how is it helpful?

- ***SEA is a high-level process;*** it is undertaken for policies, plans, and programs (PPPs), not for individual projects or actions. Such PPPs can be over-arching (multi-sector), for particular sectors, or may be for particular geographic areas.

- ***SEA promotes sustainable development;*** it helps governments and others to ensure that environmental and socioeconomic concerns are considered in a balanced way when developing and implementing PPPs.

- ***SEA is a key process to address the challenges of climate change and the energy transition;*** it provides a mechanism to assess how a PPP might enhance or impede efforts to combat the challenges of climate change and ensure a just transition to a low-carbon economy.

- ***Every SEA is different***; each one needs to be tailor-made and designed to address the specific circumstances and needs. This should be made clear in the SEA terms of reference.

- ***SEA is done by experts***; it is usually undertaken by a team of experts commissioned by a government (and sometimes by a multilateral development banks or other funding agencies).

- ***SEA is a transparent and inclusive process*** that involves broad stakeholder involvement (at all levels, from national to local) throughout the process.

- ***SEA identifies issues of concern;*** the key environmental and socioeconomic issues associated with the PPP being assessed (carried out during a scoping phase), and assembles ***baseline data*** for these issues. SEA normally uses existing and available (secondary) data, but fieldwork or research may also be undertaken to collect new (primary) data.

- ***SEA identifies benefits and impacts***; it assesses both the potential environmental and socioeconomic benefits and impacts of implementing the PPP (and alternatives to the PPP). Many of the benefits and adverse impacts will have both short- and long-term cumulative effects–the collective consequence of many individual actions and development projects.

- ***SEA recommends how to deal with outcomes;*** the success of an SEA will ultimately depend upon the implementation of its recommendations in a timely manner. These are partly set out in the SEA report and more specifically in a management plan (strategic environmental and social management plan, or SESMP) that recommends how to enhance potential benefits, avoid or mitigate adverse impacts, and make restorations (where possible and appropriate). It also details who needs to do what to implement the SEA recommendations and undertake monitoring and follow-up.

- ***SEA provides critical information*** to policymakers, planners, and decision-takers at key stages of developing policies, plans, and programs. Ideally, the SEA process should be initiated upstream at the inception of developing or revising a PPP, and implementation of the SESMP should follow through during policy implementation.

When to start SEA?

Some countries have little experience with SEA and may ask how best to introduce SEA (whether formally or informally) and "make a start," particularly for the energy sector. In this situation, it is better to be selective and start with one or a limited number of SEAs. Annex 27 discusses how to select relevant planning exercises.

How long does it take?

Usually, an SEA will take between 6 and 12 months to complete, but sometimes longer if seasonal considerations need to be addressed and it is closely integrated with a PPP process with a longer development timetable.

Cost

The cost will vary due to the length of the process and the complexity of the chosen design: from as little as USD $20,000 to 50,000 (e.g., for a rapid (two to three month), desk-based SEA) to USD $1 to 2 million (for a full SEA of a complex PPP over say an entire year).

14.2 ALL INSTITUTIONS

The following considerations apply to all institutions involved in the SEA process:

- Follow the suggested contents provided in Annex 2 when preparing ***terms of reference*** for SEAs for PPPs concerned with energy transition and renewable energy sub-sectors.

- Engage with the SEA expert team to understand any concerns or uncertainties they may have regarding the ***terms of reference*** for the SEA and clarify (modify if necessary) the terms of reference. Key discussions will be required regarding timelines and costs.

- Ensure that the terms of reference clearly set out the ***SEA process*** to be followed (having regard to the steps discussed in Chapter 3) and provide for an ***appropriate timeframe***. A short timeframe for the SEA will limit its ability to be useful and contribute effectively to decision-making. It may also prevent adequate scoping and a meaningful assessment of the likely environmental and socioeconomic impacts of the PPP and its alternatives. It will also restrict the level of stakeholder participation and affect their confidence in the SEA process. As a rule of thumb, an SEA for renewable energy is likely to require 6-12 months to undertake, assuming it is based on existing and available (secondary) data. If new data needs to be gathered or further research needs to be undertaken, a longer timeframe will be required.

- When appointing consultants, it is advisable that the team be predominantly composed of ***experts from the country concerned***. Only such experts will have thorough experience and understanding of the national and more local environment and socioeconomic issues, and familiarity with national cultural norms.

- In countries where SEA experience is limited or practice is still in its infancy, it may be necessary to engage very experienced ***international consultants*** who have knowledge of the SEA process, and preferably of the local setting. Such international consultants should be able to demonstrate SEA work experience and knowledge of the country or region concerned. They will also be available to advise and, if necessary, help coordinate the national consultant team.

- It is advisable to establish a ***Steering Committee*** (or equivalent body) to lead and direct the SEA. It should comprise representatives from key government ministries or agencies, the private sector involved in energy development, and civil society (e.g., NGOs, CSOs, trade unions, academics, etc.). Funding agencies supporting the SEA (e.g., MDBs) should also be represented. Such a Steering Committee should be limited in number (e.g., 15-20 individuals) so that it can operate effectively.

  Its main role will be to oversee and smooth the way for the SEA process and ensure that it is coordinated with the relevant decision-making process. It should also provide guidance where required, provide a standing platform for high-level stakeholder interaction and consensus-building, and advocate for support for the process. The Steering Committee should be convened by the responsible government agency initiating the SEA. An appropriate Chairperson will be required. It will also be important to identify a key “point of contact” (e.g., the Chairperson or official Convenor) for the SEA team to interact with, as necessary. The Steering Committee should coordinate the stakeholder engagement process together with the SEA consultant. Minutes of all Steering Committee meetings should be kept.

- Ensure that the critical steps in developing and approving the PPP are identified at an early stage and communicated to the SEA consultants so that they can design the SEA process to ensure that ***critical information from the SEA*** is delivered to the PPP process at the most appropriate time and to the relevant individuals/agencies responsible for PPP decision-making.

- ***Stakeholder engagement*** is critical to ensuring that an SEA addresses all legitimate concerns. It is also vital to ensure support for the goals of the PPP concerned and to enhance its successful implementation. The terms of reference should set out the minimum requirements for stakeholder engagement at national to local levels. The consultants should develop a stakeholder engagement plan as soon as possible and discuss this with the client. Stakeholder engagement should begin early and continue throughout the SEA process. It will be very important to elicit feedback from stakeholders regarding key aspects of the SEA (e.g., focus and key issues to be addressed, findings) and respond to all comments and concerns to garner trust from all participants and to ensure that all voices are heard and listened to.

- Ensure that relevant ***baseline environmental and socioeconomic data sets and legal, governance, and institutional information sources*** for the SEA are readily available to the SEA team.

- Require that the SEA team engages with the client and other agencies likely to have a role in ***implementing the Strategic Environmental and Social Management Plan*** (SESMP) when preparing its contents. Agreement/consensus should be sought on: what plan components are realistic and able to be undertaken; how it will be funded; roles, responsibilities, and recommendations for implementation, particularly as regards monitoring functions. In this way, the SESMP will be designed and "owned" by its likely implementers rather than being a mere proposal of the consultant team.

- The SESMP should indicate the frequency for ***monitoring and follow-up*** of implementation of SESA recommendations. Some indicators may require regular and frequent monitoring (e.g., quarterly); others might need less frequent monitoring (e.g., annual or biannual). The selection of these indicators is important and must be done carefully to ensure the successful measuring of SEA recommendations. Monitoring is fundamental to signaling where corrective actions are required.

- Depending on the capacity of the implementing institution, a third-party consultant may be hired to serve as a ***SESMP Management Office*** (SMO) to help set up the implementation framework and to train and develop the capacity of the responsible government institution and prepare them as to how the SEA actions should be achieved.

14.3 GOVERNMENT INSTITUTIONS

The following considerations apply to government institutions involved in the SEA process:

- Check ***with national legislation and regulations*** to determine if they require that an SEA be undertaken for a national energy plan or PPP for a renewable energy sub-sector. If so, ensure that the terms of reference for the SEA comply with all stipulated requirements.

- Ensure that all ***relevant ministries, departments, and/or agencies*** are aware of the SEA process and can engage with it. An SEA for renewable energy PPPs will likely identify issues and challenges for a range of other sectors (e.g., economy, transport, labor, health, etc.), which will have to be considered. These agencies may also have key roles to play in implementing a SESMP (including monitoring functions). So, their involvement throughout the process is advisable.

- Because many government institutions operate in a siloed fashion without mechanisms in place for effective inter-institutional coordination and cooperation, it will be important to set up a multi-stakeholder SEA Steering Committee with the responsibilities described above. This should be coordinated by the agency or institution responsible for the SEA.

- Ensure that the SEA is tiered, with and guides subsequent project-level ***environmental and social impact assessments (ESIAs)*** carried out for individual projects and assets when the PPP is implemented. Reference to the SEA and its key findings should be made in the terms of reference for the preparation of project-level ESIAs. Ideally, the SEA should be prepared well in advance of project-level ESIA, but in practice, this rarely happens.

14.4 FUNDING AGENCIES

The following considerations apply to funding agencies involved in the SEA process:

- Check what requirements there may be for an SEA to be undertaken under national legislation or regulations. Ensure that the terms of reference comply with any such national requirements.
- Determine what the funding agency's own requirements and procedures are for conducting or supporting an SEA.
- Engage with the government body having jurisdiction over any national legal or regulatory requirements for SEA and ensure that the terms of reference are acceptable to the government (or are jointly developed).
- Determine if other funding organizations are also engaged in supporting renewable energy development or supporting the energy transition in the country. They may also have safeguard requirements that an SEA be undertaken. Ensure that a single SEA is carried out that is acceptable to all interested parties and secure agreement on its terms of reference. This will likely involve the coordination of multiple funding agencies.
- Ensure that adequate funds are provided for completing the SEA. This should include both funds for the SEA consultants and the stakeholder consultation process. Potential funding of SESMP implementation post-submission of the SEA report should also be considered.
- Ensure that consultation requirements comply with lender safeguard requirements. Often, national requirements for consultation in the SEA do not meet what funding agencies require. Consultation should start as early as possible in the SEA process and continue throughout its duration.
- Ensure that reporting requirements and responsibility for review, editing, and approval of SEA recommendations are clearly defined with the SEA consultant, including timelines for both delivery and review of reports.

14.5 RENEWABLE ENERGY DEVELOPERS

Institutions and funding agencies may interact with private sector renewable energy proponents during the course of SEA execution. The following are some considerations as to how they should be engaged.

- Normally, developers of individual renewable energy projects are not involved in the preparation of an SEA. However, the recommendations of an SEA will be of great interest to developers by providing a reference framework as to how renewable sector energy development will occur.
- The private sector often forms an important group of stakeholders, and renewable energy developers should seek to be part of the consultation process.
- Similarly, developers may also wish to be involved in the review of the draft SEA and offer comments and suggestions that may be relevant to their individual project(s).
- Developers may also wish to seek representation on an SEA steering committee to be informed of policy or planning decisions that might affect renewable energy sub-sector development, including how individual planned or future projects might be affected.

14.6 STAKEHOLDER ENGAGEMENT

Reference can be made to Chapter 2 concerning how stakeholder engagement should be carried out. A key issue is that stakeholders should include all those with a legitimate interest in the energy transition PPP and SEA, whether they are likely to be directly or indirectly affected by its implementation. A stakeholder engagement plan should be prepared to ensure that an adequate and representative suite of events is organized at all levels: national, sub-national (e.g., relevant regions, provinces, and districts), and local (e.g., communities), as well as for interest groups (e.g., farmers, fisherfolk, Indigenous Peoples, resource users, coal plant and mine workers, etc.). Stakeholder consultations should not be focused just at the national level. This will alienate many people and miss key concerns and information. It is important that the consultation budget consider this multi-level requirement for consultation. Often it does not.

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

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ANNEXES

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ANNEX 1

Tools for stakeholder engagement and consultation

Source: UNECE and REC (2011)

These following approaches are described below

- Printed material inviting comments
- Displays and Exhibits
- Information hotline/ Staffed telephone lines
- Internet/Web-based consultations
- Questionnaires and Response Sheets
- Surveys
- Public Hearings
- Workshops
- Advisory Committee

Public participation method	***Enables …***			***Key features***		
	Provision of information	Gathering of comments	Collaborative problem solving	Usual cost of application	Problem-solving ability	Ease of commenting
Range of printed material inviting comments	✓	✓		$		😐
Displays and Exhibits	✓	✓		$		😐
Staffed displays and exhibits	✓	✓	✓	$$	○	☺
Information hotline	✓	✓		$		☺
Internet/web-based consultations	✓	✓	✓	$	○	😐
Questionnaires and response sheets		✓		$$		☺
Surveys		✓		$$		☺
Public hearings	✓	✓		$		😐
Workshops	✓	✓	✓	$	○○	☺
Advisory committee	✓	✓	✓	$	○○	☺

Key:		
Enables	✓	Yes
Usual cost of application	$	Lower
	$$	Higher
Problem-solving ability	○	Low
	○○	High
Ease of commenting	😐	Moderate
	☺	High

Table A1. Data on SEA Protocol Application
Source: UNECE and REC (2011)

Method: Printed material inviting comments	
Description	• Printed materials are the easiest ways to publicize and provide information on a draft plan or program and the SEA, or to publicize a participation process. Popular forms of the printed materials include: fact sheets, flyers, newsletters, brochures, issues papers, reports, and surveys, etc. These can be single purpose or produced as a series (e.g., newsletters). Printed material can be handed out, made available to be picked up, or mailed out either directly to a select mailing list, or included as 'bill stuffers' with regular mail outs such as utility bills, rates notice, or other regularly posted bills. • Printed materials aim to provide easily read information in words and drawings, to inform a wide range of stakeholders about the plan- or program-making and assessment processes or documents. • Printed material, whether handed out, dropped into letterboxes, distributed by mail, or mailed out with other material, is one of the easiest and most familiar methods for increasing awareness of an issue and soliciting responses to an issue or proposal. • Available budget, and the use of other publicity methods and tools will determine just what type of printed material will best suit your need.
Advantages	• Printed materials can reach a large number of people through mailing or via free display. • Information material with comment sheets or questionnaires facilitates feedback. • Can facilitate the public participation process. • Printed information can be a low-cost publicity means that is easily handed out and carried away. • Can be economically distributed by doubling up with existing mailing lists. • Can reach a wide audience or be targeted towards particular groups.
Disadvantages	• The problem with most printed materials is the limited space available to communicate complicated concepts. • Needs time to design, prepare text, visuals, proofread, print, and fold. • There is no guarantee that the materials will be read – may be treated as junk mail. • If mailed, the guarantee of being read is only as good as the mailing list itself; mailing lists need regular updating. • Appearance of the material should be visually interesting but should avoid a 'sales' look. • Can be lost if included with many other flyers and bill stuffers (consider using colored paper and bold headlines if mailing as a bill stuffer, to ensure this is not just binned without reading). • Can exclude those who are not print literate unless visual elements are used. • Information may not be readily understood and may be misinterpreted.
Examples of sources of information	International Association for Public Participation (2000) IAP2 Public Participation Toolbox, available at http://www.iap2/practitionertools/index.html/

<table>
<tr><th colspan="2">Method: Displays and Exhibits</th></tr>
<tr><td>Description</td><td>These tools are events that are intended to provide project information and raise awareness about particular issues. Displays can be interactive, and can be used as part of a forum, workshop, exhibition, conference, or other event. Displays and exhibits can include feedback opportunities such as blank sheets with one-line questions, and can include drawings, models, maps, posters, or other visual and audio representations illustrating an event, proposal, or issue. Interactive displays can include 'post-it' idea boards, maps and flipcharts or blank posters for comments and questions.

Displays and exhibits develop more concrete concepts of proposals or developments, and, where they offer options for interaction, gather public opinions and feedback that can be incorporated into the plan- or program-making and assessment processes.

Key issues to consider before, and the main steps to prepare for and carry out the methods, include:
Select a date and venue that will encourage the greatest number of participants to attend (generally weekends or public holidays/shopping centers/public spaces).
Arrange for a number of displays/exhibits to give details of the event/issue.
Place the display/exhibit in a well-populated public space where those most affected by the issue/event are likely to pass by.
Advertise and publicize the event with emphasis on the issue to be considered.
Advertise times when display/exhibit will be open.
Allow adequate time for setting up.
Provide adequate staffing and consider the employment of volunteers, security, and insurance issues.
Provide coordinators to facilitate participation and answer questions.
Collate feedback and publish results.</td></tr>
<tr><td>Advantages</td><td>The tool focuses public attention on an issue.
It can create interest from media and lead to increased coverage of the issue.
Allows for different levels of information sharing.
Provides a snapshot of opinions and community issues based on feedback.
People can view the displays at a convenient time and at their leisure.
Graphic representations, if used, can help people visualize proposals.</td></tr>
<tr><td>Disadvantages</td><td>The tool needs a facilitator to encourage involvement and written feedback.
Information may not be fully understood or misinterpreted if no staff provided to respond to questions or receive comments.
Public must be motivated to attend.
Can damage the proposals reputation if done unprofessionally.</td></tr>
<tr><td>Examples of practical application or key sources of further information</td><td>The Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Australia) http://www.coastal.crc.org.au/toolbox/alpha-list.asp

International Association for Public Participation (2000) IAP2 Public Participation Toolbox. http://www.iap2.org/associations/4748/files/toolbox.pdf

US Dept of Transportation (1997) Public Involvement and Techniques for Transportation Decision-Making: Transportation Fair. Washington, (accessed 12/12/02) http://www.fhwa.dot.gov/reports/pittd/tranfair.htm

Wates, N. (1999) The Community Planning Handbook. London, Earthscan.</td></tr>
</table>

Method: Information hotline/staffed telephone lines	
Description	An Information Hotline offers pre-recorded information on the planning document or an issue via the telephone and/or access to SEA and planning team members who can answer questions or provide additional information and assistance. It aims to deliver accurate, consistent information over the telephone to those who wish to know about an issue or who can provide additional information. Staffed telephone lines can serve as a link between the public and the developer during the duration of the plan or program making and assessment, making the public feel involved. Key steps in application: • Determine the information to be recorded and timetable of updates. • Advertise the phone number, e.g., via stationery and flyers printed, or a sticker e.g., on outgoing printed correspondence or promotional material. • Advertise the number in the media, and ensure it is on all your outreach material. • Set up a hotline number for callers by recording message and hooking up to the phone line. Record information that will answer the most commonly asked questions. • If staffed phone line is used, assign the person to answer the calls. The person assigned to provide information has to be briefed and trained, and has to have a pleasant telephone manner, even with difficult callers. • Set up a toll-free number for non-local callers. • In case of pre-recorded Information Hotline, offer the option of being put through to a specific person for more details. • Record calls/common complaints/concerns in telephone journal for your records and input to the participation/consultation process.
Advantages	• An Information Hotline offers an inexpensive and simple device that can ensure fast, easy, and efficient information dissemination. • Provides a one-stop service to the public to access information about the planning activity. Can describe ways the public can get information and provide feedback. • Offers a reasonably low-cost for set up and updates. • Portrays an image of "accessibility" for an organization, developer, or the SEA team. • A convenient way of receiving comments from interested parties. Not intimidating, easy for people to participate and provide comments. Promotes a feeling of accessibility.
Disadvantages	• Must be adequately advertised to be successful. • If staffed, can be time consuming and limit staff member to perform other tasks. • Designated contact must have sufficient knowledge of the activity to be able to answer questions quickly, accurately, and professionally.
Examples of practical application or key sources of further information	Department of Public Health (Flinders University) and South Australian Community Health Research Unit. (2000) *Improving Health Services through Consumer Participation - A Resource Guide for Organisations*. Commonwealth Department of Health and Aged Care. Canberra. Available at http://www.participateinhealth.org.au/how/practical_tools.htm. RCRA. 1996. *Public Participation Manual*. Ch 5: Public participation activities. http://www.epa.gov/epaoswer/hazwaste/permit/pubpart/chp_5.pdf. US EPA (2002) *National Pollution Elimination System (NPDES) Public Involvement/Participation Hotlines*. (Accessed 11/12/02) http://cfpub.epa.gov/npdes/stormwater/menuofbmps/invol_3.cfm

Method: Internet/Web-based consultations	
Description	The tool typically comprises a website on the Internet. It is used to provide information or invite feedback. Care should be taken to keep the information up to date. More interactive forms of participation on the Internet may also be developed, e.g., online forums and discussion groups. Technically, the potential tools for Internet-based consultations can be: • HTML web pages with links to documents, pictures, and graphics (moving or still) and sound. • Dedicated email address to which non-structured submissions can be sent. • Survey forms that elicit community response on particular issues (HTML or PDF to be faxed/mailed back). • Moderated bulletin boards that allow "threaded" discussions about a range of issues. • Virtual meetings using a chat room facility on specific topics. • Web-casting (i.e., audio, and visual broadcasting via the web) of meetings and events. The Internet can enhance traditional techniques but it cannot replace them. The purpose of the website should be clearly articulated and information should be accurate and timely. The resource implications of maintaining the site need to be carefully assessed and budgeted for before it is established. It should be decided whether the management of the website will be done in-house or outsourced, what web-based tools to be used, and what staff training is needed.
Advantages	• The most straightforward and inexpensive, resource-efficient technique to present and distribute information to those that have Internet access. • The audience is potentially global. • Costs are reduced as no printing or postage costs are incurred. • Has a possibility to provide timely and accurate information about and a historical record of the planning, assessment, and consultation processes. • It is a way to invite stakeholders to comment on the specific proposals and a means of receiving feedback. • An interactive medium allowing discussion and debate.
Disadvantages	• There are significant resource implications in setting up a new website. • The responses can be difficult to analyze if questions are open-ended. • Because not all stakeholders will have access to the Internet, it cannot be used to replace the traditional means of consultation – alternative means of information dissemination will also be required.
Examples of practical application or key sources of further information	iPlan initiative in New South Wales (Australia), http://www.iplan.nsw.gov.au/engagement/techniques/website.jsp

Method: Questionnaires and Response Sheets	
Description	Questionnaires are a basic tool used to collect information and are usually developed and tested to ensure that they are easily understood. Questionnaires ensure that exactly the same questions are presented to each person surveyed, and this helps with the reliability of the results. Questionnaires can be delivered via face-to-face interviews, telephone interviews, self-completed forms, mailouts, or online. Questionnaires can be distributed by email as well as posted or faxed. Response sheets can be collected at a workshop or can be picked up at a workshop and mailed back. These can also be mailed out in ways that reduce postage costs when they are included in routine mail-outs, such as the distribution of fact sheets or accounts. • Questionnaire preparation steps: • Draft questions. Keep as short as possible. • Test questions with a small pilot group to determine whether they are unbiased, straightforward, and not open to misinterpretation. The wording of questions has to be clear to avoid bias. • Indicate the purpose of the questionnaire at the outset. • Include qualitative data such as age, sex, address, education, etc. to allow for further extrapolation of the results and/or inclusion into the mailing list. • Send out questionnaires. If mailed and if the budget allows, provide free mail reply (stamped addressed envelope; freepost mailbox, etc.) to improve responses. • Document and publicize the responses.
Advantages	• Less personal if interviews or telephone surveys are not used, but anonymity can encourage more honest answers. • Useful to generate both qualitative and quantitative data. • Works well to reach respondents who live in a large area. • Provides information from those unlikely to attend meetings and workshops. • Permits expansion of the mail list. • Can be used for statistical validation. • Allows results to be extrapolated by subgroups. • Allows the respondent to fill out at a convenient time. • More economical and less labor intensive than interviews and telephone surveys as they provide larger samples for lower total costs.
Disadvantages	• Low response rates can bias the results. • Needs a return envelope/freepost address to encourage participation. • Depends on a high degree of literacy.
Examples of practical application or key sources of further information	US Department of transport (2002) *Public Involvement Techniques for Transportation Decision-Making* (accessed 13/12/02) http://ntl.bts.gov/DOCS/pubinvol.html

Method: Surveys	
Description	Surveys are a method used to collect information from a specific population. They can be used to collect broad general information from or about a large audience or specific information from target groups. Surveys can seek information that can be quantitative (facts and figures) and/or qualitative (opinions and values). Surveys use questionnaires to collect information, and these can be delivered through face-to-face interviews, self-completed written forms, telephone surveys, or electronic surveys (see also Questionnaires and Response Sheets). For a well-conducted survey using a large, random sample, surveys are usually high cost. Small-scale surveys using opportunistic sampling and volunteers can be relatively low-cost but may not produce results that can be generalized beyond a specific group of people. Surveys are designed to collect information in relation to a particular issue or planning document. The results of the surveys provide information about the demographics and/or opinions of a specific group of people. Relevant steps in designing and carrying out a survey: 1. Find out what is already known and what relevant surveys are being done or planned elsewhere in order to avoid duplication, and define the scope of the survey. 2. Talk to the developer and relevant authorities to focus the questions. 3. Determine the way the information will be obtained (see Questionnaires and Response Sheets). 4. Select your target audience. How will you sample them? How will you ensure that your survey gives a representation of the ideas of the group? 5. Pilot test the survey to ensure the readability and clarity of questions. 6. Carry out the survey. 7. Collate and analyze the results; prepare a report. 8. Make the report available to those surveyed, to appropriate authorities, and to the media.
Advantages	• Provides traceable data. • Surveys can serve an awareness-raising purpose. • When properly constructed, it can reach a broad, representative public or targeted group. • Can derive varied information from the results.
Disadvantages	• Poorly constructed surveys produce poor results. • Can be expensive if surveying a large audience. • Care must be taken that the wording of questions is unambiguous to prevent skewed results. • Care is needed in sampling to make sure representative samples are taken. • Surveys with tick boxes are the fastest and easiest to process; however, this limits the detail in the information collected.
Examples of practical application or key sources of further information	COSLA. (1998). *Focusing on Citizens: A Guide to Approaches and Methods*. Available at: http://www.communityplanning.org.uk/documents/Engagingcommunitiesmethods.pdf RCRA. (1996). *Public Participation Manual*. Ch 5: Public participation activities. http://www.epa.gov/epaoswer/hazwaste/permit/pubpart/chp_5.pdf US Department of Transportation (1996) *Public Involvement Techniques for Transportation Decision-Making* (13/12/02) http://www.fhwa.dot.gov/reports/pittd/surveys.htm

Method: Public Hearings	
Description	Public hearings are a formal way of presenting and exchanging information and views on a proposal. Formal public hearings generally tend to be best used in conjunction with more informal methods of engagement, such as informal meetings and facilitation. http://www.iplan.nsw.gov.au/engagement/techniques/publichearing.jsp - top#top Important points to consider before organizing the event: • Clearly describe the purpose of the public meeting and the issue to be considered. • Describe where in the spectrum the public hearing sits. Be particularly clear about the extent to which input provided could influence the outcome of the process. • Decide whether a public hearing is appropriate when you receive a request for one. • Advertise the public hearing by public notice. • Send the notice to each person who requested a public hearing. • Carefully schedule presentations by interested parties and ensure presenters can speak for their allotted time without interruption. • Prepare a report or record of the public hearing and make it public.
Advantages	• During such events, the public is allowed, by prior arrangement, to speak without rebuttal. • Available evidence can be worked through systematically. • Comments received are recorded and made public. • If the event is run well, it can provide a useful way of meeting other stakeholders. • Demonstrates that the responsible authority is open to all interested parties for consultations and information exchange. During such events, the public is allowed, by prior arrangement, to speak without rebuttal. • Available evidence can be worked through systematically. • Comments received are recorded and made public. • If the event is run well, it can provide a useful way of meeting other stakeholders. • Demonstrates that the responsible authority is open to all interested parties for consultations and information exchange.
Disadvantages	• It does not foster dialogue. • An adversarial mood can be created. • Public meetings can be intimidating and may be hijacked by interest groups or vocal individuals. • Minority groups and those who do not like to speak in public are not easily included. • While appearing simple, it can be one of the most complex and unpredictable methods. • May result in no consultation only information provision.
Examples of practical application or key sources of further information	

Method: Workshops	
Description	A workshop is a structured forum where participants are invited to work together in a group (or groups) on an assessment of an issue or an SEA step. The goals of a workshop are to bring participants together in a structured environment (that is, through large and small group activities, discussions, and reflection) to resolve issues and build consensus on the assessment, rather than provide information and answer questions. Alternatively, workshops can be organized to target representatives from a particular stakeholder group, e.g., NGOs, or experts of one area. Workshops require a facilitator who is able to engage all participants in the discussion; therefore, they are participatory tools that are best used with smaller numbers of participants. A variety of tools can be used within a workshop. These include many of the tools listed in this toolbox (see the CRC reference below), e.g., focus groups and/or visioning. A report has to be prepared as on the outcome of the workshop, recording opinions, suggestions, or conclusions that have been collaboratively developed and agreed to by all participants on an issue or proposal.
Advantages	• Excellent for discussion on criteria or analysis of alternatives. • Fosters small group or one-on-one communication. • Offers a choice of team members to answer difficult questions. • Builds ownership and credibility for the outcomes. • Maximizes feedback obtained from participants. • Ability to draw on other team members to answer difficult questions. • Maximized feedback obtained from participants. • Fosters public ownership in solving the problem (see IAP2 reference below). • Can provide a more open exchange of ideas and facilitate mutual understanding. • Useful for dealing with complex, technical issues and allowing more in-depth consideration. • Can be targeted at particular stakeholder groups.
Disadvantages	• Hostile participants may resist what they may perceive as the “divide and conquer” strategy of breaking into small groups. • Facilitators need to know how they will use the public input before they begin the workshop. • Several small group facilitators are usually needed (IAP2). • To be most effective, only a small number of individuals can participate; therefore, a full range of interests is not represented.
Examples of practical application or key sources of further information	Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (the Coastal CRC) http://www.coastal.crc.org.au/toolbox/alpha-list.asp (Australia) IAP2 – The International Association for Public Participation: http://www.iap2.org/ Ontario Public Consultation Guide 1994, www.ene.gov.on.ca/envision/gp/H5.pdf (Canada)

Method: Advisory Committee	
Description	Advisory committees generally comprise expert groups and governmental or non-governmental institutions with expertise in a specific field or interest in the draft plan or program. In a consultation process, they can offer advice on appropriate changes to a plan or program or recommend the introduction of specific measures. Although similar to task forces, advisory committees function as an ongoing structure, while task forces tend to be formed on a short-term basis to focus specifically on the development of a particular proposal. Advisory committees are particularly useful for involving community representatives, especially those with the necessary expertise, in complex, controversial, or significant plan- or program-making and assessment processes. Committees are not lobby groups; they have an important public function beyond individual members' own interests. Committees are more effective if their roles and tasks are clearly established before deciding on membership. Additionally, selection criteria for membership should be established. Time and resources must be committed to supporting the committee throughout the life of the project or the committee. The committee must be informed of progress, consultation results, developer and decision-maker conclusions, as well as any policy changes or emerging issues that will influence the committee's advice or role.
Advantages	• Advisory committees offer additional advice and guidance. • They can help to reduce criticism from interest groups. • They demonstrate a commitment to participatory engagement and suggest to the stakeholders that they will be able to influence decisions and outcomes within certain boundaries.
Disadvantages	• Manage conflicts of interest that may occur during the life of the committee. • May be time- and resource-consuming. Care needs to be taken to establish, manage, and monitor their ongoing operation. • Where there are divergent views or where members have unequal status, knowledge, or expertise, facilitation may be needed.
Examples of practical application or key sources of further information	Steering group for SEA of Scottish Marine Renewables (see http://www.seaenergyscotland.co.uk)

ANNEX 2

Outline for setting terms of reference for an SEA

This outline aims to assist a proponent in preparing the Terms of Reference (TOR) for a Strategic Environmental Assessment (SEA) in cases where they intend to engage consultants to undertake the SEA.

Terms of reference need to be thorough and clear. Research shows that many SEAs are unsatisfactory because they fail to follow basic principles and good practices. This outline aims to assist a proponent in preparing the Terms of Reference (TOR) for a Strategic Environmental Assessment (SEA) in cases where they intend to engage consultants to undertake the SEA.

Terms of reference need to be thorough and clear. Research shows that many SEAs are unsatisfactory because they fail to follow basic principles and good practice for SEA. In part, the reason for this is the setting of poor Terms of Reference (TOR) by the PPP proponent—often because they have limited knowledge or experience of the role and nature of an SEA.

Below are suggested generic contents for a Terms of Reference (TOR) for an SEA. They will need to be customized in every case to fit the context and focus of the specific PPP concerned. for SEA. In part, the reason for this is the setting of poor Terms of Reference (TOR) by the PPP proponent—often because they have limited knowledge or experience of the role and nature of an SEA.

Below are suggested generic contents for a Terms of Reference (TOR) for an SEA. They will need to be customized in every case to fit the context and focus of the specific PPP concerned.

List of acronyms

1. Introduction

Provide a background to the SEA:

- Indicate for what policy, plan, or program (PPP) it is to be undertaken, and why;
- Summarize the national legal, regulatory, and guideline requirements for SEA in the relevant country, along with any requirements (e.g., safeguards) imposed by organizations (e.g., MDBs) providing funding for the SEA, and emphasize the necessity to comply with these requirements.

2. Follow international principles for an SEA

Indicate that the SEA should follow international principles and good practice for SEA as set out in OECD Guidance for SEA (OECD DAC 2006) and the International Association for Impact Assessment (IAIA) SEA Guidance for the Energy Transition (IAIA 2024).

3. Description of the PPP

Describe the focus and aims of the PPP, why it is being promulgated, and what it seeks to achieve.

4. Key treaties, accords and policies, plans and proposals to be considered, and useful reports to be consulted

List those that are particularly relevant to the focus of the PPP and SEA under the following categories to guide the SEA team to important framework commitments:

- International treaties and accords/conventions (those ratified by the country and others that may be relevant);
- Legislation and national-level strategies and policies;
- Other useful reports and studies, including relevant Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) reports.

5. Aims of the SEA

Set out the specific aims of the SEA under the following headings:

5.1 Technical aims

- To provide a thorough ***review and assessment of the direct, indirect, and cumulative impacts*** (positive and negative) as well as any transboundary impacts of the PPP and development activities, projects, and initiatives that may arise during its implementation. Such assessment should address impacts of different alternatives (including scenarios) to the PPP (see below).

- Identify impacts on national ***sustainable development objectives*** (local, regional, national) or on achieving the UN Sustainable Development Goals.

- Identify ***synergies*** (and how these can be enhanced) and ***conflicts/antagonisms*** (and how these can be minimized, avoided, or mitigated) between project types or development activities likely to arise from PPP implementation.

- Generate development scenarios (to be identified and agreed upon during scoping). These may represent development meta-alternatives that examine how the PPP—and any downstream projects or activities that may arise during implementation—could unfold over the short, medium, and long term, as well as in different combinations under alternative rollout situations (e.g., business-as-usual, low economic growth, moderate growth, and high growth), along with their consequent meta-level impacts.

- Identify where ***EIAs*** (addressing both environmental and social concerns) may need to be undertaken for particular types of downstream projects/activities likely to arise during PPP implementation and recommend key issues that should be addressed by such EIAs.

- Identify issues that will need to be addressed when preparing a ***Strategic Environmental and Social Management Plan (SESMP)*** for the PPP.

- Prepare required reports; these should include a ***scoping report***, an ***interim SEA report*** covering the assessment of an alternative, the ***SEA report*** (focusing on the preferred alternative), and an associated ***Strategic Environmental and Social Management Plan*** (SESMP) for the PPP. Both draft and final reports will be required.

Indicate that the SEA report should present baseline information, assessments, analysis, and information in a way that is relevant, understandable, and readily usable by policymakers, planners, and decision-makers. The SEA team should liaise directly with the PPP proponent and with the government agency with regulatory responsibility for environmental assessment on the most appropriate format for presenting such information (note: information presentation is likely to require a mix of text, maps, tables, figures, and photographs and could be organized on a GIS basis).

5.2 Capacity building objectives

Indicate whether the country is still building its experience and skill base in SEA. In this regard, the proponent may wish to consider combining the technical assessment functions of the SEA with a capacity-building component to benefit both selected government officials and national environmental/social consultants, as well as recent graduates. This approach could provide opportunities for these individuals to gain on-the-job SEA experience at different stages of the SEA process—working alongside SEA team members, being tutored by them, and undertaking appropriate technical tasks. Additionally, training courses or exercises could be conducted for specific government agencies and other interested stakeholders on SEA in general, specific steps or stages of an SEA, and/or particular methodologies used.

The proponent may wish to indicate that it intends to second one or more government officers (e.g., from the government department or agency responsible for environmental assessment) as adjunct members of the SEA expert team (either full-time or part-time). This approach would enable them to be embedded in the process, gain operational experience in undertaking an SEA, and help increase government "ownership" of the recommendations.

An SEA does not end once the SEA and SESMP reports are submitted. Implementation of the recommendations follows and will likely continue over years. In some countries, those government agencies with roles and responsibilities to implement the actions recommended in a SESMP will require a degree of guidance and support to interpret the findings of an SEA and to both understand and carry out the tasks and roles assigned to them. Thus, the proponent may wish to frame the TOR to include the provision of "follow-up" support to assist the government agencies involved to prepare for and undertake their responsibilities for the recommended management actions.

6. Boundaries of the SEA

Indicate the geographical boundary or extent of the SEA, e.g., national, sector, region, district, catchment, protected area, cross-border, etc., and provide a map where appropriate.

7. Role of Steering Committee or other bodies

Indicate what role particular bodies will have in overseeing, guiding, or evaluating the SEA. It is often advisable to establish an SEA Steering Committee comprising of key government ministries and departments (preferably with representation of other stakeholders).

8. Scope of work to be carried out

Provide a general overview of the scope of the work to be undertaken by the SEA. Indicate what reports should be produced. Also indicate that recommendations should be made in a Strategic Environmental and Social Management Plan (SESMP) on how to mitigate negative environmental and social impacts and how to enhance positive ones. (See Annex 16 for list of issues covered by an SESMP.)

Indicate that these should address environmental and social impacts arising as a result of (a) implementing the PPP itself (mainly through projects/initiatives) and (b) indicate impacts that are likely to be due to developments that are "external" to the PPP—these might arise from other PPPs and might be regional, national, or international in origin (i.e., the bigger picture).

9. Major tasks to be undertaken

9.1 Inception report

Indicate that, following appointment, the SEA team should prepare an Inception Report for the SEA within a prescribed time period (usually within 4 weeks of taking up the assignment), setting out the background, their approach to the SEA to comply with the TOR, the steps to be followed, methods to be used, and providing a provisional timeline.

This Inception Report should indicate what overall approach will be followed for the SEA: impacts-led, objectives-led, or both.

9.2 Stakeholder analysis and action plan

- Indicate that the SEA team should undertake a comprehensive stakeholder mapping covering:
- Primary stakeholders: those ultimately likely to be affected, either positively or negatively, by the PPP and projects/initiatives arising during its implementation;

- Secondary stakeholders: the "intermediaries"—those persons or organizations who are indirectly affected by the PPP and projects/initiatives arising during implementation;
- Key stakeholders (who can also belong to the first two groups): those persons or organizations that have significant influence upon or importance related to the PPP and/or to projects/initiatives likely to arise during implementation or play key roles within organizations.

The SEA team should prepare a ***stakeholder participation and disclosure plan*** to set out the roles and responsibilities of different stakeholders in the SEA process, indicating when and how they can engage, e.g., through providing information or views, engaging in workshops, meetings, focus sessions, interviews, dialogues, etc., responding to questionnaires, participating in phone-ins or web-based information access/provision, etc. Participation should be a continuous process throughout the SEA but, usually, should be conducted in two main phases:

(a) *During scoping*—on an extensive basis at national, regional, and local levels—to:
  - Explain the purpose, role, and steps of the SESA process;
  - Enable stakeholders to present their perspective on ETM and engage in identifying/commenting on key environmental and socioeconomic issues and concerns;
  - Obtain the opinions of experts and particular groups (e.g., resource users, IPs, coal mine and coal/diesel power plant workers and their associations, women, vulnerable groups, etc.), particularly through focus group sessions; and
  - Start raising awareness about SESA and building capacity to undertake and engage in the SESA process.

(b) *Once the draft SEA and draft SESMP are available*—to present the results of the SESA and the main recommendations (including proposals set out in the SESMP). This second round would not need to be as extensive as the first round but should include feedback from multistakeholder workshops at the national level and in the main regions.

Additional consultation events should be organized as required, e.g., to discuss special issues such as reviewing and revising the provisional list of environmental and social quality objectives (ESQOs) and/or the impacts of different energy transition scenarios.

The SEA team should set up a ***communication mechanism*** to inform stakeholders of such events (date, timing, location, etc.) and indicate how feedback on progress in the SEA will be provided, when draft reports will be available for review, and how (e.g., online, from an office), how stakeholders' views and comments have been addressed, etc.

Indicate that all SEA documents and the SESMP should clearly reflect what stakeholder participation has been organized/facilitated to support their preparation (e.g., listing workshops and meetings with dates), and indicate who participated in events and where a record of meetings and issues raised can be found—preferably minutes of all meetings and events should be attached as appendices to the master documents.

The above tasks may be undertaken as part of, or in parallel to, scoping (see 9.3).

9.3 Scoping requirements:

Indicate that scoping should verify, deepen, and extend any preliminary analysis and undertake the following:

- A ***review of relevant literature,*** including relevant international treaties and accords/conventions; national-level policies, regulations, and strategies; relevant policies and plans; and EIAs and specialist studies undertaken in the SEA area;
- ***Consult with stakeholders*** as well as ***interested and affected parties*** (I&APs) (including national, local, and municipal authorities, relevant parastatals, concerned groups, local communities, technical experts, etc.) on identifying key issues and gathering stakeholder perspectives/views on the proposed PPP. This can be done through workshops, 'focus group' meetings, interviews, and electronic communications;
- Take into account ***more recent developments*** (e.g., the release of new regulations or new proposed PPPs or projects) that might have relevance to or interact with the PPP being assessed;
- Secure the ***opinions of experts***;

- An ***analysis of the country's laws, policies, regulations, strategies, and action plans***, as well as permit requirements insofar as they are relevant to the issues at hand;
- An ***analysis of the country's*** guidelines insofar as they are relevant to the issues at hand (to determine their relevance and applicability to the SEA area). Where national safeguards are not in place, then other relevant safeguards may be consulted (e.g., those of the World Bank (2017b)), ADB, or other multilateral development banks);
- Identify and secure agreement on Environmental and Social Quality ***Objectives*** to be used during the assessment and as a platform for SESMP recommendations.
- Identify possible ***alternatives*** to the PPP or its components that should be considered by the SEA and establish definitions/characterizations for each alternative.
- Identify and secure agreement on ***scenarios*** to be developed against which the impacts of the preferred alternative for the PPP should be assessed.
- Identify how the SEA can strengthen the existing ***institutional and practitioner capacity in SEA.***

A scoping report should be prepared. Indicate that this will be provided to the Steering Committee, circulated to relevant government ministries, agencies, and other stakeholders, and provided to the public for comment prior to its finalization.

Indicate that if any significant changes are made to the TOR, it may be necessary to advise stakeholders of those and seek comments before the SEA team proceeds further.

9.4 Preparation of work plan

State that this should clearly set out all activities, outputs, and a timeline, and indicate which team members will be involved, and when, in particular steps.

9.5 Baseline studies

Indicate the need to prepare a baseline profile of the SEA area. This will require the SEA team to carry out research and analysis (drawing from published and unpublished, official and unofficial sources, existing EIA reports, and ongoing work) and prepare a baseline profile of the SEA area, documenting environmental, social, economic, governance, and other key characteristics, as well as any related trends, in sufficient detail to provide a basis for subsequent assessment of impacts. These characteristics may be listed in the TOR if preliminary scoping has been undertaken prior to appointing the SEA team.

If the team finds that there are significant data gaps, or if specialist studies are found to be required (that might take time), the team should communicate this to the proponent (and Steering Committee, where appointed) so that a decision on how to proceed can be taken.

Box 3.7 in Section 3.3.8 (Chapter 3) of the guidance lists typical information that should be included in a baseline profile. The TOR should include such a list.

9.6 Legislative and regulatory profile

Indicate that the SEA team should prepare a concise overview of relevant national laws and regulations and internal commitments (e.g., under Conventions/MEAs that are pertinent to the PPP)., with specific reference to compliance requirements and constraints. This should include a description of pertinent standards governing, *inter alia*, health and safety, waste discharge, and noise. Also, the SEA team should provide a justified opinion as to whether any of the possible development downstream projects, activities, or other initiatives that may arise when implementing the PPP could be deemed illegal under national or international law, especially (but not only) in the context of effluent discharges into watercourses and air, and where developments may be located in or may affect national parks, wetland sites), or other protected areas.

The profile should also include a matrix-based, cross-comparative analysis of interactions between legal and regulatory instruments, particularly showing where any are in conflict with each other with regard to how they might influence, promote, or impede development PPPs, projects, or initiatives, and thus where clarification or harmonization may be necessary.

9.7 Development of Environmental and Social Quality Objectives

Indicate that if an objectives-led approach to the SEA is deemed to be necessary (this may be required if, for example, data is inadequate or unavailable to enable an impacts-led approach), then the SEA team should develop a suite (maximum 30) Environmental and Social Quality Objectives (ESQOs) that are a response to the key environmental and socioeconomic issues identified during scoping. Subsequent assessment will determine whether implementation of the PPP will enhance or impede achieving the agreed ESQOs. The ESQOs should conform with objectives committed to by the country in existing policies and international accords/conventions, treaties, and protocols (ICTPs) to which the country is a signatory. See Section 3.3.4, Chapter 3, for further information.

9.8 Assessment of environmental and social impacts

Indicate that the SEA team will be required to undertake a thorough ***review and assessment of the direct, indirect, and cumulative impacts*** (positive and negative) of the developments and initiatives that will be likely to arise during implementation of the PPP under different scenarios (including but not limited to business-as-usual scenarios and future low, moderate, and high growth scenarios—meta-alternatives). Scenarios may be generated through multi-stakeholder brainstorming workshops. The SEA should also assess the impacts of agreed alternatives identified during scoping.

The assessment should include identifying ***synergies*** (and how these can be enhanced) and ***conflicts/antagonisms*** (and how these can be minimized or mitigated) between elements of the PPPs and between different PPPs.

The assessment should identify where ***EIAs*** (addressing both environmental and social concerns) may need to be undertaken for particular projects/initiatives likely to arise during PPP implementation and recommend key issues that should be addressed; and provide an outline TOR for such EIAs indicating key issues that will need to be addressed.

9.9 Key themes and issues to be addressed by the SEA

Indicate any key themes, issues, existing projects, activities, and developments underway and planned in the area covered by the PPP. These may have been identified during preliminary scoping, and the SEA will need to focus on these. During scoping, the SEA team should verify these (through interactions with stakeholders) and identify any other issues that may need to be added, e.g.,

- ***Protection and conservation of critical and sensitive areas, and fragmentation of habitats and resources***
- ***Demand on natural resources*** (current and future; legal and illegal)—forests, land, water, wildlife, minerals, etc.
- ***Land tenure, land-use (current and forecast), and land-take*** (arising from developments and infrastructure)
- ***Hydrology and drainage patterns***
- ***Visual impacts*** and deterioration of sense of place—as rural and urban development changes the character of NCR and its municipalities.
- ***Pollution of land, air, and water*** due to effluent and waste discharges from industrial developments, pollution from accidents, other land-based pollution, and physical changes as a result of the new infrastructure and new companies/industries.

- ***Loss of aquatic life and altered ecological functioning*** due to pollution or other factors.

- ***Accident risks***, especially from transport trucks, chemical spillages, and road traffic accidents.

- ***Biodiversity loss***, both from physical disturbance (habitat alteration) and pollutants.

- ***Strain on municipalities and communities***, e.g., if the PPP may stimulate an influx of job seekers. In this case, there will be both positive and negative impacts. Specific issues of concern may be increased crime, overcrowding (with social and health consequences), and strain on physical and social infrastructure.

- ***Health risks*** because of pollution from industrial developments reaching nearby communities from all possible pathways, but especially air. Also, issues such as light pollution, noise, and increased electromagnetic radiation need to be addressed.

- ***Other social issues*** such as education, skills, livelihoods, poverty, gender concerns, access to resources, migration, population change, cultural dilution, etc.

- ***Protection of cultural and religious assets and heritage sites***

- ***Settlements and settlement patterns, and urban expansion***

- ***Trans-boundary issues*** (trade, transport, tourism, management of critical resources such as water, etc.)

- ***Economic issues*****,** especially the benefits of the PPP and projects arising during implementation in terms of direct and indirect jobs, import substitution, taxes, and likely spin-offs.

9.10 Key elements when assessing impacts

Indicate that positive and negative impacts should be evaluated in terms of their importance at local, regional, national, or international level, and also with regard to their short- and long-term magnitude, significance, frequency of occurrence, duration, and probability.

The SEA should distinguish between primary, secondary, synergistic, and short- and long-term cumulative effects and should consider at least a 30-year time frame.

It should be indicated when impacts are likely to be irreversible or unavoidable and which ones can be mitigated—and the degree of confidence that the SEA team attaches to their assessment of each impact and the likelihood of avoidance/mitigation being successful.

Indicate that if the SEA team identifies any significant flaws in relation to the PPP that require application of the precautionary principle, this should be clearly indicated and justified in the report (and communicated to the Steering Committee and PPP proponent immediately).

The impact assessment process must include a combination of literature review, specialist studies (where needed—to be identified and budgeted for by prospective consultants in their proposals and confirmed during scoping), expert opinion, stakeholder opinion, and rigorous analysis. It is a requirement that a comprehensive public participation and disclosure process be followed.

9.11 SEA report requirements (basic contents)

Indicate that the SEA team should prepare an SEA report that is concise and focused on significant environmental and social issues. The main text should include findings, conclusions, and recommended actions (in a SESMP), supported by summaries of the data collected and citations for any references used in interpreting those data. Detailed or uninterpreted data are not appropriate in the main text and should be presented in appendices or a separate volume. Unpublished documents used in the assessment may not be readily available and should also be assembled in an appendix or made available on a website dedicated to the SEA. Wherever possible, data should be summarized in tables, and where relevant and appropriate, the text should be supported by figures and photographs.

The SEA report should be presented according to the outline in Annex 7 of the SEA guidelines.

9.12 Strategic Environmental (and Social) Management Plan (SESMP) (basic contents)

Indicate that the SEA team should prepare a Strategic Environmental and Social Management Plan (SESMP) for the PPP, setting out:

- Measures to enhance positive and prevent, minimize, or mitigate adverse environmental and socioeconomic impacts associated with PPP implementation;
- Measures to monitor indicators linked to ESQOs (where used as a basis for assessment) and indicate institutional roles and responsibilities (including how stakeholders can be involved). The objectives of monitoring are to ensure that:
    - Mitigation and restoration measures are implemented;
    - Mitigation and restoration measures are effective, i.e., have the intended result;
    - Remedial measures are undertaken where mitigation and restoration measures are inadequate or where the impacts were underestimated in the SEA study;
    - Compliance with national (and international) standards is assessed.
- Any adjustments required to laws and regulations or to institutional arrangements to enable efficient and effective implementation of the PPP;
- Measures to build necessary capacity for these (e.g., awareness-raising, training);
- Budgetary, staffing, and equipment requirements.
- Recommendations for EIAs of subsequent renewable energy projects (by type).
- Measures should aim to ensure synergy with relevant (national and/or other) environmental and social safeguards.

Ideally, the recommendations should be developed in consultation with the institutions likely to have responsibility for their implementation. This will help to ensure their practicality and create buy-in and ownership, thus increasing the likelihood of adoption and implementation.

See Annex 16 of this guidance for the recommended content of a SESMP.

9.13 Public disclosure of draft reports

The SEA team should work with the proponent/steering committee to ensure that two notices regarding the draft SEA report (and draft SESMP) are published, each one week apart, in newspapers with a nationwide circulation or announced through broadly used social media and in other local media. The public should be allowed a fixed period (conventionally 30 working days from the date of the first advertisement) to submit comments on the draft reports. The invitation for public comments (notice) should state where the plan and SESA documents can be found (e.g., on a dedicated SEA website or physically at a designated office) and how, by when, and to whom comments should be submitted.

10. Monitoring and review of SEA and SESMP

Indicate what monitoring, evaluation, and review procedures will apply to the SEA and SESMP.

11. Work schedule

Indicate the time period within which the SEA and SESMP should be completed and the requirement for the SEA team to submit a detailed work plan and schedule of activities in the inception report.

12. Deliverables

Indicate the deliverables required, e.g.,

1. Inception report, including work plan
2. Stakeholder analysis and stakeholder engagement plan
3. Scoping report
4. Quarterly progress reports
5. Interim SEA report
6. Draft and final reports on any special studies conducted
7. Draft and final SEA report
8. Draft and final SESMP (if required separately).

ANNEX 3

PPP Screening Form

Proponents Reference Number: ____

Submission Date:____

Proponent's Address: ____

PPP Title: ____

PPP Sector: ____

PPP Area of Implementation (National, Region, District, Town, trans-national):______________

____

PPP SCREENING COMMENTS:

The following comments should provide a summary—to draw the attention of the competent authority to key points in the SEA report.

1. CHARACTERISTICS OF THE PPP ITSELF:

- To what extent will the PPP set a framework for downstream projects and other activities (e.g., concerning their location, nature, size, and operating conditions or by allocating resources)?____
____
____
____

- Is the PPP likely to influence other PPPs—at national to local levels? ______________________
____
____
____

- To what extent will the PPP enable the integration of environmental and social considerations (and their relationship with economic concerns and drivers) and promote sustainable development? ____
____
____
____

- What are the main environmental and social problems associated with the PPP?_____________
____
____
____

- How might the PPP provide a means to implement national legislation on the environment (for example, PPPs linked to waste management or water protection) or social conditions? _________
____
____
____

- To what extent is the proposed PPP likely to be politically or publicly contentious?____________
____
____

- Is the PPP being unprecedented (e.g., pioneering, addressing new issues)? ________________

2. CHARACTERISTICS OF THE EFFECTS AND OF THE AREA LIKELY TO BE AFFECTED:

- Regarding the impacts, what is their probability, magnitude, duration, spatial extent (geographical area and size of the population likely to be affected), frequency, and reversibility?

- Are there any inherent uncertainties, and what is the level of confidence in predicting the effects of the proposed PPP?

- Are there any important information gaps that have made it difficult to predict impacts?

- What is the nature of the short- and long-term cumulative effects, and are they likely to be significant (both additive and synergistic)?

- Are there likely to be any trans-boundary effects (i.e., the PPP is likely to affect other municipalities, Dzongkhags, regions, or countries)?

- Are there any high risks to the environment, social conditions, or human health (e.g., due to accidents), safety, and/or the integrity of social or ecological systems?

- What social and/or ecological systems in the PPP area of influence have low resilience and high vulnerability to disturbance or impact (e.g., poor communities or sensitive ecosystems)?

- What areas in the influence of the PPP have high value or are vulnerable and are likely to be affected by the PPP due to:
  - having unique, special, or highly valued natural or cultural elements (e.g., threatened biodiversity or sacred areas);
  - being protected areas (e.g., national parks, nature reserves, biological corridors, heritage sites, Ramsar sites) or areas of recognized local, district, national, or international importance for conservation;

- having existing levels of environmental quality that are close to defined limits of acceptable change (i.e., there is a definite risk that limits of acceptable change will be exceeded); or environmental quality standards have been exceeded; or
- intensive land-use?

  ____
  ____
  ____

- What impacts will the PPP have on areas or landscapes that have a recognized national or international protection status? ______________________________
  ____
  ____
  ____

- Will the PPP be likely to result in major changes in actions, behaviors, or decisions by individuals, businesses, NGOs, or government that could lead to:
  - The stimulation of development of infrastructure or other changes in urban or rural land use;
  - An increase in the transformation and development of natural habitat or of areas important to nature conservation;
  - Major changes in the pattern of settlement, land occupation, and/or demographics in an area;
  - Major changes in the development or use of technology that could have negative implications for health and/or safety;
  - The introduction of alien and potentially invasive organisms;
  - Changes in society's consumption of energy and in particular fossil fuels, and therefore, in emissions of carbon dioxide and other greenhouse gases;
  - Changes in the rate of society's consumption of and/or demand on natural resources, including water?

  ____
  ____
  ____

Record of Decision: (tick where applicable)

Recommended/Not recommended for SEA: ______________________________

Recommended for EIA Study: ______________________________

Names of Reviewers:

1. ____

Signature: ______________________________ **Date:** ______________

2. ____

Signature: ______________________________ **Date:** ______________

ANNEX 4

List of issues to be covered by an SEA Report

The list below includes issues that should be covered in an SEA report. It does not necessarily represent chapter or section headings, nor the order in which information should be provided. The contents of an individual SEA report will also need to be guided by the TOR for the SEA, the context, focus of study, and requirements set by the proponent of the PPP (policy, plan, or program).

- Title of report
- Table of contents
- Acknowledgements
- List of acronyms and abbreviations
- Executive Summary
- Introduction and background (including scope of SEA)
- Brief description of policy, plan, or program
  - Objective, purpose, and rationale of the PPP;
  - Other development initiatives likely to arise during implementation; and of other projects or initiatives (including at a broader scale, national or international), where these will likely influence or impact PPP or its area;
  - Alternative policy or plan options and strategies;
  - Areas and sectors affected;
  - Proposed activities for PPP;
  - Implementation plan and time scale of PPP.
- Methodology of SEA
- Baseline profile and trends
  - Baseline environmental and social conditions, especially areas potentially affected
- Description of authorities, jurisdictions, and key institutions—their roles and responsibilities
- Policy, legal, and administrative framework
- Related PPPs
- Future development scenarios and development alternatives
- Assessment of significant environmental and social impacts.
- Prediction and evaluation of impacts of the PPP, including short- and long-term cumulative effects, compared against indicators
- Prediction and evaluation of impacts of alternative PPP options and comparison against environmental and socioeconomic indicators
  - A justification for the preferred alternative
- Recommended avoidance/mitigation of adverse impacts and enhancement of synergies and positive impacts
- Identification of preferred long-term restoration alternative(s), where appropriate
- Linkages with ongoing projects and how they fit in the proposed PPP
- Overview of public/stakeholder engagement activities undertaken
- Summary of stakeholder concerns and expectations and how these have been addressed (details to be provided in appendix)
- Impacts on sustainable development objectives (local, regional, national)
- Conclusion and recommendations (including recommended PPP changes and need for subsequent EIAs)
- References
- Appendices—including:
  - List of SEA team members (with brief outline of experience).
  - Record of consultation meetings, stakeholders consulted, and stakeholder opinions (an issues-response form should be used to show how stakeholder issues have been addressed in the report).
  - Relevant technical appendices

Supplementary reports should be prepared for specialist studies conducted.

ANNEX 5

Example review of PPPs relevant to the Preliminary SEA of Bhutan's Road Sector Master Plan (2007-2027)

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
POLICIES AND STRATEGIES		
Water Policy, 2007	*Vision*: Water is the most important natural, economic, and life-sustaining resource, and we must ensure that it is available in abundance to meet the increasing demands. Present and future generations will have assured access to adequate, safe, and affordable water to maintain and enhance the quality of their lives and the integrity of natural ecosystems. Emphasis on water resources management within river basins and aquifers, including both upstream and downstream water users.	• Localized and seasonal water shortages for drinking and agricultural purposes • Increasing sediment load in rivers is decreasing the expected output and economic life of hydropower plants • Pressure on water resources is mounting due to competing demands from different users • New demands from other sub-sectors such as hydropower and industries • Rapid urbanization has serious impacts both on water demand and associated pollution • Increasing demand for timber, firewood, and non-timber forest produce is starting to have negative impacts on watersheds • Climate change will reduce the natural river flow-regulating capacity of glaciers
Sustainable Hydropower Development Policy, 2008	• Develop hydropower projects in an accelerated manner to reach an installed capacity of 10,000 MW by 2020 • Projects to cover: micro/mini, small, medium, large, and mega.	• Project developers are required to carry out comprehensive EIAs, make suitable provisions for mitigation of adverse impacts, and implement an Environmental Management Plan and other risk management measures. • Need to protect water catchment areas by promoting sustainable agricultural/land use practices and nature conservation works; • Need for sustainable water resources management • Annual rental paid for private land acquired • Free 10,000 KWh/yr provided for every acre of private land acquired (or cash-in lieu) to the owner. • Developers must provide up to 1% of project costs to cover rehabilitation/resettlement of displaced persons, and provide employment to at least one member of every displaced family.
Cottage, Small and Medium Industry (CSMI) Policy, 2012	Provides direction for the development of CSMI, preparing them for the opportunities and challenges of globalization; ensuring they play an increasing role in fostering economic	• CSMI accounts for 98% of all industries in Bhutan • Policy fosters job creation

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	development; to generate employment and support equitable distribution of income and bring about balanced regional development	
Irrigation Policy, revised 2011 (draft)	Provides direction on measures to increase the irrigated area and improve irrigation water management and optimal utilization of national water resources for crop production.	• A significant proportion of arable land remains under rain-fed conditions, while c. 10% of irrigation systems is non-functional. • Irrigation technology and on-farm water management remain rudimentary. • Decentralization has impeded the planning and design of irrigation projects. • Lack of water storage systems • Poor-quality irrigation schemes that are highly prone to damage during peak monsoons and high-water demand periods; and often washed away during natural calamities. • Conflicts among conjunctive water users/uses from a common source • Pollution of water by agro-chemicals is not yet assessed. • Channel and on-farm water is not managed efficiently resulting in land degradation and water wastage.
Land Policy, final draft 2010	Goal: to strive for sustainable use of land through efficient and effective land management and prudent land administration for socioeconomic development and conservation of the natural environment in the country. *Objectives*—to: • Coordinate and harmonize the use of land by different users; • Provide access to land for all Bhutanese citizens and juristic persons • provide secured land tenure and rights to title holders; • Generate land revenue and control land speculation; • Undertake broad zoning based on land use capability to fulfill land needs for different purposes;	See objectives

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	• Enhance equitable, sustainable, and efficient use of land resources; • Ensure protection and conservation of ecology	

National Urbanisation Strategy, 2008	*Objectives*—to:
	• Develop a proactive approach to the country's urban growth in a sustainable and environmentally sound way that minimizes the negative effects of urbanization;
	• Ensure balanced regional growth;
	• Develop a strategy for improving the quality of life of the growing urban population in a way that embraces rather than undermines the local culture and values;
	• Develop a set of recommendations to improve local government systems in
	• Bhutan, including municipal finance and institutional aspects.
		• Very rapid rates of urbanization
		• Limited availability of serviced land
		• In general, urban centers consume prime agricultural lands in the valleys and encroach on forested hill slopes.
		• Lack of proper infrastructure and facilities for drainage, sanitation and waste disposal have cumulative adverse impacts on the environment.
		• Increased timber logging and conversion of slopes into urban uses
		• Primary environmental pressures on the urban environment arise from:
		  ○ Water supply
		  ○ Waste water collection and treatment
		  ○ Drainage and flooding
		  ○ Solid waste collection and disposal
		  ○ Hill cutting and erosion
		• Secondary environmental issues are:
		  ○ Electrification and street lighting
		  ○ Noise
		  ○ Traffic congestion
		  ○ Air pollution
		  ○ Pedestrian areas
		  ○ Household fuel supply
		• Concerns of the poor (most of them migrants who do not own land in the town):
		  ○ Unaffordable rentals that seem to be responsible for squatting. Housing for poor is critical
		  ○ Housing with access to quality /effective basic and social services.
		  ○ Livelihoods and local economic development, youth unemployment
		  ○ Transport
		• Urban development related activities have the potential to negatively impact the cultural heritage structures and systems

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
		• Loss of the traditional extended family as the proportion of migrants in the urban areas increase • Household will be the major social loss. • Culture and heritage consist of a number of intangible and tangible aspects of which the traditional built environment, community spaces and places form the most important as they are mostly home to and imbibe within themselves traditional rituals, ceremonies, and festivals; arts, crafts and textiles including dances, poetry/literature (folklore, myths, legends), music and religion; values and relationships; dressing and etiquette; social setup and structures.
Economic Development Policy, 2010	*Vision*—to: • Promote a green and self-reliant economy sustained by an IT-enabled knowledge society guided by the philosophy of Gross National Happiness • Work towards achieving a minimum economic growth rate of 9% annually and strive to be a middle-income nation with economic self-reliance by 2020. • Achieve full employment (97.5%). *Strategies:* • Diversify the economic base with minimal ecological footprint. • Harness and add value to natural resources in a sustainable manner. • Increase and diversify exports. • Promote Bhutan as an organic brand – in natural resources, tourism, culture, handicrafts, textiles, and agro-produce. • Promote industries that build the Brand Bhutan image. • Reduce dependency on fossil fuels, especially with respect to transportation.	• Economic development should take into account environment mainstreaming in a phased manner that allows for industries to grow as well as engage in cleaner production • Government to provide incentives for the promotion of green technology, micro-hydro projects, solar, wind, biomass, energy efficiency, and conservation programs. • Conservation efforts to be one of the main drivers for developing the "Brand Bhutan" theme. • Aims to protect biodiversity and genetic resources and promote indigenous knowledge. • Commits to use non-renewable resources (i.e., minerals) in a sustainable manner to diversify the economy while at the same time ensuring due environmental considerations. • Commits to pursue corporate social responsibility in the construction industry. • Organic farming will be a major focus area. • Commits to phasing out use of harmful chemical fertilizers and pesticides • Encourages bio-exploration and bioprospecting. • Concludes that the "sensitive mountain ecology and the difficulties of building multi-lane highways make tunneling the most viable option to reduce travel time as well as increase connectivity throughout the country. The development of the road sector, especially tunnels, shall be in sync with the hydropower development."

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
Mineral Development Policy, 2011 (draft)	*Objectives*—to: • Develop the scarce mineral resources for optimum value addition so that maximum benefit accrues to the nation; • Allow selective and cautious development of minerals for socioeconomic development while ensuring environmental sustainability and inter-generational equity in the larger interest of the country; • Ensure the availability of construction materials at affordable prices to all the citizens; • Increasingly contribute to the national economic development by enhancing generation of revenue and employment; • Promote human resource development and ensure that mineral development is carried out by technically qualified professionals; • Promote investment in the mineral sector by technically and financially competent entities; • Develop an integrated mineral information system in the country; • Ensure effective regulation, administration, management, and monitoring of the mineral sector.	• The mining sector is an important catalyst for economic growth in terms of revenue and employment generation. • Mine reclamation and restoration. • Impacts on communities surrounding mines. • Mining companies must contribute to a community development fund to be used specifically for drinking water schemes, water source protection, social forestry schemes, renovation of religious sites belonging to the community, and other schemes as may be prioritized by the community, managed by a Tshogpa appointed by the affected communities, • Priority for employment accorded to the local affected community.
Forestry Policy, 2010	*Objectives*—to: • Manage Bhutan's forests for sustainable production of economic and environmental goods and services and to meet the long-term needs of society. • Manage Bhutan's production forests for sustainable supply of timber, other forest products, and environmental goods and	• Loss of forest cover due to establishment of development projects. • Forest fires. • Watershed services. • Biodiversity. • Appropriate vegetation composition • Sustainable timber supply. • Illegal logging, poaching, illegal trade of wild flora and fauna

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	services and to meet the long term needs of society; • Maintain species persistence and ensure long term sustainability of Bhutan's biodiversity, ecosystem services, natural habitats, and cultural heritage through a network of protected areas, biological corridors, and management of other parts of the forest landscape for positive environmental outcomes; • Provide for effective and integrated watershed management, maintain, and improve water and watershed conditions, and contribute to sustainable livelihoods through the provision of watershed services; • Empower rural communities manage forests sustainably for socioeconomic benefits, poverty reduction, and to contribute to overall sustainable forest management at the national level; • Facilitate raising forestry crops on registered land of individuals or institutions and accrue ecological, social, and economic benefits; • Enable an economically viable and efficient forest-based industry aimed at adding value to forest products and build capacity of the private sector and rural communities to utilize, process, and market forest products; • Establish a dynamic organizational setup through institutional reforms for appropriate managerial and technical capacity to implement all policy objectives.	• Human-wildlife conflict. • Conservation of scared/heritage sites. • Local community access to forest resources (timber, firewood, medicinal plants and herbs, non-wood forest products, etc.)

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
Renewable Energy Policy, 2011	Long-term objectives: • Enhance energy security and broaden the energy portfolio; • Conserve the environment and reduce greenhouse gas (GHG) emissions; • Enhance socioeconomic development. Short-term objectives: • Support and promote research and development in renewable energy (RE) technologies (solar, wind, biomass, etc.) with the long-term objective of a viable energy resource, harness the potential of RE resources, and adopt RE technologies in the country; • Develop a RE roadmap for each of the RE technologies by mapping capacity, generation potential, and cost of generation by location across the Kingdom. • Design appropriate tariffs for various RE technologies to offer a secure and stable market to investors and project developers with guaranteed incentives provided by the government; • Enable, encourage, and facilitate both public and private sector participation for the development of RE; • Enable to set realistic targets for RE for the energy mix in line with the principles of GNH; institutionalize the development of national and local capacities and capabilities for enhanced and optimum utilization of RE systems; • Promote efficient and cost-effective RE systems by providing time-bound incentives; and	• Land acquisition for projects, and compensation

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	• Establish the necessary administrative, basic physical infrastructure, and institutional mechanisms to implement the provisions of this policy. • Strengthen regulatory functions in the RE sector	
(b) PLANS		
11th Five Year Plan	Introduced “green” concept: prioritizes environmental management and reduction of GHG and pollution based on pro-poor, low-carbon, eco-friendly, energy- and cost-efficient modalities and strategies	
Phibsoo Wildlife Sanctuary: Conservation Management Plan (2012-2017)	Main objectives: • Reduce conservation threats posed by human-wildlife conflicts, poaching, and free-range grazing; • Strengthen the infrastructure for effective management of PWS and implementation of planned management interventions; • Enhance professional and public knowledge for local biodiversity conservation and related community development.	• Human-wildlife conflicts • Poaching • Free-range grazing in forest habitats (large numbers of cattle) • Loss of cereal crops to wildlife • Indirect costs: loss of time, added cost of production, expenditure on torches, batteries, and kerosene, and construction of elevated guard shelters (machans). • Wildlife predation on livestock (lower scale than crop damage) • Proximity to regional wildlife trafficking routes • Spread of animal diseases—where wild and domestic animals overlap. • Lack of research and information • Limited conservation management infrastructure • High security risks due to insurgency in bordering India

ANNEX 6

Overview of selected analytical and decision-making tools for SEA

Source: OECD/DAC (2006)

1. TOOLS FOR PREDICTING ENVIRONMENTAL AND SOCIOECONOMIC EFFECTS

1.1 Carrying capacity analysis (CCA) determines the human population that can be "carried" by a particular area on given consumption levels, i.e., it identifies the limits to growth. The "capacity" concept is controversial, with continued debate on what exactly it is and how land can be managed to increase capacity. Ecological carrying capacity usually refers to the maximum population size of a species that an area can support without reducing its ability to support the same species in the future. More information at www.ilea.org/leaf/richard2002.html.

1.2 Network analysis (also called cause-effect analysis, consequence analysis, or causal chain analysis) explicitly recognizes that environmental systems consist of a complex web of relationships and that many activities' impacts occur at several stages removed from the activity itself. It aims to identify the key cause-effect links describing the causal pathway from initial action to ultimate environmental outcome. In doing so, it can also identify assumptions made in impact predictions, unintended consequences of the strategic action, and possible measures to ensure effective implementation. It is useful for identifying cumulative impacts. The technique involves, through expert judgement, drawing the direct and indirect impacts of an action as a network of boxes (activities, outcomes) and arrows (interactions). (Source: Therivel, 2004). For more information, see European Commission (1999).

1.3 Ecological (environmental) footprint analysis addresses the human impact on the Earth's ecosystems, measuring and visualizing the resources required to sustain households, communities, regions, and nations, converting the seemingly complex concepts of carrying capacity, resource use, waste disposal, etc. into an understandable and usable graphic form. An excellent handbook is Wackernagel and Rees (1996).

1.4 Social and economic analysis/surveys. Information on many of the key tools available for social analytical and survey work is described in the *PSIA User's Guide* for practitioners in developing countries. DFID has funded work on Tools for Institutional, Political, and Social Analysis of PSIA (TIPS Sourcebook) (soon to be available on the World Bank website). Most are available on the World Bank PSIA website:
http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPSIA/0,,menuPK:490139~pagePK:149018~piPK:149093~theSitePK:490130,00.html

Ministries of finance and other governmental bodies usually use general and partial equilibrium models for planning purposes. These predict how changes in the economy, due to for example fiscal reforms or exchange rate reforms, will affect demand, supply, and relative prices. In general, these models can indicate changes in the use of different natural resources, such as energy use and agricultural output. In some cases, models also include effects on different forms of pollution. For more information, see http://siteresources.worldbank.org/INTEEI/214584-1115794388939/20486164/ToolkitForAnalyzingEnvironmentalAspectsofPolicyLending.pdf

1.5 Expert judgment of direct and indirect impacts: relatively quick and cheap, and can be used for applications including collecting data, developing alternatives from the strategic policy level to the detailed site level, analyzing and ranking them, predicting impacts, and suggesting mitigation measures. One or preferably several experts with specialist knowledge covering the range of impacts of the strategic action brainstorm/discuss/consider the relevant issue. This is sometimes formalized, e.g., through the Delphi Technique, which uses consecutive cycles of questionnaires of expert participants until agreement on a subject is reached (Source: Therivel 2004).

1.6 Geographical information system (GIS): a tool to organize and present information. It combines a computerized cartography system that stores map data and a database management system that stores attribute data. This allows links between the two data sets to be displayed. GISs are often only used to map data. However, they are also valuable analytical tools, e.g., for calculating areas and distances, identifying viewing areas from a point, constructing buffer zones around features, drawing contour lines using interpolated values between points, and superimposing maps of the above. For more information, see European Environment Agency (1998).

1.7 Land use partitioning analysis: assesses the fragmentation of land into smaller parcels that might result from linear infrastructure development. It involves comparing before and after scenarios. For more information, see European Environment Agency (1998).

1.8 Mapping of transmission channels: a component of Poverty and Social Impact Assessment that identifies the channels through which a particular policy change or other major intervention is expected to affect stakeholders. There are six main transmission channels: employment, prices (production, consumption, and wages); access to goods and services; assets (physical, natural, social, human, and financial); transfers and taxes; and authority. Impacts may be direct (from changes in the policy levers altered by the reform) or indirect (from reform through other channels). The nature of impacts may also vary over time, and so will net impacts on various stakeholders. More information at http://lnweb18.worldbank.org/ESSD/sdvext.nsf/81ByDocName/Approach3Understandingtransmissionchannels

1.9 Modelling (also called forecasting): techniques predict likely future environmental conditions with and without the strategic action. Modelling involves making a series of assumptions about future conditions under various scenarios and calculating the resulting impacts. Models typically deal with quantifiable impacts: air pollution, noise, traffic, etc. Most models used in SEA have evolved from EIA techniques. Many are computerized. (Source: Therivel, 2004). The June 1998 issue of *Impact Assessment and Project Appraisal* (Vol. 16, No. 2) is devoted to modelling, though mainly in the context of EIA. See also European Commission (1999).

1.10 Overlay maps: obtained by superimposing maps of areas of constraint using transparencies (e.g., overlaying areas of importance for landscape, wildlife, and groundwater protection). The overlay maps can identify areas that would be appropriate or inappropriate for development and produce easily understandable results that can be used in public participation exercises. For more information, see European Commission (1999).

1.11 Participatory techniques for assessment: available for work with stakeholders and those likely to be directly or indirectly affected by a strategic action, so they can engage in the process of assessing impacts. They include, for example: participatory learning and action (PLA); participatory dialogues; focus groups and round tables; consensus-building, negotiations, and conflict resolution. A useful guide to such techniques is Pretty *et al*. (1995). A participatory poverty assessment (PPA) collects poor people's views regarding their own analysis of poverty and survival strategies. PPAs focus on poor people's capacity to analyze their situations and to express their priorities themselves. PPAs are an effective tool for obtaining direct feedback from the poor on a country's poverty profile and the impacts of policy reform. Guidance materials on PPA are available at www.worldbank.org/poverty).

1.12 Quality of life assessment (QoLA): aims to identify what matters and why in an area so that the good and bad quality of life consequences (environmental, societal, and economic) of strategic actions can be better considered. The technique involves identifying benefits and disadvantages that an area offers present and future generations, assessing:

- The importance of each, to whom, and why?
- Whether there will be enough of them;
- What (if anything) could substitute for the benefits?

The answers lead to a series of management implications from which a "shopping list" of things that any development or management of the area should achieve and their relative importance. (Source:

Therivel, 2004). For more information, see Countryside Agency *et al*. (2002). www.qualityoflifecapital.org.uk.

2. TOOLS FOR ANALYSING AND COMPARING OPTIONS

2.1 Compatibility appraisal: ensures that a strategic action is internally coherent and consistent with other strategic actions. This is not strictly an SEA function, more one associated with good planning. Normally, two types of matrices are used:

- An internal compatibility matrix plots different components/statements of the strategic action on both axes, with compatibility/incompatibility between the actions marked in the cells with a tick or cross. It is usual to undertake a compatibility analysis between the objectives of the PPP and the SEA objectives;
- An external compatibility matrix plots the strategic actions (as a whole) against other relevant (normally higher- and equal-level) strategic actions. Matrix cells are filled by listing those statements of the strategic action that fulfill the requirements of the other strategic actions or explaining how the evolving strategic action should take the requirements into account. When no statements in the strategic action fulfill the other's requirements, or where they conflict, this may need to be addressed. (Source: Therivel, 2004).

2.2 Cost-benefit analysis, scenario analysis, and multi-criteria analysis to identify priorities and viable alternatives:

Cost-benefit analysis (CBA): A relatively simple and widely used technique for deciding whether to make a change. The technique adds up the value of the benefits of a course of action and subtracts the costs associated with it. Costs are either one-off or may be ongoing. Benefits are most often received over time. The effect of time is built into the analysis by calculating a payback period—the time it takes for the benefits of a change to repay its costs. In its simple form, CBA is carried out using only financial costs and financial benefits, e.g., a simple cost/benefit analysis of a road scheme would measure the cost of building the road and subtract this from the economic benefit of improving transport links. It would not measure either the cost of environmental damage or the benefit of quicker and easier travel to work. A more sophisticated approach to CBA is to try to put a financial value on these intangible costs and benefits. Guidance on the use of CBA is available at http://www.mindtools.com/pages/article/newTED_08.htm.

Scenario analysis/sensitivity analysis: Can be used to describe a range of future conditions. The impact of a strategic action can be forecast and compared for different scenarios—sensitivity analysis—to test the robustness of the strategic action to different possible futures. Forecasts based on current trends and/or scenarios representing trends outside the decision-makers' control are generated, and the strategic action's impacts are predicted based on these forecasts and scenarios. Sensitivity analysis measures the effect on predictions of changing one or more key input values about which there is uncertainty. The Stockholm Environment Institute has developed the Polestar Manual for scenarios (http://sei.se.master.com/texis/master/search/?q=scenarios&xsubmit=Search%3A&s=SS.).
Scenario planning is an example of a number of tools developed within the private sector (See, e.g., Shell International 2000). It is used to evaluate future, long-term, business environments and develop strategies that serve the traditional business goals of survival, maintenance, and growth in competitive markets. The intention is to develop strategies that are robust enough to be able to adapt the company to shocks and surprises in the business environment. It does this through a systematic process, usually engaging external stakeholders, to consider the nature and impact of uncertain futures and important drivers/influences on changes in technological, societal, environmental, economic, political, commercial, cultural, etc., environments.

The goal of scenario planning is to assist strategic planners and policy analysts to make more resilient choices through understanding a wide range of possible futures and designing pathways to arrive at desired positions.

Key stages in this process include:

- Agree the wide range of issues to address.
- Identify participants (lateral thinkers).
- Workshops and interviews of a "brainstorming" nature.
- Identify uncertainties and drivers of change.
- Develop matrices to describe possible combinations of critical uncertainties.
- Elaborate scenarios for each of the above combinations—again through group discussion.
- Describe requirements (PPPs) to move towards a preferred vision and constraints to be overcome in getting there.

Multi-criteria analysis (MCA): techniques can assess a variety of options according to a variety of criteria that have different units (e.g., $, tonne, km, etc.). This is a significant advantage over traditional decision-aiding methods (e.g., cost-benefit analysis), where all criteria need to be converted to the same unit (e.g., dollars only). They also have the capacity to analyze both quantitative and qualitative evaluation criteria (e.g., yes/no, pluses and minuses). MCA techniques have three common components: a given set of alternatives; a set of criteria for comparing the alternatives; and a method for ranking the alternatives based on how well they satisfy the criteria. An MCA manual is available at www.cifor.cgiar.org/acm/methods/mca.html.

2.3 Opinion surveys to identify priorities: for methods go to http://gsociology.icaap.org/methods/surveys.htm

2.4 Risk analysis or assessment: established itself as an essential tool for the management of environmental risk. An issue for environmental risk assessment is the lack of an easily defined measure of what constitutes *harm* to the environment. In some cases, definitions of environmental damage are laid down in statute, but in others, appropriate criteria will need to be selected on the basis of scientific and social judgments. For a comprehensive treatment of the basic principles of environmental risk assessment and management, see Calow (1998). Many sources provide guidelines for environmental risk assessment, e.g., http://www.defra.gov.uk/environment/risk/eramguide/index.htm.

2.5 Vulnerability analysis: assesses the impacts of a planned activity or different development scenarios on the vulnerability of an area. Vulnerability maps are produced showing the degree of vulnerability for selected targets (e.g., people, flora and fauna, landscape). These are overlaid and 'weighted' (using GIS and multi-criteria analysis) to indicate areas of high vulnerability and then related to expected levels of impact associated with different development options (e.g., noise increase, groundwater decline)—revealing the locations of negative impacts regarding different targets and the alternatives with the least impacts. For further information, see van Straaten (1999).

3. TOOLS FOR ENSURING FULL STAKEHOLDER ENGAGEMENT

3.1 General information, techniques, etc.: many guidelines are available for effective community involvement and consultation, e.g.,
www.rtpi.org.uk/resources/publications/ConsultationGuidelines_web.pdf
www.iap2.org/associations/4748/files/toolbox.pdf; www.unece.org/env/eia/publicpart.html.

3.2 Consensus building processes: a conflict-resolution process used mainly to settle complex, multiparty disputes. Since the 1980s, it has become widely used in the environmental and public policy arena but is useful whenever multiple parties are involved in a complex dispute or conflict. It allows them to work together to develop a mutually acceptable solution. More information is at www.beyondintractability.org/m/consensus_building.jsp.

A short guide to consensus building is available at http://web.mit.edu/publicdisputes/practice/cbh_ch1.html.

3.3 Stakeholder analysis to identify those affected and involved in the PPP decision: incorporates economics, political science, game and decision theory, and environmental sciences. Current models apply a variety of tools on both qualitative and quantitative data to understand stakeholders, their positions, influence with other groups, and their interest in a particular PPP. In addition, it provides an idea of the impact of the PPP on political and social forces, illuminates the divergent viewpoints towards proposed PPPs and the potential power struggles among groups and individuals, and helps identify potential strategies for negotiating with opposing stakeholders.
Go to http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/stakeholderanalysis.htm.

SOURCES OF FURTHER INFORMATION ON SEA TOOLS

- A modular Capacity Development Manual for the Implementation of the UNECE Protocol on Strategic Environmental Assessment is being developed by UNECE. It will be available at www.unece.org.

- Therivel, R. (2004). *Strategic Environmental Assessment in Action*, Earthscan: London contains an appendix with SEA prediction and evaluation techniques. It covers expert judgement, quality of life assessment, overlay maps, land use partitioning analysis, geographical information systems, network analysis, modelling, scenario/sensitivity analysis, cost-benefit analysis, multi-criteria analysis, life cycle analysis, vulnerability analysis, carrying capacity, ecological footprint, risk assessment, and compatibility appraisal.

- Rauschmayer F. and Risse N. (2005). A Framework for the Selection of Participatory Approaches for SEA, *Environmental Impact Assessment Review*, 25(6): 650-666. Covers: mediation, mediated modelling, consensus conferences, citizens' juries, and cooperative discourse.

- Finnveden G., Nilsson M., Johansson J., Persson A., Moberg A., and Carlsson T. (2005). Strategic Environmental Assessment methodologies: Applications within the Energy Sector. Environmental *Impact Assessment Review*, 23(1): 91-123. This paper covers: future studies, LCA, environmentally extended input/output analysis, risk assessment of chemicals and accidents, impact pathway approach, ecological impact assessment, multiple attribute analysis, environmental objectives, economic valuation, surveys, and valuation methods based on mass, energy, and area.

ANNEX 7

Example of objectives compatibility analysis: compatibility of objectives for Poole Port Masterplan (UK) against environmental and social quality objectives

Source: Ramboll (2012).

Port of Poole Masterplan objectives	**To continue to operate a commercially viable port with a diversity of activities**	**To continue to promote safe use of the harbor for all**	**To continue to educate and promote amongst harbor users the sustainable use of the harbor for commerce, recreation, and amenity**	**To continue to protect and maintain the special natural features of the harbor**	**To support the wider economy and community**
ESQOs					
1: To preserve, protect, and enhance biodiversity on or in the vicinity of the port	-	-	√	√	-
2: To reduce accidents and incidents in the port and harbor and reduce risk/improve safety for the users of the harbor	√	√	√	-	-
3: To improve the strength of the region's economy, including through providing a diverse range of employment opportunities	√	-	-	-	√
4: To improve the accessibility of community amenities and facilities to local residents	-	-	√		-

5: To encourage the protection of water resources	-	-	-	√	-
6: To minimize the impact on soil and land resources, including contamination and loss	-	-	-	√	-
7: To contribute towards improving local air quality	-	-	-	-	-
8: To contribute towards the reduction of greenhouse gas emissions	-	-	-	-	-
9: To contribute towards the protection and enhancement of sites, features, and areas of historical and cultural value	-	-	-	√	-
10: To contribute towards the protection and enhancement of the landscape character of the area	-	-	-	√	-
11: To contribute towards the improvement of levels of congestion and reliability on the road networks in the vicinity of the port	-	-	-	-	√
12: To contribute towards the reduction of noise levels from activities on port land	-	-	-	-	-

KEY:	
√	Likely compatibility
–	Relationship complex (or there is more than one potential outcome, depending on the interpretation of the Masterplan objective and the way that it is met
X	Likely incompatibility

ANNEX 8

Developing SEA environmental and socioeconomic quality objectives, indicators, and targets

Environmental and social quality objectives (ESQOs) are widely used to ensure that the right level of consideration is achieved. An objective is a statement of what is intended, specifying a desired direction of change. For these Guidelines, a distinction needs to be made between three types of objectives:

- The ***objectives of the PPP*** in question: government policies and guidance increasingly require these to be based on sustainability considerations, and the development of ESQOs for a SEA may help to promote ideas for making them more environmentally friendly and sustainable.
- ***External objectives***: other objectives to which the PPP proponent needs to have regard independently from the SEA process. They may include environmental protection objectives (which, if binding, must be covered in the SEA report), but they can also be economic or social. They may also include objectives of international conventions, treaties, and regional accords to which a country is a signatory, as well as the UN sustainable development goals (SDGs).
- ***SEA ESQOs***: devised to test the environmental and social effects of the PPP or to compare the effects of alternatives.

Objectives can be expressed so that they are measurable (e.g., an objective to reduce greenhouse gas emissions could be expressed as “reduce CO_2 emissions by 12.5% by 2010”). The achievement of objectives is normally measured by using indicators.

ESQOs can often be derived from environmental protection and social objectives identified in other PPPs or from a review of baseline information and environmental and social problems. Stakeholders may also suggest ESQOs for the SEA.

Some SEA ESQOs and indicators are shown in Table A8.1. They are derived from a much larger matrix of ESQOs and indicators developed during scoping for the ADB’s Energy Transition Mechanism (ETM).

These objectives and indicators can be adapted (by addition, modification, or deletion) to take account of national circumstances, contexts, and concerns.

Table A8.1: SESA environmental and socioeconomic quality objectives for key issues, suggested indicators, and related sustainable development goals and Just Transition principles

Source: ADB, (2023)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
Environmental					
Climate change	1	Reduce emissions of GHGs from energy generation	13	1,2	• Pre-closure emissions of CO_2 from stacks (tonnes /yr) (*to provide a measure of reduction when CFPP is closed*) • CH_4 emissions (e.g., from uncapped abandoned mine shafts and dams) (tonnes /yr) in ETM-affected areas
	2	Increase resilience of the country's overall energy supply to climate change impacts	13	1, 2	• Vulnerability of energy supply to climate change impacts (low, medium, high)
Habitats, biodiversity, and protected areas	3	Minimize loss of habitats, biodiversity, and ecosystem(s) integrity and services	14,15		• Area of natural habitat and critical habitat (Ha) *[as per IFC PS6 definitions (IFC 2012)]* in ETM-affected areas
					• Population of key indicator species (to be determined at national level) in ETM-affected areas (numbers) *(to measure change compared with baseline data)*
	4	Minimize deforestation	13,14		• Forest coverage in ETM-affected areas (Ha)
	5	Reduce encroachment and degradation of protected and sensitive areas	15		• No of reported cases of illegal resource extraction (e.g., poaching, illegal fishing, illicit felling) in Pas
					• Volume of seized illegal timber (cubic m) taken from protected and sensitive areas
Air quality	6	Reduce all forms of air pollution	3,14,15		• Ambient concentration of $PM_{2.5}$ at selected sites ($\mu g/m^3$), • Ambient concentration of NO_2, at selected sites ($\mu g/m^3$),

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
					• Direct emissions of SO_2, NOx, $PM_{2.5}$, CO, heavy metals, and volatile organic compounds (VOCs) (g/kWh) at selected sites
Surface water quality	7	Reduce all forms of water pollution (surface and groundwater)	3,6,14,15		• Water quality at selected sites (heavy metals, nitrate, phosphate, BOD) (mg/L) • COD/TN/TPh/TSS/Temp/T bacteria Volume of discharge (m^3 / kWh)
Solid waste	8	Reduce waste disposed to landfills (e.g., by increasing repurposing, recycling, and reuse of assets)	3,15		• Volume waste disposed to dump sites by energy operators under ETM (tonnes) • Percentage of waste diverted from landfills by energy operators under ETM (%)
	9	Improve safe handling, storage, and disposal of solid waste	3,15		• Capacity of recycling plants in country (tonnes/yr) • Number of hazardous waste treatment facilities • Capacity of hazardous waste treatment facilities
Materials use	10	Minimize use of non-renewable and toxic materials used in developing new assets	3,6,15		• % of non-renewable resources used in constructing new renewable energy assets
Land contamination	11	Maintain soil and groundwater quality and reduce land contamination	6,15		• Number of pollution incidents linked to the continuing operation of CFPPs/mines (in the period up to retirement) and after retirement/closure, and to ETM funded renewable energy projects
Noise and vibration	12	Minimize disturbance caused by noise and vibration	3		• Number of hours in which noise at selected sites exceed a set standard (to be determined) (dBA) during both operation (whilst awaiting retirement) of CFPPs/mines and during retirement/closure process; • Number of hours in which noise at selected sites exceed a set standard (to be determined) (dBA)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
					during construction and operation of renewable energy projects • Average day time noise at boundary of selected projects (dBA)
Land degradation	13	Minimize soil, river bank and sea bed erosion, and sedimentation of surface water	14,15		• Extent of degraded land or impacted surface waters (Ha) in ETM-affected areas
Land use change	14	Minimize loss and degradation of productive agricultural land, forests, grazing land, and fisheries	15		• Extent of such lands lost/degraded (Ha) in ETM-affected areas
Water use	15	Minimize use of local water resources and ensure efficient use/reuse of water	3,6,11		• Net volume of water used (m^3/yr)
Visual impacts	16	Minimize extent of visual change to landscape and loss of aesthetic value	3		• Number of complaints regarding a negative aesthetic impact • Area subjected to a change in view (size of viewshed) (Ha)
Health and safety	17	Ensure population health, and safety of communities and workers	3,6,8		• Life expectancy (yrs) • Incidence of specific diseases in affected areas (number of cases reported to clinics/hospitals) (*if such data is available/accessible*) in affected areas • Number of accidents related to CFPPs/mines whilst awaiting retirement under ETM, and during retirement/closure process • Number of accident related to construction and operation of renewable energy projects under ETM

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
Socioeconomic					
Economic growth	18	Enhance economic development and diversification, and increase in economic growth (regionally and nationally)	8	1,3	• Per capita GDP
					• Volume of coal exports (national) (metric tons)
					• Inflation rate (%)
					• Contribution of coal and renewable energy to GDP (%)
Employment and skills	19	Enhance and maintain opportunities for employment and decent work for all, and maintain income levels	1,8,9	1,4	• Number of people employed long-term (more than 1 year) in each type of energy project under ETM (coal power plants, mines, renewable energy projects)
					• Number of workers losing income from ETM projects
	20	Minimize loss of skilled workers	1,8,9	1,4	• Number of skilled jobs lost
					• Number of workers retrained/re-skilled
Local economy and livelihoods	21	Minimize loss of livelihoods, including for vulnerable groups and indigenous peoples	1,2,10	1,4	• Number of small businesses closing due to implementation of ETM
					• Number of people having reduced income due to ETM implementation
	22	Enhance equitable opportunities for new/improved and diversified and sustainable livelihoods	1,2,10	1,4	• Number of new jobs available in non-ETM businesses in ETM-affected areas
	23	Improve access to affordable and quality housing	3,11	1,4	• Average price of land and housing (rental and for sale)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
	24	Minimize gender inequality and minimize vulnerable groups being disadvantaged	4,8,10	1,5	• Number of social security entitlements, benefit, and/or (financial) support packages claimed under ETM, by sex, age, disability, and indigenous status
					• Percentage of all job advertisements for ETM projects targeting women and vulnerable groups via positive / affirmative action (%)
					• Number employed in non-ETM businesses in ETM affected areas by sex, age, disability, and indigenous status
					• Percentage of females employed in ETM facilities (%)
					• Number of females retrained/reskilled for other jobs following CFPP/mine closure under ETM
					• Number of people from indigenous communities employed in ETM facilities
					• Number of people from indigenous communities retrained/re-skilled following CFPP/mine closure under ETM
	25	Minimize competetition by men for jobs in sectors dominated by women	4.8,10	1,5	• Number of men in ETM-affected areas employed in women-dominated sectors
Food security and price	26	Improve food security for all	2,3	1,4	• Status of food security—as measured by availability of selected communities (e.g., in shops/markets) (plentiful/moderate/scarce)
					• Price of rice, corn, meat, and vegetables in selected communities
					• Food quality in selected communities (good/moderate/poor)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
					• Rice production in selected communities (tons/yr)
					• Nutritional level in selected communities (average Kcal/person/meal)
Physical and economic displacement	27	Minimize physical and economic displacement	3,16	1,4	• Number of households relocated due to ETM projects
					• Number of households suffering lost land due to land acquisition for ETM projects
Conflicts	28	Reduce conflicts (e.g., over-use of and access to land, between migrant workers and local population, between developers and local communities)	16	1,4	• Number of reported disputes
Community cohesion and engagement	29	Minimize disruption to household relationships	11	1,4	• Number of reported cases of domestic violence linked to CFPP/mine closure or development of renewable energy projects under ETM
					• Number of divorces linked to CFPP/mine closure or development of renewable energy projects under ETM
	30	Enhance inclusive and transparent engagement by communities, interested parties, and affected parties (CIAPs) in the planning and implementation of ETM initiatives	8,16	1,5	• Number of public and private consultation events organized for ETM (overall and for individual projects?)
					• Number of submissions/comments received for ETM (overall and for individual projects)
					• Percentage of representatives from vulnerable groups attending meetings (overall and for individual projects) (%) • Percentage of consultation events that provide for representation by NGOs/CSOs/trade unions

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
Public services and infrastructure	31	Maintain and improve local public facilities and services	9	1,4	• Number of facilities by type in each ETM affected area
					• Number of grievances (made through designated grievance mechanism) about adequacy of particular public services and infrastructure per month/year
					• Number of doctors per 1000 head population in each ETM affected area
Human rights	32	Avoid infringement of human rights of workers, communities, and vulnerable groups (including in supply chains)	10,16	1,4 5	• Reported cases of complaints about infringements of human rights linked to CFPP/mine closure under ETM
					• Reported cases of complaints about infringements of human rights linked to renewable energy projects under ETM
					• Number of children reported to be working on ETM projects falling into the category of child labor
					• Number of reported cases of bonded laborers in renewable energy projects under ETM
					• Number of workers recorded to be underpaid (less than legal minimum wage for normal working hours, less than statutory overtime pay for overtime hours) in renewable energy projects under ETM
					• Number of persons reporting infringements on freedom of movement (passports withheld by renewable energy projects)
					• Number of substandard contracts identified on ETM projects
Migration	33	Minimize outmigration			• Rate of migration out of communities where CDFPP/mines closed under ETM (%)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
	34	Minimize the number of unskilled immigrants competinglocal people for employment in ETM facilities		1,4	• Number and percentage of unskilled, semi-skilled, and skilled workers by gender and origin (international, national, local, and project affected persons) per ETM facility
Cultural heritage	35	Preserve heritage sites (historic buildings, archaeological, and cultural sites)	3		• Number of cultural heritage sites impacted per ETM facility (including associated infrastructure)
List of Sustainable Development Goals					

- ***No poverty***: End poverty in all its forms everywhere.
- ***Zero hunger***: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
- ***Good health and well-being:*** Ensure healthy lives and promote well-being for all at all ages
- ***Quality education****:* Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- ***Gender equality****:* Achieve gender equality and empower all women and girls
- ***Clean water and sanitation***: Ensure availability and sustainable management of water and sanitation for all
- ***Affordable and clean energy****:* Ensure access to affordable, reliable, sustainable, and modern energy for all
- ***Decent work and economic growth****:* Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all
- ***Industry, innovation and infrastructure***: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
- ***Reduced inequalities***: Reduce inequality within and among countries
- ***Sustainable cities and communities***: Make cities and human settlements inclusive, safe, resilient, and sustainable
- ***Responsible consumption and production***: Ensure sustainable production and consumption patterns
- ***Climate action***: Take urgent action to combat climate change and its impacts

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)

- ***Life below water***: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
- ***Life on the Land:*** Protect, restore, and promote sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; and halt and reverse land degradation and biodiversity loss
- ***Peace, justice, and strong institutions***: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels
- ***Partnerships for the goals***: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

MDB Just Transition Principles

- MDB support for a just transition aims to deliver climate objectives while enabling socioeconomic outcomes, accelerating progress towards both the Paris Agreement and the SDG.
- MDB support for a just transition focuses on ***moving away from GHG emissions-intensive economic activities*** through financing, policy engagement, technical advice, and knowledge sharing, in line with MDB mandates and strategies and country priorities, including NDCs and long-term strategies.
- MDBs will encourage support for a just transition by building on existing MDB policies and activities, mobilizing other sources of public and private finance, and enhancing coordination through strategic plans that aim to deliver ***long-term, structural economic transformation***.
- MDB support for a just transition seeks to mitigate negative socioeconomic impacts and increase opportunities associated with the transition to a net zero economy, ***supporting affected workers and communitie***s, and enhancing access to ***sustainable, inclusive, and resilient livelihoods*** for all.
- MDB support for a just transition encourages transparent and inclusive planning, implementation, and monitoring processes that ***involve all relevant stakeholders and affected groups*** and that further ***inclusion and gender equality***.

ANNEX 9

Developing scenarios

Scenarios are a technique for presenting alternative views of the future. They identify some significant events, the main actors and their motivations, and they convey how the world functions. Scenario development allows us to think systematically about and understand the nature and impact of the most uncertain and important driving forces affecting our future.

The purpose of scenario development is not to imminently decide which scenario is correct; rather, it is to look at each plausible future scenario and examine how prepared a country or organization is, or how robust a PPP is, for the potential change and consequences.

Scenario development helps policy-makers anticipate hidden weaknesses and inflexibilities in organizations, methods, and PPPs. Most development PPPs are fixed in that they tend to assume a self-validating future—one usually based on extrapolation or prediction that dominates decision-making (and usually termed the ***default scenario***). However, we live in a world in which there are sudden changes and ***uncertainties*** (no one predicted the COVID pandemic!)—so PPPs fail to hold up under the stream of real events—and lead us into ***shocks and surprises.***

Scenario development deals with "what if?" questions and helps clarify a vision of the way ahead, capable of modification but allowing progress.

Thus, constructing scenarios enables the feasibility and effectiveness of a proposed PPP or its alternatives to be evaluated in different future conditions. There are four main steps involved in constructing scenarios. These are:

- Identifying the strategic issues associated with the PPP (i.e., what are the critical success factors and key concerns);
- Analyzing the present conditions and levels of environmental quality and social well-being;
- Identifying the most important and relatively predictable factors, or 'key drivers of change' and the uncertainties that will determine the nature of the future environment in which the proposed PPP or its alternatives will operate and linking them together into a framework; and
- Deriving two to four realistic scenarios associated with the effects of these most important factors on present conditions and determining which critical outcomes have the most potential to affect the proposed PPP and particularly components of the PPP.

Table A9.1: indicates a typical scenario building process.

Table A9.1: Scenario building process

Scenario building steps and tasks	Comments
Identify scenario setting	• Identify key factors and keep focus—avoid drifting or going too broad; • Consider the appropriate time frame for the scenario.
Identify and analyze key drivers of change	• Select macro/broad drivers, possibly global; • Drivers include social, technological, political, economic, and environmental forces; • Understand forces and dynamics; • Undertake initial research and analysis; • Organize a multi-stakeholder workshop and seek expert options.

Scenario building steps and tasks	Comments
Ranks drivers according to importance and uncertainty	• Identify 2/3 most important factors/trends and the most uncertain ones; • Focus attention on selection of the scenario logics, e.g., high importance/low uncertainty forces (these are the potential shapers of different futures for which longer-term planning should prepare).
Select scenario logics	• Plot selected drivers on axes (e.g., high-low, improving-declining) along which the scenarios can be constructed (see example in Figure A9.1); • From the different plots, select a manageable number of scenarios (about 3) that are most worthy of articulation; • Eliminate those whose combinations of logics are implausible/inconsistent.
Flesh out the scenarios	• Prepare a written description of the selected logical scenarios.
Assess the impacts of the PPP or alternative under each scenario	• Assess the environmental and social impacts of the PPP or its alternatives under each scenario and compare.

Figure A9.1: Example scenario plot for global growth
Source: McKinsey and Company (2015)

The process of scenario building should raise awareness of uncertainties, risks, and constraints that could be encountered in the future

In developing and assessing scenarios, the “worst case” scenario should be identified. The issues and consequences of the “do nothing” (or “business as usual”) scenario should also be identified, as these two scenarios can serve as a benchmark for the evaluation.

It can also be very helpful for the SEA to examine basic ***meta scenarios*** in relation to economic growth, e.g.

- *Baseline scenario* (the current situation)—drawing from the baseline profile;
- *Business as usual scenario*: essentially organic growth extrapolating current plans and trends (i.e., current trends continue, developments in the pipeline are realized, but there is not much stimulation for added growth and there is little significant change to the current situation);
- *Low growth scenario:* as with business-as-usual but with a low level of stimulation to growth with some new developments (e.g., new infrastructure);
- *Moderate growth scenario*: a moderate level of stimulus for growth is provided by the government, with planned expansion or improvement of infrastructure and improved production—consistent with Bhutan’s objective to achieve balanced regional growth.
- *High growth scenario*: a high level of stimulation is provided to achieve significant and rapid development.

Such scenarios can also be used as alternatives to be assessed.

ANNEX 10

Consolidated checklist for the quality assurance, review, and performance evaluation of a comprehensive SEA

There are a number of SEA quality assurance, review, and evaluation checklists available on the internet. This *Consolidated Checklist* combines the following resources:

- EU SEA Directive-based environmental report quality review table; quoted in Fischer (2007).
- IAIA (2002)
- NEMA (2012)
- Report Review Sheet. In NEMA (2012)
- ODPM (2005).
- Therivel R. (2006).
- Therivel R. (2010).

The Consolidated Checklist provides a relatively complete and robust system to quality-assure, review, and evaluate a ***comprehensive*** SEA from start-to-end (i.e., from scoping process to development outcomes), focusing different sections of the consolidated checklist on:

- Scoping Process and TORs;
- Draft SEA Report:
- Internal/Administrative Review
- Detailed Content Review
- SEA Outcomes.

It goes without saying that quality assurance, review, and evaluation procedures have to be modified for ***SEAs that are quick appraisals or semi-detailed.***

INTRODUCTION

Note: The checklist cannot be used in a "cookbook" fashion. Each SEA is unique; each SEA is tied to its TORs (including any limitations imposed on it by budget, available resources, data gaps, and context). The reviewer will NOT be able to answer all the listed questions in all cases; some questions may not be relevant to a specific SEA exercise. The "checklists" are meant to ***guide reviewers*** (and to guide those responsible for conducting SEAs and writing SEA reports)! The checklists are not a prescription, and they cannot replace (context-specific) good judgment!

The checklists comprise 11 sections that will provide reviewers and practitioners some insights into what to include in a comprehensive SEA and what to look for during review. Please always bear in mind the context specificity of the actual SEA exercise, the SEA's tier (policy vs. program level), the SEA's administrative level (national vs. local), and the SEA TORs (especially budget and allocated resources).

Section 1 can be used to conduct quality assurance on a scoping report.

Section 2, *"General Review,"* mainly reviews the Report Presentation. NECS should complete this review before the report is sent to other stakeholders for review.

Sections 3 to 8 cover a "*Detailed Content Review,*" which can be used by internal and external reviewers to systematically review these important SEA report chapters:

- Section 3: PPP description;
- Section 4: Policy and legal framework and links;
- Section 5: Description of the environmental baseline;
- Section 6: Determination of impact significance and evaluation of alternatives;
- Section 7: Mitigation and Environmental Management and Monitoring Plan (EMMP);
- Section 8: Consultation process.

Sections 9–11 can be used to monitor and evaluate SEA outcomes:

- Section 9 reviews aspects of the decision-making process;
- Section 10 reviews the SEA process overall.
- Section 11 looks at certain aspects related to SEA performance.

The review of scoping, the review of the SEA report in general and in detail, and the review of the SEA outcomes will occur at different times in the PPP/SEA timeline. Table A10.1 summarizes the review system.

Table A10.1: The review systems at a glance

Type of Review	Topic/Review section	Main (Responsible) Entity
Review of SEA Scoping	1. Scoping procedure	PPP proponent/SEA consultant/and competent authority
Review of the SEA Report: General Review	2. General Review of the SEA Report	Mainly competent authority
Detailed Content Review	3. PPP description 4. Policy and legal framework and links 5. Description of the environmental baseline 6. Determination of impact significance and evaluation of alternatives 7. Strategic Environmental and Social Management Plan (SESMP) 8. Consultation process	Reviews conducted by: • Lead agencies; • Public review; • Independent Committees (Technical Advisory Committee, or Independent Expert Commission). All review comments consolidated and considered by competent authority
Review of Outcomes: SEA Implementation	9. Decision making 10. IAIA SEA process review 11. SEA performance monitoring and evaluation	Competent authority

PROPOSED REVIEW PROCEDURE

- Within a given review exercise, each reviewer would be expected to summarize his/her review comments by topic/review section (and in the case of Lead Agencies, also by mandate, e.g., energy).
- Each entity could then summarize all the comments of its reviewers by topic. For instance, in the case where external reviewers are participating (e.g., during the technical review of the SEA document), each Lead Agency could summarize the comments of all of its reviewers by topic (e.g., Environmental Baseline).
- The competent authority is the entity that would have to consolidate the review comments from all the entities involved in the review process for its deliberations and final decision and recommendations.

1. REVIEW OF SCOPING

Was the methodology used to conduct scoping described? Was it adequate? (i.e., did it lead to a correct identification of key issues, objectives, stakeholders, and alternatives?)

Is there a clear description of the PPP and the PPP's objectives, the scope of the strategic action, and what the PPP can and cannot do?

- Were the objectives of the PPP confirmed and clarified and are they in line with existing (environmental, social or other) objectives?
- Were the PPP objectives and targets reviewed against the national, regional, or local environmental and social action plan(s)?
- Were the links between the PPP and higher- and lower-tier strategic actions considered?

Did the scoping process describe enough baseline to identify key problems? Did the scoping process identify key sustainability issues? Does the scoping report:

- List the environmental, social, and sustainability issues considered in the assessment?
- Describe how key environmental, social, and sustainability issues were identified?
- Highlight what matters are more appropriately assessed at other levels or layers of decision-making?
- Provide information on existing environmental, social, and sustainability problems that are relevant to the PPP, including those relating to any areas of particular importance to sustainability?
- Outline the significant issues that need to be studied during the SEA?
- Provide valid reasons for eliminating some issues from further consideration (i.e., explain why certain issues were "scoped" out.).
- Regarding studies to be conducted during the SEA, are the baseline-data-collection requirements related to the SEA objectives?

Did the scoping process identify adequate SEA objectives?

- Does the scoping report provide information on relevant international and national environmental protection and social objectives?
- Were the international and national environmental protection, social, and sustainability issues adequately considered in selecting and developing the SEA objectives, indicators, and targets?
- Was the national policy and institutional framework adequately considered in selecting and developing SEA objectives, indicators, and targets (e.g., other development, sectoral, or poverty alleviation objectives)?
- Were the SEA objectives described and clearly defined, quantitatively where appropriate?
- Do the SEA objectives and indicators cover an appropriate range of environmental, social, and sustainability topics, including relevant objectives for the biological (e.g., biodiversity and ecosystems), physical (e.g., for soil, water, air, landscape, climate change), and socio-cultural and economic components (e.g., for health, equity, poverty, heritage, or economy)?
- Were adequate decision criteria identified for the assessment (e.g., the use of relevant standards)?
- Were the technical, procedural, and other difficulties discussed (e.g., technical deficiencies, data gaps, or lack of know-how)? Were the assumptions and uncertainties made explicit?

Did the scoping process identify reasonable or adequate alternatives? Does the scoping report:

- Consider and describe how reasonable alternatives were identified and selected for further assessment?
- Were the alternatives that were selected for further assessment appropriate to the scale (national vs. local) and level (policy, plan, or program) of decision-making?
- Do the alternatives deal with the key issues identified in the issue analysis?
- Do the alternatives include (among others) the "do nothing"/"do minimum"/"business as usual" alternative and the "most environmentally beneficial" alternative?
- Are the alternatives in the PPP proponent's remit (i.e., in terms of geographical scope, objectives, and legal competence)?
- Are the alternatives feasible (i.e., are the relevant resources and technology available)? Are the alternatives implementable?

- Are the alternatives relevant to the decision-making process (i.e., are the alternatives for "real," as opposed to made-up for the SEA exercise)?
- Were reasons given for eliminating some alternatives? (Also see 6b: *Evaluation of alternatives and selection of preferred alternative.*).

Was the stakeholder consultation process conducted during scoping relevant and adequate? (i.e., were key stakeholders identified? Was the stakeholder consultation process culturally appropriate)?

Was a careful stakeholder analysis carried out to identify and characterize stakeholders?
- Was the start of the PPP planning process announced, and were key stakeholders brought together to agree on the problem, objectives, and alternatives?
- Were appropriate consultation bodies (including NGOs) and relevant authorities (including environmental and health authorities) consulted in appropriate ways and at appropriate times on the content, scope, alternatives, SEA objectives, and level of information to include in the SEA report?
- Was an appropriate communication plan/stakeholder engagement plan developed for the full SEA?
- Did the scoping process identify adequate spatial and temporal boundaries for the SEA?

Terms of References for the SEA study:
- Do the SEA TORs focus on significant issues?
- Does the SEA work plan to implement the SEA study seem appropriate?
- Does the SEA budget to implement the SEA study seem appropriate?
- Is the budget sufficient to implement the work plan?
- Was a management team and an SEA coordinator appointed?
- Is the list of experts (with supporting accreditation) adequate to conduct the study?
- Are the methods of data analysis and sources of relevant information listed?

2. GENERAL REVIEW OF THE SEA REPORT

*** The reviewer may need to interview some stakeholders.*

Is the SEA report complete, acceptable, and adequate (as defined below)?
- Does the SEA contain these chapters: non-technical summary, introduction, PPP description, environmental and social analysis (baseline description, evaluation of alternatives and risks, mitigation measures, consultation), recommendations, accompanying SESMP and appendices?
- Does the ***non-technical summary*** explain the overall approach to the SEA, the objectives of the strategic action, the objectives of the SEA, the main alternatives considered, the proposed mitigation and monitoring plan, and how the SEA changed the strategic action?
- Specifically, does the ***non-technical summary*** provide a statement summarizing:
- How were environmental/social/sustainability considerations (and their relationship with economic concerns and drivers) integrated into the PPP?
- How were the SEA report and the results of the consultations taken into account?
- The reasons for choosing the selected PPP over other reasonable alternatives?

Is the SEA report:
- Clear and concise in its layout and presentation? Does it use simple, clear language?
- Adequate in scope? (i.e., has it adopted a good time horizon? An adequate spatial scale)?
- Practical in focus? (i.e., does it focus on a limited number of key issues, targets, and indicators)?
- Presented as an integrated whole? (e.g., are the chapters harmonized)?
- Carried out in a professional manner? (i.e., does it provide an impartial/balanced analysis)?
- Presented in an open manner? (i.e., are the methods and data accessible? Are assumptions explicit?

Does the SEA report:
- Define necessary technical terms? Does the report avoid technical jargon?
- Identify the decision-maker?

- Identify who carried out the SEA and their competences?
- Provide a declaration jointly signed by the SEA consultant and the PPP owner?
- Use maps, other illustrations, and summary tables where appropriate?
- Describe the methodology used in the SEA (i.e., methodology for scoping, impact identification, prediction, evaluation, comparison of alternatives, stakeholder identification, and analysis)?
- Were the methods used appropriate to the size and complexity of the assessment tasks?
- Were difficulties explained (e.g., technical deficiencies or lack of know-how; data uncertainties or data quality issues)?

Was the draft PPP and draft SEA made available for public consultation and review by relevant authorities in a timely manner? Does the SEA report:

- Explain who was consulted and what consultation methods were used?
- Provide proof that various stakeholders were consulted (e.g., signed statements and/or minutes) and summarize the comments received and how each comment was addressed?
- Focus on the big issues or relevant strategic issues?
- Discuss the scope of the SEA? (i.e., is the scoping report attached?)
- Comply with the policy, legal, and administrative framework for conducting an SEA (including being in compliance with existing procedural and substantive guidelines)?
- Comply with the TORs?
- Identify all sources of information, including expert judgment and matters of opinion?
- Provide adequate information (i.e., comprehensive, rigorous, understandable, and in compliance with the TORs) from the point of view of the PPP owner? What is missing?

3. DESCRIPTION OF THE PROPOSAL (+ LINKS)

Does the SEA report:

- Clearly highlight the strategic action's purpose and objective(s)?
- If the SEA procedure was simultaneous with the PPP-making process, does the SEA describe how the SEA and the PPP-making processes were integrated:
    - ***Simultaneous with integrated SEA process*** (i.e., one team): Does the report describe what inputs and how the SEA inputs were integrated? Is this well documented?
    - ***Simultaneous with parallel SEA process*** (i.e., two teams): Does the SEA report describe what inputs/how/when the SEA inputs were integrated into the various decision-making windows/opportunities)?
- Identify the degree to which the PPP sets a framework for other projects/other activities (e.g., in terms of location, size, nature, and operating conditions, or resource allocation and future projects that will require EIAs)?
    - Explicitly highlight the links to project-level EIA (i.e., does it explain what type of projects requiring EIA will follow from implementing the PPP)?
- Clearly outline the expected content of the PPP, including the area covered and the implementation timeframe?
- Identify (and describe to the extent possible) PPP implementation activities that could influence:
    - Important ecosystem services/important ecosystem diversity;
    - Areas with legal and/or international status?
- Identify (and describe to the extent possible) PPP implementation activities that could influence:
    - Changes in land use or lead to the depletion of natural resources;
    - The production of raw materials, chemicals, and other hazardous products;
    - The generation of pollutants and wastes?
- Identify (and describe to the extent possible) PPP implementation activities that could lead to these *direct drivers of change* (also see Section 'Baseline'):
    - Land conversion;
    - Fragmentation (and isolation of important habitats);
    - Extraction and use of natural resources;
    - Wastes (all types);
    - Disturbance of ecosystem composition, structure, or key processes;
    - Introduction of alien species;
    - Restoration;
    - Population changes;
    - Conversion or diversification of economy or land use;

  - Enhanced transport, services, or access;
  - Marginalization and exclusion?
- Identify (and describe to the extent possible) PPP implementation activities that could lead to *indirect drivers of change*:
  - Societal changes (demographic, economic, socio-political, scientific, or changes in social values) (e.g., a new technology could result in more intensive use of a resource in the future)?
- Are the *assumptions about what the strategic action will 'look' like* when implemented clearly stated or, if implicit, do they make sense? (This query is repeated in Section 6)

4. POLICY AND LEGAL FRAMEWORK AND RELATIONSHIP TO OTHER PPPS

Does the SEA report:
- Clearly explain the PPP's links to other related PPPs, including links between the strategic action and related higher- and lower-tier strategic actions?

Consistency and compatibility analyses:
- Does the SEA identify and describe any conflicts that exist between the SEA objectives (e.g., an internal consistency analysis on the SEA objectives)?
- Does the SEA identify and describe any conflicts that exist between the PPP's objectives (i.e., internal consistency analysis of the PPP objectives)?
- Does the SEA identify and describe any conflicts that exist between the SEA objectives and the PPP's objectives (compatibility analysis)?
- Does the SEA identify and describe any conflicts that exist between the PPP's objectives and the objectives of other PPPs (compatibility analysis)?
- Where the proposed PPP, other strategic actions, or other objectives are in conflict, does the report clearly document the reasons for the conflict, and does it make recommendations on how to reconcile the PPP [or how to reconcile the other PPP(s)] to promote sustainability?
  - Where identified conflicts are not reconcilable, does the SEA explicitly state which PPP, action, or objective will dominate?
- Does the report succinctly summarize all of the above, highlighting the most relevant to the PPP (relevant in terms of important problems and/or tier of assessment)?

5. ENVIRONMENTAL BASELINE DESCRIPTION

Bearing in mind the likely PPP activities (identified in Section 3), does the SEA report:
- Describe the relevant aspects of the current biological, physical, social-cultural, and socioeconomic environment, as per TOR requirements?
- Provide a "trend" analysis of relevant, important aspects (i.e., does it describe or predict the future environment ***without*** the PPP)?
- Describe ***in detail*** the environmental and social characteristics of the area likely to be significantly affected, including areas beyond the physical boundary of the PPP that are likely to be affected?
- ***Specifically,*** does the SEA provide sufficient information/baseline information on the likely significant effects of the different options on (where relevant):

  Biological component:
  - Biodiversity and ecosystem services;
  - Protected areas;

  Physical component:
  - Soil
  - Water
  - Air
  - Climate and climate change
  - Landscape

  Social-cultural and socioeconomic component:
  - Population

- Human health
- Cultural heritage, including architecture and archaeology
- Material assets
- Resource use (e.g., water, land use)
- Economy

And the (important/relevant) interrelationship between the above biological, physical, and social-cultural and socioeconomic components?

- Does the baseline data cover more than just an inventory of species? Was there a focus on important ecological systems, their services, their resilience and vulnerability, and the significance of the ecological services for human wellbeing?

Does the report:

- Explain data sources, data gaps, and assumptions, where relevant?
- Describe the tools and methods used to complete the baseline description?

6. DETERMINATION OF IMPACT SIGNIFICANCE & EVALUATION OF ALTERNATIVE OPTIONS

6.1 Impact identification, prediction, and evaluation

- Are ***assumptions about what the strategic action will "look" like*** when implemented clearly stated or, if implicit, do they make sense? (Same query seen in Section 3)
- Are ***assumptions*** about the likely ***impacts*** of the strategic action's implementation clearly stated, or if implicit, do they make sense?
- Is the area and time over which the predictions are made appropriate?
- Is an effort made to prioritize those effects that most affect sustainability?
- Is the level of detail of the predictions appropriate (is it proportional to the level of detail of the strategic action and the baseline data, and is it "fit for purpose"? (Are the predictions overly detailed or insufficiently detailed?)
- Is the level of uncertainty regarding the predictions documented?
- For each alternative or option, are the likely significant impacts on the environment identified, described, predicted, and evaluated?
- For ***each alternative***, does the SEA:
    - Identify both positive and negative effects?
    - Identify the probability, duration (short-, medium-, or long-term, permanent or temporary), frequency, and reversibility of the effects?
    - Identify the magnitude and spatial extent of the effects (geographical area and size of population affected)?
    - Identify the secondary, cumulative, and synergistic effects?
    - Identify the transboundary effects?
    - Identify risks to human health and to the environment (e.g., due to the risk of accidents)?
    - Are the impacts on different groups of people identified and evaluated (e.g., on those stakeholders already negatively affected by environmental impacts and risks)?
- Has impact evaluation been carried out against a clearly stated and reasonable basis? e.g., evaluated against the current situation, future situation, environmental standards, SEA objectives, or environmental limits?
- In evaluating "significance," is the "importance" of environmental components considered using various ways of viewing importance, e.g.:
    - ***Institutional recognition*** (i.e., the attribute is acknowledged in the policy and legal framework or has relevant accepted standards, regulations, and thresholds);
    - ***Public recognition*** (i.e., the public recognizes the feature as important);
    - ***Technical recognition*** (i.e., the feature is recognized as important based on scientific or technical knowledge)?
- Were the tools and methods used to identify and evaluate impacts adequate?

6.2 Evaluation of alternatives/options and recommendations on the preferred alternative/option

- Was each alternative/option evaluated against the SEA objectives or relevant baseline?

- Were the environmental, social, and sustainability effects (both adverse and beneficial) of each alternative/option compared to the other alternatives/options?
- Were the residual impacts (impacts remaining after mitigation) of each alternative/option evaluated and compared?

Does the SEA report:

- Outline how the alternatives were assessed and the reasons for selecting the preferred alternative(s)?
    - Did the assessment and the procedure for comparison use credible tools/methodology?
    - Did the evaluation/comparison of alternatives involve appropriate stakeholders?
- Are credible reasons given for eliminating certain alternatives?
- Are "trade-offs" explained and justified?
- If "trade-offs" are necessary:
    - Are irreversible impacts avoided?
    - Are impacts that would exceed environmental thresholds or limits avoided?
    - Are sensitive areas avoided?
    - Are areas that have already been cumulatively affected avoided?
    - Is greater weight given to longer-term impacts?

7. MITIGATION AND STRATEGIC ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (SESMP)

7.1 Mitigation: *Does the SEA report:*

- Document that the mitigation hierarchy of first avoidance, then mitigation, and then compensation was followed?
- Identify measures to avoid, reduce, repair, or compensate for any significant adverse effects of implementing the PPP?
- Mainly, propose mitigation measures that are within the PPP proponent's remit or control?
- Identify measures that are likely to be effective (i.e., measures that will manage a good share of the impacts caused by the strategic action)?
- Clearly commit to measures to avoid, reduce, repair, or compensate for any significant adverse effects of implementing the PPP (e.g., is there a budget and an organizational framework for implementing impact mitigation and monitoring)?
- Identify and commit to measures to enhance the positive effects of implementing the PPP?
- Where relevant, identify mitigation measures that need to be taken into account in follow-on project consents (e.g., does it identify subsequent EIAs? or the need to conduct specific types of assessments, e.g., poverty impact assessment or gender impact assessment)?

7.2 SESMP: *Does the SESMP:*

- Summarize the impacts related to the PPP?
- Describe the mitigation measures envisaged to prevent, reduce, or compensate for any significant adverse effects on the environment or social conditions related to the PPP (including the need for subsequent EIAs or the need for specific designs, equipment, or operating procedures)?
- Summarize the enhancement measures related to the PPP?
- Describe the SESMP implementation framework:
    - Explain how existing monitoring arrangements may be used, and where appropriate?
    - Propose monitoring measures that are clear and practicable?
    - Provide clearly defined indicators based on the baseline information and on the objectives of the PPP and the SEA?
    - Describe the measures envisaged to monitor the significant environmental and social effects of the PPP implementation?
    - Describe how monitoring will identify and manage unforeseen adverse effects in a timely manner, e.g., in the case where SEA predictions prove to be inaccurate?
    - Provide thresholds that signal the need for corrective actions?
    - Propose adequate action in response to significant adverse effects?
    - Ensure that the collected monitoring data addresses deficiencies in the SEA's baseline information?

    - Describe the institutional arrangements (responsibilities for mitigation and monitoring, and any coordination arrangements)?
    - Describe the implementation schedule (e.g., methods, sampling locations, detection limits, timing, frequency of measurements, and duration of mitigation measures)?
    - Describe reporting procedures?
    - Provide cost estimates (initial investment and recurring expenses)?
    - Provide for institutional strengthening and capacity building requirements (equipment requirements and training requirements)?
- Describe how stakeholders provided input to the mitigation and monitoring plan?
- Describe the role of the various stakeholders (including the public) during the SESMP implementation?
- Define outcome indicators?
- Provide an evaluation plan (with an adequate budget and clear responsibilities)?

8. CONSULTATION PROCESS (DURING SCOPING, THE SEA STUDY, THE SEA REVIEW, AND DURING IMPLEMENTATION AND MONITORING)

- Was there effective cooperation between the SEA team and the PPP proponent? If not, how could this be improved in the future? ***(May require interviews.).***
- Was SEA consultation an integral part of the PPP-making process (in the case of a simultaneous [parallel or integrated] SEA model)?
- Was an SEA consultation integrated into the SEA design and implementation (e.g., were stakeholders consulted on the SEA TORs, the baseline, the evaluation of alternatives, the identification of mitigation and monitoring measures, and the SEA review)? (Relevant to the "separate" and the "simultaneous" SEA models.)
- Overall, was the consultation process adequate and effective? How could it be improved in the future?
- Was there broad participation in the SEA, that is:
    - Were relevant professional, technical, social, and NGOs groups represented?
    - Did the decision-makers participate (to ensure adoption and endorsement)?
    - Were the communication methods effective, i.e., tailor-made to the needs of the different audiences?
    - Did the SEA process promote collective learning and feedback? Did the SEA process support the development of local assessment capacity?

Does the SEA report:
- Describe ***how/when*** the relevant stakeholders were ***identified*** and how their interests were ***analyzed*** (i.e., during scoping, SEA preparation, and SEA review)?
- Describe ***how/when*** the relevant authorities (including environment and health authorities), lead agencies, and the public were ***consulted*** (i.e., during scoping, SEA preparation, and SEA review)?
- Specifically, describe ***how/when*** the ***draft PPP*** and the ***draft SEA report*** were made ***available*** to relevant authorities, lead agencies, and the public, and ***how/when*** they were allowed to ***express their opinions*** on the documents?
- Was an appropriate range of stakeholders consulted (i.e., was the stakeholder analysis sufficient)?
- Were these stakeholders consulted in ways and at times that gave them an early and effective opportunity with appropriate timeframes to express their opinion on the draft PPP and draft SEA report:
    - ***Lead agencies and other authorities?***
    - ***Environmental and health authorities*?**
    - ***Expert committee*** (TAC, SERC, or IEC)?
    - The ***public*** (or more likely, the designated public representatives likely to be
    - affected by, or having an interest in the PPP)?
    - Was there an effort to ***involve vulnerable stakeholders*** (e.g., very poor) in the consultation? If so, was it successful? How could this be improved in the future?

Does the SEA report:
- Summarize and address all stakeholder views?

- Highlight how the consultation results were considered in decision-making?
- Provide adequate documented evidence of the consultation events?
- Outline a grievance mechanism if stakeholders feel that their opinions have not been sufficiently addressed?

OUTCOME REVIEW

9. DECISION-MAKING

- Was the SEA conducted as an integral part of the decision-making process? (i.e., in the case of a simultaneous SEA model [integrated or parallel], were SEA inputs considered during decision windows? In the case of a separate or a reactive (ex-post) SEA, were SEA inputs considered when approving, revising, or amending the strategic action)?
- Does the Final SEA Report explain how the SEA findings and stakeholder inputs were considered during decision-making?
- Was the Final SEA Report and the opinions of those consulted taken into account in finalizing and adopting the PPP?

What was the influence of the SEA on the PPP process?

- Was the SEA proactive? i.e., did the SEA provide assessment results early enough to influence decision-making?
- Did the SEA provide useful information for those responsible for developing the PPP?
- Did the SEA identify the issues most important to ***sustainable outcomes***, rather than dealing with all environmental and socioeconomic issues?
- Did the SEA address questions and concerns not initially included in the PPP? What was appreciated most? What proved irrelevant?
- Could the SEA findings be effectively conveyed to the decision-makers?
- Were decision-makers willing to consider the SEA inputs and willing to integrate the findings into decision-making?
- Did the SEA actually make the PPP more environmentally sound?
- Did the PPP process make sufficient reference to the findings of the SEA?

Did the SEA build capacity and improve accountability and transparency?

- Did SEA empower weak and vulnerable stakeholders?
- Did the SEA help build capacity by training decision-makers on implementation?
- Did the SEA build capacity to collect data and provide documentation?
- Did the SEA enhance the transparency of the decision-making processes and accountability of decision-makers on the environmental implications of the PPP?
- Did decision-makers justify/correct their decisions based on the SEA findings and SEA monitoring?
- Did the SEA exercise lead to a better understanding of the potential of this approach? Did the SEA exercise encourage subsequent SEA applications (did the SEA results identify other PPPs requiring SEA? Was the SEA process fruitful and/or a positive experience, making the participants more willing to participate in the next SEA)?

** Some of the above questions may require interviews.

10. IAIA SEA PROCESS REVIEW

Was the SEA integrated?

Did it:

- Ensure an environmental assessment/sustainability appraisal of all the PPP's strategic decisions?
- Address the interrelationships of biophysical, social, and economic aspects?

Was it:

- Tiered to policies in relevant sectors and transboundary regions and, where appropriate, to project EIA and decision-making?

Sustainability-led? Did it:
- Facilitate identification of more sustainable development options and alternatives?

Focused? Did it:
- Provide sufficient, reliable, usable information for planning and decision-making?
- Concentrate on key issues of sustainable development?
- Was it customized to the characteristics of the decision-making process?
- Was it cost- and time-effective?

Accountable? Was it:
- The responsibility of the strategic decision's lead agencies?
- Carried out with professionalism, rigor, fairness, impartiality, and balance?
- Subject to independent checks and verification?

Did it:
- Document and justify how sustainability issues were considered in decision making?

Participatory? Did it:
- Inform and involve interested and affected public and government bodies throughout the decision-making process?
- Explicitly address stakeholders' inputs and concerns in the report and in decision-making?
- Provide clear, easy-to-understand, necessary information?
- Ensure sufficient access to all relevant information?

Iterative? Did it:
- Make available the assessment results early enough to influence the decision-making process and inspire future planning?
- Provide sufficient information on a strategic decision's actual implementation impacts to judge whether the decision should be amended?

Overall comments on the SEA process:
- What is/what was the view of key stakeholders (particularly the more vulnerable) and those responsible for developing the PPP on the SEA procedure and results?
- How could it be improved in the future?
- What were the most significant constraints to achieving an effective SEA?
- What were the most significant positive factors ensuring the success of the SEA?
- Did the SEA address equity, social acceptability, and incorporate the precautionary principle?

** Some of the above questions may require interviews.

11. SEA PERFORMANCE REVIEW: IMPLEMENTATION, MONITORING, AND EVALUATION

Did the SEA predict future outcomes correctly?
- Were the assumptions made during the SEA for modelling impacts and/or institutional and governance requirements, correct?
- Were there any PPP-related unforeseen impacts? Explain.

What was the influence on the implementation process?
- Did the SEA improve the strategic action (i.e., did the SEA result in relevant amendments or modifications to the PPP? Did it identify more sustainable alternatives?)
- Did the SEA lead to more effective implementation? (e.g., did it inform subsequent lower-tier decision-making? Did it improve monitoring and follow-up?)
- Did the SEA succeed in actually changing the PPP implementation or budget plans, or other subsequent measures, making the PPP more environmentally sound?
- Did the PPP implement measures that better reflect the goals of sustainable development?

- Were the options implemented in a more environmentally sound manner?
- Did the recommendations of the SEA lead to:
    - Institutional development (e.g., an advisory group on environment or better inter-sectoral coordination)?
    - Subsequent EIA requirements?
    - Improved governance (e.g., empowerment of vulnerable stakeholders)?
    - More sustainable implementation/more sustainable resource use by the PPP?
- Did the different stakeholders implement their relevant SEA recommendations?
- How do the stakeholders view the SEA process and its outcomes now?

What was the influence on direct and indirect goals of sustainable development?
- Are there any indications that the SEA contributed to:
    - Achieving SDGs and/or other goals of relevance in the particular case?
    - Environmental protection and sustainability?
    - Improving conditions of environment and natural resources in the relevant
    - area?
    - Enhancing transparency, accountability, and good governance?
    - Improvements to future PPP making? (e.g., were key environmental issues identified? Were lessons learned? (Do planners have a better understanding of sustainability issues?)
- Did the sustainable development benefits of the SEA outweigh the costs of conducting the SEA?

ANNEX 11

Trend analysis

For conducting many SEAs, trend analysis is likely to be one of the most useful approaches. Trend analysis can be defined as an interpretation of changes over time without and with the proposed/revised PPP (policy, plan, or program). It has several advantages:

- It can help to describe the past trends and current situation by tracing any trends or patterns in the relevant territories in time periods covered by the SEA.
- It can also help in predicting future 'baseline' trends without the proposed PPP being implemented (the so-called 'zero alternative'), since some trends can be safely extrapolated based on information about their future drivers. However, it is important to note that oversimplified extrapolation, which does not consider how the trend will evolve once it reaches a key breaking point (e.g., when the carrying capacity of the surrounding environment has been reached or exceeded) or once the counter-trend becomes stronger, may be misleading. Such analyses can open many new insights and can be useful not just for the SEA process but also for the development of the PPP as such.
- Lastly, the trend analysis can facilitate the assessment of cumulative impacts of proposed developments (including downstream projects) in the PPP on the identified future "baseline" trends.

Trend analysis can combine many different tools, and it has the capacity of analyzing cause-and-effect relationships even in situations constrained by significant data gaps. The presentation of trends can be fairly simple, e.g.,

- Storylines that describe the overall trends, their main drivers, their territorial dimensions, and key concerns and opportunities arising from these trends;
- Maps showing spatial development patterns;
- Graphs: these can be (a) simple graphs that use available data sets to illustrate the evolution of key issues and/or their drivers over time, or (b) complex graphs that provide a comprehensive overview of the correlation between the evolution of drivers over time and the corresponding (sometime delayed) changes in the issues addressed by the analysis.

Proper understanding of the current situation and trends and their likely evolution if the PPP is not implemented provides the basis for predicting environmental and social effects within the SEA. These trends may be influenced in various ways by, e.g.,

- Market forces—e.g., higher prices for minerals can stimulate mining,
- Major development projects that have been already approved but not implemented yet,
- PPPs other than one being directly assessed by the SEA; and
- Changed climatic conditions

The impacts of these developments may not yet be visible or fully evident. The forward-looking analyses undertaken by an SEA should outline the expected future environmental and social trends since it is important to understand impacts of the PPP on the "future environment" in which the PPP will operate. Many environmental and social issues may improve and many may get worse in the future irrespective of the proposed PPP (e.g., some ecosystems will be lost anyway; many environmental features will become even more important; the population will grow anyway and place increased demand on land and natural resources). It is also important to consider that, in the near future, some environmental and social trends may be affected by climate changes, e.g., increasing temperatures, flash floods, landslides, forest fires, glacial retreat and glacial lake outburst floods (GLOF), water shortages, declining yields of some crops (e.g., maize and rice) and increases for others (e.g., potato), changes in pests and plant diseases as well as rainfall patterns, shifts of forest types to higher elevations, changes in the ranges of species, increased risk of water-borne diseases, and spread of vector-borne diseases (e.g., malaria, dengue).

SEA requires consideration of long-term trends, and the SEA team needs to present sound judgments on the ongoing environmental and social changes (which may be linked) that are relevant to the PPP. In this regard, it should be noted that the most common deficiencies in analyzing current situations and trends do not usually arise from the lack of data but rather from poorly targeted analyses that focus on irrelevant issues. This task therefore demands, especially in the case of large-scale PPP, focused analytical thinking, a strategic approach to data collection, and qualified expert judgments.

In order to ensure that the assessment of the current situation stays focused, it is recommended to concentrate on the main environmental and social issues, objectives, and guiding questions that have been identified in the preceding SEA scoping step. The SEA experts need to gather just enough information to answer the following questions:

- How good or bad is the current situation? How far is the current situation from any established thresholds or targets?
- Are particularly sensitive or important elements of the receiving environment affected, e.g., vulnerable social groups, non-renewable resources, protected areas, endangered species, rare habitats? Are the problems reversible or irreversible, permanent or temporary?
- What is driving these trends?
- What is the expected future continuation of these trends, if one considers impacts of other already agreed projects or PPPs and considering impacts of climate change?

Both qualitative and quantitative information can be used for this purpose. The description of the past and current trends can be made on the basis of data available from existing information sources (e.g., State of the Environment reports, data from other available PPPs, research projects, donor analyses), or through expert judgments (in cases where data are lacking). SEA experts should not embark on collecting raw data at this stage, unless very clear key issues are identified for which no data are available. They are required to accomplish this task while taking into account available studies and considering the key driving forces behind these trends. When maps are easily available, these analyses may be supplemented by maps showing spatial dimensions and linkages between the key environmental, social, and economic issues in the study area.

The data on the current and future environmental and social trends serve not just to inform future SEA steps but may also strengthen the analysis of the overall development context during the elaboration of the PPP. In cases where the SEA process is carried out during the elaboration of the PPP, information gathered or generated during this step can be provided to the PPP planning team and may strengthen the analysis of the overall development context.

Analysis of environmental and social trends without the PPP can significantly benefit from inputs from key authorities, academia, business groups, or NGOs that have the relevant information. Workshops, roundtables, and formal meetings, etc. can be used for this purpose.

Tips for practice

Keep the focus when collecting information: Do not collect excessive details or use information just because it is there. Concentrate on environmental and social issues, objectives, and guiding questions identified in the scoping phase, and do not overburden the evaluation of the situation with irrelevant information.
Set a time limit for information collection. Do not expect to be able to obtain all relevant information in the first SEA of a PPP, but make arrangements to fill any major gaps for future replacements or reviews of PPP.
Use the expertise within environmental and social authorities and key stakeholders to identify and interpret relevant data and predict trends.
When describing the past trends, try to determine the main economic or social factors that drive these trends. This information may later help you to analyze whether the PPP positively or negatively influences these driving forces.
Consider the impacts of other relevant PPPs and outline the likely expected evolution of environmental trends, if the proposed PPP were not to be implemented.
Consider the impacts of the expected climate changes on future environmental and social trends, as increased risk of hazards may increase vulnerability.
Where possible, supplement these analyses by maps showing spatial dimensions and linkages between the key environmental, social, and economic issues.
Share and double-check this information with the planning team.

Tables A11.1 and A11.2 provide fictional examples of a trends analysis for past trends and future trends, respectively.

Table A11.1: Fictional example of past trends analysis for terrestrial biodiversity

Analysis of past trends and current situation	
Theme:	**Terrestrial biodiversity**
Issues:	Condition and extent of natural areas and connectivity of important ecosystems

Please describe:

- An overall context of the theme addressed (i.e., original/natural potentials and constraints, etc.—basic facts such as volumes, acreage, etc.—accompanied by a short commentary on their importance—international, national, provincial, local)
- List issues that you have chosen to focus on within this theme and justify in 1-5 sentences for each issue why it is important—wherever possible, relate it to official documents that also recognize these issues as important
- For each issue, analyze its past trend (e.g., how has the situation evolved so far, whether the trend is improving or worsening, whether it reaches any critical bottom-lines or turning points, etc.).
- Factors (drivers) that positively or negatively affect this trend or that limit the trend (counter-trends). When doing so, you may wish to cross-refer to any relevant national/provincial/local SPPs or major projects.
- The key problems and/or the key geographic areas of specific concern (of national, provincial, and local importance)
- Always quote sources of data (e.g., full references in footnotes) and, when necessary, provide commentary on their quality and uncertainties—if you find that some critical pieces of information are missing or may be doubtful (contradictory, incomplete, etc.), state it clearly.

E.g.

- In 1990, the province had an extensive population of XX critically endangered species (out of which XX species are endemic) and of XX endangered species (out of which XX species are endemic). Further to this, the province hosts a small population of XX species, which are not protected, but they play a significant role in the lifestyles of the local ethnic groups.
- Valuable natural ecosystems in areas (see attached map) accounted for ZZ ha (25% of the territory of the province) in 1995. They were connected by bio-corridors KVD and HWD, which played an important role in the migration of XX critically endangered or endangered species. The Biodiversity Conservation Action SPP of the province (elaborated in 1994 by SWA but not yet awaiting formal approval by the Provincial People's Committee) has suggested ensuring that at least 15% of the territory becomes protected to halt biodiversity decline.
- Until 2006, 9% of the territory of the province has received various degrees of protection. ZZZ ha in location XYZ that hosts species SSS has been declared a national park which is also classified as a habitat of international importance (see ministerial meeting XSW and resolution by KWC). ZZZ ha in location UBF serves as a breeding ground for species GDE has been declared protected area, etc. Areas GBH 1-3 have been proposed as special use forests.
- At the same time, ZZ ha (5% of valuable important ecosystems found in the province) have been irreversibly damaged by the conversion of these natural ecosystems to mining and agriculture. The remaining valuable ecosystems that are endangered by forestry practices FFF. As overall degradation of the ecosystems regards, it should be noted that the status of existing protected areas does not entirely prevent degradation of already protected ecosystems (e.g., forestry practices GHJ cause impacts YUZ in locations DRT).
- A study by FAO found out that the most important driving force for deforestation in rural areas is the development of paved roads in rural areas. The pavement of new roads contributes to 85% of forest loss. Corridors along the newly paved roads (5–10 km on each side of the road) quickly become deforested due to illegal logging and subsequent small-scale illegal agricultural activities and informal settlements. So far, all government measures to tackle this problem have been ineffective due to a lack of enforcement.
- The bio-corridor KVD has been irreversibly damaged by road developments in AA1. Migration of critically endangered species XX has stopped with the fragmentation of this bio-corridor; however, some migration reportedly takes place through the bio-corridor HDW. The bio-corridor HDW thus serves as the only migration route for species XX and plays the key role in the viability of these

populations of these migratory species in the province, and in the country generally.

+ supplemented by any graphic aids to illustrate the trend—graphs, maps, pictures, or boxes with local stories that provide representative examples of the trend.

Future trends without the proposed SPP

Theme:	**Terrestrial biodiversity**
Issues:	Condition and extent of natural areas and connectivity of important ecosystems

Key factors that will influence these trends:	Likely expected positive or negative impacts of these factors on the given trend:
Outline key factors that may positively or negatively influence the future trend in this issue without the SPP. These may include: • market drivers; • new policies, laws, and regulations and economic incentives, • other agreed SPPs; • major projects; and • climate change!	Explain in detail: • Character of impact (what exactly causes this impact or assumptions that form the basis for your prediction) • Probability and key uncertainties • Geographic scale—directly and indirectly affected territories • The key concerns associated with this impact All these statements need to be substantiated (calculations, examples, references to international and national literature, maps, graphs), which can be annexed to illustrate the impact.
Spatially-focused plans (Ps) for Development of Tourism for 2007-2013 (Ministry of Tourism, 2006)	10 ha of coastal ecosystems that are part of the planned protected area ZDT may be lost in the next 6 years because of planned tourism projects in LKT, HWT, and CZD. The scale of impact depends on the outcomes of the detailed design of these planned projects that will also be subject to EIAs.
Forestry Ps (MARD, 2005)	Natural ecosystems that could be declared protected areas are likely to decrease by approximately 5% in the next 6 years, mainly because of recently adopted changes in the forest classification and approval of logging projects at QSW and GRF.
Aquaculture projects in XYZ and ZSY (approved by the District People's Committee in 2006)	Both projects have damaged bio-corridor GJY. No plans for rehabilitation of these bio-corridors exist.

Summary of key trends in the relevant environmental issue without the implementation of the SPP

Please use the above information to outline:

- How good or bad is the current situation? Do trends show that it is getting better or worse?
- How far is the current situation from any established thresholds or targets?
- Are particularly sensitive or important elements of the receiving environment affected, e.g., vulnerable social groups, non-renewable resources, endangered species, rare habitats?
- Are these problems reversible or irreversible, permanent or temporary?
- How difficult would it be to offset or remedy any damage?

E.g.

- Valuable natural ecosystems that could be declared as protected amount to 25% of the territory. Until now, 9% of these ecosystems have been declared protected areas, but the most important bio-corridors that connect them have been damaged.
- Valuable natural areas are likely to decrease by approximately 5% in the next 6 years, mainly because of the recently adopted Transport Development SPP and approved future projects for aquaculture and tourism. No plan for rehabilitation of bio-corridors exists.

Table A11.2: A fictional example of assessment of impacts of future environmental and social trends as influenced by the actions proposed in a PPP for terrestrial biodiversity

<table>
<tr><th colspan="3">Analysis of future trends with the SPP</th></tr>
<tr><td>Theme:
Issues:</td><td colspan="2">Terrestrial biodiversity
Condition and extent of natural areas and connectivity of important ecosystems</td></tr>
<tr><td colspan="3">Summary of the past and future trends without the SPP
Summarize the past and future trends without the SPP, e.g., through 5-10 sentences that remind the reader of the past trends, current situation, and future trends without the SPP.

E.g.
Valuable natural ecosystems that could be declared as protected cover 25% of the territory. Until now, 9% of these ecosystems have been declared protected areas, but the most important bio-corridors that connect them have been damaged.
These areas will decrease by approximately 5% in the next 6 years, mainly because of the recently adopted Forestry Policy and approved future projects for windfarming, aquaculture, and tourism. No SPPs for rehabilitation of biocorridors exist.</td></tr>
<tr><td colspan="3">Expected direct effects of the proposed SPP on the future trend in these issues</td></tr>
<tr><td>Components of the SPP</td><td>Expected environmental risks (negative impacts) and environmental opportunities (positive impacts)</td><td>Proposed mitigation and enhancement measures</td></tr>
<tr><td>Feature or component of the SPP that cause these impacts (these may be the overall development direction pursued by the SPP, clusters of projects or individual projects proposed in the SPP).</td><td>Explain in detail:
• Character of risk/impact (what exactly causes this risk/impact or assumptions for this prediction)
• Probability and key uncertainties
• Geographic scale: directly and indirectly affected geographic areas that will become of specific concern
• Duration and reversibility
• Key concerns associated with this impact

When doing so, make sure that you judge these impacts on the basis of future trends without SPP (e.g., some important ecosystems or development opportunities may be lost as a result of development trends without the SPP, or some ecosystems or development opportunities may become even more important since they will provide the only remaining assets in the study area).

All these statements can be substantiated by detailed calculations, examples, and references to international and national literature and supplemented by graphic aids (maps, graphs) to illustrate the impact.</td><td>Provide your recommendations for possible changes in this proposed strategic orientation of the RDP.

You may also suggest additional “flanking” measures for future management of environmental issues that you’ve identified.</td></tr>
<tr><td>Project 1.1.1.</td><td>The construction will most probably lead to fragmentation of ecosystem AXT that will form an integral part of the only remaining regional bio-corridor. This impact can be either short-term or permanent, depending on the effectiveness of mitigation.</td><td>This loss of bio-corridor can be compensated by the restoration of damaged ecosystems AXT after the construction.</td></tr>
<tr><td>Project 1.2.3.</td><td>….</td><td>….</td></tr>
</table>

Expected future cumulative effects of the SPP on the trends for the issue
Summarize the worst-case scenario and the best-case scenario for the future evolution of this trend if all direct and indirect impacts of relevant components of the SPP on the trend happen. E.g. <u>Worst-case scenario</u> If SPP proceeds as planned, 250 ha of natural ecosystems in location CDR, etc. will be lost and 4 bio-corridors DWS, etc. of international importance will be permanently damaged. This trend will most likely lead to the extinction of species FRD, GWS, etc. <u>Best-case scenario</u> If all recommended changes to SPP are adopted, only 50 ha of natural ecosystems in location DRT, etc. will be lost and only 2 important bio-corridors will be temporarily damaged. This damage, which will occur in any case, can be compensated by the establishment of new protected areas in XXX. Species FRD and GWS will remain critically endangered, and greater attention needs to be given to their protection.

ANNEX 12

Analytical methods that can be used in an SEA

Source: UNECE and REC, (2006).

This annex provides a menu of selected analytical tools and techniques that can be used in an SEA and offers an overview of each method. In practice, the SEA experts may find it appropriate to vary their approach, for instance, in combining qualitative and quantitative assessment. The following methods are described:

- Expert judgments
- SWOT
- Checklists
- Matrices
- Spatial analyses: overlay maps and GIS
- Trends analysis/extrapolation
- Networks and flow diagrams
- Delphi technique
- Modelling
- Multi-criteria analysis

The key features of these tools can be summarized as follows:

Tools	**Application within the SEA process**				
	Identification of issues and impacts	**Analysis context and baseline**	**Contributing to develop-ment of alternatives**	**Assessment of impacts**	**Comparing key options for decision-making**
Expert judgment	✓	✓	✓	✓	✓
Checklists	✓				
SWOT	✓	✓			✓
Matrices	✓		✓	✓	✓
Networks and flow diagrams	✓	✓		✓	
Spatial analyzes: Overlay maps and GIS	✓	✓	✓	✓	✓
Trends analysis/extrapolation	✓	✓	✓	✓	✓
Delphi technique	✓	✓	✓	✓	✓
Modelling	✓	✓	✓	✓	
Multi-criteria analysis			✓	✓	✓

Tool: Expert judgment	
Linkages to other tools	Matrices Delphi technique Modelling Multi-criteria analyses
Purpose	Expert judgment is a process for obtaining data directly from experts in response to a technical problem.
Description	Expert judgments are part of any SEA process. This is inevitable because SEA is an analytical process that examines the relevant trends and risks through: • Identification of key strategic issues relevant for the plan (and its position in the decision-making process); • Determination of the spatial and temporal scale of the relevant issues; and • Selection of appropriate indicators (or proxy-indicators) that simplify the evaluation and turn it into manageable assessment. Use of all analytical approaches and tools in the SEA is therefore always influenced by expert judgments. The SEA tools that most rely on the expert judgments include: • Matrices: experts need to use their own judgment to determine the key impacts, synergies, or conflicts addressed by the matrix; • Modelling: experts need to use their own judgement to identify the specific issues and interactions that need to be modeled; determine key assumptions and boundaries of the modeling; Select a suitable model and verify it, calibrate it, and fine-tune it to fit the local situation and data availability; and • Multi-criteria analyses: experts need to use their own judgement to determine the assessment criteria, their relative importance (weights), and performance (scoring) of each proposed option. This summary deals with one specific form of expert judgment when the recognized "experts" in the relevant fields directly formulate explicit and quantitative views on the probability and magnitude of the expected impacts and explain uncertainties in these predictions. Well-organized expert judgments do not mean "guessing", since the participating experts need to usually clearly explain: • Assumptions on which the judgment is based (when would the risk/impact occur and what it is caused by); • Character of the predicted risk/impact (e.g., probability of the risk/impact, its nature and scale, and duration and reversibility); • Directly and indirectly affected geographic areas, ecosystems, or persons (e.g., particularly sensitive or important elements of the receiving environment, vulnerable social groups, non-renewable resources, endangered species, etc.); • Baseline situation (e.g., the past, present, and future actions that should be considered when judging this risk/impact and the relative importance of the expected risk/impact when compared with the baseline situation); • Key concerns associated with the predicted risk/impact (e.g., how far is the predicted impact from any established thresholds or targets); and • Magnitude of key uncertainties in this judgment. When these rules of good practice are expected, expert judgment can reflect the life-long experience and expertise of participating experts. Such judgments can be, especially in situations of significant data gaps, more precise than quantitative predictions based on incomplete data. Such expert judgments are best obtained through the canvassing of opinions from a representative set of recognized experts in a given field and their iterative discussion. Expert judgments can be formulated through simple participatory

	tools such as workshops, interviews, or questionnaires with a problem-solving focus (these tools are described in Annex 2.). The most sophisticated means of collective expert judgment is the Delphi technique, which is separately described in the annexes). The Chinese Provisional Measures for Public Involvement in EIA (Yuhuan, 2012), for instance, allow for the use of expert judgments through consulting expert opinions in written or other forms (Article 20) or through organizing evaluation meetings with relevant experts (Articles 21-23). Consulting expert opinions in written or other forms requires that the individual experts and organizations that accept such consulting arrangements provide clear opinions on consulting matters and reply in writing. Any written opinion should be signed by individual experts and affixed with the employer's seal. Any different opinions in collective expert consulting shall be described by the consulting organization in consulting replies. Evaluation meetings with relevant experts require determination of the major topics for review according to the scope and extent of environmental impact and the assessment factors, notification of the related organizations and individuals of the time, venue, and major topics of the meeting, and elaboration of the meeting record. The meeting record summarizes the different opinions based on presented facts and can be prepared in the form of the meeting minutes or the meeting conclusions. The basic rules for the use of expert judgments formulated by the US Environmental Protection Agency (U.S. Environmental Protection Agency, n.d.) may also be of interest. These can be summarized as follows: • At least five individuals need to be used in any expert judgment process, unless there is a lack or unavailability of experts. • The individuals involved in expert judgment have an appropriate level of knowledge and experience for the questions or issues addressed. • At least two-thirds of the experts involved in expert judgment are not directly employed by the proponent. • The public and relevant authorities are provided with a reasonable opportunity to comment on the scientific and technical validity of these expert judgments.
Usual application within SEA	The expert judgment can be used at any stage of the SEA process. It is usually used when: • The key issues of concern are being identified; • Periodical results or final results are prepared to check the results achieved and • Difficulties arise in the use of qualitative tools or when there are problems without solutions to collect opinions on the specific issue or to identify the solution.
Inputs and data demands	Basic information on the proposed development and affected environment, possibly complemented by a series of questions on the specific issue.
Outputs	Direct response from experts to a technical problem.
Advantages	• Expert judgment is a tool that provides quick and effective advice • It can operate in situations of significant data gaps
Disadvantages	• The quality of the outcome depends on the knowledge and competence of participating experts. • The judgment will also be affected by the comprehension of the background/briefing material. If the material is not complete or includes deficits, it will affect the conclusions. • The outcome can also be influenced by the quality of the entire process.

<table>
<tr><th colspan="2">Tool: Analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT analysis)</th></tr>
<tr><td>Description</td><td>SWOT is used as part of the diagnosis of the current situation. It highlights the key internal issues (strength and weaknesses) and the key external issues (opportunities and threats) that should be considered in the planning or in the assessment process. The following table shows the logic of a SWOT analysis.
<table>
<tr><th></th><th>Positive</th><th>Negative</th></tr>
<tr><td>Internal</td><td>Strengths</td><td>Weaknesses</td></tr>
<tr><td>External</td><td>Opportunities</td><td>Threats</td></tr>
</table>

SWOT was originally developed in business management, but it is increasingly used in the elaboration of SPPs. Regardless of its specific application, the SWOT analysis applies the following simple sequence of tasks.

Step 1: List internal factors (what is here and now): List all strengths that exist now. Then, in turn, list all weaknesses that exist now. Be realistic, but avoid modesty.

Step 2: List external factors (what is relevant for the future developments): List all opportunities that exist in the future. Then, in turn, list all threats that exist in the future.

Step 3: Review the SWOT analysis: When the analysis has been completed, a SWOT profile can be generated and used as the basis of goal setting, strategy formulation, and implementation. The completed SWOT profile is usually arranged as follows:

<table>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>1.
2.
3.
…..</td><td>1.
2.
3.
…..</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>1.
2.
3.
…..</td><td>1.
2.
3.
…..</td></tr>
</table>

These tasks can be performed by planning teams as well as assessment teams. However, SWOT analysis offers a useful tool in participatory discussions and is generally more effective if it engages stakeholders with different viewpoints.</td></tr>
<tr><td>Usual application within SEA</td><td>• Analysis context and baseline
• Identification of constraints (risks) and opportunities (benefits)</td></tr>
<tr><td>Advantages</td><td>• SWOT reduces a large quantity into a simple overview of key issues that could be considered in the planning.
• SWOT is a useful tool for obtaining various viewpoints on the current situation and can be very well used in participatory processes.
• Demand for data: Small: undertaking SWOT largely depends only on personal knowledge and insights of participants in the SWOT process.
• Cost and time requirements: Small: SWOT can be done as a quick exercise by a single person or as a rapid appraisal process of a current situation that involves a large number of stakeholders.
• Ability to deal with uncertainties: Medium to High: By examining future opportunities and threats SWOT highlights key future uncertainties.
• Transparency: High: SWOT is a very transparent technique.</td></tr>
<tr><td>Disadvantages</td><td>• SWOT has a tendency to oversimplify the situation.
• Analysis of current internal situation through simple presentation of strengths</td></tr>
</table>

	and weaknesses does not explain why these strengths and weaknesses occur (their root causes) and whether there are any linkages between them. • Classification of external factors as opportunities or threats is somewhat arbitrary; the same point may feature both as a strength and as a weakness. For example, "increased exports" may be presented as a strength and "reliance on exports" as a weakness.
Examples of practical application or key sources of further information	Community Tool Box, a website from the United States, has an easy to follow description of how to do a SWOT analysis (http://ctb.ku.edu/tools/en/sub_section_main_1049.htm) An example of an interesting SWOT analysis that examined key trade, poverty and environmental issues and linkages in rural development programs of the European Commission DG Development can be found at: http://europa.eu.int/comm/development/body/theme/rurpol/outputs/diagnostic/html/5.htm

Tool: Formal and informal checklists	
Description	A checklist presents a catalogue of issues that might be considered when assessing particular types of plans or programs. Checklists may list: • Environmental, including health, are concerns usually associated with certain plans and programs. • Relevant environmental, including health, objectives for various development activities • Indicators or specific guiding questions that can be asked when evaluating a plan or program in certain fields
Usual application within SEA	• Analysis context and baseline • Identification of issues and impacts
Advantages	• Help remember all the information relevant to a task • Provide a simple way of identifying whether certain issues are relevant to a proposal and help to avoid overlooking potential issues
Disadvantages	• Do not offer a very analytical approach to analysis • Encourage neglect of any important effects that are not present in the checklist • May cloud judgment with irrelevant information • Do not specify the nature of cause-and-effect relationships; are prone to pigeonholing impacts into certain categories, whereas, in reality, an impact may be part of a complex system.

Tool: Matrices	
Linkages to other tools	Expert judgments
Purpose	Matrices enable identification or presentation of: • Impacts of proposed development on various elements of the environment (matrices of impacts), or • Synergies or conflicts between proposed development and the relevant environmental objectives (matrices of conflicts or synergies). Matrices visually summarize these effects in a user-friendly way. As such, can be used to quickly compare the pros and cons of proposed development options.
Description	A simple matrix can help to identify various effects of a single intervention. More complex matrices can show cumulative effects of numerous projects on various environmental issues or objectives. Basic matrices can mark the existence of impacts or conflict/synergy using

	simple symbols (e.g., X, XX). More elaborate matrices use various characters, numerical scores, colors, or even textual descriptions to outline the nature, scale, importance, and duration or reversibility of each effect. Presented information should be easy to verify—matrices thus need to be accompanied by a text explaining the nature of specific effects.
Usual application within SEA	Matrices belong to the most commonly used tools in SEAs in the European countries. They can be very easily used for: • Identification of effects • Presentation of effects • Comparison of alternatives
Inputs and data demands	Basic information on the proposed development: a simple list of proposed development objectives or development activities. Basic information on the local environment: a simple list of relevant environmental issues or relevant environmental objectives in the study area.
Outputs	Visual summary of impacts or conflicts/synergies
Advantages and disadvantages	• Matrices help to systematically identify impacts or conflicts/synergies • They can easily present outcomes of qualitative or quantitative assessments • They generally do not consider spatial issues and local territorial issues • They force users to consider many potential interactions; this may divert attention to minor impacts.
Further reading	Further information on the various uses of matrices can be found at: http://en.wikipedia.org/wiki/Matrix_methods

Tool: Spatial analyzes: Overlay Mapping and Geographical Information Systems (GIS)	
Linkages to other tools	-
Purpose	To illustrate the spatial distribution of relevant issues and impacts.
Description	Spatial analyses are undertaken through the preparation of maps with different information that is relevant to the SEA. When these maps are laid over each other, they can: • Provide a composite picture of the receiving environment (e.g., sensitive areas or resources, current pressures, etc.) and resulting development opportunities and constraints • Present impacts of previous developments and show linkages between different issues (e.g., correlation between air pollution concentrations and development of transport networks, correlation between water pollution and sitting of industrial facilities, etc.) • Identify potential impacts of future activities. Outline cumulative impacts of different activities on one issue (e.g., impacts of agricultural developments, new housing, and new industrial zones on water quality.) • Indicate spatial concentrations of different environmental impacts (e.g., map showing specific areas that will be subject to excessive air pollution, water pollution, and noise pollution). Spatial analyses can be based on manual elaboration of transparent maps (overlay mapping) or elaboration and processing of electronic maps (Geographical Information Systems, GIS). While overlay mapping may be a simpler form of the analysis, it delivers only one series of maps and overlays. Elaboration of base maps for GIS is more demanding; however, once these maps have been prepared, GIS allows users to easily add further information or to flexibly amend existing maps within the GIS.
Usual application within SEA	• Analysis of context and baseline • Identification of issues and impacts, including cumulative and synergistic impacts • Development and comparison of alternatives

Inputs and data demands	• Base maps of appropriate scale (e.g., topography, land uses, etc.) • Maps indicating location of key development initiatives or spatial distribution of relevant environmental issues (e.g., air quality, water quality).
Outputs	• Maps showing spatial distribution of key issues or impacts. • These maps can be developed to visualize past, present, and future situations.
Advantages and disadvantages	• Spatial analyses can consider topography and local territorial issues, • If the relevant maps are not readily available, spatial analyses can be expensive and time-consuming.
Further reading	British Geological Survey report (2004) on Strategic environmental assessment (SEA) and future aggregates extraction in the East Midlands Region presents a number of GIS usage methods and approaches: http://www.mineralsuk.com/britmin/CR_04_003N.pdf

Tool: Trend analysis and extrapolation	
Description	Accurate trend analysis is one of the most important aspects of any strategic assessment. In the context of an SEA, it can be defined as an interpretation of environmental pressures and changes in the state of the environment, including health, over time. Trend analysis uses data sets and helps to trace any trends or patterns. Trends can be linear, exponential, or cyclical, and they should, where possible, be analyzed over a correct temporal scale. The presentation of trends can be fairly simple, e.g., a line graph, or quite complex, e.g., using three-dimensional graphics or video simulation. There are numerous computer programs that facilitate trend analysis (e.g., the simplest ones being computer spreadsheet software, more advanced ones including RATS, GAUSS, JMP, etc.). Trend analysis facilitates the presentation of the main linkages between environmental pressures and corresponding (sometime delayed) changes in the state of the environment. As such, it can also assist in predictions of future impacts. Some trends can be safely extrapolated on the assumption that the trend is going to continue in the same dynamic. When doing so, it is important to realize that virtually every trend has a corresponding counter-trend. Oversimplified extrapolation that does not consider how the trend will evolve once it reaches a key breaking point (e.g., when carrying capacity of the surrounding environment has been reached or exceeded) or once the counter-trend becomes stronger may be misleading. Trend extrapolation can thus play an important role in medium-to-short-term forecasts when no major counter-trends or breaking points are expected. Long-term trends can be precisely determined only through modelling, if at all.
Usual application within SEA	• Analysis of context and baseline • Assessment of impacts
Advantages	• Can greatly assist in the quantification of cumulative impacts in cases where environmental data are available over long periods of time
Disadvantages	• There are often situations where it is not possible to obtain relevant or sufficient data on specific environmental pressures. • In cases where there are gaps in data, it becomes important to use appropriate statistical methods to ensure the proper interpretation of trends. Such analysis may be quite cumbersome.

Examples of practical application or key sources of further information	Different examples of trend analysis are presented in the Transport Analysis Guidance on *SEA for Transport Plans and Programmes* (2004) by UK Department for Transport, available at http://www.webtag.org.uk/webdocuments/2_Project_Manager/11_SEA/2.11.pdf

Tool: Networks and Flow diagrams	
Linkages to other tools	Modelling
Purpose	Networks and flow diagrams (sometimes also called system diagrams) can be in SEA used to illustrate: • Implications of the proposed decisions on the subsequent decisions and their knock-on effects on other developments (decision trees); or • A gradual progression from direct immediate effects to indirect, longer-term, or delayed effects (effect networks).
Description	Steps for constructing a decision tree might comprise: • List the proposed developments. • Identify the effects of these proposals on other decisions or developments. • Identify secondary knock-on effects of these decisions or developments, illustrating their wider indirect implications. Steps for constructing an effect network might comprise: • List the proposed developments. • Identify effects of these proposed developments on the directly affected elements of the environment. • Identify secondary knock-on effects on other elements of the environment, including health, illustrating pathways from direct effects to indirect effects. • When doing so, determine whether any cumulative effects on the same element of the environment, including health, occur. • If appropriate, consider a loop to show any feedback. • If appropriate, use quantitative techniques as a simple form of modelling to evaluate the effects. This approach constitutes a simple form of modelling and allows the evaluation of effects (see more on modelling).
Usual application within SEA	• Identification of issues and effects. • Assessment of effects. • Development and comparison of alternatives.
Inputs and data demands	• Basic information on the proposed developments. • Basic information on the local environment—a simple list of relevant elements of environment in the study area.
Outputs	• Illustration of the cause-effect relationships
Advantages	• Flow diagrams help identify indirect and delayed effects. • They clearly illustrate the interaction pathways; the mechanism of cause and effect is made explicit • Flow diagrams provide a good basis for choosing which processes could be quantified or modelled in further detail.
Disadvantages	• Flow diagrams do not illustrate spatial or temporal scales of impacts. • They use a holistic approach to impact assessment, so it may require a considerable effort to complete. • They can become too complex.

Tool: Delphi Technique	
Linkages to other tools	Expert judgments
Purpose	Delphi Technique enables identification of prevailing judgment within a large group of experts who do not directly interact with each other.

Description	The Delphi technique represents the systematic and powerful tool for formulation of collective expert judgments. It is based on the following principles: • There is no face-to-face interaction; • Each participant is given time for thought and an equal opportunity to contribute; and • In particular, disagreements are recorded to examine different points of view and to increase understanding. The Delphi technique is based on the following key steps: • Clarify what information is needed, design the questions, and determine the time line of the process. • Identify the appropriate number of experts to serve on the Delphi panel and explain the tasks. • Prepare and distribute the initial set of open-ended or closed-ended questions. • Collect and analyze the first responses and compile the responses. If open-ended questions were used extensively, analyze and present the first set of responses within an appropriate theoretical framework. • Send the same question out to the same panelists a second and third time. The process may be repeated with additional waves, if necessary. Include the responses with the question so that panelists can read the other opinions and adjust their own opinions. Respondents will read each other's ideas and answer the question again. As information is exchanged, people incorporate each other's perspectives and information into their thinking and arrive at a fairly accurate understanding of the critical issues to consider in their decision-making process. • Always prepare and distribute a final report to panelists. One of the motivations for participating in a Delphi panel, particularly for specialists, is to learn first-hand, before others, what the results of the Delphi study are. It processes identification of prevailing judgment within a large group of experts who do not meet and who may not even know each other's identity in order to minimize personal influences. It thus enables the participation of experts from geographically dispersed locations. The approach used in the Delphi technique also defines some useful principles and steps for the formulation of expert judgment through other less time-consuming techniques (e.g., workshops, conferences, etc.).
Usual application within SEA	• Identification of effects • Assessment of effects • Comparison of alternatives
Inputs and data demands	• Basic information on the proposed development. • Basic information on the receiving environment.
Outputs	• Prevailing professional judgment from a large group of experts.
Advantages	• Delphi technique can deal with quite technical or complex issues. • It allows sharing of ideas and consensus in decision-making by a large number of stakeholders who do not know each other's identity and can be even geographically distanced. • It is convenient to participants, as they can contribute from their own office or home.
Disadvantages	• It takes time for the organizers (can run for several months). • Participant commitment may falter if the process takes too long or they have other commitments. • Large amounts of data need to be carefully assessed and distributed, so the process can be expensive to manage.
Further reading	Nehiley, J. M. (2001) *How to Conduct a Delphi Study*

	Dick, B. (2000), *Delphi face to face*, available at http://www.uq.net.au/action_research/arp/delphi.html

Tool: Modelling	
Linkages to other tools	• Networks and flow diagrams • Spatial analyses
Purpose	Models facilitate simulation of environmental impacts.
Description	Modelling generally tends to be used in SEA only when other analytical tools would provide insufficient predictions. Models of relevance to SEA are mainly those developed to simulate specific environmental impacts. Environmental modeling typically includes the following basic steps: • Define the very specific issues and interactions that need to be modeled; • Define key assumptions and boundaries of the modelling; • Identify the suitable model and fine-tune it to fit the local situation and data availability; • Collect the basic data on the local environment (e.g., topography, wind speed and direction, flow regimes, etc.). • Collect the input data for the past and current situations (e.g., emission levels) and run the model to enable its verification and calibration; • Run the model for the different scenarios that are considered in the assessment (e.g., emissions from the different proposed project and from other actions that are considered during the assessment). Developing a new model is generally very costly. Established and accepted models can be used if they are carefully calibrated to ensure that the simulation fits the specific features of the study area. The most common models include: Air Quality Models can simulate the cumulative impacts of a number of projects on the local air quality. They typically consider factors such as the wind direction and speed, air quality and humidity, details of the topography of an area, and location of developments that emit air pollutants. Water Quality Models can simulate the dispersion of various pollutants under different flow or tidal conditions. They require data on flow regimes (and/or tidal conditions) and can typically predict changes in the dissolved oxygen, coliform bacteria, sediment, or chemical concentrations. Other water quality models can simulate the behavior of pollutants in a lake environment. These models normally consider various inputs of chemicals (e.g., discharge, inflow in rivers, and deposition from the atmosphere) and their removal factors (e.g., irreversible reaction in the water and sediment, outflow in the water, and sediment burial). They typically yield mass balance equations for the water columns and the bottom sediments, but they may also consider pollutant transfer through sediment-water exchanges (e.g., by diffusion and deposition). Soil Quality Models can calculate soil degradation (e.g., erosion, degradation of the organic matter, etc.) or leaching and accumulation of chemicals (fertilizers, pesticides, heavy metals) applied to soil. They typically consider the physical-chemical properties of the soil and the chemical behavior of the applied chemicals in a soil environment. Noise Models can consider the cumulative noise levels from more than one source. They typically consider details of the topography of an area and locations of noise emitters.
Usual application within SEA	• Assessment of impacts • Development and compassion of alternatives

Inputs and data demands	Use of models typically requires the following input data: • Specific impact that needs to be modeled; • Key assumptions and boundaries of the assessment; • Data on the local environment (e.g., topography, wind speed and direction, flow regimes, etc.); • Input data on relevant emissions from the proposed project and from other actions that are considered during the assessment.
Outputs	• Simulation that quantifies the expected impacts.
Advantages	• Models can be relatively easily manipulated through assumptions made in their design or adaptation. • Models, once constructed, can simulate effects over time and in space. • It can facilitate numerous simulations based on different assumptions and input data. • Modelling results can be effectively combined with GIS.
Disadvantages	• No model can realistically address every intricacy of the natural system. • The accuracy of a model totally relies on the quality of baseline data. • Construction or calibration and running model is usually very demanding in terms of cost, expertise, and time.
Further reading	The Canadian Environmental Modelling Centre at Trent University develops, validates and disseminates mass balance models, which describe the fate of various chemicals in the environment. Their site www.trentu.ca/academic/aminss/envmodel/models/models.html offered (as of 2007) fifteen freeware models that can be freely used for basic modelling of air, water and soil quality. International Environmental Modelling and Software Society is a global not-for-profit association of persons and organizations dealing with environmental modelling. It operates a site http://www.iemss.org that offers a comprehensive information various aspect of environmental modelling, software and related topics.

Tool: Multi-criteria analysis	
Linkages to other tools	Expert judgements
Purpose	• Multi-criteria analysis numerically evaluates all alternative options against several criteria and combines these separate evaluations into one overall evaluation. • It can be used to identify a single most preferred option, to rank options, or simply to distinguish acceptable and unacceptable options so that a limited number of options can be shortlisted for a detailed appraisal.
Description	Multi-criteria analysis (MCA) helps to manage complexity in decision-making by converting the evaluation to a numerical score. All MCA approaches incorporate judgments that are expressed in weights of criteria and in performance evaluations of each option. Usual steps in a multi-criteria analysis are as follows: *1. Identify assessment criteria* so that they can measure key consequences of proposed alternative options. The proposed set of criteria should be carefully examined to ensure that: • The set of criteria is complete (no significant criteria are missing). • There are no redundant criteria (these may include insignificant criteria or criteria where all options perform equally). • Criteria are measurable (it must be possible to assess, at least qualitatively, how well each option performs in relation to the criterion). • Criteria are mutually independent (there is no double counting).

	2. Analyze the relative importance of criteria (weighting). Most MCA techniques determine the relative weights of each criterion in the decision-making. Methods of weighting vary from simple techniques (e.g., comparing criteria against each other to determine their relative weight) to complex methods (e.g., sociological surveys to determine the importance of each criterion in the affected community). *3. Analyze performance (scoring).* Determine what constitutes the best and the worst performance in the given context. Then, score the performance of each option with regard to each assessment criteria. Scoring can be basically done through three means: • Expert judgments that assign scores to show performance of each option when it comes to each assessment criteria (e.g., 0-100-point scale) • Compare options against each other. These methods vary from simple mutual comparison of options (e.g., on criterion 1, the option A scores best, C second, and B third) to more complex comparisons (e.g., programs based on fuzzy sets that turn linguistic evaluations into numerical scores). • Performance is determined on the basis of a criterion-specific curve that defines gradual progression from the worst to the best performance. *4. Multiply weights and scores for each of the options and derivation of their overall scores.* Each option's performance on a criterion is multiplied by the weight of the respective criterion—this is done for all the criteria. The sum yields the overall relative score for the given option. The results for all the options are compared and discussed. *5. Analyze sensitivity to changes in scores or weights.* Sensitivity shows how changes in the scores or weight affect the results of MCA. Such analysis may be essential if: • There are serious uncertainties about the performance of some options against selected criteria, or • If decision-makers or stakeholders argue about the relative weights of criteria used in MCA.
Usual application within SEA	• Determination of relative importance of impacts • Assessment of impacts • Comparison of alternatives
Inputs and data demands	• Carefully identified assessment criteria reflecting the key environmental consequences of all proposed alternative options • Judgments on relative importance/weights of these criteria • Judgments on the performance of each option with regard to all criteria
Outputs	• Conversion of assessment into numerical scoring
Advantages	• MCA takes into account different criteria at the same time (i.e., they avoid decision-making processes based on a single criterion); • MCA may be used to bring together the views of the different stakeholders in the evaluation; • MCA is transparent and explicit (the scores and weights are recorded and easy to audit); • MCA may facilitate communication with decision-maker and sometimes with the wider community. • MCA reduces rational debate about various pros and cons of proposed alternative options into discussion about abstract numbers (scores and weights)
Disadvantages	• MCA cannot facilitate consensus on very controversial decisions; • By presenting quantitative information (aggregated scores), MCA may create a false impression of accuracy. This sometimes hides the fact that all MCAs heavily depend on a value judgment; • MCA may be easily manipulated by those who perform it (i.e., simple

	sensitivity analyses that are normally performed within MCA show criteria that best influence outcomes; this knowledge can be used to manipulate the entire analysis).
Further reading	Multi-criteria Analysis Manual of the UK Government, available at http://www.odpm.gov.uk/index.asp?id=1142251 The Journal of Multi-Criteria Decision Analysis (ISSN: 1099-1360). By subscription only. More information can be obtained from the editor val@mansci.strath.ac.uk or at http://www.interscience.wiley.com/jpages/1057-9214/ Department of the Environment, Transport and the Regions, *Review of Technical Guidance on Environmental Appraisal:* A Report by EFTEC (Economics for the Environment Consultancy) http://www.defra.gov.uk/environment/economics/rtgea/1.htm

ANNEX 13

Comparative assessment of growth scenario assessments in Bangladesh (rated with and without mitigation measures)

Source: CEGIS/Integra, (2021).

A: Without mitigation
R: Risk score: where existing environmental and social safeguard policies, regulations, and guidelines are not fully or effectively implemented or enforced, and/or where no or ineffective mitigatory action is taken to avoid, minimize, restore, mitigate, or offset potential impacts of development, and/or the use of clean and sustainable technologies is not compulsory.

			Low growth	Medium growth	High growth
ENVIRONMENTAL OBJECTIVES					
Forests, protected areas and biodiversity	1	Reduce overexploitation/degradation of habitats, loss of biodiversity, and ecosystem(s) integrity and services	-3	-2	-4
	2	Reduce illegal activities related to protected areas and biodiversity	-3	-2	-3
	3	Reduce the introduction and spread of Invasive Alien Species	-3	-2	-3
Waste and pollution	4	Reduce poor management and unsafe disposal of solid and liquid waste (urban and industrial)	-4	-2	-3
	5	Reduce all forms of pollution (air, land, water, noise, light, etc.)	-4	-2	-3
	6	Minimize emissions of greenhouse gases	-3	-3	-3
Climate change and disasters	7	Reduce vulnerability to climate change and natural disasters (salinity intrusion, floods, storm surges, etc.)	-4	-3	-4
Water	8	Increase dry season freshwater flow in rivers	-3	-2	-3
	9	Reduce high/peak flows in rivers during monsoon season	0	0	-2
Land degradation	10	Minimize loss of land due to degradation (e.g., erosion of river banks/water channels, soil salinity, soil erosion, etc.)	-3	-2	-3
Land use change	11	Minimize conversion of agricultural land (e.g., conversion to shrimp ponds)	-2	-3	-3
SOCIOECONOMIC					
Economic growth	12	Ensure significant economic development and diversification, and increase in economic growth	-2	-2	-3
Employment	13	Enhance opportunities for employment and new/improved livelihoods	-2	-2	-3

			Low growth	Medium growth	High growth
		(particularly for fisheries, agriculture, and eco-tourism)			
Health and sanitation	14	Improve health services and the health of society (e.g., by reducing vulnerability to diseases)	-2	-1	-1
	15	Improve and extend water supply and sanitation services	-2	-3	-3
Education skills and training	16	Improve access to education for all, increase attendance (by reducing drop-out rates), and improve skills development and training	-2	-1	-1
Migration	17	Reduce migration from rural (including disaster-prone and risk-prone) areas to urban areas	-2	-2	-2
Women and children	18	Improve gender equality and empowerment of women	-1	0	0
Social inclusion	19	Increase the inclusion of landless and marginal land holders in development activities in the SW region	-3	-2	-2
Conflicts and security	20	Reduce conflicts over use of land	-3	-2	-3
Cultural and natural heritage sites	21	Preserve heritage sites (historic buildings, archaeological, and cultural sites, and enhance cultural diversity (e.g., language, arts, etc.) and also Sundarbans natural heritage sites	-3	-1	-2
Food	22	Improve food security	-2	0	0
Agriculture and fisheries	23	Increase agricultural and fish production	-1	0	0
Power and energy	24	Increase uptake of renewable energy	-2	-1	-1
	25	Increase efficiency in production and consumption of energy	-2	0	0
	26	Increase access to affordable energy	-1	0	0
Tourism	27	Improve tourism management and behavior to limit noise, pollution, and other negative impacts and to remain within the carrying capacity of the Sundarbans for tourism.	-2	-1	-1
Infrastructure, transportation	28	Improve the connection of communities and improve access to infrastructure, services, and facilities	-2	-1	-1

			Low growth	Medium growth	High growth
and communications	29	Optimize the existing and future physical footprint of transport services (rail, road, waterways)	-2	-1	-1

B: With Mitigation

M: Mitigated score: where existing environmental and social safeguard policies, regulations, and guidelines are fully and effectively implemented and enforced, and the government implements effective measures to avoid, mitigate, minimize, restore, or offset potential impacts of development and ensures the use of clean and sustainable technologies.

			Low growth	Medium growth	High growth
ENVIRONMENTAL OBJECTIVES					
Forests, protected areas and biodiversity	1	Reduce overexploitation/degradation of habitats, loss of biodiversity, and ecosystem(s) integrity and services	0	+2	+4
	2	Reduce illegal activities related to protected areas and biodiversity	0	+2	+4
	3	Reduce the introduction and spread of Invasive Alien Species	0	+2	+4
Waste and pollution	4	Reduce poor management and unsafe disposal of solid and liquid waste (urban and industrial)	0	+2	+4
	5	Reduce all forms of pollution (air, land, water, noise, light, etc.)	+1	+3	+4
	6	Minimize emissions of greenhouse gases	0	+2	+1
Climate change and disasters	7	Reduce vulnerability to climate change and natural disasters (salinity intrusion, floods, storm surges, etc.)	+1	+2	+4
Water	8	Increase dry season freshwater flow in rivers	0	+2	+4
	9	Reduce high/peak flows in rivers during monsoon season	0	0	+2
Land degradation	10	Minimize loss of land due to degradation (e.g., erosion of river banks/water channels, soil salinity, soil erosion, etc.)	0	+2	+3
Land use change	11	Minimize conversion of agricultural land (e.g., conversion to shrimp ponds)	0	0	0
SOCIOECONOMIC			**Low growth**	**Medium growth**	**High growth**
Economic growth	12	Ensure significant economic development and diversification, and increase in economic growth	+1	+3	+4
Employment	13	Enhance opportunities for employment and new/improved livelihoods (particularly for fisheries, agriculture, and ecotourism)	0	+2	+3
Health and sanitation	14	Improve health services and the health of society (e.g., by reducing vulnerability to diseases)	0	+2	+3

	15	Improve and extend water supply and sanitation services	0	+2	+4
Education. skills and training	16	Improve access to education for all, increase attendance (by reducing drop-out rates), and improve skills development and training	0	+2	+4
Migration	17	Reduce migration from rural (including disaster-prone and risk-prone) areas to urban areas	+1	+2	+4
Women and children	18	Improve gender equality and empowerment of women	+1	+2	+4
Social inclusion	19	Increase the inclusion of landless and marginal land holders in development activities in the SW region	+1	+2	+3
Conflicts and security	20	Reduce conflicts over use of land	0	+2	+2
Cultural and natural heritage sites	21	Preserve heritage sites (historic buildings, archaeological, and cultural sites) and enhance cultural diversity (e.g., language, arts, etc.) and also Sundarbans natural heritage sites	0	+1	+3
Food	22	Improve food security	0	+3	+4
Agriculture and fisheries	23	Increase agricultural and fish production	+1	+2	+4
Power and energy	24	Increase uptake of renewable energy	0	+2	+3
	25	Increase efficiency in production and consumption of energy	+1	+3	+4
	26	Increase access to affordable energy	+1	+3	+4
Tourism	27	Improve tourism management and behavior to limit noise, pollution, and other negative impacts, and to remain within the carrying capacity of the Sundarbans for tourism.	0	+1	+3
Infrastructure, transportation and communications	28	Improve the connection of communities, and improve access to infrastructure, services and facilities	+1	+2	+3
	29	Optimize the existing and future physical footprint of transport services (rail, road, waterways)	+1	+2	+4

ANNEX 14

Checklist questions for assessing significance of impacts

1. What are the likely impacts (negative and positive) of the policy option on the environment and social conditions (ESC)?
2. Is the PPP in line with national strategic environmental and social goals?
3. What is the public response regarding exploitation of the environment and changes to social conditions?
4. What is the impact on ownership of natural resources?
5. What are the costs and financial benefits regarding natural resources, the environment, and social conditions?
6. How will the financial benefits be used for improved livelihoods, environment conservation, and management?
7. Are the production processes environmentally sustainable and socially acceptable?
8. What are the costs of the economic gains in terms of damage to environment and natural resources or negative impact on social conditions?
9. Do the economic gains promote further damage to the environment or deterioration of social conditions?
10. Will the PPP require the movement of people that will cause concentration in other areas and need for other facilities such as waste management facilities?
11. Will the PPP cause the relocation of human and financial resources away from environmental management or the provision of social services?
12. What are the transboundary environmental and social implications?
13. Which multilateral environmental agreements (MEAs)/protocols will be affected by the PPP?
14. Will national obligations under MEAs not be met because of implementing the PPP?
15. Will the PPP affect national or international heritage sites?
16. Will different social groups be affected in a way that will result in them causing negative impacts on the environment?
17. Will the PPP affect gender balance in terms of access, ownership, and control over natural resources and benefits realized from them?
18. Is the PPP consistent with the Constitution and provisions of the relevant legislation and regulations in Bhutan?
19. Will the PPP require the enactment of new legislation on the environment?
20. Does the PPP unnecessarily expose the environment to abuse or the public to risk and therefore the need for more controls and enforcement?
21. Does the PPP affect the roles and mandates of environmental or social sector institutions?
22. Does the PPP have the potential to cause overlap of responsibilities and mandates?

ANNEX 15

The role of a Strategic Environmental and Social Management Plan (SESMP)

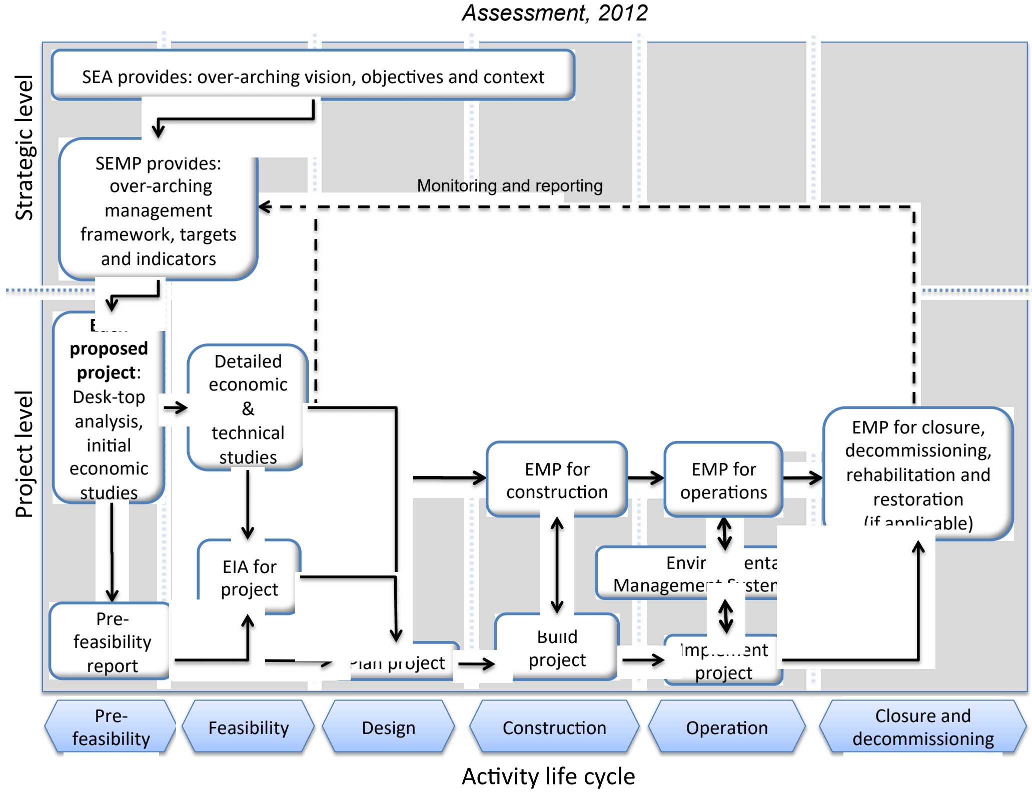
A SESMP should be an integral part of a PPP and act as an ***overarching framework*** and roadmap for addressing the cumulative impacts of projects, development initiatives, and activities planned to be implemented under the PPP (see Box A15.1). To fulfill this role, the SESMP should set limits of environmental and social quality (i.e., performance targets) that need to be achieved as a whole (by the concerted, collaborative oversight of relevant authorities) and, at a lower level, by the proponents of individual projects. Guided by the overall SESMP, individual Environmental Management Plans (EMPs) prepared for each individual project will need to incorporate all relevant environmental and social management specifications. Thus, the SESMP does not remove the obligation to a developer for conducting a project-specific EIA and EMP where required by national legislation or regulations or the need to secure required permits for development activities/projects.

Box A23.1: Relations between SEA, SESMP, ESMP AND EMS

The undertaking of the SEA will not rule out the need for subsequent project-level EIAs. Even though the SEA might set development parameters (e.g., good practice for particular development activities), individual projects with the potential to cause significant environmental and social impacts will still require an EIA to address site-specific concerns and circumstances. This tiered approach means that the major, consolidated, and integrated efforts made to conduct the SEA will result in the subsequent EIAs (which could be many in number) needing relatively less effort, cost, and time (Figure A15.1).

Figure A15.1: The continuum between SEA, SESMP, EMP and EMS

Source: Unpublished training materials developed by the Southern Africa Institute for Environmental Assessment, 2012



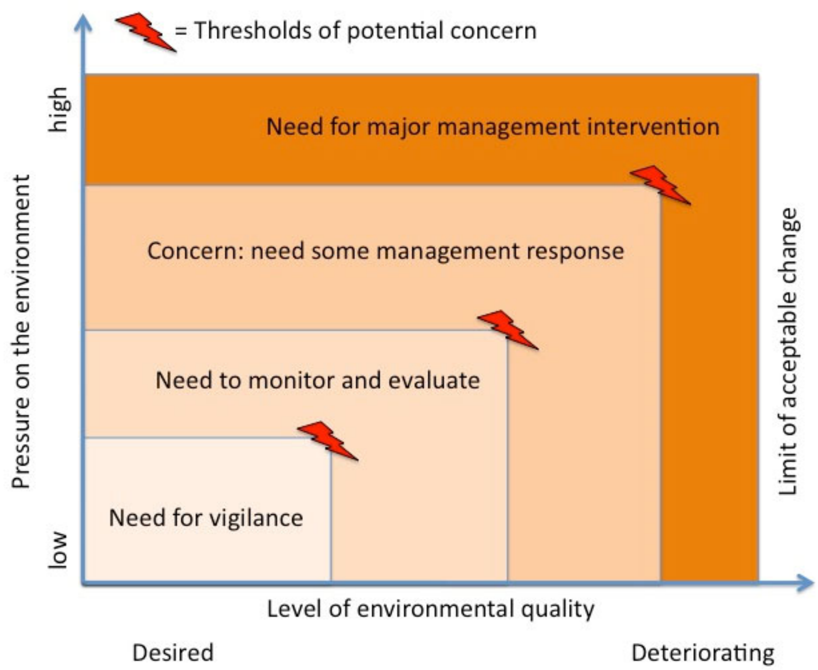
Developing environmental and social quality objectives (ESQOs) (see Section 3.3.4 of these guidelines) will require a combination of public and expert opinion, scientific research, and an examination of policy, ethical, and legal requirements. These informants constitute the ***"input"*** into the objectives. The objectives must each articulate a specific goal, provide a context, set standards, and elaborate on a small number of key indicators that need to be monitored. These will collectively make up the SESMP, which is the framework within which individual projects need to be planned and implemented and within which a number of institutions need to undertake certain actions.

The objectives must specify targets that are outcomes-based, practical, achievable, measurable, and enforceable. Wherever possible, they should be acceptable to all key stakeholders.

Implicit within all environmental and social quality objectives is a minimum management objective that any changes to the environment or social conditions must be within acceptable limits (following the precautionary principle) and that pro-active intervention will be triggered by the responsible party to avoid unwanted changes that breach a specified threshold (Figure A15.2).

Figure A15.2: Environment pressure and quality, and trigger points for a management response

Source: Binedel and Brownlie, (2007).



Through the SESMP, the information obtained during monitoring will enable the PPP proponent to prepare an annual SESMP report for the PPP.

Institutional and procedural arrangements will need to be established for the above purposes (through discussion and consensus amongst key authorities and actors) and maintained to ensure that the monitoring system runs effectively and that data from year to year are replicable, comparable, and auditable.

The SESMP should also indicate any capacity-building required to ensure that the SESMP can be effectively implemented, including any institutional adjustments or procedures, recruitments or new assignments, and training for national and local officials and civil society organizations.

It will be necessary to ensure that proposed implementation measures are workable. In this regard, the SEA team should review the implementation of previous SESMPs.

ANNEX 16

List of issues to be covered by a Strategic Environmental and Social Management Plan (SESMP)

In some situations, a stand-alone SESP may be required by the PPP proponent. The SESMP should outline the measures to be taken during PPP implementation and operation to enhance positive and prevent, minimize, or mitigate adverse environmental and social impacts associated with the PPP and projects or activities likely to arise during its implementation.

The SESMP should include:

- ***Summary of impacts***
    - The predicted negative environmental and social impacts for which mitigation is required and the positive impacts, which can be enhanced, should be identified and briefly summarized. Cross-referencing to the SEA report or other documentation is recommended so that additional detail can be readily referenced.

- ***Mitigation measures***
    - Identify feasible and cost-effective measures to reduce potentially significant adverse environmental and social impacts to acceptable levels;
    - Each mitigation measure should be briefly described with reference to the impact to which it relates and the conditions under which it is required (e.g., continuously);
    - The mitigation measures should be accompanied by, or referenced to, designs, equipment descriptions, and operating procedures that elaborate on the technical aspects of implementing the various measures;
    - Where mitigation measures may result in secondary impacts, their significance should be evaluated
    - Need for a subsequent EIA(s).

- ***Environmental and Social Quality Objectives*** (ESQOs)

- ***Environmental and Social Performance Monitoring Program/Mechanism***
    - Provide details for a monitoring and evaluation mechanism for the environmental and social impacts of the PPP and development projects/initiatives likely to be implemented during its implementation, with monitoring indicators and a corresponding evaluation procedure and methodology. It should aim to signal when steps are required to enhance benefits or to remove or reduce risks and negative impacts. The proposed mechanism should take into account existing national legislation and provisions regarding EIA. The monitoring program should clearly indicate:
    - The linkages between impacts identified in the SEA study
    - Indicators to be measured
    - Methods to be used
    - Sampling locations
    - Frequency of measurements
    - Detection limits (where appropriate)
    - Definition of thresholds that will signal the need for corrective actions.

- ***Compliance***
    - Indicate measures to ensure ***compliance with relevant safeguards*** during both preparation and implementation of the PPP and projects/initiatives that may arise during its implementation. Bhutanese safeguards should take precedence. Where Bhutanese safeguards do not exist, then reference may be made to other safeguards (World Bank safeguards).

- ***Institutional arrangements***

- Roles and responsibilities of different jurisdictions, authorities, and actors in implementing the SESMP (particularly coordination, mitigation, and monitoring). As far as possible, recommendations should be institution-specific (who should do what).

- ***Implementation schedule and reporting procedures***
  - Timing, frequency, and duration of the mitigation measures;
  - Procedures to report the progress and results of mitigation and monitoring measures.

- ***Cost estimates***
  - Initial investment and recurring expenses for implementing all measures contained in the SESMP;
  - Where practicable, decisions regarding appropriate mitigation measures should be justified by an economic evaluation of potential environmental and social impacts.

- ***Institutional Strengthening/Capacity Building***
  - Equipment requirements: Indicate type of equipment and number of units;
  - Training/study tours: Information should be provided regarding type of training, number to be trained, duration of the training, the organization providing the training, and costs.

- A ***stakeholder consultation procedure*** for the monitoring and evaluation mechanism.

- ***Guidance and recommendations for project-level EIAs***.

ANNEX 17

International and regional organizations concerned with renewable energy

Bioenergy Europe

Bioenergy Europe (https://bioenergyeurope.org/) is a non-profit, Brussels-based international organization bringing together 40 associations and 157 companies, as well as 11 academia and research institutes from across Europe. It aims to develop a sustainable bioenergy market based on fair business conditions. Founded in 1990, Bioenergy Europe is a non-profit, Brussels-based international organization bringing together 40 associations and 157 companies, as well as 11 academia and research institutes from across Europe.

Global Bioenergy Partnership

The Global Bioenergy Partnership (GBEP) (www.globalbioenergy.org) was founded in 2006 and now has more than 80 members. It brings together public, private, and civil society stakeholders in a joint commitment to promote bioenergy for sustainable development. The Partnership focuses its activities in three strategic areas: sustainable development, climate change, and food and energy security.

Global Solar Council

The Global Solar Council (GSC) (www.globalsolarcouncil.org), founded in 2015 and based in the USA, is an international non-profit association of the national, regional, and international associations in solar energy and the world's leading corporations. With a primary goal of enabling solar energy, it offers programs in regulatory policy, trade policy, new market opening, and jobs and skills training.

Global Wind Energy Council

The Global Wind Energy Council (www.gwec.net) is the international trade association for the wind power industry. Its mandate is to communicate the benefits of wind power—to national governments, policy-makers and international institutions. It provides authoritative research and analysis on the wind power industry in more than 80 countries around the world, and transparent information to governments about the benefits and potential of wind power. GWEC supports collaboration between policy-makers in different countries to help them share best practices and experiences in adding clean power to their energy mix.

Global Wind Organisation

The Global Wind Organisation (GWO) (https://www.globalwindsafety.org/) is a non-profit body founded and owned by its members, all of whom are globally leading wind turbine manufacturers and owners/operators. It promotes an injury-free work environment in the wind turbine industry, setting common international standards for safety training and emergency procedures.

Hydropower Sustainability Council

The Hydropower Sustainability Council (HSC) (www.hydrosustainability.org/) is the multistakeholder governing body of the Hydropower Sustainability Standard and Tools. Its membership is open to all stakeholders involved in the development of hydropower.

International Energy Agency

The International Energy Agency (IEA) (www.iea.org) was created in 1974 to help coordinate a collective response to major disruptions in the supply of oil. While oil security remains a key aspect of its work, the IEA has evolved and expanded significantly since its foundation to focus on all fuels and technologies. The IEA recommends policies that enhance the reliability, affordability, and sustainability of energy. It examines the full spectrum of issues, including renewables, oil, gas, and coal supply and demand, energy efficiency, clean energy technologies, electricity systems and markets, access to energy, demand-side management, and much more. Since 2015, the IEA has opened its doors to major emerging countries to expand its global impact and deepen cooperation in energy security, data and statistics, energy policy analysis, energy efficiency, and the growing use of clean energy technologies.

International Hydropower Association

The International Hydropower Association (www.hydropower.org) is a non-profit organization representing organizations committed to the responsible and sustainable development and operation of hydropower, and operating in over 120 countries. IHA members include leading hydropower owners and operators, developers, designers, suppliers, and consultants. Around a third (450 GW) of global installed hydropower capacity is directly managed and operated by IHA's membership.

International Geothermal Association

The International Geothermal Association (IGA) (www.lovegeothermal.org) is an international non-profit, non-political, non-governmental association representing the geothermal power sector worldwide. The organization works for the promotion and worldwide deployment of geothermal energy technology and advocates a future energy system based on renewable energy. The IGA has consultative status to the UN and special observer status to the Green Climate Fund. With partners, the IGA sets standards such as the Geothermal Sustainability Assessment Protocol (GSAP) (2021). It also maintains the geothermal power database and organizes regular conferences.

International Renewable Energy Agency

The International Renewable Energy Agency (IRENA) (www.irena.org) is an intergovernmental organization that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a center of excellence, and a repository of policy, technology, resource, and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar, and wind energy, in the pursuit of sustainable development, energy access, energy security, and low-carbon economic growth and prosperity.

IRENA's role is to seek out, establish, and develop new synergies, facilitate dialogue, share best practices, promote enabling policies, build capacity, and foster cooperation at the global, regional, and national levels. IRENA encourages investment flows and works to strengthen technology and innovation, with diverse stakeholders contributing to these shared goals.

International Solar Energy Society

The International Solar Energy Society (ISES) (www.ises.org) is a non-profit, UN-accredited membership NGO founded in 1954. It informs and connects its diverse membership of researchers, academics, professionals, practitioners, businesses, decision-makers, and advocates in more than one hundred countries. It promotes solar research and development, provides authoritative advice on renewable energy issues worldwide, advocates for a sustainable global solar industry, and promotes energy education for everyone at all levels.

Ocean Energy Council

The Ocean Energy Council (OEC) (www.oceanenergy council.com), based in the USA, works to improve public knowledge and acceptance of ocean energy (tidal and wind) as a viable resource. It provides a forum for presenting the considered professional recommendations of the ocean energy community to the US Department of Energy and other government bodies as well as international energy organizations. It also fosters the educational advancement and growth of its members in the field of ocean energy and works to educate the public on the potential and current status of the development of ocean energy.

Ocean Energy Europe

Ocean Energy Europe (OEE) (www.oceanenergy-europe.eu). Launched in 2013, it is the largest network of ocean energy professionals in the world. It represents over 120 organizations, including Europe's leading utilities, industrialists, and research institutes.

Solar Energy International

Solar Energy International (SEI) (www.solarenergy.org) is a non-profit educational organization. Its primary mission is to provide industry-leading technical training and expertise in renewable energy to empower people, communities, and businesses worldwide. Through its training program (Renewable Energy Education Program, REEP), SEI offers hands-on workshops and online courses in solar PV, micro-hydro, and solar hot water. Additionally, it works cooperatively with grassroots and development organizations in the Americas, Africa, Malaysia, and Caribbean.

Solar Foundation

The Solar Foundation (www.thesolarfoundation.org), based in the USA, is a non-profit, non-partisan organization that aims to advance the use of solar worldwide through research products, educational outreach, and leadership.

Wind Europe

WindEurope (https://windeurope.org), formerly the European Wind Energy Association (EWEA), promotes wind energy across Europe. It has over 400 members from across the whole value chain of wind energy: wind turbine manufacturers, component suppliers, power utilities and wind farm developers, financial institutions, research institutes, and national wind energy associations.

WindEurope coordinates international policy, communications, research, and analysis and provides various services to support members' requirements and needs in order to further their development, offering the best networking and learning opportunities in the sector.

WindEurope analyzes, formulates, and establishes policy positions for the wind industry on key strategic sectoral issues, cooperating with industry and research institutions on a number of market development and technology research projects. It also produces a large variety of information tools and manages campaigns aimed at raising awareness about the benefits of wind and enhancing social acceptance, dispelling myths about wind energy, and providing easy access to credible information.

WindEurope regularly organizes numerous events, ranging from conferences, exhibitions, and launches to seminars and workshops.

World Bioenergy Association

World Bioenergy Association (WBA) (www.worldbioenergy.org), based in Sweden, represents a wide range of actors in the bioenergy sector and supports the sustainable development of bioenergy globally.

World Coal Association

The World Coal Association (www.worldcoal.org) is a global association with members across the coal value chain committed to a transition to clean coal. Its work encompasses government advocacy, policy, media, and industry representation. The WCA calls for level playing field policy and greater collaboration between industry, government, and investors to advance both global economic and climate aspirations. It is committed to building a sustainable future for global coal and playing an active role in achieving our worldwide economic and environmental aspirations. WCA's activities are focused on those markets that continue to produce and/or use coal, as it actively supports their right to choose coal. It works with industry stakeholders across the globe and uses its voice to educate and raise awareness of coal and clean coal technologies.

World Solar Thermal Electricity Association

World Solar Thermal Electricity Association (STELAWorld) (www.stelaworld.org) was formed in 2011 to work with international agencies like IEA, IRENA, UNFCCC, UN Development Programme, the World Bank, and many more. It assists policy-makers and energy investors to access information on solar thermal electricity development and value and the rapidly reducing cost of solar thermal electricity production.

ANNEX 18

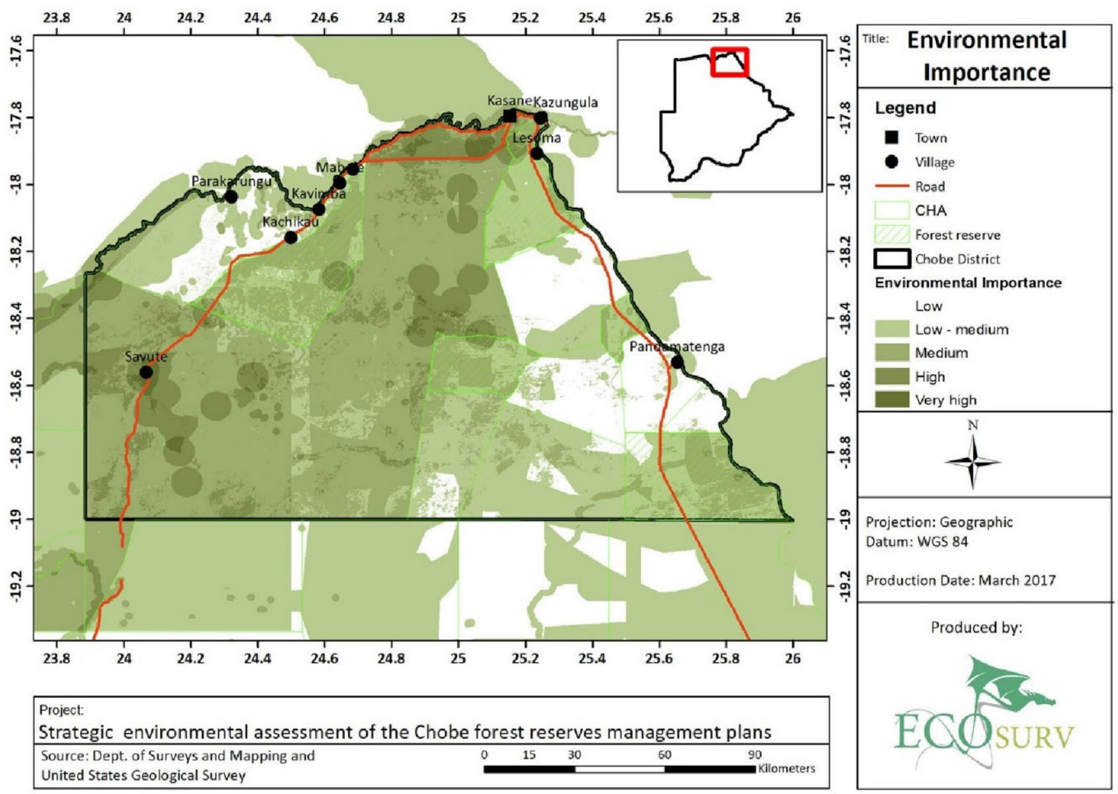
Sensitivity mapping for Chobe Forest Reserve, Botswana

Source: Ecosurv (2018)

An initial SWOT focused an SEA of the Chobe Forest Reserve, Botswana, on the main cumulative impacts and opportunities. Each cumulative impact was placed within a resilience framework of domain (social, economic, and biophysical), scale, and time. This provided an understanding of where cumulative impacts were within the overall landscape and what was driving them.

GIS data was then used to generate a land use conflict matrix of the three domains. The layers were combined to provide an overview of areas of sensitivity for biophysical aspects and for socioeconomic aspects, so that these can be evaluated separately. Figure A18.1 provides an example of the environmental importance of different areas of Chobe District.

Figure A8.1: Environmental importance of areas in Chobe District



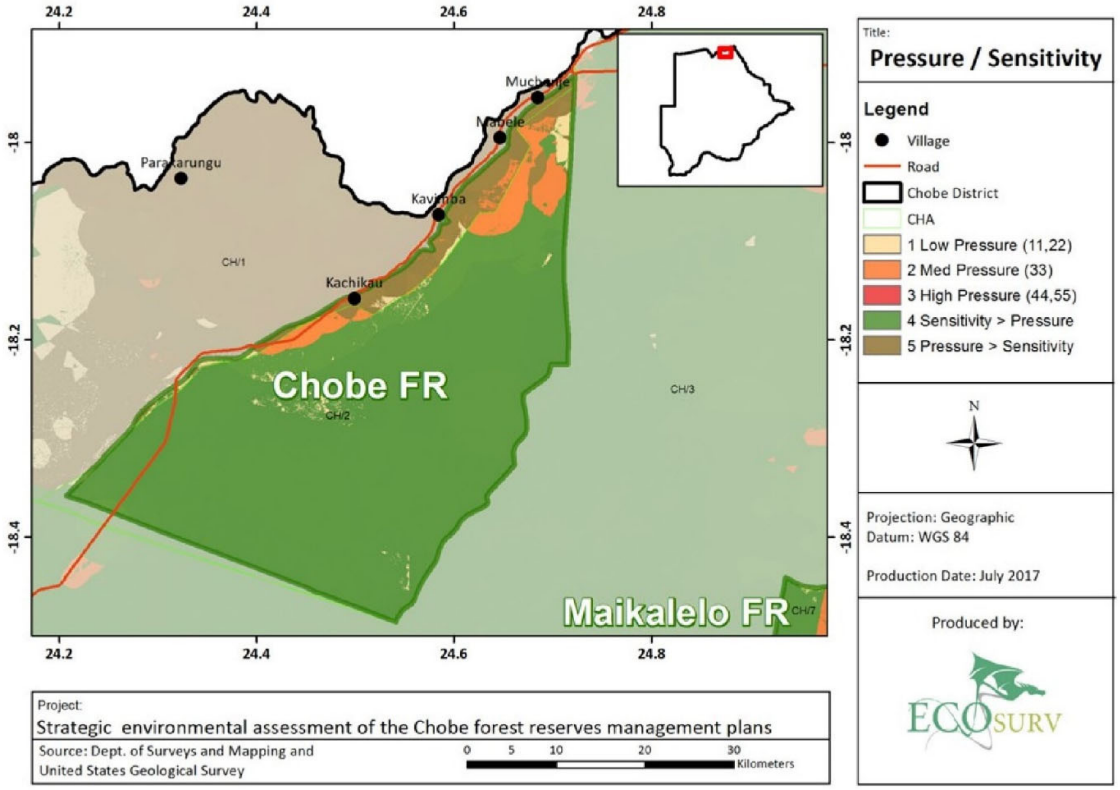
Subsequently, these layers were ranked to assign a standardized value so that they could be analyzed for potential land use conflicts using the LUCIS conflict management tool. The tool combined the different inputs to identify preferences and objectives and allowed decisions to be made on factual evidence as to what types of land use should be selected for which locations.

In the case of the SEA, the final raster GIS was a grid of cells each containing 25 possible combinations of socioeconomic and biophysical values. Thus, where socioeconomic values were high (as in arable agricultural areas) and biophysical values were low, no conflict was identified. But where both were high, conflict occurred and required management to address.

The mapped raster values provided a framework for management planning of each forest area.

From stakeholder workshops, a number of data sets were identified that were used to prepare a description of the present state, and the pressures and sensitivity maps an overlay of the two (pressure x sensitivity) was used to spatially highlight the main areas of concern. Figure A18.2 is an example of combining environmental sensitivity with pressures to identify areas of existing and potential conflict.

Figure A18.2: Pressure-sensitivity map for Chobe Game Reserve

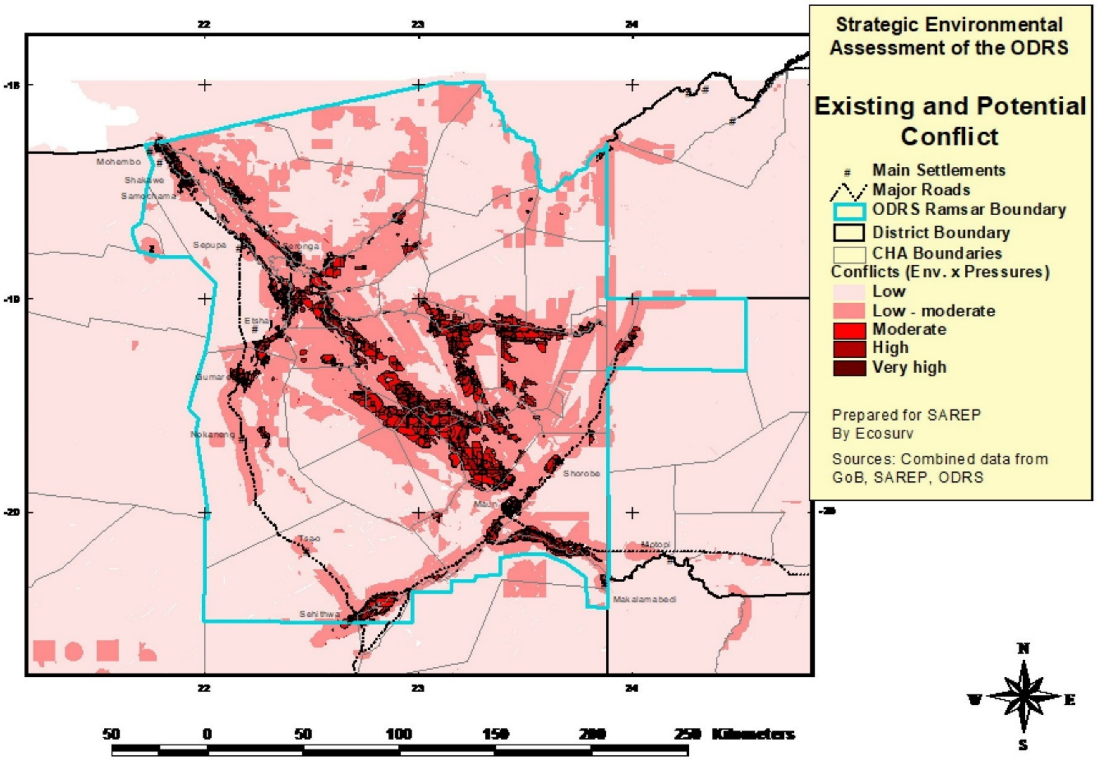


A hub-type SEA was undertaken for the Okavango Delta Ramsar Site (ODRS) in 2010–2012. Because of its complexity and multiple land uses, the SEA included a wide range of specialists from different disciplines. The SEA was undertaken for the Tawana Land Board (as the owners of the ODRS) and guided by the Department of Environmental Affairs (DEA) as the party responsible for the Ramsar treaty implementation.

Figure A18.3 is an example of combining environmental sensitivity with pressures to identify areas of existing and potential conflict.

The SEA influenced the review and updating of the Okavango Delta Ramsar Site (ODRS). It provided clear guidelines and targets for most of the development pressures faced by institutions such as the Tawana Land Board. The use of LUCIS (Land Use Conflict Information System) was adopted by the Land Board in planning on most conflict areas, especially in the panhandle area of the Okavango Delta.

Figure A18.3: Map show areas of existing and potential conflict, Chobe Forest Reserve



Alternatives

ANNEX 19

Definition of terms

Adaptive management: (also known as adaptive resource management or adaptive environmental assessment and management). A structured, iterative process of robust decision-making in the face of uncertainty, with an aim to reduce uncertainty over time via system monitoring.

Agenda 21: A comprehensive plan of action to be taken globally, nationally, and locally by organizations of the United Nations' system governments and major groups that was agreed at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. It has effectively been replaced in the global policy sphere by subsequent international agreements such as the UN's 2030 Agenda for Sustainable Development (which includes the sustainable development goals), the Paris Agreement on Climate Change 2015, and the Sendai Framework for Disaster Risk Reduction 2015-2030.

Alternatives: A key principle of SEA is to consider alternatives to a PPP, or elements of a PPP. This provides the opportunity to identify and explore different ways (different options, choices, or courses of action) to deliver a PPP's objectives while addressing environmental and socioeconomic issues. The timely consideration of alternatives in SEA and the planning process provides an opportunity to identify and explore ways of accommodating the future development needs of an area or sector, taking into account the intrinsic environmental and socioeconomic conditions. Alternatives should be realistic, reasonable, viable, and implementable alternatives that promote environmental and socioeconomic benefits while fulfilling a PPP's objectives.

Examples of alternatives used in SEA include: PPP implementation under different economic growth regimes (e.g., high, moderate, low); use of different technologies (e.g., hydropower power versus solar versus wind, etc.); different geographic areas for implementation, etc.

Baseline data: data that describe issues and conditions at the inception of the SEA. Serves as the starting point for measuring impacts, performance, etc., and is an important reference for evaluations.

Benchmark: A standard or point of reference against which things can be compared, assessed, measured, or judged. Benchmarking is the process of comparing performance against that of others in an effort to identify areas of improvement.

Capacity assessment: A structured and analytical process whereby the various dimensions of capacity are assessed within a broader context of systems, as well as evaluated for specific entities and individuals within these systems.

Capacity development: The process by which individuals, groups, and organizations, institutions, and countries develop, enhance, and organize their systems, resources, and knowledge—all reflected in their abilities, individually and collectively, to perform functions, solve problems, and achieve objectives.

Civil society organizations: the multitude of associations around which society voluntarily organizes itself and which represent a wide range of interests and ties. These can include community-based organizations and non-government organizations. Sometimes indigenous peoples' organizations are erroneously lumped into CSOs. Indigenous Peoples form distinct societies, with their own laws, languages, epistemologies, ontologies, and methodologies, including in the area of renewable energy.

Competent authority: means the designated regulatory body charged with monitoring compliance with the national statutes and regulations regarding a country's SEA system.

Cross-boundary impacts: see Impacts

Cumulative effects/impacts: see Impacts

Decision-makers/decision-taker: Policy-making, planning, and decision-making and decision-taking systems vary, and the meaning depends greatly on national or agency circumstances and procedures. A decision maker or taker may be (i) an official responsible for broad-scale or sectoral development plans or (ii) an elected Councilor or Minister.

Direct impacts: see Impacts

Environment: Mostly used in an ecological sense to cover natural resources and the relationships between them. But, social aspects (including human health) are also often considered part of "the environment." Issues relating to aesthetic properties as well as cultural and historical heritage (often in "built" environments) are frequently included.

Environmental assessment (EA): The umbrella term for the process of examining the environmental risks and benefits of proposals prior to decisions on them being made. Interpretations of the scope of EA also vary, particularly regarding the social dimension. It is usual to consider the physical/biological impacts of development on directly affected groups (e.g., impacts on downstream water supply, displacement, and local communities or vulnerable groups). But many institutions routinely include consideration of social impacts that are mediated by the environment (such as the human impacts of water pollution). Some agencies undertake "environmental and social assessments" or separate "social assessments" to identify adverse social impacts and promote other social goals, such as social inclusion or poverty reduction. The relative importance of the different dimensions varies depending on the issue involved. In the case of a dam, for example, it is increasingly routine in EA to consider both physical/ecological and social impacts.

Environmental clearance: A decision, usually issued in writing by a competent authority, to authorize a project to proceed from an environmental and social perspective. It may include terms to ensure that the project is managed in an environmentally sound and sustainable way. Note that, "environmental clearance" is as not as common in regulatory terms in the UK/Europe compared to North America.

Environmental Impact Assessment (EIA or ESIA): first introduced in the USA as a requirement of the National Environmental Protection Act (NEPA) in 1969. It is a process, applied mainly at the project level, to improve decision-making and to ensure that development options under consideration are environmentally and socially sound and sustainable. As a process, EIA identifies, predicts, and evaluates foreseeable impacts, both beneficial and adverse, of public and private development activities, alternatives, and mitigating measures and aims to eliminate or minimize negative impacts and optimize positive impacts. In the early days of EIA application, the focus tended to be mainly on biophysical impacts. But nowadays, EIA also covers social impacts. The term Environmental and Social Impact Assessment (ESIA) is preferred by some organizations (particularly IFIs) as it specifically makes reference to "social." A subset of additional processes has emerged since EIA was introduced, including social impact assessment, cumulative effects assessment, environmental health impact assessment, risk assessment, and biodiversity impact assessment.

Environmental security: A condition in which a nation or region, through sound governance, capable management, and sustainable utilization of its natural resources and environment, takes effective steps toward creating social, economic, and political stability and ensuring the welfare of its population.

Environmental and Social Impact Assessment: see Environmental Impact Assessment

Environmental and social quality objectives (ESQOs): are specified targets/aims agreed upon during an SEA for environmental and social quality (e.g., prevention of loss of biodiversity, improved job opportunities) that should be met when implementing a policy, plan, or program. ESQOs and associated indicators form the core element of the monitoring component of a strategic environmental and social management plan (SESMP).

Environmental impact statement*:* means written documentation produced after evaluating the environmental consequences, including cumulative impacts, of a proposed policy, plan, or program. It may be a separate report or part of a proposal.

Ex ante assessment: An evaluation of the environmental and social impacts of a PPP undertaken during its formulation phase by looking at the expected or intended results of the PPP and predicting and extrapolating its potential significant impacts. It is a way of assessing whether a proposed project is feasible and leaves the opportunity to consider alternatives and adjust the plan, program, or policy to avoid or enhance the results.

Ex post assessment: An evaluation of the environmental and social impacts of a PPP undertaken after implementation has begun—effectively examining the results of PPP implementation. It provides an opportunity to adjust the PPP to avoid, minimize, or enhance the results.

Good governance: Governance is the exercise of political, economic, and administrative authority necessary to manage a nation's affairs. Good governance is characterized by participation, transparency, accountability, rule of law, effectiveness, equity, etc.

Impacts: (can be environmental and/or social)

> ***Direct impacts*** are caused as a direct consequence of the PPP or of a component of the PPP or of downstream projects during PPP implementation. For example, road building activities can give rise to land take, removal of vegetation, and severance of farmland. The removal of gravel material from a borrow pit, for use in surfacing the road, is an obvious direct impact of road construction. In this case, the land area in which the pit site is located has been directly affected by activities associated with the road project.
>
> ***Indirect impacts*** (also known as secondary, tertiary, and chain impacts) are usually linked closely with the PPP or with components of the PPP or downstream projects; they may have more profound consequences on the environment than direct impacts. Indirect impacts are more difficult to measure but can ultimately be more important. Over time, they can affect larger geographical areas of the environment than anticipated. Examples include degradation of surface water quality by the erosion of land cleared because of a new road and urban growth near a new road. Another common indirect impact associated with new roads is increased deforestation of an area, stemming from easier (more profitable) transportation of logs to market or the influx of settlers. In areas where wild game is plentiful, new roads often lead to the rapid depletion of animals due to poaching.
>
> ***Induced impacts*** (a type of indirect impact) result from activities that occur in response to socioeconomic opportunities associated with new development, e.g., as a result of: opening up access to previously remote areas and untapped resources; creating potential for employment and/or enterprises to service new settlements. Induced impacts may be attributable to a project's facilities and activities, or to "associated facilities" that are not funded by the project but without which the project would not be viable. Induced activities are not part of the project scope, design, or objectives and may not be essential for it to operate. In effect, they compound impacts from a project and associated activities and result in cumulative impacts.
>
> ***Cumulative effects/impacts*****:** the incremental impact of a project when added to impacts from other relevant past, present, and reasonably foreseeable developments, as well as unplanned but predictable activities enabled by the project that may occur later or at a different location. World Bank, (2017b).
>
> ***Synergistic impacts*****:** another term for cumulative impacts
>
> ***Cross- or trans-boundary impacts***: impacts that are caused as a result of a PPP or its component or downstream projects and occur beyond the boundary of the area in which the PPP is focused. Boundaries can be at different scales: administrative areas at local to national level, protected areas, national borders.

Indicator: A signal that reveals progress (or lack thereof) towards objectives: provides a means of measuring what actually happens against what has been planned in terms of quantity, quality, and timeliness.

Indigenous peoples: distinct social and cultural groups that share collective ancestral ties to the lands and natural resources where they live, occupy, or from which they have been displaced. The land and natural resources on which they depend are inextricably linked to their identities, cultures, livelihoods, as well as their physical and spiritual well-being. They often subscribe to their customary leaders and organizations for representation that is distinct or separate from that of the mainstream society or culture. Many Indigenous Peoples (IPs) still maintain a language distinct from the official language or languages of the country or region in which they reside; however, many have also lost their languages or are on the precipice of extinction due to eviction from their lands and/or relocation to other territories (World Bank, 2023.). The term indigenous peoples is commonly used by MDBs (e.g., IFC (2012b)) and the United Nations (see: https://social.desa.un.org/issues/indigenous-peoples/indigenous-peoples-at-the-united-nations).

Indirect impacts: see Impacts

Irreversible Negative Impact: An impact that cannot be undone in time using reasonable means.

Iterative: The act of repeating a process, usually with the aim of approaching a desired goal, target, or result. Each repetition of the process is called an "iteration," and the results of one iteration are used as the starting point for the next iteration.

Just Transition: A concept first used in the 1980s by US trade unions to protect workers affected by new water and air pollution regulations. The trade union movement developed JT as a framework to encompass a wide range of social interventions needed to secure workers' rights and livelihoods for those economies shifting to sustainable production, primarily combating climate change and protecting biodiversity. In recent years, the concept has gained traction with reference to meeting climate goals by ensuring the whole of society—all communities, all workers, all social groups—are brought along in the pivot to a net-zero future and that no one is left out of it. (See Annex 20).

Lead agency: any government ministry, institution, department, parastatal, state corporation, or local authority in which any law vests functions of control or management of any element of the environment, natural resources, or social service.

Limits of acceptable change (LAC): extremes in environmental or social quality beyond which society would find further change unacceptable. LAC relates to a level of environmental quality (usually biophysical) or social quality that is either desired or would be tolerated by society (often a qualitative value).

Mainstreaming/Upstreaming: Integrating environment into development planning processes.

Marine spatial planning (MSP): A public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process. Ehler and Douvere (2009) provide a clear, straightforward step-by-step approach to setting up and applying MSP (see also: spatial planning).

Mitigation: Measures to avoid, reduce, restore, and, if necessary, offset significant adverse impacts on environmental or social receptors. The sequence of mitigation follows the mitigation hierarchy (see below).

Mitigation hierarchy: A framework, or sequence of actions implemented, for managing risks and potential impacts. The hierarchy usually encompasses: to anticipate and avoid, or where avoidance is not possible, minimize, and where residual impacts remain, compensate/offset risks and impacts. Once a project comes to the end of its useful life, then restoration/rehabilitation of the land/ecosystem at a site is usually required.

Monitoring: At a project level, monitoring means a program of systematic, objective, and quantitative measurements, observations, and reporting of projects that may have environmental and social impacts. For SEA, monitoring recommendations should be broader and include, e.g., assessing environmental and social conditions and trends, observing PPP development and implementation, and developing information for reporting to national policy-makers, planners, international forums, and the public.

Non-government organization (NGO): see CSO.

Plan: A purposeful, forward-looking strategy or design, often with coordinated priorities, options, and measures that elaborate and implement policy.

Policy: A broad statement of intent that reflects and focuses the political agenda of government and initiates a decision cycle. A general course of action or proposed overall direction that a government is pursuing or intends to follow; a policy guides ongoing decision-making.

Policies, plans, and programs (PPP): have different meanings in different countries according to the political and institutional context. Also, in a particular country or jurisdiction, there may be instruments that are not labeled as a policy, plan, or program but which have a similar meaning or intent, e.g., a strategy that may be similar to a plan. These should be treated as a PPP and be subjected to SEA (if the law or regulations require this).

Policy reform: a process in which changes are made to the formal “rules of the game”—including laws, regulations, and institutions—to address a problem or achieve a goal such as economic growth, environmental protection, or poverty alleviation. Usually involves a complex political process, particularly when it is perceived that the reform redistributes economic, political, or social power.

Program: A coherent, organized agenda or schedule of commitments, proposals, instruments, and/or activities that elaborate and implement policy.

Project: A project is a set of tasks that must be completed in order to arrive at a particular goal or outcome. In terms of environmental and social assessment, it refers to a development activity or initiative (including those that involve construction). For renewable energy developments, a project might encompass the following:

- Hydropower schemes (reservoir-based, run-of-river, micro schemes);
- Wind farms (onshore or offshore)
- Solar farms;
- Geothermal power plants
- Tidal power developments
- Bioenergy production (mainly growing bioenergy crops
- Associated infrastructure may also be included (e.g., transmission lines, access roads, electricity storage facilities, ports, harbors, and terminals, etc.).

Proponent: In an SEA, the proponent is the authority or organization (often a government ministry or department) that has lead responsibility for preparing or implementing a policy, plan, or program. In EIA, the proponent is the organization, company, or individual that is proposing and developing a project.

Receptor: A receptor is a component of the environment or social fabric that could be adversely affected by the implementation of a PPP, e.g., habitats, biodiversity, land, soil, water, air, and climate, material assets, cultural heritage and landscape, communities, human health, rights, etc.

Responsible authority: The organization that prepares and/or adopts a plan or program subject to an SEA.

Scenarios: Scenarios are a technique for presenting alternative views of the future. In SEA, simple scenarios are sometimes used (e.g., low economic growth, medium economic growth, or high economic growth) to compare how the impacts of an individual PPP or, in some situations, a suite of PPPs may differ in nature, extent, and severity under different possible circumstances. Modelling is sometimes used to predict how different scenarios might unfold.

For an SEA of a PPP concerned with the energy transition, it might be useful to develop scenarios of the nature of the transition (what energy resources will be developed and where) during different timeframes (e.g., near-term, medium-term, or long-term).

The process of scenario planning is well developed and can involve various actors to identify significant events, drivers of change, and contrasts; responses to change may differ according to actors' different motivations. Scenario development allows us to think systematically about and understand the nature and impact of the most uncertain and important driving forces affecting our future (see Annex 9).

Scoping: An early stage in SEA to review the context and extent (spatial and temporal boundaries of the SEA) and identify key environmental and socioeconomic issues, providing an opportunity to focus the report on the important issues to maximize its usefulness to the authorities, decision-makers, and public. Scoping should identify baseline and other data requirements and initiate collection, identify any critical information gaps, and determine the relevant criteria for assessment. It should also determine the scope of the analyses needed and identify the stakeholders to be involved (and how). Furthermore, scoping should involve identifying alternatives (to the PPP or elements of the PPP) to be assessed and identifying relevant environmental and social quality objectives (ESQOs), targets, and indicators. It may also involve a review of the policy, legal, and institutional framework.

Sectoral guidelines: means all guidance documents, including codes of best practice, published by government ministries or agencies.

Sectoral strategy: A policy framework, for the long- and/or medium-term, which has been adopted by a government as a plan of action for a particular area of the economy or society.

Spatial planning: Spatial planning systems refer to the methods and approaches used by the public and private sector to influence the distribution of people and activities in spaces of various scales. Spatial planning can be defined as the coordination of practices and policies affecting spatial organization. Spatial planning is synonymous with the practices of urban planning in the United States but at larger scales, and the term is often used in reference to planning efforts in European countries. Discrete professional disciplines that involve spatial planning include land use, urban, regional, transport, and environmental planning. Other related areas are also important, including economic and community planning. Spatial planning takes place on local, regional, national, and inter-national levels and often results in the creation of a spatial plan (see also: marine spatial planning).

Stakeholder: Those who may be interested in, potentially affected by, or influence the implementation of a PPP. Stakeholders may include government (national and local), local communities, NGOs, civil society, the private sector, and, in the context of development cooperation, donor agencies.

Steering committee: a broad-based, multi-stakeholder committee for the SEA to: provide oversight, advice, support, and guidance; facilitate access to critical information; review reports; build ownership of the SEA process amongst key actors; and advocate for the uptake of its recommendations.

Strategic action: refers to an action taken to implement a policy, strategy, plan, or program.

Strategic environmental assessment (SEA): A systematic process for incorporating environmental and social considerations across different levels of strategic decision-making—plan, program, and policy levels. It encompasses a family of approaches on a continuum from institutional assessment to impact analysis and spatial mapping. Some organizations prefer the term Strategic Environmental and Social Assessment (SESA) (notably IFIs).

Strategic Environmental and Social Assessment (SESA): see Strategic Environmental Assessment

Strategic environmental and social management plan (SESMP): sometimes called a Strategic Environmental Management Plan (SESMP). A plan (either stand-alone or sometimes as a section of a SEA report) that presents strategies and procedures to enhance positive and prevent, minimize, or mitigate adverse environmental and social impacts associated with a PPP and projects or activities likely to arise during implementation of a PPP. These procedures should include measures to ensure compliance with relevant safeguards. The SESMP should set out: (a) the roles and responsibilities of different jurisdictions, authorities, and actors in implementing the SESMP; (b) a simple performance monitoring and evaluation mechanism for the environmental and social impacts of the PPP and subsequent development projects/initiatives, with monitoring indicators and a corresponding evaluation procedure and methodology; (c) steps required to enhance benefits or to remove or reduce risks and negative impacts; (d) a stakeholder consultation procedure for the monitoring and evaluation mechanism; and (e) guidance and recommendations for project-level EIAs.

Sustainable development goals: an intergovernmental set of 17 aspiration goals with 169 targets—contained in UN Resolution A/RES/70/1 of 25 September 2015. They cover a broad range of sustainable development issues, including ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests. The SDGs replace the former Millennium Development Goals.

Sustainability: A social goal for people to coexist on Earth over a long time. Specific definitions of this term are disputed and have varied with literature, context, and time. It is often described as having three dimensions (or pillars): environmental, economic, and social, and many publications emphasize the environmental dimension. In everyday use, *sustainability* often focuses on countering major environmental problems, including climate change, loss of biodiversity, loss of ecosystem services, land degradation, and air and water pollution. The idea of sustainability can guide decisions at the global, national, and individual levels (e.g., sustainable living). A related concept is sustainable development, and the terms are often used to mean the same thing. UNESCO distinguishes between the two terms, considering "s*ustainability"* as a long-term goal (i.e., a more sustainable world), while using *sustainable development* to refer to the many processes and pathways to achieve it."

Synergistic impacts: see Impacts.

Target PPP: the particular policy, plan, or program that is the subject of the SEA.

Threshold: Levels that should not be exceeded; points at which irreversible or serious damage could occur, either to ecosystems and/or to social systems (health, safety, or wellbeing). The threshold concept is commonly invoked as a necessary component of environmental assessment and, more broadly, land-use decision-making. Many consider thresholds as objective and finite stopping points at which a harmful activity or development trajectory should cease because further activities will result in an unacceptable change or risk to the environment. Although ecological thresholds can play an important role in environmental assessment, they are not a simple solution to complex socioecological decisions, nor do they ensure objective decision-making. A threshold, even if precise, is only one component of the assessment process. In contrast to the often-naive expectation of precise and definitive science-based thresholds, management or significance thresholds recognize a continuum of risk that can be weighed against socioeconomic interests. That risk continuum can guide the incremental increase in monitoring and precaution that should accompany the review and implementation of individual projects or land-use change that results in cumulative effects across watersheds. Johnson and Ray (2021).

Tier: A layer or ranking in a hierarchy, as in policy, plan, or program.

Tiering: addressing issues and impacts at appropriate decision-making levels (e.g., from the policy to project levels).

Valued environmental and social components (VEC): The IFC defines VECs as environmental and social attributes that are considered to be important in assessing risks; they may be:

- physical features, habitats, wildlife populations (e.g., biodiversity),
- ecosystem services,
- natural processes (e.g., water and nutrient cycles, microclimate),
- social conditions (e.g., health, economics), or
- cultural aspects (e.g., traditional spiritual ceremonies).

While VECs may be directly or indirectly affected by a specific development, they are often also affected by the cumulative effects of several developments. VECs are the ultimate recipients of impacts because they tend to be at the ends of ecological pathways.

ANNEX 20

SEAs supporting PPPs in the energy sector and multi-sector plans with an important (renewable) energy component

<table>
<tr><th colspan="2">Energy sector PPPs subject to SEA</th><th colspan="2">Multi-sector PPPs subject to SEA</th></tr>
<tr><td colspan="4">International level</td></tr>
<tr><td>Energy policy</td><td>Nile equatorial lakes region 2007</td><td rowspan="4">River basin plan</td><td rowspan="4">• Kenya / Tanzania 2012</td></tr>
<tr><td>Mekong hydropower plan</td><td>• Mekong river 2010</td></tr>
<tr><td>Power development plan</td><td>• Greater Mekong Sub-region 2015</td></tr>
<tr><td>Energy strategy</td><td>• European Union, 2022</td></tr>
<tr><td colspan="2">National level</td><td colspan="2"></td></tr>
<tr><td>Energy policy</td><td>• Slovak Republic 1997, 2000
• Canada 2002
• Czech Republic 2002
• Ghana 2009
• Myanmar 2014
• Rwanda 2015
• Zambia 2019
• Nigeria 2022</td><td>National spatial plan</td><td>• Netherlands 2011, 2013
• Montenegro 2015</td></tr>
<tr><td rowspan="2">Energy plan</td><td rowspan="2">• Belgium 2008
• Vietnam 2011, 2014, 2019
• Estonia 2014
• Australia 2015
• Taiwan 2015
• Samoa 2017
• Cape Verde 2017
• Angola 2018
• Nigeria 2019
• Bhutan 2019
• Philippines 2021
• Ghana 2022
• Nigeria 2022</td><td>River basin plans</td><td>• Croatia 2015
• Rwanda 2015
• Vietnam 2008
• Georgia 2010
• Bolivia 2012</td></tr>
<tr><td>Marine spatial plan</td><td>• Germany 2009
• Estonia 2015
• Netherlands 2016
• Sweden 2018
• Ireland 2023
• Scotland 2023</td></tr>
<tr><td>Energy and climate plan</td><td>• EU member states 2018-2023
• Serbia 2023</td><td rowspan="5">Corridor plan</td><td rowspan="5"></td></tr>
<tr><td>Energy strategy</td><td>• Montenegro 2013
• Serbia 2015
• Jordan 2020
• Scotland 2023
• Zambia 2023</td></tr>
<tr><td>Renewable energy plan</td><td>• South Africa 2015, 2019
• Azerbaijan 2016
• Zambia 2022</td></tr>
<tr><td>Off shore energy plan (mainly wind)</td><td>• UK 2003, 2004, 2005, 2006, 2008, 2009, 2011, 2014, 2016, 2017, 2018, 2019, 2022
• Ireland 2010
• Netherlands 2014, 2021</td></tr>
<tr><td>Hydropower sector plan</td><td>• Nepal 1997, 2014,
• Lao PDR 2004
• South Korea 2007
• Vietnam 2009</td></tr>
</table>

	• Albania 2018 • Myanmar 2018		
Oil and gas sector (on land and off shore)	• Ghana • Cyprus • Tanzania • Uganda • Mozambique • Kenya		
Sub-national level			
Electricity supply plan	• Canada 2012	Regional development plan	• Tanzania 2015, 2016
Hydropower development plan	• Vietnam 2008 • Bhutan 2011 • India 2012, 2014 • Pakistan 2014	Regional energy strategies	• Netherlands 2022
		Spatial plan	• Montenegro 2010 • Serbia 2010

Source: Information gathered through archive and web-search (English only - so missing SEAs available only in local languages other than English). The names of the plans may have changed.

ANNEX 21

The role of spatial planning frameworks for renewable energy planning

Spatial planning frameworks play a critical role in shaping the deployment of renewable energy infrastructure and guiding the integration of renewable energy policies into broader land use and development strategies.

Identifying suitable sites: Spatial planning helps identify suitable locations for renewable energy projects, taking into account factors such as resource availability (e.g., solar irradiation, wind speed, hydro potential), land (or marine) use compatibility, environmental constraints (e.g., key biodiversity areas), and community preferences.

Zoning and land allocation: Spatial planning involves zoning regulations and land allocation policies that designate areas for different land uses, including renewable energy development. By designating specific zones or areas for renewable energy projects (e.g., solar parks, wind farms, hydropower installations), spatial planning frameworks provide clarity and certainty for developers, streamline permitting processes, and minimize conflicts with other land uses such as agriculture, conservation, or residential development.

Integration with regional development plans: Spatial planning frameworks are often integrated with regional development plans, economic strategies, and infrastructure investment priorities. Spatial planning facilitates coordinated decision-making across sectors and jurisdictions, ensuring that renewable energy projects contribute to broader regional development objectives.

Community engagement and participation: Spatial planning frameworks may provide opportunities for community engagement and participation. Public consultations, stakeholder workshops, and participatory mapping exercises enable local communities to voice their concerns, preferences, and aspirations. Meaningful community engagement fosters social acceptance, builds trust, and enhances the legitimacy of plans and projects.

Infrastructure siting and grid integration: Spatial planning facilitates the siting of renewable energy infrastructure such as transmission lines, substations, and interconnection facilities to ensure efficient grid integration and energy distribution. Strategic placement of infrastructure can optimize grid reliability, reduce transmission losses, and support the integration of variable renewable energy sources into the electricity grid.

Cross-border cooperation: Spatial planning frameworks enable cross-border cooperation and coordination on renewable energy development in transboundary regions. By harmonizing planning processes, sharing data and expertise, and addressing shared challenges such as energy security and environmental protection, neighboring countries can maximize the mutual benefits of renewable energy deployment and promote regional energy integration.

ANNEX 22

Relations between sector plans and national energy plans

***Transportation**:* Transportation policies directly impact energy consumption through fuel efficiency standards, vehicle emissions regulations, and incentives for alternative fuel vehicles such as electric cars and public transportation. National energy policies often include measures to promote cleaner transportation technologies, reduce dependency on fossil fuels, and improve overall energy efficiency in the transport sector.

Industry: Industrial activities consume large amounts of energy for manufacturing processes, heating, and cooling. National energy policies may include measures to encourage energy efficiency improvements, adoption of cleaner technologies, and industrial sector decarbonization through incentives, regulations, and voluntary programs. Additionally, energy policies can influence industrial competitiveness and productivity by ensuring access to affordable and reliable energy sources.

Buildings and construction: Buildings account for a significant portion of energy consumption and greenhouse gas emissions through heating, cooling, lighting, and appliances. National energy policies often include building codes, energy efficiency standards, and financial incentives to promote energy-efficient building design, retrofits, and renewable energy integration. These policies aim to reduce energy demand, lower utility bills, and improve indoor comfort and air quality.

Agriculture and forestry: Agriculture and forestry activities have implications for energy production, land use, and greenhouse gas emissions. National energy policies may address bioenergy production from agricultural residues and forest biomass, promote sustainable land management practices, and support renewable energy deployment in rural areas. These policies aim to enhance energy security, rural development, and environmental sustainability in the agricultural and forestry sectors.

Water management: Water resources management is closely linked to energy production and consumption, particularly in hydropower generation, water pumping, and wastewater treatment. National energy policies may incorporate measures to improve water efficiency in energy production processes, mitigate water-related risks to energy infrastructure, and promote integrated water-energy planning to optimize resource use and minimize environmental impacts.

Technology and innovation: Technology and innovation policies play a crucial role in driving advancements in energy technologies, such as renewable energy, energy storage, smart grids, and energy-efficient appliances. National energy policies may include research and development funding, technology demonstration projects, and incentives for private sector investment in clean energy innovation. These policies aim to accelerate the deployment of cost-effective and scalable clean energy solutions to address energy and environmental challenges.

Economic and trade policies: Economic and trade policies can influence energy markets, investment decisions, and international cooperation on energy issues. National energy policies may align with broader economic objectives, such as promoting job creation, fostering economic growth, and enhancing international competitiveness in clean energy industries. Additionally, trade agreements and partnerships can facilitate energy trade, technology transfer, and collaboration on shared energy challenges at the national and global levels.

Environmental and climate policies: Environmental and climate policies are closely intertwined with energy policy, as energy production and consumption are major contributors to air and water pollution, greenhouse gas emissions, and climate change. National energy policies may align with environmental and climate objectives by setting targets for renewable energy deployment, emissions reductions, and energy efficiency improvements. These policies aim to mitigate environmental impacts, protect public health, and advance climate resilience and adaptation efforts.

ANNEX 23

The Netherlands: On shore wind development supported by an SEA, an example of tiering

Source: NCEA, (2024)

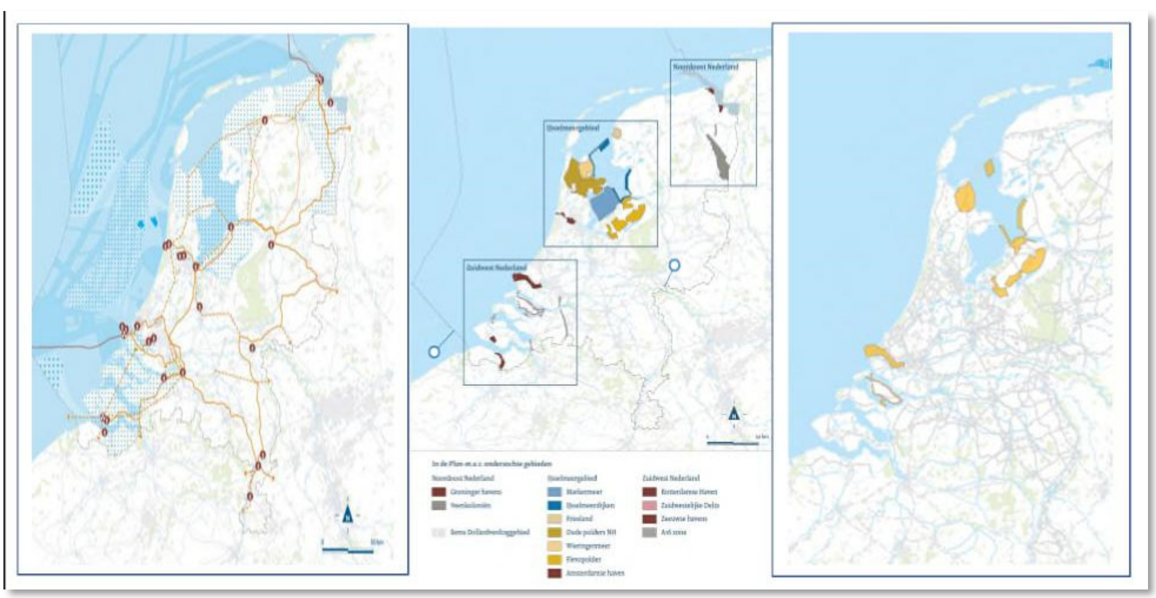
National spatial policy: In 2011, the Dutch government adopted a national policy for infrastructure and spatial development indicating targets for renewable energy.

National wind policy (on land): Subsequently, the Dutch Government developed a specific policy for wind energy, for which also an SEA was done.

Key issues/method: In this SEA, potential locations for wind energy were further delineated within the selected “promising areas” (Map A), and three alternatives were compared (maximum energy yield, nature protection, and landscape protection) on their impacts and attaining national goals and targets for wind energy. Also, a sensitivity analysis was carried out for each location, focusing on potential influence from other policies and (spatial) developments in the area (such as a new airport) (Map B). Eventually, specific locations were designated for large-scale wind energy development (Map C), justified by the results of the SEA (November 2013).

Map A **Map B** **Map C**

A: ‘Promising areas’ for large scale wind energy infrastructure + spatial planning
B: Potential locations studied in the SEA (National wind energy policy)
C: Locations selected for large scale wind energy



In both SEAs mentioned above, stakeholders and the public were consulted. In the final policy document, all stakeholder comments were presented in an Annex, with a response from the government whether and how these comments influenced the SEA or the policy. To follow up on stakeholders’ calls for ensuring solid community engagement in and financial benefit from wind energy projects, the government promised to investigate whether and how a (financial) participation plan (for projects larger than 15 MW) could be made legally binding and part of permitting conditions. Also, a code of conduct has been developed for the organization of stakeholder acceptance (IPO/VNG).

Influence: These SEAs resulted in designated areas where large-scale wind farms can be developed that are supported by a majority of the stakeholders, to a large extent due to the introduction of the benefit sharing mechanism.

The SEA also helped define criteria and conditions for developing wind energy projects (>100 MW) and specific points of attention at each location that should be quantitatively analyzed and mitigated.

ANNEX 24

International power planning: the Energy Union's National Energy and Climate Plans

Source: https://www.energy-community.org/dam/jcr:c9886332-a1f5-43ee-b46c-31c637aedfa6/PG_03_2018_ECS_NECP.pdf

The Energy Union's National Energy and Climate Plans (NECPs) are strategic documents developed by European Union (EU) member states to outline their approaches towards achieving the EU's energy and climate targets for 2030. These plans are a critical component of the EU's overarching strategy to transition towards a sustainable, secure, and competitive energy system. Each NECP covers five key dimensions: (i) decarbonization, (ii) energy efficiency, (iii) energy security, (iv) internal energy market, and (v) research, innovation, and competitiveness.

NECP shall consist of the following main sections:

a) An overview of the process followed for establishing the plan, including public consultation and involvement of stakeholders and their results, and regional cooperation;
b) National objectives, targets, and contributions relating to the dimensions of the Energy Union;
c) Planned policies and measures in relation to point (b) as well as investment needs;
d) Current situation of the five dimensions of the Energy Union;
e) Where applicable, a description of the regulatory and non-regulatory barriers and hurdles related to renewable energy and energy efficiency;
f) An assessment of the impacts of the planned policies and measures and their consistency with the long-term greenhouse gas emission reduction objectives;
g) A general assessment of the impacts of the planned policies and measures on competitiveness linked to the five dimensions of the Energy Union;
h) Member States' methodologies and policy measures for achieving the energy savings requirement.

Furthermore, Member States shall describe their assessment, at national and, where applicable, regional level, of:

- The impacts on the development of the energy system and greenhouse gas emissions and removals, including a comparison with the projections based on existing policies and measures;
- The macroeconomic and, to the extent feasible, the health, environmental, skills, and social impact of the planned policies and measures, including a comparison with the projections based on existing policies and measures. The assessment methodology shall be made public;
- Interactions between existing policies and measures within a policy dimension and between existing policies and measures. Projections concerning security of supply, infrastructure, and market integration shall be linked to robust energy efficiency scenarios.

The NECPs are subject to an SEA under the EU SEA Directive. The described above approach to NECPs has some resemblance to an SEA (e.g., stakeholders' consultation, public transparency, consistency analysis among policies, institutional "skills," assessment of health, environmental, and social impacts). Integration of NECPs with an SEA is relatively simple and straightforward.

A number of countries have already completed the NECP process, including SEA. Finland and Estonia have integrated completed SEAs in their NECP submissions. Denmark, the Czech Republic, and Cyprus have applied SEAs to their NECP processes.

ANNEX 25

Key decisions in energy sector plans and key issues in associated SEAs for energy plans

ENERGY PLANNING: national energy authority / authorities in the lead		
Type of plan	Key decisions	Key issues in SEA
INTERNATIONAL		
Energy networks 1. ***e.g., African Power Pools (West, East, and Southern)*** 2. ***…***	• Energy security: diversification to reduce single source dependency; minimizing geopolitical risks or supply disruptions. • Enhancing the resilience of energy infrastructure against natural disasters, cyberattacks, and other threats. • Renewable energy integration to reduce fossil fuels and enhance energy stability. • Reliable and affordable energy to all, particularly in developing regions with a lack of basic energy services. • Leveraging energy projects to create jobs and stimulate economic growth. • Developing and enforcing joint standards and regulations • Strategies for engaging the private sector	• Energy infrastructure alternatives; • Maximise renewable in energy mix; reduce perverse incentives for carbon-based energy. • Governance arrangements/international coordination for environmental monitoring and management • Ensure benefits for all segments of society • Promote sustainable practices and mitigate environmental degradation • Assessing and addressing risks related to geopolitical instability, natural disasters, and climate change • Alignment with other sector plans • Need for revision, updating, or strengthening of laws and regulations • Measures to rehabilitate areas affected by phasing out coal (mines and energy facilities); • Cumulative effects with other sector plans
NATIONAL		
National energy plan ***Vietnam SEA for Power Development Plan (Annex 28*** ***Netherlands Regional Energy Strategies (Annex 29)***	• Energy mix: ambition/targets for renewables (NDC); role of transition fuels; balance domestic/imported energy • Infrastructure: transmission and distribution; centralized or decentralized energy systems; smart grid technology and grid resilience; storage solutions • Regulations: emissions limits; incentives and subsidies; market reforms; role of the private sector • Energy efficiency standards for buildings, transportation, and industry. • Technology development: hydrogen, carbon capture and storage, new energy solutions	• Energy demand under climate scenarios • GHG emission reduction (NDC targets) • Air and water pollution/health effects: cleaner technologies and regulation • Water scarcity/reliability (hydrogen production, run-of-the river hydropower, cooling). • Land use, habitat destruction, forced displacement • Resource depletion • Energy access and equity (avoid energy poverty) • Environmental injustice and health disparities. • Long-term costs and benefits of energy alternatives

	• Phasing out fossils	
Hydropower plan ***Quang Nam Hydropower Plan, Vietnam (Annex 30)*** ***Pakistan Jammu & Kashmir hydropower*** ***(Annex 31)***	• Type and location of HP facilities • Grid integration: stability and peak load management, stored HP • Multi-purpose use (irrigation, flood control, public water supply, recreation) • Policy alignment with national energy policies, development goals, and sustainability targets. • Comply with international regulations on water rights, environment, and land use.	• Climate vulnerability (floods; underperformance) • Portion of river basin(s) to remain free flowing/guarantees for migratory animals • Environmental flows for downstream functional ecosystems • Limits of acceptable change in hydrology • No-go areas/sites (protected; human use; indigenous territory) • GHG emissions by reservoirs (methane) • Forced physical or economic displacement • Cumulative effect of HP cascades and multiple water uses. • Need for upstream land conservation at basin level for sediment control (lifetime of reservoir) • Erosion of coastal zone and river bed/embankments

ANNEX 26

Key decisions and key issues in SEA for multi-sector plans relevant to energy interests

MULTI-SECTOR PLANNING: lead authority is either a spatial / regional authority, or a working group composed of relevant departments		
Type of plan	Key decisions	Key issues in SEA
INTERNATIONAL		
Economic corridors	• Infrastructure development for transportation and trade (including energy) • Priority sectors/industries (all need energy supply) • Harmonization of regulations and procedures for cross-border trade and investment. • Strategies for engaging the private sector, including energy sector	• Spatial delineation of alternative energy infrastructure corridors • Arrangements/coordination for environmental monitoring • Ensure benefits for all segments of society, including access to energy • Promote sustainable practices and mitigate environmental degradation • Climate and geopolitical vulnerabilities and risk
International river basin plan	• Water allocation (including for hydropower and power plant cooling) to up- and downstream countries • Water rights and allocation mechanisms to prevent conflicts and promote cooperation. • Adopt an IWRM approach that considers land, water, and related resources. • Legal/institutional frameworks for cooperation and conflict resolution among riparian countries.	• Strategies to adapt to climate change; early warning systems for floods and droughts in support of hydropower and other water dependent sectors. • Protecting and restoring aquatic and riparian ecosystems for optimal water storage and flood control; maintaining sufficient flow in support of healthy ecosystems. • Establish frameworks for monitoring and data sharing among basin countries.
NATIONAL		
National spatial plan ***Namibia Integrated Land Use Plans & SEA*** ***RSA: Wind and solar Spatial Plan (Annex 32)***	• Zoning of land use, including areas needed for energy production and energy transmission corridors. • Mixed-use developments and their energy supply • Transportation planning (multi-modal, motorized and non-motorized) and type of energy used • Utility infrastructure (water, communication networks).	• Sustainable resource management (water, energy, raw materials) • Conservation of high biodiversity areas delivering critical ecosystem services. • Green multipurpose infrastructure (e.g., green spaces, corridors, or buffer zones). • Climate risks and vulnerability • GHG emissions reduction • Promote nature-based solutions for resilience
National development plan	• Goals on economic growth, social equity, and environmental sustainability, directly link to energy • Inventory and development potential of energy resources. • Priorities for infrastructure projects • Planning for the provision of social services	• Reduced carbon sequestration by loss of biodiversity. • Air, water, and land pollution, including GHG emissions • Overexploitation and degradation of natural resources (water, soils, biomass) • Application of circular economy principles (opportunities for biogas technology)

Special economic zone	• Location: proximity to power supply • Type of SEZ and energy requirements • Infrastructure development (transport, energy) • Regulations: taxation, customs duties. • Public-private partnerships	• Environmental regulations, sustainable planning, enforcement, and monitoring. • Investment in green technologies. • Social issues: health, forced displacement • Circular economy principles for industrial production to avoid pollution, solid waste, GHG emissions, and resource depletion. • Greening of energy supply
River basin management plans ***Rwanda: Integrated Catchment Plan & SEA (Annex 33)*** ***India: Hydropower planning in Upper Ganges basin (Annex 34)***	• Water allocation (hydropower, cooling) • Governance, institutional coordination (Gov, private, NGO), • Legislative measures • Climate adaptation and resilience (storage, flood defense, drought) • Type and location of (stored) hydropower facilities • Targets and actions for water quality	• Drivers of change (economic development, population increase, resource use, etc.) • Cumulative impacts of existing and planned activities, up- and downstream • Climate vulnerability (rainfall, hydrology, erosion, sea level rise) • Nature-based solutions for climate adaptation • Habitat restoration, species conservation, and invasive species control
Marine spatial plan ***Ireland: Maritime Spatial Plan (Annex 35***	• Zoning for specific uses such as conservation, fishing, shipping, wind power, and oil and gas exploitation. • Coordinating with other policy domains to address land-based problems (pollution, plastics, eutrophication, sediments)	• Interference with pathways of migratory birds and bats • Interference with other uses (fisheries, shipping, etc.) • Sensitive/no-go areas (level of protection)
Coastal zone mgmt. plan ***Kenya: SEA for Tana Delta Land Use Plan***	• Protect coastal communities, infrastructure, and natural habitats from hazards (erosion, flooding, storm surges, sea-level rise, tsunamis). • Land use planning balances economic activities, habitat conservation, and hazard mitigation. • Adapt to climate change	• Preserving and restoring coastal ecosystems is vital for maintaining biodiversity, resilience to climate change, and ecosystem services. • Address land-based emissions from industry, agriculture, and urban areas to reduce water pollution in coastal areas (pollutants; plastics).

ANNEX 27

Selecting energy sector plans for SEA

The case of the Quan Nam provincial hydropower plan (Vietnam) gives a good approach to start with the introduction of SEA by first doing a "safe" ex-post assessment of a plan already agreed upon. This experience was used, after SEA became a legal obligation, to further develop the instrument on several successive National Power Plans.

In answering the question of what type of plan can benefit most from SEA, there are two approaches:

1. **The most influential plan**: a national energy plan makes fundamental choices for the future of the entire energy sector, which translates into detailed follow-up planning. It seems to be the obvious and most relevant plan to be assessed. However, it is an ambitious endeavor, and the plan may simply not be open for update for a prolonged period.

2. An alternative approach is to simply focus on the **first available energy-related plan** scheduled for revision that would benefit from an SEA.

To determine which plan can benefit most from an SEA, a number of questions can be asked:

- **Country energy system.** What elements of a country's energy system have the most relations with other sectors, have the most contested spatial claims, or lead to public debate? For this one has to have a good understanding/description of the energy system. The elements in Box A27.1 provide entry points. Note that some of the elements are directly linked to other than energy planning frameworks. For example, energy consumption is defined by other sectors; location of energy infrastructure is linked to spatial planning; energy markets may be governed by finance departments.

- **Country planning system.** Understand and describe the country specific system of energy planning and multi-sector planning linked to energy sector interests as described in Chapter 4, Section 4.4. Indicate relevant cross-linkages from an energy perspective. Use Annex 21 on the role of spatial planning frameworks for renewable energy planning and Annex 22 on relations between sector plans and national energy plans for inspiration.

- **Open policy choices.** Which policy choices are definite, and what choices need to be elaborated? Think of tasks for the energy transition defined in the Nationally Determined Contributions under the Paris Agreement or use the key issues for the energy transition in the second part of Box A27.1 for inspiration.

- **Describe the key decisions** in terms of What, Where, How, and When as described in Table A27.1.

- **Timing of plan updates.** Make a time schedule indicating when a relevant planning exercise and moment of decision-making are foreseen.

Box A27.1: Elements of a country's energy system and issues linked to the energy transition

- **Energy resources:** Energy systems rely on primary energy sources, including fossil fuels (such as coal, oil, and natural gas), renewable energy sources (such as solar, wind, hydro, biomass, and geothermal), and nuclear energy. The availability and diversity of energy resources influence the resilience and sustainability of the energy system.
- **Energy production infrastructure:** Energy production infrastructure encompasses facilities and technologies for extracting, refining, processing, and generating energy

from primary sources. This includes power plants, refineries, drilling rigs, mines, and renewable energy installations.

- **Energy transmission and distribution networks:** Transmission and distribution networks transport energy from production facilities to end-users, including households, businesses, and industries. These networks consist of power lines, pipelines, substations, transformers, and distribution grids.
- **Energy storage systems:** Energy storage systems play a crucial role in balancing supply and demand, stabilizing the grid, and integrating variable renewable energy sources. Storage technologies include batteries, pumped hydroelectric storage, compressed air energy storage, and thermal storage systems.
- **Energy consumption sectors:** Energy consumption sectors represent the end-users of energy, including residential, commercial, industrial, transportation, and agricultural sectors. Each sector has unique energy demands, consumption patterns, and efficiency opportunities.
- **Energy policies and regulations:** Energy policies and regulations govern the development, operation, and management of the energy system. This includes policies related to energy security, environmental protection, renewable energy deployment, energy efficiency, pricing, subsidies, and market competition.
- **Energy markets and economics:** Energy markets facilitate the buying and selling of energy resources, products, and services. These markets operate under various economic models, including regulated monopolies, competitive markets, and hybrid systems. Factors such as supply and demand, market dynamics, pricing mechanisms, and government interventions influence energy market outcomes.
- **Energy technologies and innovation:** Advances in energy technologies and innovation drive the transformation of energy systems, improving efficiency, reducing costs, and expanding the use of renewable energy sources. Key technologies may include solar panels, wind turbines, electric vehicles, smart grids, energy-efficient appliances, etc.
- **Environmental and social considerations:** Environmental and social considerations are integral to the sustainability and resilience of energy systems. This includes minimizing environmental impacts (notably air pollution), addressing climate change (notably greenhouse gas emissions), protecting biodiversity, ensuring energy access for all, and promoting social equity and justice.
- **International energy relations:** Energy systems are increasingly interconnected at the global level through trade, investment, and cooperation. International energy relations involve negotiations, agreements, and partnerships related to energy security, supply chains, geopolitics, and sustainable development goals.

Several key issues are likely to shape the future of country energy systems (no order of priority):

- **Energy demand projections** taking into account economic growth, technological advancements, policy changes, demographic trends, and historical consumption patterns. Drivers of energy demand include economic factors (GDP growth, industrial output), demographic factors (population growth, urbanization rates), technological factors (changes in energy efficiency, new technologies, or energy intensity), policy and regulatory factors (subsidies, tax incentives, environmental regulations), and behavioral factors (consumer behavior, preferences for energy sources).
- **Energy transition challenges**, including the intermittency of renewable energy sources, how to address peaking power (which refers to power plants that generally run only during periods of high electricity demand, known as peak demand), balancing power (a critical component of modern power systems that ensures the electricity supply meets demand in real-time and maintains overall grid stability), grid integration issues, investment barriers, and the social and economic impacts on communities dependent on fossil fuel industries. The inclusion of intermittent renewable energy sources like wind and solar adds complexity to balancing the

grid. Effective market structures are needed to incentivize balancing services, and investments in advanced technologies like smart grids, battery storage, and responsive load management systems are essential.

- **Transition fuels** bridge the gap between traditional fossil fuels and renewable energy sources. Transition fuels, such as natural gas, have lower carbon emissions compared to coal and oil. By replacing more carbon-intensive fuels, transition fuels help to reduce overall greenhouse gas emissions in the short to medium term. They provide a reliable and flexible source of energy that can complement intermittent renewable energy sources to stabilize energy grids. It is essential to recognize that they are not a long-term solution to climate change.
- **Energy security and resilience** are a critical concern in the face of geopolitical uncertainties, natural disasters, and cyber threats. Countries will need to diversify their energy sources, enhance grid reliability, invest in energy storage and smart grid technologies, and strengthen international energy cooperation to mitigate risks and disruptions.
- **Decentralization and digitalization** of energy systems are reshaping how energy is produced, distributed, and consumed. Distributed energy resources such as rooftop solar, energy storage, and electric vehicles, coupled with digital technologies, are enabling more flexible, efficient, and resilient energy systems.
- **Electrification of end-use sectors** such as transportation, heating, and industry requires expanding electric vehicle infrastructure, promoting heat pumps and electric heating, and incentivizing electrification in industrial processes.
- **High energy consumption sectors** have difficulty reducing their carbon emissions. These include industrial processes (chemicals, refining, steel, etc.) and heavy-duty transport (freight trucks, bus fleets, shipping, aviation). Fossil fuels can be replaced by green hydrogen. Green hydrogen allows for storage and transportation of energy. The uneven worldwide distribution of renewable energy requires international transportation of hydrogen.
- **Energy access and equity:** Ensuring universal access to affordable, reliable, and clean energy services remains a priority, particularly in developing countries. Closing the energy access gap requires investments in off-grid and mini-grid solutions, rural electrification initiatives, and policies that prioritize the needs of marginalized communities.
- **Circular economy and resource efficiency**: Moving towards a circular economy model in the energy sector can help reduce resource depletion, waste generation, and environmental impacts. This involves promoting energy efficiency, recycling and reuse of materials, and designing products and processes with lifecycle considerations in mind.
- **Climate change adaptation:** Countries need to increase resilience to climate-related hazards, and integrate climate considerations into energy planning, infrastructure development, and policy-making processes.
- **Just Transition and social impacts**: Managing the social impacts of the energy transition, such as job displacement, community disruption, and economic disparities, is essential for ensuring a just and equitable transition. Governments, industry, and civil society must collaborate to support affected workers and communities through retraining programs, job creation initiatives, and social safety nets. Both the phasing out of carbon and the mining for lithium, cobalt, nickel, copper, and other critical minerals required for the transition have serious consequences. This has led to calls for a just transition, which the IPCC defines as *"a set of principles, processes and practices that aim to ensure that no people, workers, places, sectors, countries, or regions are left behind in the transition from a high-carbon to a low-carbon economy."*
- **Global Energy Governance** and cooperation mechanisms are crucial for addressing transboundary energy challenges, promoting sustainable energy development, and achieving international climate goals. Multilateral agreements, partnerships, and

initiatives are needed to facilitate knowledge sharing, technology transfer, and capacity building across borders.

Table A27.1: Schematic presentation of key energy decisions, type of plans in which these decisions are elaborated, and focus of SEA for such plans

	Key decisions	Type of plan	SEA focus
What	• Fuel mix • Private versus public responsibility • Energy import / export • International network of electricity • Energy access • Centralised or decentralised energy systems	National energy plan	• Drivers of environmental change: emissions, exploitation of natural resources • Climate scenarios for demand projections • Alignment with other sector plans • Alignment to NDCs
Where	• Site location for energy facilities, on land and marine area. • Corridor trajectories for power- and pipelines	National and sub-national spatial plans, or combined spatial/energy plans	• Land use change • Biodiversity and ecosystem services • Human occupation / uses • Vulnerable groups (winners and losers) • Climate vulnerability and risks
How	• Technology choices	From energy sub-sector plans to project design	• Drivers of environmental change: emissions, exploitation of natural resources • Climate vulnerability and risks
When	• Timeline of implementation	All plans	• Consistency with timelines of other plans and regulations

Making a choice. With the understanding of the energy system, the issues on which planning decisions are needed, and the inventory of relevant planning frameworks, a choice for what plan process an SEA can be most appropriate can be made. The time schedule may play a role in deciding what plan to choose to get the most benefits from the SEA process. And last, but not least, the level of commitment and ambition of the lead authority and the available capacity and funding to implement the process can be defining factors in the selection.

ANNEX 28

SEA of National Power Development Plan, Vietnam

Source: NCEA (2012)

The Plan: The national Power Development Plan VII provides a long-term strategic framework to guide the development of the power sector. It analyzes future economic and social development trends, summarizes energy requirements, and evaluates the costs and benefits of preferred supply options. PDPs had no systematic accounting of environmental and related social costs, a focus on a narrow energy mix with limited consideration of renewables other than hydro, and little consideration of demand-side management.

Approach to the SEA: In 2005, SEA became a legal requirement. The SEA for PDP VII was a joint responsibility of the Ministry of Industry and Trade (in charge of PDP), the Institute of Energy (subsidiary to MoIT, implementing the SEA), the Ministry of Natural Resources and Environment (appraises the SEA), and the Prime Minister's Office (issues the final decision on SEA and PDP).

Main accomplishments of the SEA, embedded in a longer-term learning process:

(i) This is the first SEA making extensive use of transparent, quantitative analysis using spatial analysis (zonal statistics) and monetization of impacts (value transfer method).

(ii) It is the first SEA to look at the complete energy mix—valuation and comparison of all supply and efficiency options—rather than only looking at individual energy sources.

(iii) From an initial strong focus on thermal power located in populated areas and a shift from oil to coal, during the closely coordinated planning and assessment process the PDP moved towards more ambitious energy efficiency and renewable energy targets (predominantly small HP), emphasizing the need for power source-specific mitigation and compensation measures (such as environmental water releases for HP projects).

(iv) Building on the SEA for the PDP VII, the revision of the PDP VII (3 years after PDP VII) resulted in even more ambitious energy efficiency and renewable energy targets (additional reduction of 22,000 MW coal-fired power plants and 7-fold increase in renewable energy targets compared to PDP VII).

Additional lesson: The contributions of the SEA of the PDP VII should not be viewed individually but as a result of a decade-long engagement with conceptual and technical support to IoE and MoIT. This yielded results and influenced the PDP in ways that would not have been possible if this was treated as a one-time, stand-alone SEA exercise only. Continuous engagement over a period of 10 years meant that the national agency was truly owning and independently implementing the SEA.

ANNEX 29

SEA supporting Regional Energy Strategies, The Netherlands

Source: NCEA (2022)

Plan: Sub-national energy sector plan

In the Netherlands, the national targets for energy transition have been set in the National Energy and Climate Plan 2019 that has been subject to SEA. CO_2 emissions are set to be reduced by 49% (compared to 1990) in 2023 and by 100% in 2050. These targets have been translated to sub-national authorities in 30 regions. In each region, regional energy strategies subject to SEA were developed in 2021. They focus on generating sustainable electricity, mainly through solar and wind facilities.

Method/key issues

Site selection was the key issue in the SEA process. An integrated, landscape approach was applied to balance the different interests. These strategies were developed through participatory processes involving all relevant authorities, the private sector, and communities. Local initiatives are supported, and the aim is benefit-sharing for 50% of all installed solar and wind. Alternatives for selection of sites for wind and solar farms were developed, compared, and publicly discussed.

Influence of SEA and plan

Selection of areas to develop wind and solar farms that are accepted by the majority of the people affected.

ANNEX 30

SEA for the Quang Nam Hydropower Plan, Vietnam

Source: OCED (2012)

The Plan and SEA: The provincial hydropower plan incorporated close to 40 hydropower projects, including 8 large projects (60-225 MW). By the time the SEA was completed, the number of planned projects had increased to over 60, with proposals continuing to come in.

The SEA of the Quang Nam Province Hydropower Plan was the first SEA undertaken in Viet Nam. It was conducted on a plan already approved (ex-post assessment) to gain experience.

Key issues: The SEA resulted in four critical strategic concerns in the basin: integrity of ecosystems, water supply, impacts on ethnic minority groups, and economic development. The SEA concluded that the pace and scale of the proposed hydropower developments were at a level that could not be sustained. While the hydropower plan would bring national benefits (energy and income), these benefits would not be captured within the basin locality unless measures such as a river basin management fund were established.

The SEA made a number of recommendations relating to the integrated management of the basin, including a proposal to develop an "intact rivers" policy to secure the maintenance of one or two complete river sequences (from headwaters to sea) free of barriers to ensure a full sequence of habitats and fish migratory routes.

Influence of the SEA: Since its completion, a number of SEA recommendations have been implemented. These include a freeze on all hydropower development within the Song Thanh Nature Reserve located high in the catchment, the trial of benefit-sharing mechanisms for hydropower by the Electricity Regulator of Vietnam, the restructuring of the River Basin Organization, and the development of an updated river basin plan.

Additional lessons from an ex-post assessment:

- The relevance of strategic assessment processes for hydropower planning was highlighted.
- Ex-post assessment can still be effective in identifying opportunities for enhancing sustainability.
- Adding social and economic assessments to the SEA increased its acceptability within government, which tends to give emphasis to meeting immediate economic objectives.
- Even though time-consuming and intensive, the involvement of government stakeholders and consultations with communities clearly contributed to the success by increasing stakeholder ownership.

ANNEX 31

SEA of Hydropower Plan on Azad-Jammu-Kashmir State, Pakistan

Source: NCEA (2021)

Hydropower plan and SEA

The government of Azad-Jammu-Kashmir State (AJK) agreed to volunteer its hydropower plan (the 'Plan') for SEA piloting. In 2014, there were 12 operational hydropower projects in the state. An additional 13 are under construction, while 37 more sites have been identified for detailed feasibility (total technical capacity ~9000 MW). The SEA took the form of an ex-post assessment based on the collection of 62 existing or proposed projects that make up the de facto plan. The main objectives of the pilot SEA of the hydropower plan were to:

- Assess the potential environmental and social risks and benefits associated with the current hydropower plan;
- If necessary, suggest alternative plan options that better optimize economic, environmental, and social outcomes.

Key issues/method

Based on ecological criteria, the rivers in AJK were divided into nine zones. The ecological sensitivity of each river zone was assessed and discussed, followed by a determination of the sensitivity of river sections to the development of hydropower projects (HPPs). A similar analysis of socioeconomic conditions was undertaken for each of the sections and rated as least, moderate, or highly sensitive to HPP development. Finally, both analyses have been combined, which showed that the nine proposed HPPs in the Poonch River basin all rank highest for potential ecological and social impact, and therefore this section is indicated as a highly sensitive zone.

Influence of SEA

One of these nine projects in the Poonch River is the Gulpur project that was initially rejected by the funding agencies (IFC, ADB) because the proponents had not taken into account the specific requirements in relation to its location in a planned national park. This National Park was not yet approved due to opposition by government planners who were afraid that its protected status would prevent the use of hydropower from the river. Then the pilot SEA was conducted, and the sub-sequent IFC requested to carry out an EIA of four combined hydropower projects in Poonch River, including the 100 MW Gulpur HPP. This EIA could be carried out very quickly, as it could be based on the SEA pilot. As a result of the EIA and the described alternatives, the impacted area of river flow could be reduced from 7 km to 0.5 km. Furthermore, the proposed Gulpur hydropower dam was changed from a dam including a large reservoir into a run-of-the-river project, providing the same hydropower yield as the dam initially planned. A biodiversity action plan for the project impact area was prepared for investments in biodiversity conservation. An important secondary result of this process was that the resistance against the establishment of Poonch National Park by the authorities ceased and the protected status of the park was approved. A biodiversity management plan for the entire river will be prepared, taking into account the accumulated impacts of the four dams. In sum, the influence of the SEA was:

- The proposed Gulpur reservoir dam was changed into a run-of-the-river project;
- Poonch National Park was established and investments in conservation were made.

Lessons learned

- The pilot did not have a budget for primary data collection. Fortunately, the consulting team had access to excellent primary environmental and social data from previous impact assessment studies undertaken in the state. Without this information, the pilot SEA would not have been able to produce the river sensitivity and HPP ranking, which was a crucial outcome of the study.

- Maps produced as part of the SEA study were of significant value. These were used for discussions with public officials in AJK, who often do not have enough time to read long, technical reports. At consultation meetings with government officials, the maps engendered spirited engagement that clearly led to organizational learning.

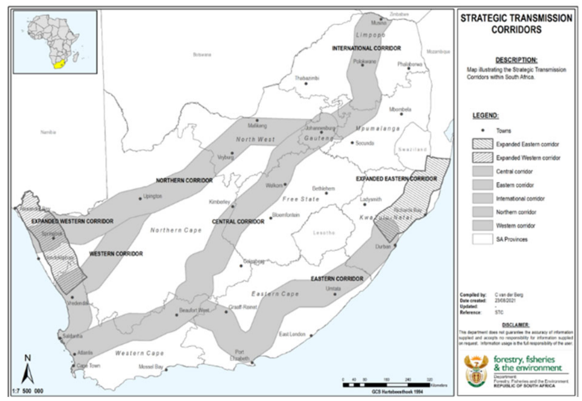
ANNEX 32

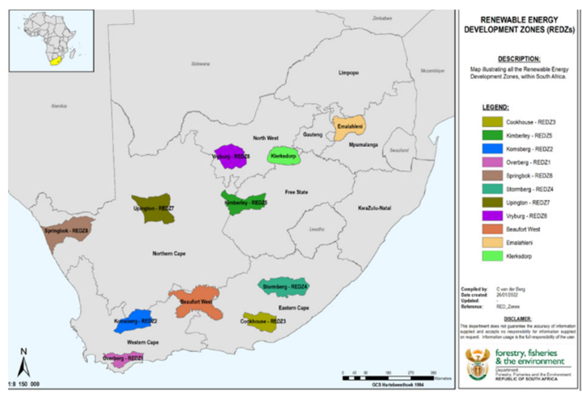
SEA for wind and solar spatial plan, South Africa

Source: Renewable energy development zones (redzs) and Strategic Transmission Corridors (2021)

Plan: In 2013, 550 projects were proposed for large-scale wind and solar PV farms. The Ministry decided that a strategic plan was necessary to guide the development of these projects. A plan was prepared to develop renewable energy development zones. This plan was subject to SEA.

Key issues/method: By making use of the Geographic Information System (GIS), a strategic country-wide and integrated approach was applied to identify the most suitable sites. The first step was identifying the suitability for wind by making use of a wind atlas and for solar farms by making use of solar radiation maps. The second step was identifying areas that need to be excluded for reasons of sensitivity, such as protected areas and biodiversity corridors. For economic reasons, areas too far away from the main electricity network were excluded (see map power transmission corridors). The loss of electricity increases considerably after several hundreds of kilometers of transport from a solar or wind park towards the main network. The third step was overlay mapping of the potential sites and the sites excluded, resulting in eleven sites. Through the SEA, a participatory process was organized in which all key authorities, the private sector, and communities were engaged in the selection of the most suitable sites. Criteria applied were loss of agricultural land, biodiversity effects (birds and bats), noise, landscape, and socioeconomic. This resulted in eight areas that were suitable for large-scale development of wind and solar farms; three sites were excluded; see map.





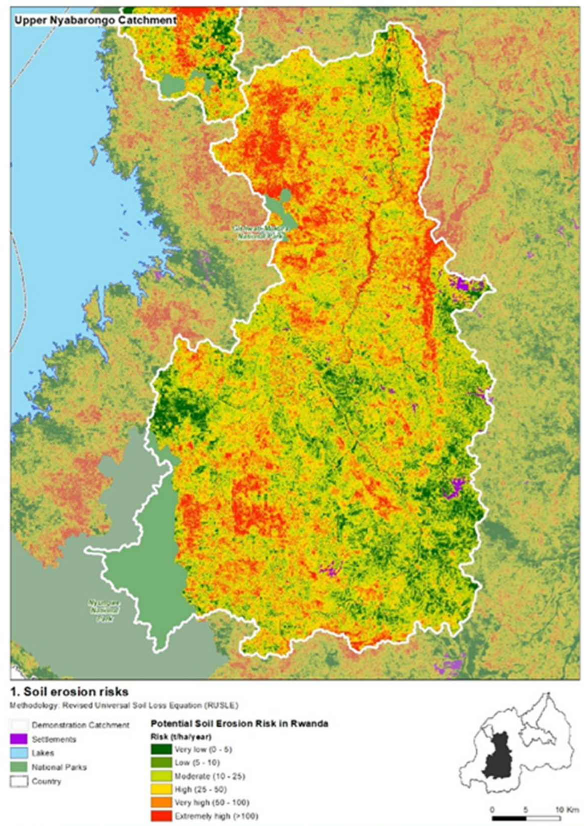
Result/influence: Most suitable sites were selected and mostly accepted by the key stakeholders. SEA provides guidance to the provincial authorities who are mandated to issue permits, based on an EIA, to develop wind and solar farms.

ANNEX 33

SEA and integrated river basin plan for Upper Nyabarongo Basin, Rwanda

Source: NCEA (2021)

Plan: The Upper Nyabarongo basin represents 13% of the surface of Rwanda. It is part of the Nile Basin, and it has abundant water resources with an average annual rainfall above 1,600 mm and an elevation ranging between 1,460 and 2,950 meters. The predominance of steep slopes and high rainfall within this catchment make it highly potential for hydropower development. Currently, five hydropower plants are operational with a total capacity of 51.5 MW, and a new 120 MW plant is planned. In total, 1.2 million people live in this basin in high densities (900–1,500 inhabitants/km2). Poverty rates are high. The cause of poverty has often been linked to high population growth and declining soil fertility in a largely agrarian-based economy. The rivers have very high sediment loads due to soil erosion from hillside agriculture, deforestation, and mining; see map. Mining may also lead to contamination with heavy metals, posing a human health risk. The sediment load results in high removal costs for drinking water intake, as well as turbines and related infrastructure for hydropower stations. Both hydropower and drinking water intake often need to shut down during periods of extreme sediment load, while operations also suffer from regular interruptions due to required sediment removal from settling basins associated with the intake. It also effects the lifetime of the hydropower plants, with the high shutdown time of the hydropower facilities being an important reason for the relatively high electricity prices. The above-mentioned challenges hinder the sustainable use and further exploration of the opportunities for development. That was the main reason for the development of this river basin plan, aiming to *"effectively manage land, water, and related natural resources, to contribute to sustainable socioeconomic development and improved livelihoods, taking into consideration environmental flow, downstream water demands, and resilience to climate change, and minimize water-related disasters."* One of the specific objectives is to reduce the sedimentation of the rivers, which is a serious threat for hydropower use and development.



SEA issues: This plan requires to be subject to SEA and have been integrated. A multi-sector institutional structure was developed to engage stakeholders and finally to approve the plan/SEA by a steering body represented by five ministries. During this integrated process, a list of interventions or projects was identified to improve or enhance basin management. Based on these measures, the following four alternatives were assessed and compared:

A: increased water storage;
B: increased water storage + sustainable land management;
C: increased water storage + sustainable land management + water use efficiency;
D: increased water storage + sustainable land management + water use efficiency + reduced irrigation.

Alternative C was selected as the preferred alternative. This alternative has the desired effect of balancing the need for energy security by maximizing the potential for hydropower development with food security while avoiding local water shortages. This can be achieved by combining the development of water storage, sustainable land management of 55,000 ha, enhanced water use efficiency in all sectors (especially in irrigation), afforestation on very steep slopes, terracing on agriculture land, and protection of buffer zones of rivers. The photo above, shows the implementation of rehabilitation works.

Influence of SEA and plan

- With a focus on hydropower, measures that will stop and prevent soil erosion are implemented, both important to (i) secure the utilization of the existing hydropower capacity and (ii) find investors who are interested in developing new hydropower projects.
- Water allocation plans were made for all sub-catchments, per month, per water user (including environmental flow), and for the planning of 2024, 2030, and 2050, including environmental flow. These then formed the basis for water permits.

ANNEX 34

SEA supporting hydropower planning in the River Ganges upper basin

Source: NCEA (2021)

Uttarakhand is a small state in India located in the Himalaya Region with 8.5 million inhabitants. It has a hydropower potential of 20,000 MW, of which 16% has been utilized. Based on the state energy plan, 70 hydropower projects are located in two biodiversity-rich river sub-basins of the River Ganges, namely Alaknanda and Bhagirathi; 17 are commissioned hydropower projects with a total installed capacity of 1,851 MW; 14 projects of 2,538 MW capacity are in the advanced stage of construction; and 39 projects with an installed capacity of 4,644 MW are proposed for construction in the future (see figure below). Hydropower projects in Alaknanda and Bhagirathi Basins. The River Ganges is revered as a goddess in Hinduism, life-giving and life-sustaining for the environment, ecology, and socioeconomic wellbeing of the people of India. For this purpose, certain minimum depths of flow and good water quality have to be maintained, particularly during the dry season. Concerns about the hydropower projects in the upper reaches of the Ganges have increased because of their anticipated environmental impacts that may threaten the status of the entire Ganges River system. An SEA was conducted on the assumption that the changes in the length of two free-flowing headstreams of the Ganges and the direct loss of terrestrial habitats would be the key factors leading to the aggregated impacts of multiple dams planned in the two sub-basins. These direct impacts may result in compounding effects on a range of receptors, including biodiversity, and on the flow of ecosystem benefits for a range of stakeholders.

The aims of the SEA were identified as follows:

(i) Safeguard priority areas for conservation of terrestrial and aquatic biodiversity in the two basins;
(ii) Provide a 'risk forecast' of dam-induced changes in environmental flows at the basin level that may impair the longitudinal connectivity of riverine ecosystems supporting rare and endangered fish fauna;
(iii) Prioritize to what degree the biodiversity values and habitats should be protected and what ecosystem services would have to be maintained in the event all developments proceed as proposed in the state energy plan.

Therefore, the following four alternatives with different scales of hydropower development were assessed:

3. Alternative 1: (N = 17): Assessment of commissioned projects (the no extra dam alternative).
4. Alternative 2: (N = 31): Assessment of the combined impacts of commissioned projects (N = 17) and those under different stages of construction (N = 14).
5. Alternative 3: (N = 70): Assessment of all projects, including commissioned projects (N = 17), those under construction (N = 14), and those that are still in the form of proposals for consideration (N = 39).
6. Alternative 4: (N = 39) Assessing the proposed projects.

These alternatives provided the estimates of overall gains and losses for biodiversity and power production in the event of developments proceeding as planned or when regulated by proposing exclusion of some dams to optimize benefits for conservation and power development.

Influence of SEA

- Exclusion of 24 proposed projects (1,254 MW) in Uttarakhand state's energy plan.
- Recognition of the concerns to protect river ecosystems biodiversity conservation in the existing water management policies. Implicitly, such a shift in the biodiversity policy would also help to maintain cultural and religious services for human well-being.
- Adoption of environmental flow standards for all dams and a national policy on e-flow.

ANNEX 35

SEA supporting Maritime Spatial Plan and Offshore Renewable Energy Plan, Ireland

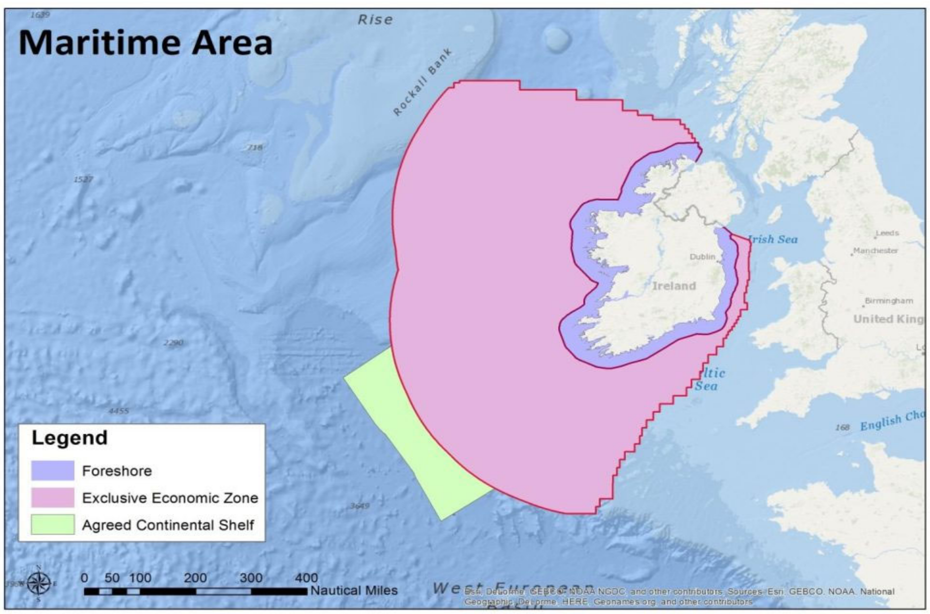
Source: https://assets.gov.ie/77208/2ecbb6ad-4b05-4394-90f4-522df666c10a.pdf

Maritime spatial plan:

The first Maritime Spatial Plan (2021) provides a long-term planning framework for how Ireland will use, protect, and enjoy the seas up to 2040. This plan is made under the Irish Maritime Area Planning Act (2021) that was transposed from the EU Maritime spatial planning directive (2014). The maritime area is restricted to the 200-mile exclusive economic zone; see map. In the plan, 16 sectors are distinguished, and present and future use will be agreed upon. The entire maritime area is divided into smaller areas for which plans are made, identifying the opportunities for development such as offshore wind. Use is made of GIS and comprehensive public participation.

Key issues and method:

In the SEA (2021), alternatives for most of the identified sectors were developed, assessed, consulted, and compared. The SEA also suggested mitigating measures to offset negative impacts identified.



Offshore renewable energy plan:

In 2023, the development of this plan started. The plan aims to select sites for project development, especially wind farms up to 5 gigawatts in 2030, in areas selected in the maritime spatial plan. Due to the considerable depth of large parts of the maritime area, the opportunity of applying floating wind farms was studied as well.

Key issues and method:

The SEA supporting the development of this plan will be finished in 2024. The SEA process facilitated public consultation and discussions on conflicting interests between, for example, fisheries and wind farms in the selected areas.

Influence: The first SEA facilitated a public debate on the future use of the maritime area of Ireland and resulted in the exclusion of some activities, for example, wind farm development, because fisheries and biodiversity prevail. In the second, SEA-specific sites were identified for the development of wind farms accepted by the majority of the public.

ANNEX 36

EU requirements for National Renewable Energy Action Plans (NREAP) and National Energy and Climate Plans (NECP)

A36.1 EU member states

The European Commission requires EU member states to submit a National Renewable Energy Action Plan (NREAP) outlining commitments and initiatives to develop renewable energy by 30 June 2010. NREAPs provided a detailed road map of how each member state expected to reach its legally binding 2020 target for the share of renewable energy in its total energy consumption, as required by Article 4 of the Renewable Energy Directive (2009/28/EC). The plans set out sectoral targets, the technology mix expected to be used, the trajectory to be followed, and the measures and reforms to be undertaken to overcome the barriers to developing renewable energy.

Each NREAP report provided details of the expected share of energy provided by renewable sources up to and including 2020. The overall target for EU countries is to obtain 20% of their energy usage from renewable energy sources, although targets for each country vary considerably. In addition, targets are broken down further by each energy use sector, including transport, electricity, and the heating and cooling sectors.

In the European Union, a Regulation on the Governance of the Energy Union and Climate Action (EU) 2018/1999 entered into force on 24 December 2018 as part of the Clean Energy for All Europeans package. Under rules in this regulation, all member states were required to prepare a draft (by 2020) of a 10-year integrated national energy and climate plan (NECP) (Box A36.1) for the period from 2021 to 2030, charting how they aim to meet the EU's energy and climate targets for 2030. The NECPs outline how EU countries intend to address: energy efficiency; renewables; greenhouse gas emissions reductions; interconnections; and research and innovation. Each Member State is required to ensure that the public is given early and effective opportunities to participate in the preparation of the draft integrated national energy and climate plan.

Box A36.1: Integrated national energy and climate plans

The integrated national energy and climate plans (NECP) provide an overview of the current energy system and policy situation. They set out national objectives for each of the five dimensions of the Energy Union and corresponding policies and measures to meet those objectives. A socially acceptable and just transition to a sustainable low-carbon economy requires changes in investment behavior, as regards both public and private investment, and incentives across the entire policy spectrum. The plans should be stable to ensure the transparency and predictability of national policies and measures to ensure investment certainty.

The draft plans offer a common, solid, and comparable platform to actively engage and discuss in a synchronized way across Europe with civil society, business, and local governments on the EU's common challenges and long-term priorities in the fields of energy and climate.

Source: https://energy.ec.europa.eu/system/files/2019-06/national_energy_and_climate_plans_v4_0.pdf

According to Chapter 2, Article 3 of the Regulation, integrated national energy and climate plans shall consist of the following main sections:

a) An overview of the process followed for establishing the plan consisting of an executive summary, a description of the public consultation and involvement of stakeholders and their results, and of regional cooperation with other Member States in preparing the plan;
b) A description of national objectives, targets, and contributions relating to the dimensions of the Energy Union;

c) A description of the planned policies and measures in relation to the corresponding objectives, targets, and contributions set out under point (b) as well as a general overview of the investment needed to meet the corresponding objectives, targets, and contributions;
d) A description of the current situation of the five dimensions of the Energy Union, including with regard to the energy system and greenhouse gas emissions and removals, as well as projections with regard to the objectives referred to in point (b) with already existing policies and measures;
e) Where applicable, a description of the regulatory and non-regulatory barriers and hurdles to delivering the objectives, targets, or contributions related to renewable energy and energy efficiency;
f) An ***assessment of the impacts of the planned policies and measures*** to meet the objectives referred to in point (b), including their consistency with the long-term greenhouse gas emission reduction objectives under the Paris Agreement and the long-term strategies;
g) A ***general assessment of the impacts of the planned policies and measures on competitiveness*** linked to the five dimensions of the Energy Union;
h) An annex setting out the member state's methodologies and policy measures for achieving the energy savings requirement.

Furthermore, under Article 8, Member States shall describe their assessment, at national and, where applicable, regional level, of:

- The ***impacts on the development of the energy system and greenhouse gas emissions*** and removals for the duration of the plan and for a period of ten years following the latest year covered by the plan, under the planned policies and measures or groups of measures, including a comparison with the projections based on existing policies and measures or groups of measures as referred to in paragraph 1;

- The ***macroeconomic and, to the extent feasible, the health, environmental, skills, and social impact of the planned policies and*** measures or groups of measures, including a ***comparison with the projections based on existing policies and measures or groups of measures***. The methodology used to assess those impacts shall be made public;

- ***Interactions*** between existing policies and measures or groups of measures and planned policies and measures or groups of measures within a policy dimension and between existing policies and measures or groups of measures and planned policies and measures or groups of measures of different dimensions. Projections concerning security of supply, infrastructure, and market integration shall be linked to robust energy efficiency scenarios;

Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2018%3A328%3ATOC&uri=uriserv%3AOJ.L_.2018.328.01.0001.01.ENG#:~:text=This%20Regulation%20sets%20out%20the%20necessary%20legislative

The integrated NECP approach requires a coordination of purpose across all government departments. It also provides a level of planning that aims to ease public and private investment. The fact that all EU countries are using a similar template means that they can work together to make efficiency gains across borders (*National Energy and Climate Plans (NECPs)*. Each member state must submit a progress report every two years.

The EU Regulation on the Governance of the Energy Union and Climate Action (EU 2018/1999) requires that an NECP should include an assessment of the impacts of the planned policies and measures (Box 4.5, bullet (f)); but it does not specifically state that countries undertake an SEA for the NECP.

Notably, the EU SEA Directive (2001/42/EC) (transposed into EU member states' laws) does not apply SEA to policies. But it does apply to energy plans, and NECPs are plans, and the EU Directive explicitly requires an SEA for energy plans. It does not appear that SEAs have routinely been undertaken when NECPs have been developed by EU member states. The UK did not prepare such an SEA for its draft NECP in 2020 (Box A36.2).

Box A36.2: Environmental assessment of the UK's draft NECP

Section 5 of the report on the UK's integrated NECP (DBEIS 2020 Section 5) discusses the impact assessment of planned policies and measures. It sets out climate risks and the expected impacts (improvements) of proposed measures on air quality, as well as the macroeconomic health, environmental, employment, and education, skills, and social impacts, including just transition aspects. But these issues are described in very general terms in narrative format with some tables. It concludes that future investments will be likely to be highly sensitive to how climate change evolves over the next two to three decades. There is no indication of what impact assessment methodology was used, if any. If SEA had been applied to this plan and other NECPs, it would likely have addressed a much wider range of environmental and social concerns likely to arise when implementing the NECP.

Those member states that did undertake an SEA include Bulgaria, Ireland, and Slovenia (Box A36.3). But the 'quality' of these SEAs varies. Some were completed after the Strategic Environmental Management Plans (SEMPs) (see Section 3.5) started to be implemented, others are still not complete (e.g., Bulgaria). Only two of the SEAs could be judged as complying with the steps required by the EU Directive (Spain and Slovenia).

Box A36.3: SEA of NECP, Slovenia, 2019-2022

Slovenia carried out a comprehensive SEA of its NECP in parallel to the plan process. It involved both internal (experts) and open scoping on effects, criteria, and measures. This involved extensive stakeholder participation, including a scoping workshop with interested ministries, organizations, and NGOs, as well as public discussion and a public presentation of the SEA report. The SEA addressed various key themes: mitigation and adaptation to climate change; population and health; sustainable use of natural resources; biodiversity and good ecological status of protected areas, including Natura 2000 European Ecological Network; protection of cultural heritage; landscape and stable society. The significance of likely impacts was assessed for four scenarios: existing measures; additional measures 1; additional measures 2; and an ambitious scenario with the recommendations of the European Commission 2030 with a view to 2050.

The SEA was prepared by an external team of SEA experts. The process of plan preparation was led by the Ministry of Infrastructure, and the SEA process by the Ministry of the Environment and Spatial Planning, which issued an opinion on the SEA Report quality and an environmental acceptability decision (after checking that environmentally accepted measures and mitigation measures were included in the plan).

Sources:

a) Personal; communication, Vesna Kolar, 03-02/2024
b) https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/nacionalni-energetski-in-podnebni-nacrt/dokumenti/%23c96

A36.2 EU applicant countries

Contracting parties (countries aspiring to join the EU) of the Energy Community[1] are also developing NECPs (first drafts due by June 2023, final draft by June 2024). Unlike EU member states, they are obliged by an SEA Decision of the Community's Ministerial Council[2] and the Governance Regulation of the Community[3] for SEAs to be prepared when preparing such plans. Their preparation is monitored by the Energy Community Secretariat. To date (February 2023)[4], the following have been completed:

- Albania: the NECP was adopted before the SEA was completed. The NECP will be reviewed to reflect the SEA findings before finalisation.
- Macedonia: adopted the NECP without the (obligatory) consent of the Ministry of Environment to ensure its alignment with the SEA and that public comments have been considered. The NECP will be reviewed before finalisation.
- Georgia, Montenegro and Serbia are currently undertaking SEAs for their NECPs.
- Other countries are in the early stage of the NECP process, except for Ukraine due to martial law and the ongoing conflict with Russia.

[1] For more information about The Energy Community, visit (www.energy-community.org).
[2] https://www.energy-community.org/dam/jcr:33b7fa10-df38-44ae-b2bf-58c250a4a298/Decision_2016_13_MC_ENV.pdf
[3] https://www.energy-community.org/dam/jcr:c755f9db-f6e7-448c-9cf5-0a5f02113ae2/19thMCDecision14_CEPII_30112021.pdf
[4] Information provided by Energy Community Secretariat, Vienna. Personal communication, Vesna Kolar, 03/02/2024

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

REFERENCES

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Links to the complete guidance document and to individual chapters are also available.

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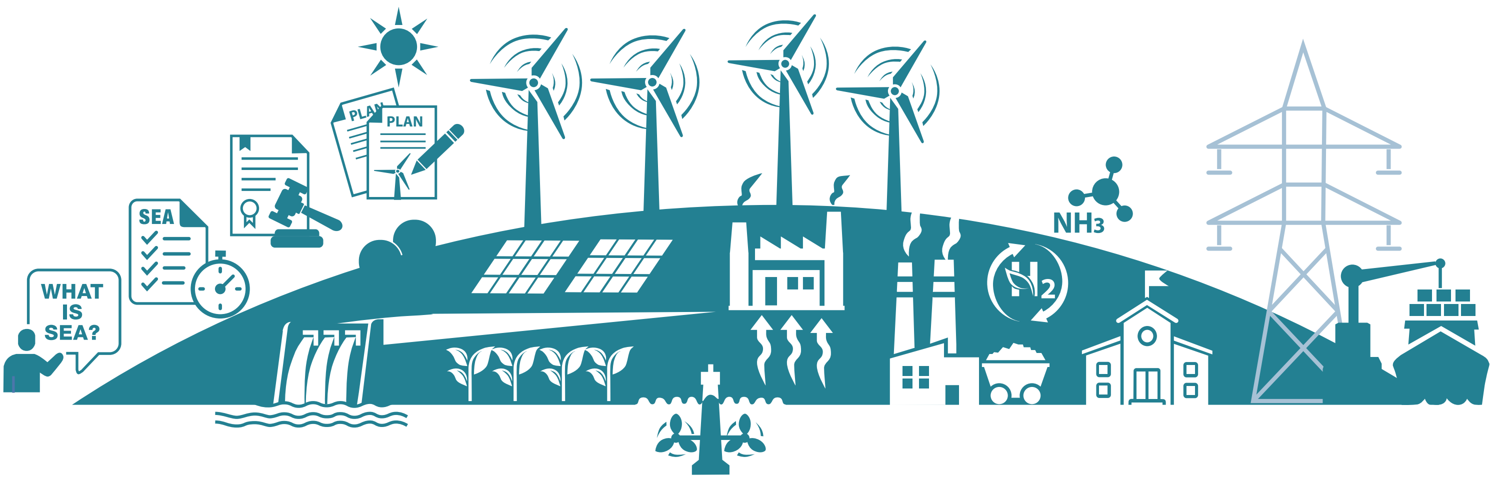

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