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OCEAN ENERGY IN ISLANDS AND REMOTE LOCATIONS

INSIGHTS FROM FIVE EXPERTS

OES OCEAN ENERGY SYSTEMS

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INTRODUCTION

This publication presents a collection of interviews with five distinguished experts who have spearheaded ocean energy projects in various islands and remote locations around the world. These interviews offer valuable insights into the unique challenges and opportunities associated with harnessing ocean energy in isolated areas.

The discussions revolve around four key areas of inquiry:

1

PROJECT OVERVIEW

Each expert provides a compelling overview of their respective ocean energy projects, highlighting their specific island or remote location. They present the primary objectives of their projects, their methodologies for identifying these unique sites and key challenges they encountered during project implementation.

2

TECHNICAL IMPLEMENTATION

The experts provide a deep dive into the technical aspects of their projects. They discuss the critical role of integrating ocean energy into existing energy infrastructure, emphasizing the significance of system integration in optimizing energy stability and sustainability. Furthermore, they discuss the technical limitations and site-specific modifications required to overcome the challenges posed by these remote locations.

3

ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

From a socio-economic perspective, the experts illustrate how their projects have contributed to the energy needs of the islands or remote locations. They offer insights into their engagement strategies with local communities and stakeholders, emphasizing the importance of local involvement throughout the project's lifecycle. The interviews also explore the environmental impact assessments conducted and the strategies employed to mitigate any potential harm to the fragile ecosystems of these regions.

4

LESSONS LEARNED AND FUTURE OUTLOOK

The publication concludes with a reflection on the most significant lessons learned from implementing ocean energy projects in islands and remote locations. The experts provide guidance on how these experiences can be applied to future projects in similar locations, underscoring the importance of adaptable technologies and community-driven approaches. Moreover, they share their plans and aspirations for scaling up existing projects or replicating them in other islands and remote locations, reaffirming their commitment to sustainable energy solutions for isolated communities worldwide.

This publication serves as a comprehensive resource for policymakers, researchers, and citizens interested in the dynamic field of ocean energy, offering firsthand accounts and expert insights into the challenges and opportunities of renewable energy in remote and island settings.

INTERVIEWS

Explore the exciting world of ocean energy with us as we share conversations with experts who have led amazing projects in islands and faraway places around the world. These interviews give us a special look at into the diverse projects and the challenges and innovations they represent.

The following experts share their experiences and expertise:

AUSTRALIA

KING ISLAND UNIWAVE200 PROJECT – PAUL GEASON

Paul, CEO of Wave Swell Energy, provides an in-depth overview of the King Island UniWave200 project, shedding light on its objectives, site selection, and the specific challenges faced when harnessing ocean energy in the waters of King Island.

UK

NOVA INNOVATION TIDAL ARRAY AT SHETLAND ISLANDS – KATE SMITH

Kate, Environmental Manager at Nova Innovation, discusses the groundbreaking Tidal Array project at the Shetland Islands, emphasizing its role in advancing tidal energy technology and its integration with the local energy infrastructure.

SWEDEN & UK

MINESTO'S TIDAL ENERGY KITE AT FAROE ISLANDS – PATRIK PETTERSSON

Patrik, Development Engineer at Minesto, shares insights into their innovative tidal energy kite project situated in the Faroe Islands. They delve into technical aspects, system integration, and the adaptations required for success in a remote island setting.

FRANCE

SABELLA D10 PROJECT AT USHANT ISLAND – ROBIN FALCONE

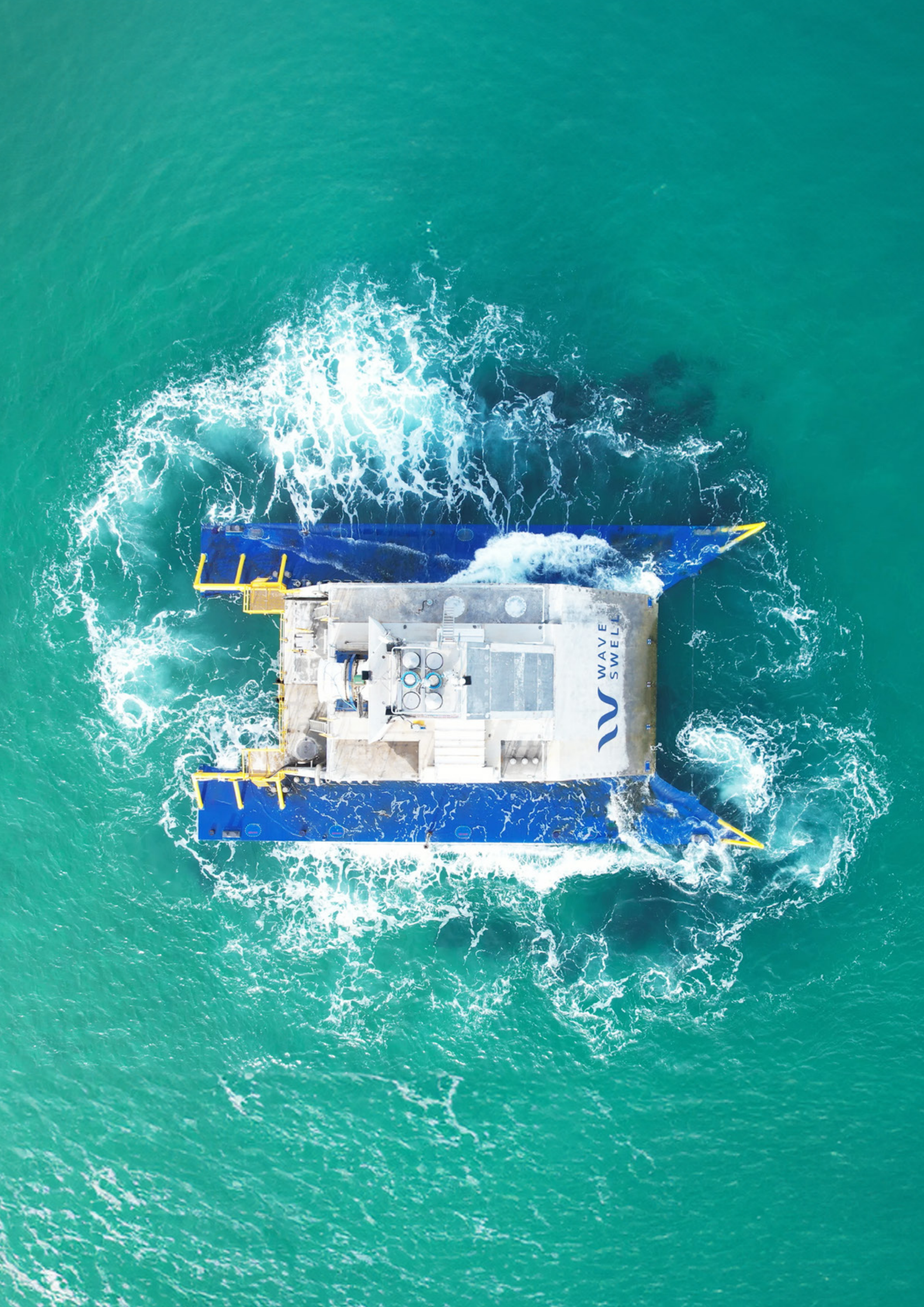
Robin, Project Manager at Sabella, presents the captivating D10 project at Ushant Island, highlighting how it aligns with socio-economic goals, engages local communities, and mitigates environmental impact in a sensitive coastal environment.

US

ORPC'S RIVGEN POWER SYSTEM IN ALASKA – STUART DAVIES

Stuart, CEO at ORPC, shares his experiences in deploying the RivGen® Power System in the Village of Igiugig, Alaska, showcasing how ocean energy can provide sustainable solutions in remote communities.

These interviews explore the objectives, site selection, technical considerations, socio-economic impacts, environmental considerations, and future prospects of ocean energy projects in islands and remote locations. Together, they provide a comprehensive resource for those interested in the promising field of renewable energy in isolated communities worldwide.


WAVE
SWELL

OCEAN ENERGY ISLANDS

KING ISLAND UNIWAVE200 PROJECT

PAUL GEASON

OVERVIEW

The Wave Swell Energy (WSE) project involved designing, constructing, deploying, operating and maintaining, and then decommissioning and recycling a 200kW version of WSE’s unidirectional OWC technology, dubbed the UniWave200. This unidirectional OWC technology, unique to WSE, had not previously been demonstrated anywhere in the ocean.

INTRODUCTION

What were the main objectives of the project?

The broad objectives of the project were to validate the conversion efficiency of the technology across a wide range of wave heights and periods, to demonstrate the robustness and survivability of the technology, and to gain experience in the operation and maintenance of a UniWave WEC in ocean conditions. The entire wave-to-electricity conversion efficiency has subsequently been independently validated to average just on 50% for waves greater than 0.5 metres in height.

How did you identify the specific island or remote location as a suitable site for your project?

The south-east coast of King Island was identified as an ideal location for the demonstration of the technology. The specific location at Grassy Harbour was deemed to have a wave climate that exhibited the full range of wave conditions across a year, while also offering ample periods of smaller waves to ensure ease of access for regular inspection and experimentation which was critical for the demonstration. In addition, the utility at King Island, Hydro Tasmania, is a leading expert in the incorporation of renewables into small island microgrids, thereby ensuring a highly appropriate partner for the project.

What were the key challenges you faced in implementing the project in such a unique location?

King Island is a remote location. This presented logistical challenges in terms of having key personnel on site on a regular basis, which is an important requirement for the early-stage demonstration phase of a new technology. In addition, the COVID pandemic commenced soon after construction of the WEC commenced. This created challenges, the most serious being that the State of Tasmania, where construction was occurring, locked out all visitors other than the most critical of emergency workers. Despite these impediments, the WSE team was still able to complete the construction, transport the WEC to site, deploy it, and then successfully operate the unit for a substantive period prior to COVID lock down and lock out measures being lifted.

TECHNICAL IMPLEMENTATION

Can you elaborate on the integration of the project with the existing energy infrastructure, including any storage solutions?

The WEC was attached to the King Island grid through an electrical kiosk at the nearest onshore interconnection point via a subsea cable, minimizing any effects on the environment. As a microgrid, it was incumbent upon WSE that its delivery of electricity into the grid was smooth. This was achieved by WSE incorporating a state-of-the-art short-term energy storage system into its core technology. Supercapacitors were included in the power take-off system, allowing for a smoothing of the energy delivered into the grid, turning an oscillatory input into a relatively constant output. The integration of the project into the grid also helped to lower the battery storage requirements of the island by reducing periods when stored battery energy was needed due to other renewables having not been generating in the hours previous.

What role does system integration play in maximizing the benefits of your project for the island's energy stability and sustainability?

Hydro Tasmania's King Island Renewable Energy Integration Project incorporates wind turbines and solar panels into the island grid to reduce its use of diesel fuel. The project also uses flywheels, batteries, as well as a resistor to dissipate excess energy (usually during periods of high wind). The integration of WSE's UniWave200 allowed for some of the gaps in the wind and solar generation to be filled by wave energy, thereby further reducing Hydro Tasmania's usage of diesel fuel. It also reduced the potential requirements of the grid's battery, providing energy at times that otherwise may have resulted in the battery being drawn upon. This effect has the potential for lowering the overall combined cost of energy and storage in future systems involving the technology, where a lower battery capacity may be sufficient.

Did you face any technical limitations or modifications specific to the island or remote location and how did you address them?

No limitations were encountered that were specific to King Island itself, although there were general issues related to a deployment on any remote island. These mostly pertained to the supply-chain logistics and the difficulties and cost of staff travelling to the island.

ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

On a socio-economic perspective, how can the project contribute to the energy needs of the island or remote location?

Like most island communities, there is a desire to reduce and eventually eliminate the use of diesel fuel for electricity generation. The incorporation of the UniWave200 WEC into the King Island grid partially achieved this aim, in that roughly every 3kWh of energy generated from the project resulted in 1 litre of diesel being displaced from the community's generation mix. This was a positive for the island, providing cleaner and emissions-free power and reducing air-polluting diesel emissions. It also potentially lowered the combined cost of energy and storage by lowering storage capacity requirements. The project provided both direct and indirect on-island jobs and facilitated the development of local technical skills to service the project.

How did you engage with local communities and stakeholders during the project development and implementation stages?

WSE embarked on a comprehensive community consultation process early in the project's development. This included holding well-advertised on-island information sessions at which key WSE personnel answered questions from island residents. It also included engaging with the local island newspaper and radio services to educate King Island residents about the project. WSE also maintained a strong on-island presence, with important project personnel getting to know the community and engendering a positive view of the project. Furthermore, throughout the lifecycle of the project WSE employed, both directly and indirectly, several residents of the island to assist with key tasks ranging from installation, maintenance through to decommissioning.

How did you assess and mitigate the potential environmental impact of the project?

WSE engaged a prominent Tasmanian environmental advisory group, Project e, to coordinate the permitting and environmental process for the project. This included the identification and detailing of all potential impacts the project might have on the local environment. It also included the coordination of the Development Application to King Island Council and the Lease of Crown Land administered by the Tasmanian Department of Primary Industries, Parks, Water, and Environment.

No adverse environmental effects were identified as being likely during the review process. Permits were duly granted under the proviso the site be returned to its original condition upon the conclusion of the project.

WSE also commissioned Marine Solutions Tasmania Pty Limited, a leading environmental services firm, to complete a marine environment impact assessment at Grassy Harbour, King Island, at the conclusion of the project. The assessment concluded the two-year long deployment and operation of the UniWave200 wave-energy converter had no noticeable effect on the ocean, seafloor, and ecology of immediately surrounding areas.

An independent noise monitoring program also identified the maximum decibel reading at a distance of 50 metres from the device to be 64.3dB (this was when the turbine was spinning at its peak rotational velocity of 2000 RPM), which is roughly the volume of a normal conversation. The noise levels were generally below this value most of the time.

LESSONS LEARNED AND FUTURE OUTLOOK

What were the most significant lessons learned from implementing the project in an island or remote location?

An important lesson – one that was confirmed more than learned - was that operating a first-of-its-kind demonstration of a new technology on a remote island entails considerable costs associated with the logistics of the supply chain and related transport. This included travel to and from the island of key staff and contractors.

Another lesson – again, confirmed more than learned – is that the ocean is an unforgiving environment in which to conduct activities. The utmost care must be afforded during all such activities, and when in doubt, over-engineering a solution is the preferable option. A very risk averse philosophy is advised, and the taking of such risks is to be avoided unless a high degree of confidence already exists.

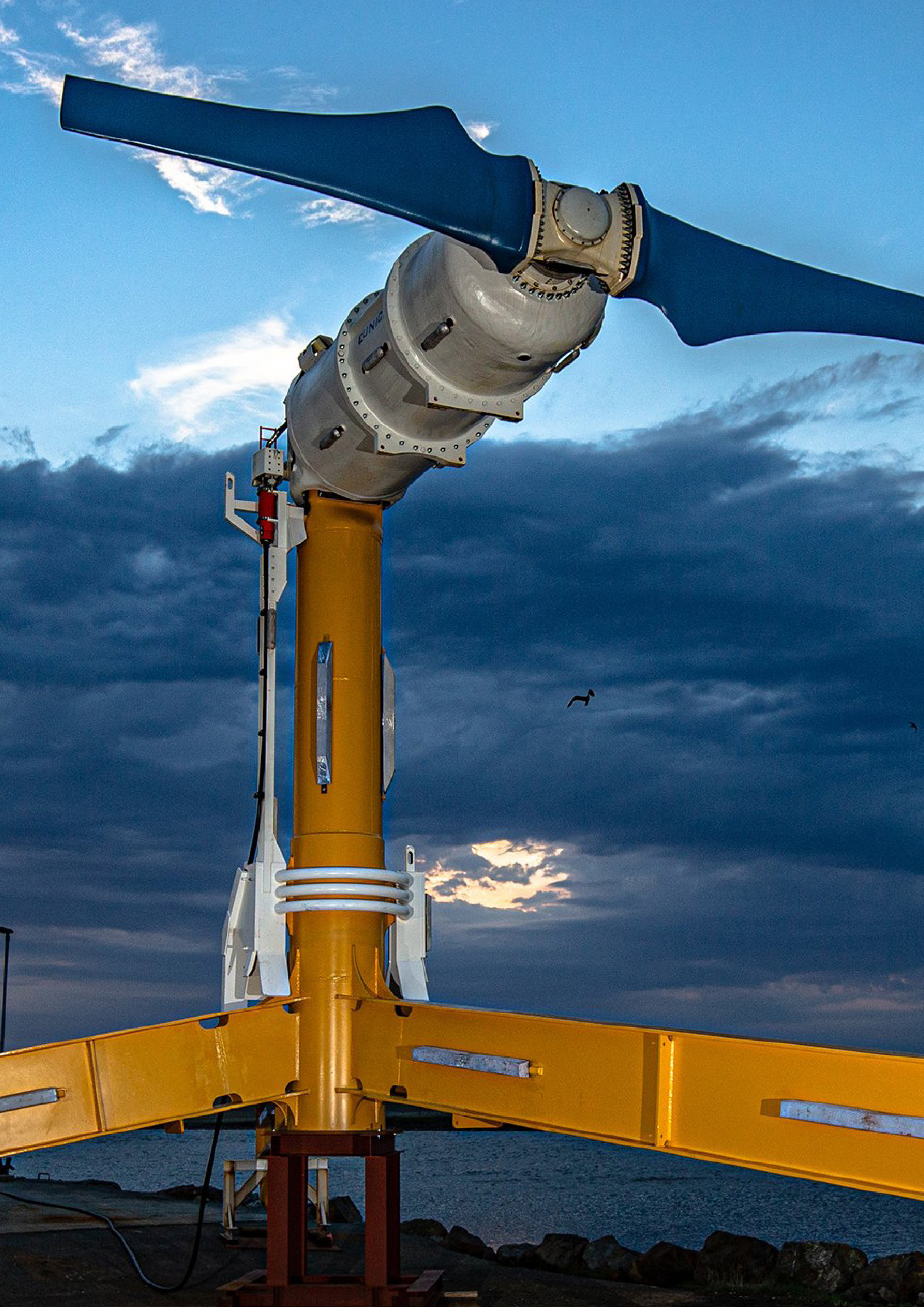
Finally, as some scour mitigation was required after the WEC was deployed, it was concluded that this measure would have been more effectively enacted prior to deployment.

How can these experiences be applied to future projects in similar locations?

Future projects in similar locations would see any required scour protection employed prior to installation, more consideration to the logistics to ensure a more cost-effective outcome in that regard, and a similar risk averse attitude taken to all engineering activities conducted in the ocean.

Are there any plans for scaling up the project or replicating it in other islands or remote locations?

The demonstration of the WEC at King Island has provided evidence of the benefits our technology can deliver to remote island and coastal communities as well as the potential for delivery of emissions free electricity to utility scale grids globally.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NOVA INNOVATION TIDAL ARRAY AT SHETLAND ISLANDS

KATE SMITH

OVERVIEW

Nova designs, builds and deploys tidal energy turbines. In 2016 Nova installed the world’s first offshore tidal array in Bluemull Sound between Yell and Unst, the two most northerly inhabited islands in Scotland. In 2023 Nova completed the doubling of the size of the Shetland Tidal Array from three to six turbines.

INTRODUCTION

What were the main objectives of the project?

Building on the success of installing the Shetland Tidal Array, Nova won funding for the EnFAIT (Enabling Future Arrays in Tidal) project, with the aim of reducing the cost of tidal energy by 40%. This was achieved by proving our turbine technology and expanding understanding of how tides can be harnessed to produce clean, predictable and reliable energy. The project has advanced the industry, accelerated the commercialisation of tidal energy and demonstrated key benefits for the local community and economy.

How did you identify the specific island or remote location as a suitable site for your project?

Nova identified Shetland for our first project because of its tidal resource and support for marine energy in Scotland. The tidal resource and other site conditions in Bluemull Sound were ideally suited to Nova's turbines, and discussions with local stakeholders identified it as a location with potential for local benefits and limited constraints.

What were the key challenges you faced in implementing the project in such a unique location?

Developing the world's first tidal array at the extreme north of Scotland was not without its challenges. However, the small size of Nova's turbines enabled local companies to be used for vessels, construction, and other services. All our turbine blades are now manufactured in Shetland, demonstrating how tidal energy can deliver benefits and diversification opportunities for local businesses.

TECHNICAL IMPLEMENTATION

Can you elaborate on the integration of the project with the existing energy infrastructure, including any storage solutions? What role does system integration play in maximizing the benefits of your project for the island's energy stability and sustainability?

Shetland is currently an 'islanded' network, with all electricity supplied by local sources, primarily via diesel fired generation. The predictability of tidal energy, combined with energy storage provides an ideal solution for clean power generation in remote island communities like Shetland.

In 2018, Nova worked with Tesla to add integrated battery storage to the Shetland Tidal Array, creating the world's first baseload tidal power station, supplying controllable, flexible renewable energy to the Shetland grid. The addition of Electric Vehicle (EV) charging facilities in 2021 provided valuable facilities for the local community.

Did you face any technical limitations or modifications specific to the island or remote location and how did you address them?

During the EnFAIT project Nova installed three new turbines with improved performance in the array. Our latest turbine (the M100-D) is direct drive, removing the need for a gearbox, making it more efficient and reliable. Fewer moving parts improve reliability and extend the period between maintenance intervals from one to more than two years.

ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

On a socio-economic perspective, how can the project contribute to the energy needs of the island or remote location?

Nova believes the resourcefulness and expertise of remote communities can make a major contribution to tidal energy. The STA demonstrated this, with 60% of the supply chain coming from the Scottish Highlands and Islands and 25% from Shetland.

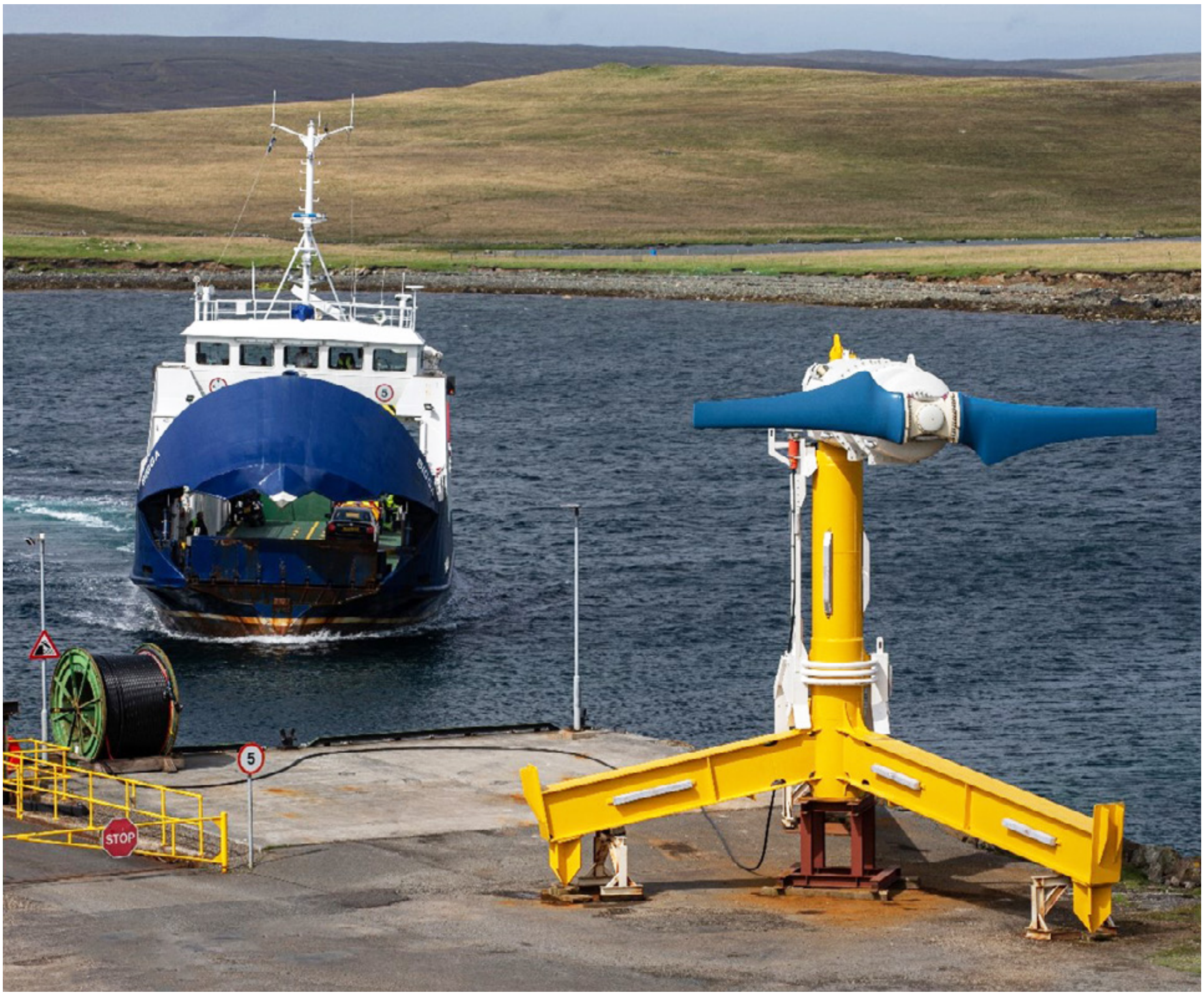
How did you engage with local communities and stakeholders during the project development and implementation stages?

Nova worked closely with local communities and stakeholders during project planning to understand any concerns and ensure our turbines would not affect activities like fishing. We maintain these close links through open dialogue, public meetings and exhibitions, and visits to local schools to help children learn about tidal energy.

How did you assess and mitigate the potential environmental impact of the project?

Uncertainty about the effects of tidal turbines could have been a barrier to gaining project consents but the regulator (Marine Scotland) and its environmental advisors were pragmatic and flexible, working with Nova to overcome this. Together we identified that carefully phased turbine installation, combined with environmental monitoring, would provide evidence about the environmental effects of turbines, while avoiding environmental harm.

Monitoring using subsea cameras has created one of the best global datasets on the effects of tidal turbines. No negative impacts on marine wildlife have been de-



tected. These results have been shared at international conferences and in key publications including the IEA-OES-Environmental 'State of the Science' report. We look forward to contributing to the 2024 edition of the State of the Science.

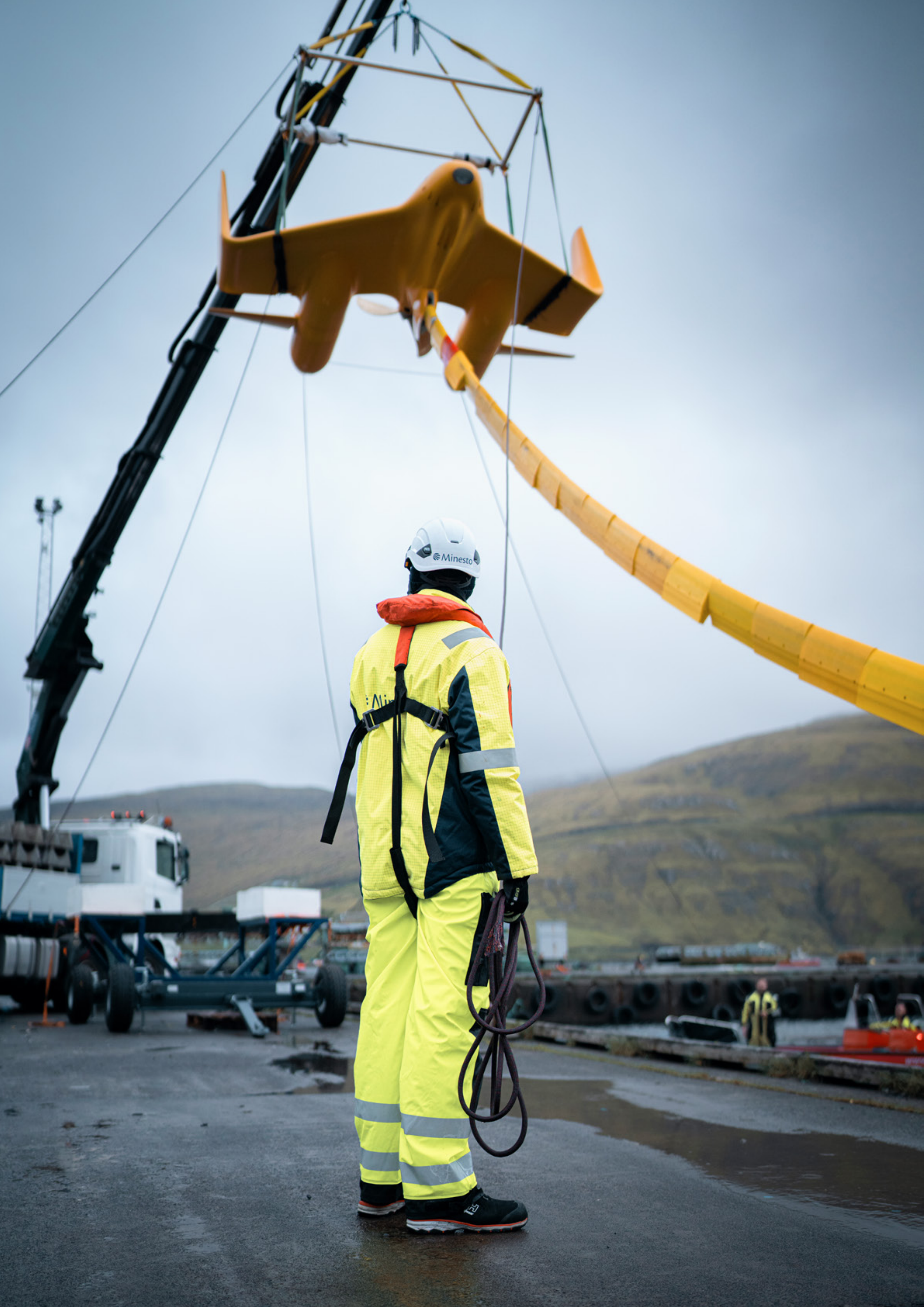
LESSONS LEARNED AND FUTURE OUTLOOK

What were the most significant lessons learned from implementing the project in an island or remote location?

The Shetland Tidal Array has delivered a step change in the lifetime cost of energy for tidal power, slashing costs by 40%, proving high array reliability and availability, and building public and investor confidence in tidal energy. Drawing on lessons from wind energy, Nova's initial turbines were relatively small, enabling us to demonstrate reliability and availability and refine their design before scaling up. Phased installation of turbines also meant we could incorporate learning and experience gained into each sequential stage.

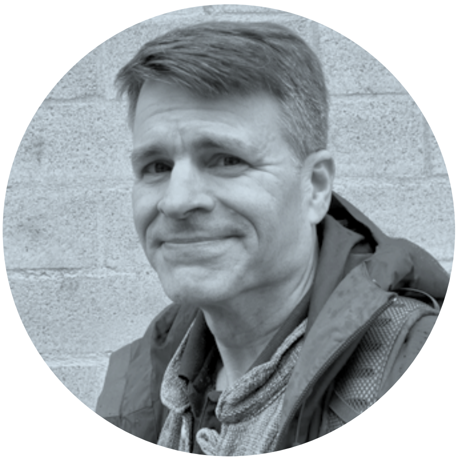
How can these experiences be applied to future projects in similar locations? Are there any plans for scaling up the project or replicating it in other islands or remote locations?

All Nova's learning and experience from Shetland is being applied to design, build, and demonstrate an enhanced version of our M100-D turbine. This will feature blade pitch control, increasing the amount of power generated, and a more compact turbine body, reducing its weight and cost. We're building on our success in Shetland with a pipeline of other tidal energy projects. These innovations will continue to lower the cost of tidal energy, help address the climate emergency, and improve energy security.


Minesto

MINESTO'S TIDAL ENERGY KITE AT FAROE ISLANDS

PATRIK PETTERSSON



OVERVIEW

In the Faroe Islands, Minesto is part of one of the world's most ambitious energy transition schemes – to reach 100% renewable energy by 2030. During 2019-2021, the European Commission and the Swedish Energy Agency supported a project to bring the Deep Green technology to market readiness. We continue to build, install, and service tidal energy kites and sell the electricity to the local electric utility company SEV. This far we have two 100 kW kites, and a 1.2 MW kite in the making.

INTRODUCTION

What were the main objectives of the project?

The overall aim of the Deep Green Island Mode project was to manufacture the power plants under commercial conditions and demonstrate them to stakeholders in the field. The objective was to confirm the technical feasibility and business opportunity presented by Deep Green Island Mode. In particular, we aimed to identify the needs and demands of utility clients and other stakeholders, and to identify the best business model to exploit the technology.

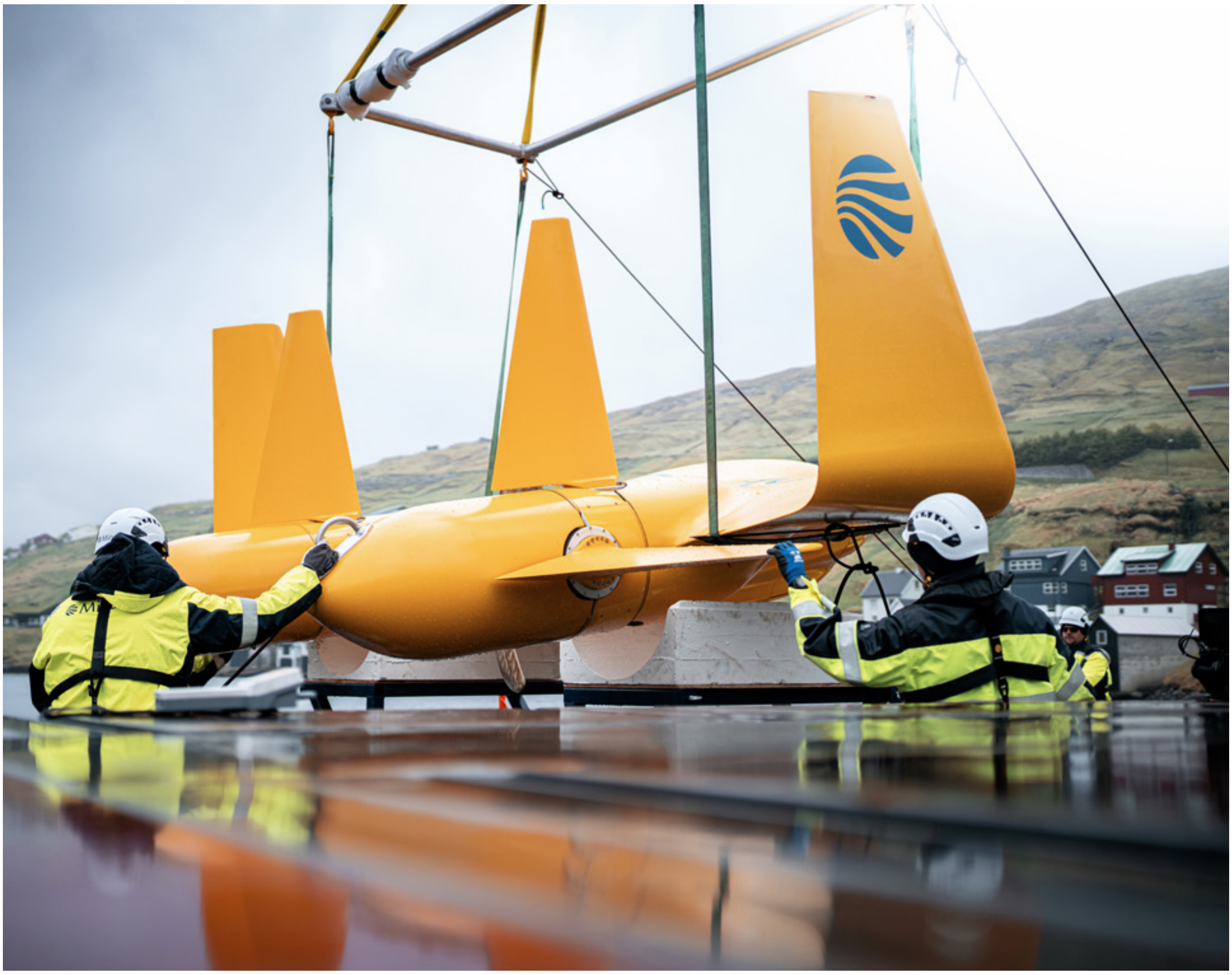
How did you identify the specific island or remote location as a suitable site for your project?

When we contacted the Faroe Islands, they were performing measurements of their tidal resource. Their strong commitment to realize 100% renewable energy generation helped motivate us.

The Vestmannasund site was selected by considering tidal velocities, water depth, seabed conditions, proximity to a resourceful port, and distance to a suitable electrical grid connection point. We assessed the location using ADCP measurements, bathymetry surveys, and a hydrodynamic model. We also performed a navigational risk assessment. A seabed video survey was carried to assess ground conditions in more detail and target the micro-sites for the installations.

What were the key challenges you faced in implementing the project in such a unique location?

During the pandemic restrictions, the transportation of people to and from site was at times challenging. Like in all projects, building relationships with stakeholders and gaining their support is key, not the least to obtain access to data. The time aspect of securing permits, grid access and other agreements was critical. We are grateful to our customer and partner SEV for their support in this process.



TECHNICAL IMPLEMENTATION

Can you elaborate on the integration of the project with the existing energy infrastructure, including any storage solutions?

The electricity generated by the powerplants feeds directly into the Faroese grid. The utility company SEV has a direct view of our kite control operator interface.

What role does system integration play in maximizing the benefits of your project for the island's energy stability and sustainability?

Adding tidal energy to the Faroese energy mix can lower the total installed capacity and reduce the need for energy storage.

Did you face any technical limitations or modifications specific to the island or remote location and how did you address them?

No, we did not. The powerplants in the Faroe Islands are the first grid-connected tidal kites in the world, and the conditions there are well-suited to our technology.

ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

On a socio-economic perspective, how can the project contribute to the energy needs of the island or remote location?

The project focused on island mode systems, relatively small in size, but with potential to remove the need for running diesel generators in remote coastal communities. The next step for this technology is to build the first commercial demonstration array of Deep Green power plants. This will create jobs locally at the operational sites, but more importantly, show the significant potential of this technology to lower greenhouse gas emissions on a global scale by becoming an integrated part of the renewable energy mix.

How did you engage with local communities and stakeholders during the project development and implementation stages?

Through formal and informal meetings, a good cooperation with SEV, and participating in local cultural events. We have now had a local presence on a daily basis for many years. The close cooperation with SEV has been a key factor. There are posters about Minesto in the harbours nearby. We work together with authorities, harbours, and suppliers. The local press writes about us.

How did you assess and mitigate the potential environmental impact of the project?

SEV conducted an impact assessment for the project. The assessment discusses how the project could impact nature and environment, analysing the potential impact on fish, seabirds, whales and seals. At the request of SEV, Havstovan (the Faroe Marine Research Institute) made an assessment of the potential ways the planned pilot project could impact animals around the project site.
We have monitored the behavior of seabirds and whales around the powerplants. The posters around the site ask the general public to report any unusual behaviour of wildlife around the kites.

LESSONS LEARNED AND FUTURE OUTLOOK

What were the most significant lessons learned from implementing the project in an island or remote location?

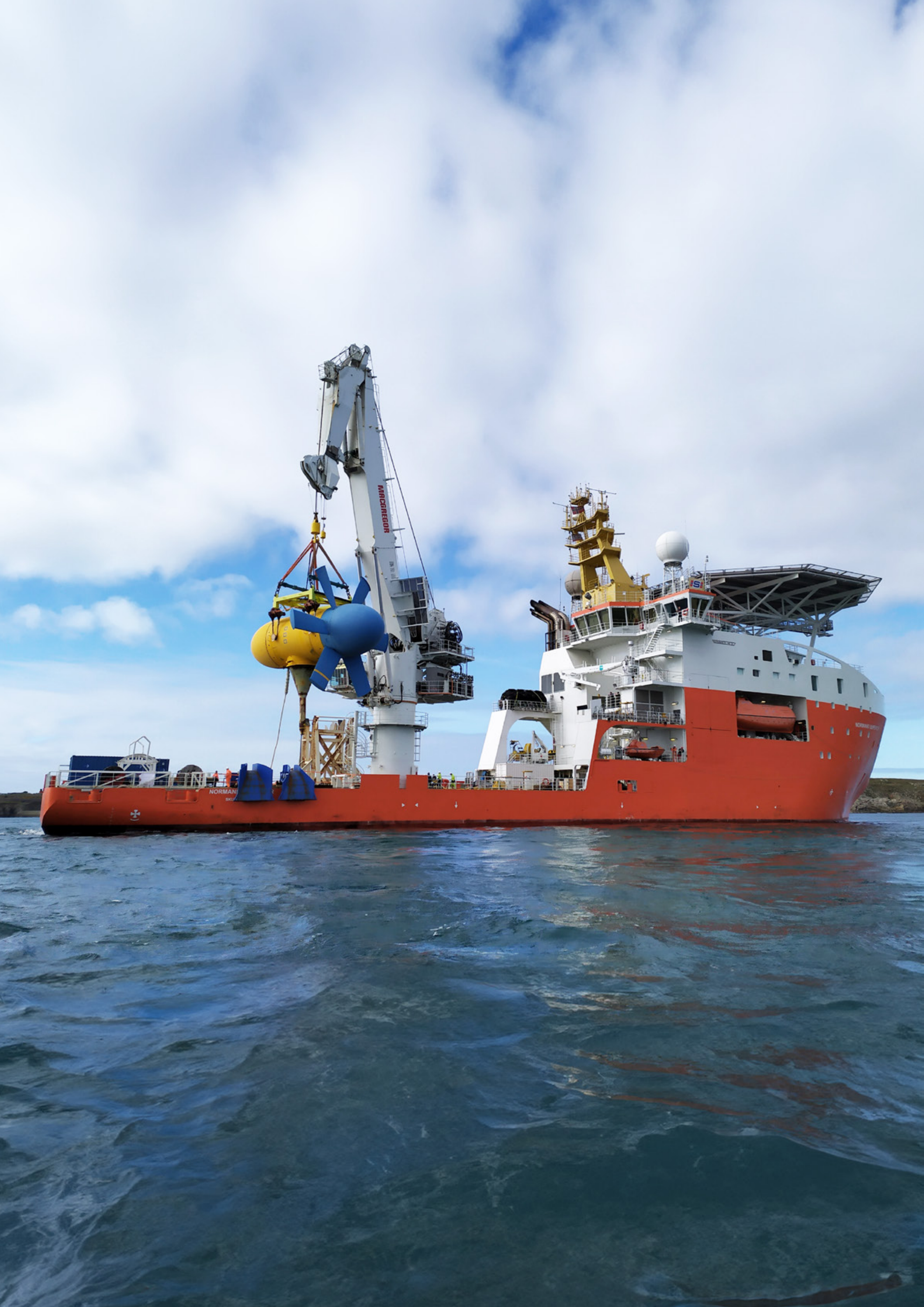
The local relationships are crucial. Establishing and maintaining continuous communication with local authorities, municipalities and the utility company is key to success. We have also actively been using local suppliers and contractors where possible as this adds value to the project in several important dimensions.

How can these experiences be applied to future projects in similar locations?

We have concluded that the way the projects have been executed on the Faroe Islands will function as a template for how we will approach future projects in similar locations. Identifying, approaching, and creating relationships with the key local stakeholders with knowledge of local conditions ranging from resource to legislation - including potential suppliers and contractors as well - as early as possible paves the way for successful and efficient project execution.

Are there any plans for scaling up the project or replicating it in other islands or remote locations?

Yes, there are. Minesto has a detailed plan for large-scale buildout of tidal energy in the Faroe Islands. The plan sets out a stepwise installation of tidal kite arrays in several locations around the islands. The phase difference of the tidal wave between the locations helps giving the power more of a base load character. Tidal power could supply a significant portion of the Faroe Islands' growing electricity consumption and support the Faroese goal of 100% renewable energy by 2030.
Minesto is also in dialogue with other interested parties around the world.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NORMAN

SABELLA D10 PROJECT AT USHANT ISLAND

ROBIN FALCONE

OVERVIEW

The Sabella D10 project was nominated in 2011 as part of the “Marine Renewable Energy Demonstrators” call for interest launched by ADEME (French Agency for Environment and Energy Management). The project consisted of the construction and deployment of an industrial tidal stream generator in Fromveur Passage, off the coast of Ushant Island, Brittany.

The D10 project has opened the door to the integration ofrenewable energies on Ushant Island. Notably, it has significantly diminished the island’s reliance on fossil fuels, which we now recognize as critical and unsustainable.

INTRODUCTION

What were the main objectives of the project?

Initiated in 2012, the D10 project aims to design, manufacture, deploy, and exploit a commercial-type (1MW) tidal turbine. Thanks to this demonstration and the D10 turbine, SABELLA has demonstrated its ability to successfully lead a TRL7 project.

Through this project, SABELLA aimed to achieve various objectives, including obtaining power curve certification (IEC 62600-200), establishing a continuous operating system to demonstrate the design’s strong reliability, and, most importantly, acquiring extensive knowledge about the site (including energy potential, wave and stream characteristics) and grid injection.

How did you identify the specific island or remote location as a suitable site for your project?

The tidal energy market poses unique challenges, with a global potential that is more limited and geographically specific compared to wind and solar energy. To attract investors and convince policymakers that tidal energy is a valuable resource worth developing into a robust industry, it is essential to focus on regions where the overall energy potential is sufficient and, at least for the time being, where electricity costs are high. Ushant Island, with its expensive and heavily carbonated energy mix, stands out in this regard, particularly due to its proximity to one of Europe’s most powerful tidal streams, the Fromveur.

What were the key challenges you faced in implementing the project in such a unique location?

The Fromveur is a highly sensitive area situated within the Parc Naturel Marin d’Iroise (PNMI). Therefore, the most significant challenge in implementing this project is obtaining the necessary consents, which included environmental impact studies and public information dissemination. Of course, the Fromveur region is known for its strong wave climate combined with a huge depth, and exporting electricity to a small, isolated grid are also big challenges we had to overcome.

TECHNICAL IMPLEMENTATION

Can you elaborate on the integration of the project with the existing energy infrastructure, including any storage solutions?

Surprisingly, the island of Ushant possesses significant renewable energy potential, despite its reliance on a highly carbon-intensive energy mix. The island benefits from stable, powerful winds, high radiation levels for its latitude, and ranks as France’s second-largest potential source of tidal power, along with the Fromveur.

Since Ushant Island is not connected to the mainland, its electricity supply is heavily dependent on oil-fired power stations, requiring rigorous management of the balance between electricity production and consumption. Through the D10 project, SABELLA collaborated closely with the local grid operator to define and meet the grid injection requirements necessary for ensuring grid stability. These requirements, including authorized power ramps, led to the development and rapid mastery of a high-performance smoothing system by SABELLA. Since April 2022, the SABELLA D10 turbine has been successfully injecting electricity into the grid in a gradual manner and has quickly obtained the authorization to inject the maximum allowable power as per the grid infrastructure.

What role does system integration play in maximizing the benefits of your project for the island’s energy stability and sustainability?

The D10 project has opened the door to the integration of renewable energies on Ushant Island. Notably, it has significantly diminished the island’s reliance on fossil fuels, which we now recognize as critical and unsustainable. Furthermore, the project has demonstrated its capability to maintain a stable grid even with renewable energy penetration rates exceeding 70%. These achievements clearly illustrate the value and feasibility of diversifying the energy mix in island regions.

Did you face any technical limitations or modifications specific to the island or remote location and how did you address them?

Stability constraints in small, non-interconnected zones necessitate a deep understanding of both the site and the technology. To ensure a stable and high-quality grid injection, we conducted thorough analyses and optimized production thresholds based on swell and current conditions. During certain extreme events, we had to limit the generator's output to mitigate the risk of a blackout on the island. This approach also allowed us to incrementally validate the effectiveness of the smoothing system. In the event of future technical and economic optimizations for turbines, there may be a need to revise the design, with a potential focus on implementing a pitch system.

ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

The most important feedback for the island's energy future and for the permissible penetration rate of the grid.

Thanks to the D10 project, we now have evidence that the grid can accommodate up to 70% renewable energy, and 50% tidal power. While these thresholds have been achieved primarily during the highest coefficients, the potential installation of a tidal farm could allow us to maximize the frequency of such penetration rates.

How did you engage with local communities and stakeholders during the project development and implementation stages?

The D10 project marked a significant milestone as the first to witness the installation of a commercial-scale tidal turbine successfully connected to the grid. The connection, authorization, and environmental impact assessment procedures required close collaboration with various stakeholders, including the city of Ushant, the PNMI, and the French authorities. It is worth noting that these stakeholders have been exceptionally supportive from the project's inception.

How did you assess and mitigate the potential environmental impact of the project?

The D10 project on Ushant underwent a thorough environmental authorization process, including obtaining the necessary permits to occupy the public maritime domain. As part of this process, an extensive impact study was conducted to assess and mitigate the potential environmental effects of the project.

In collaboration with the marine natural park and government departments, a range of monitoring measures were established to oversee the operation of the tidal turbine. These measures encompass acoustics, current measurements, fish monitoring, and addressing biofouling colonization. Regular reports on the monitoring activities are submitted to the relevant authorities, and an annual presentation is made to the marine natural park team.

LESSONS LEARNED AND FUTURE OUTLOOK

What were the most significant lessons learned from implementing the project in an island or remote location?

The D10 project has empowered the SABELLA collective to intensify its efforts in the realm of tidal power projects in remote and isolated areas. The primary lessons and feedback gained from this experience include:

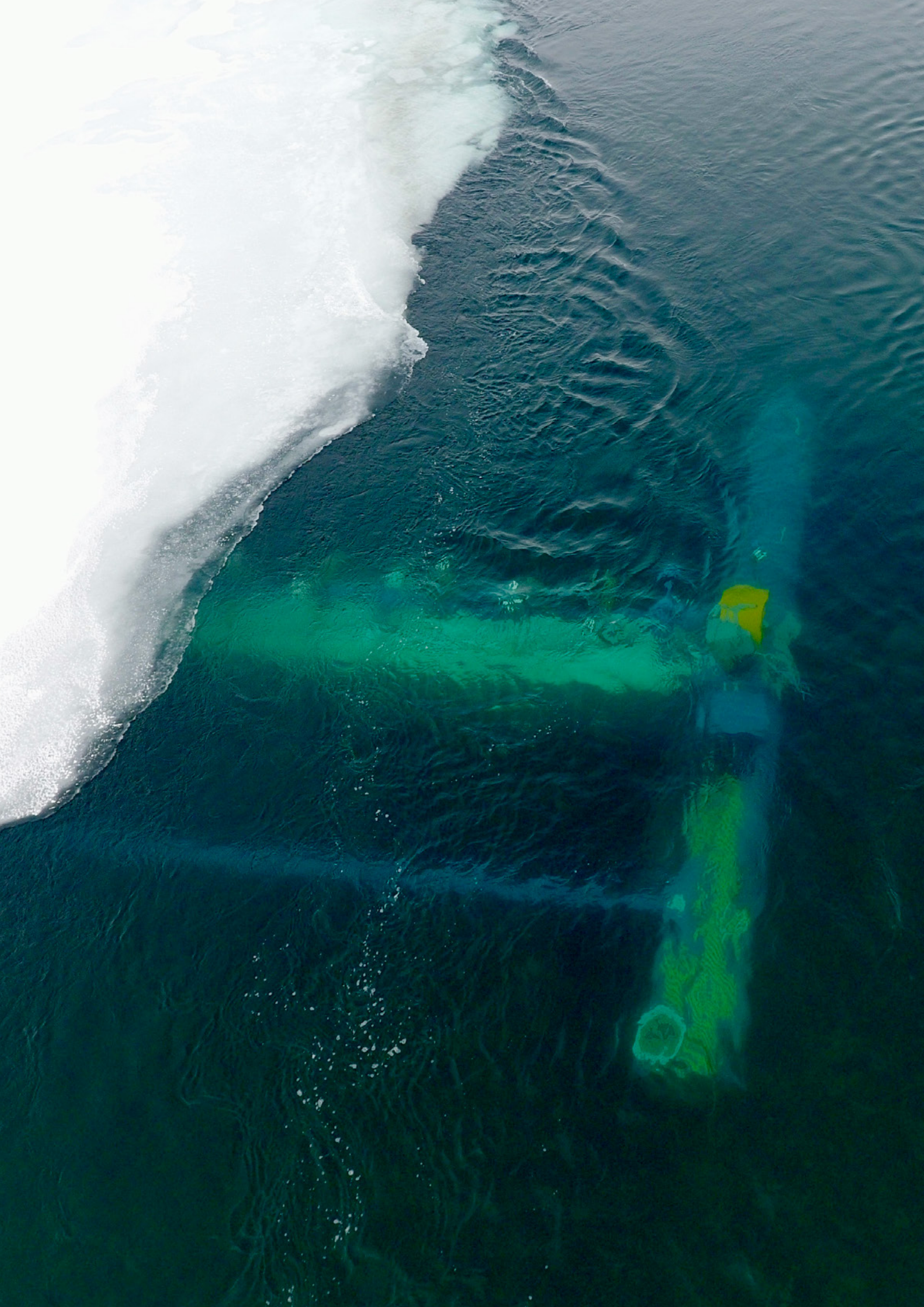
- Grid integration on small electricity grids
- Deepening knowledge of site-specific and technological characteristics
- Establishing effective collaboration with local stakeholders
- Developing and implementing authorization protocols
- Development of operational scenarios in line with the available resources, which are often not tailored to the scale of such projects.

How can these experiences be applied to future projects in similar locations?

This feedback has been compiled and can be standardized to be applied to different projects in isolated areas. This applies to technical, organizational, and authorization aspects.

Are there any plans for scaling up the project or replicating it in other islands or remote locations?

The potential of the Fromveur is very significant. So, we are closely examining our next steps. Particularly, we are in the planning stages for the development of a pilot farm with a capacity of 4 MW. This will enable us to significantly increase the share of tidal energy to the island's energy mix and validate the technology for implementing an array of turbines. For us, this represents the natural continuation of the D10 project, along with the development of the 2-turbine TIGER project that we are developing in the nearby Gulf of Morbihan.



OCEAN ENERGY IN REMOTE AREAS

ORPC'S RIVGEN POWER SYSTEM IN THE VILLAGE OF IGIUGIG, ALASKA

STUART DAVIES

OVERVIEW

ORPC is a U.S.-based company headquartered in Portland, Maine, with subsidiaries in Canada, Chile and Ireland. Their power systems convert the kinetic energy from river and tidal currents into clean, predictable, affordable sources of renewable electricity. The company develops clean energy solutions for remote and tribal communities, as well as solutions to power existing infrastructure like EV chargers.

INTRODUCTION

What were the main objectives of the project?

Igiugig is a remote community in southwestern Alaska with a year-round population of 70 predominantly Yup'ik, Aleut and Athabascan peoples. It is located on the Kvichak River 275 air miles from Anchorage. Igiugig's islanded grid has historically used diesel for electricity generation, resulting in high costs and environmental risk. The Kvichak River is one of nine rivers that flow into Bristol Bay, home to one of the world's largest wild sockeye salmon runs.

Igiugig has been partnering with ORPC to bring a renewable energy based microgrid solution to the community, supported by local contractors. In May 2019, the Federal Energy Regulatory Commission issued a 10-year pilot project license to the Igiugig Village Council to construct, operate and maintain the Igiugig Hydrokinetic Project. Igiugig is the first tribal entity in the U.S. to achieve this approval. The U.S. Department of Energy's Office of Indian Energy and Water Power Technologies Office, as well as the Alaska Energy Authority and ORPC, have provided support and funding for the Igiugig Project.

The project goal is to install two ORPC RivGen devices, smart microgrid controls, and a battery energy storage system that will form the grid, move the existing diesel generators into a back-up role and enable the community to operate without diesel generators between 60% to 90% of the time in a given year.

How did you identify the specific island or remote location as a suitable site for your project?

For decades, Igiugig has been powered by costly diesel, delivered by air transport or barge and stored in a tank farm adjacent to the Kvichak River and Igiugig's power plant. With assistance from the Alaska Energy Authority, Igiugig invited ORPC to demonstrate its technology in the Kvichak River in 2014. Since then, Igiugig has demonstrated significant effort and on-going commitment to install hydrokinetic power systems in the Kvichak River.

What were the key challenges you faced in implementing the project in such a unique location?

When ORPC first began the project in Igiugig, we had to adapt to the harsh, arctic environment, and a May to October timeframe in which to conduct on-water activities safely. By design, we installed and operated the RivGen System using equipment and marine vessels typically found in rural and remote areas. Because of its remote location and limited transportation options (planes or a seasonally-operated barge), there is the challenge of getting personnel to Igiugig to work alongside local contractors for scheduled upgrades and maintenance.

TECHNICAL IMPLEMENTATION

Can you elaborate on the integration of the project with the existing energy infrastructure, including any storage solutions?

This project incorporates into Igiugig's existing power system two RivGen devices, an upgrade of smart grid electronics and controls, and the use of a battery energy storage system. Schneider Electric is the microgrid integrator for the project and provided the smart controller and battery energy storage system.

What role does system integration play in maximizing the benefits of your project for the island's energy stability and sustainability?

Installation of the smart grid and battery energy storage system allow river energy to provide baseload, or continuous, electricity to the community. This combined system allows for diesel generators to move to a back-up role.

Did you face any technical limitations or modifications specific to the island or remote location and how did you address them?

Igiugig was able to operate with one RivGen device working in conjunction with its existing diesel-powered infrastructure. To truly transform the local grid to operate as 100% renewable energy-powered, the community made the decision to upgrade its infrastructure and install the microgrid controls. ORPC was able to work closely with Schneider Electric through the challenges of integrating ORPC's RivGen Power System with SE's control systems. Both companies believe this “microgrid in a box” concept can be replicated in remote and rural communities around the world.

ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

On a socio-economic perspective, how can the project contribute to the energy needs of the island or remote location?

The RivGen project offers Igiugig the opportunity to generate renewable, predictable energy from a local resource, thereby lessening dependence on diesel fuel that is subject to price volatility and a risk to the environment. Long-term community cost savings is a primary benefit, but beyond that our goal is to help Igiugig move toward energy sovereignty, with the ability to produce its own power and the opportunity to maintain and operate the RivGen power system on its own. Training of local personnel and assisting with workforce development is a key part of the project.

Igiugig has been limited to a certain amount of subsidized diesel fuel per year, which has an impact on its population size and potential economic activity. By adopting renewable technology that is scalable and baseload, the community can continue to add capacity to the system over time, enabling Igiugig to take on activities like fish processing that could benefit the economic well-being of residents.

How did you engage with local communities and stakeholders during the project development and implementation stages?

ORPC believes strongly in a community-led approach wherever we work. During the project development process, ORPC worked closely with the community on project siting and pre-application study implementation. Weekly meetings keep lines of communication open between Igiugig and ORPC. Inspections and maintenance are conducted in partnership with trained local workforce.

How did you assess and mitigate the potential environmental impact of the project?

Sockeye salmon is a key species for subsistence and commercial fishing in the Bristol Bay region. ORPC has collaborated with researchers from the University of Alaska Fairbanks and community members in Igiugig to monitor interactions between turbine foils and salmon during adult and smolt migrations. More than 100 million sockeye salmon smolts and 10 million sockeye salmon adults have passed by our turbines in Igiugig, with no observed injuries or mortalities from hundreds of hours of video monitoring.

ORPC and Igiugig use an adaptive management approach to review and adjust project monitoring and operations with regulatory agencies. The project's Adaptive Management Team, consisting of ORPC, Igiugig Village Council, federal and state resource agencies, local entities, and resource experts, meets regularly to discuss project operations, environmental monitoring protocols and outcomes, and study or monitoring proposals for upcoming salmon migration seasons.

A lifecycle analysis of the project by independent academic researchers has estimated that the carbon dioxide intensity of the village's electricity generation is reduced by 98 percent over a 20-year RivGen deployment. Our goal is to help Igiugig reduce their dependence on fossil fuels by providing an affordable clean anergy alternative to diesel, and those numbers help demonstrate we're on the right path.

LESSONS LEARNED AND FUTURE OUTLOOK

What were the most significant lessons learned from implementing the project in an island or remote location?

Since 2019, when ORPC installed its first commercial unit, there have been millions of turbine rotations of the RivGen device and no observed negative effects to the environment. Our staff and local partners have learned how to operate in the ever-changing conditions of remote Alaska, from managing supply logistics to device operation and maintenance through four Alaska winters, a frazil ice event and the breakup of two feet of lake ice flowing over the device. Between 2019 and 2021, the project set the record for the longest running hydrokinetic device in the Americas, having survived temperatures of -40 degrees and ice flows. We continue to learn from the conditions that Igiugig presents and improve our operations accordingly.

How can these experiences be applied to future projects in similar locations?

Lessons learned in implementing the Igiugig project have allowed ORPC to refine our product and services for remote communities. Igiugig exemplifies a global market opportunity in which we estimate, based on reports from the World Bank and other sources, that 700 million people are dependent upon diesel generators for their electricity. As a result, they pay up to 15 times more than conventional electricity prices. Our time spent learning about Igiugig's needs, identifying the challenges of that environment, and tailoring solutions means we are now more capable to meet the needs of remote communities around the world facing similar energy issues.

Are there any plans for scaling up the project or replicating it in other islands or remote locations?

ORPC has received inquiries about our products from more than 50 countries worldwide. We installed a RivGen Power System at the Canadian Hydrokinetic Turbine Test Centre in Manitoba, Canada, in 2022. We're also preparing for our first installation in South America, a RivGen Power System to be deployed in early 2024 in Chile Chico, a gateway community to Patagonia.

Along with our commercially-proven RivGen system, we have deployed three other power systems in Maine this year — two Modular RivGen devices and a single-turbine version of our TidGen® device. ORPC's global team is pursuing opportunities in Europe, Africa, Southeast Asia and elsewhere around the world.

LESSONS LEARNED

Embarking on the journey of harnessing ocean energy in islands and remote locations has revealed a valuable set of lessons. Drawing upon the experiences and insights of five projects presented in this document, we summarise the most significant takeaways.

From cost-effective innovation to the importance of fostering local relationships, overcoming logistical challenges, and demonstrating strong commitment to environmental preservation, these lessons are the result of years of dedication, adaptation, and perseverance:

RELIABILITY AND COST REDUCTION

One of the standout achievements from the Shetland Tidal Array project was a remarkable 40% reduction in the lifetime cost of tidal power generation. This achievement was made possible by adopting a strategic approach that began with the installation of relatively small turbines. These smaller turbines allowed developers to prove the reliability and availability of the technology and refine its design before considering larger-scale deployments. Additionally, the phased installation of turbines allowed for continuous learning and improvement, as each sequential stage incorporated valuable lessons from the previous ones. This underscores the importance of a cautious and step-by-step approach when introducing new technologies in challenging environments.

LOGISTICS CHALLENGES

Operating in remote locations present significant logistical challenges particularly related to supply chain management and transportation. These experiences emphasized the importance of meticulous logistical planning and resource allocation when undertaking projects in remote areas.

IN-DEPTH SITE UNDERSTANDING AND ADAPTATION TO LOCAL CONDITIONS

The Igiugig project in remote Alaska provided valuable insights into adapting to ever-changing and extreme conditions. The project set records for device longevity despite facing temperatures as low as -40 degrees and challenging ice flows. Developers gained valuable experience in managing supply logistics, device operation, and maintenance through harsh winters and environmental challenges. These experiences have enabled the refinement of products and services tailored to the unique needs of remote communities worldwide. This lesson emphasizes the importance of conducting thorough assessments to tailor the technology to the specific environmental conditions and energy needs of remote regions.

COMMUNITY ENGAGEMENT

Establishing and maintaining close communication with local authorities, municipalities and utility companies emerged as a critical factor for success. Identifying and creating early relationships with local stakeholders, including potential suppliers and contractors, is emphasized in all interviews as a key strategy for efficient project execution. Effective collaboration with local stakeholders should extend beyond energy-related aspects. Lessons here could also include the importance of addressing broader community needs, such as employment opportunities and infrastructure development.

ENVIRONMENTAL IMPACTS AND REGULATORY PROCESSES

All interviews demonstrate the importance of responsible monitoring to ensure minimal impact on local ecosystems. Collaboration with researchers and community members to monitor interactions between marine life and the ocean energy devices helps mitigate potential harm. Adopting an adaptive management approach, involving regular review and adjustment of project monitoring and operations with regulatory agencies and local entities, is vital. The establishment of an Adaptive Management Team helps ensure continuous evaluation and improvement of project protocols. Lessons in this area also focus on streamlining regulatory processes to expedite project approvals while ensuring environmental safeguards.

In summary, these lessons emphasize the importance of local engagement, collaboration, responsible environmental monitoring, logistical planning and adaptive management in ocean energy projects implemented in islands and remote locations.

These shared insights offer valuable advices for future endeavors, as the world looks to sustainable energy solutions to power remote communities and reduce their dependence on fossil fuels by providing an affordable clean anergy alternative.

10 KEY MESSAGES

1. **STEP-BY-STEP APPROACH**
Encourage a step-by-step approach, beginning with smaller installations to prove technology reliability and reduce costs before scaling up.

2. **ADDRESS LOGISTICS CHALLENGES**
Recognize the significant logistical challenges in remote locations and promote meticulous planning and resource allocation for supply chain management and transportation.

3. **ADAPT TO LOCAL CONDITIONS**
Understand the importance of adapting to extreme and ever-changing conditions in remote areas, with a focus on refining products and services to meet the unique needs of local communities. Promote comprehensive assessments to tailor ocean energy technology to the specific environmental conditions and energy needs of remote regions.

4. **SUPPORT MICROGRID INTEGRATION**
Recognize the need for specialized solutions and expertise in adapting ocean energy systems to the unique grid requirements of isolated areas.

5. **DEVELOP RESOURCE-ADAPTIVE SCENARIOS**
Advocate for flexible project planning that aligns with available resources, particularly in resource-constrained remote areas.

6. **PROMOTE COMMUNITY ENGAGEMENT**
Emphasize the value of close communication and collaboration with local authorities, municipalities, and utility companies. Encourage the development of early relationships with local stakeholders for efficient project execution.

7. **MITIGATE ENVIRONMENTAL IMPACTS**
Stress the importance of responsible environmental monitoring and mitigation measures to minimize the impact of ocean energy projects on local ecosystems. Advocate for adaptive management approaches that involve regular review and adjustment with regulatory agencies and local entities.

8. **STREAMLINE AUTHORIZATION PROTOCOLS**
Encourage streamlined regulatory processes to expedite project approvals while maintaining environmental safeguards.

9. **FOCUS ON LONG-TERM COMMUNITY BENEFITS**
Recognize the socioeconomic advantages of ocean energy projects, including job creation, improved quality of life, and enhanced economic resilience in remote communities.

10. **FACILITATE SCALABILITY AND REPLICATION**
Support the scaling up of successful projects and assess the transferability of lessons learned to diverse geographical contexts.

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