Renewable and Sustainable Energy Reviews 58 (2016) 952–965

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Social implications of siting wind energy in a disadvantaged region – The case of the Isthmus of Tehuantepec, Mexico

María Elena Huesca-Pérez [a,*], Claudia Sheinbaum-Pardo [b], Johann Köppel [a]

[a] Environmental Assessment and Planning Research Group, Technische Universität Berlin (Berlin Institute of Technology), Sekr. EB 5, Straße des 17. Juni 145, 10623 Berlin, Germany

[b] Instituto de Ingeniería, Universidad Nacional Autónoma de México, Circuito Exterior S/N, Edificio 12, Cubículo 319, Ciudad Universitaria, Coyoacán, C.P. 04510 México D.F., Mexico

ARTICLE INFO

Article history:
Received 18 March 2015
Received in revised form
5 November 2015
Accepted 27 December 2015
Available online 15 January 2016

Keywords:
Wind energy
Planning
Social impact
Disadvantaged region
Mexico

ABSTRACT

This paper reviews the social implications of wind energy from four points of view: socio-environmental, socio-economic, socio-cultural, and stakeholder's involvement, and analyzes wind power projects in the Isthmus of Tehuantepec, Mexico, alongside the background of the literature review. Local economy, geographic conditions, culture, and stakeholders are fundamental when planning a wind project. Technology implementation for sustainable development must recognize the importance of reducing emissions and other environmental impacts, and maximizing socio-economic benefits. The aim of this paper is to review social implications of wind energy, with special emphasis on a disadvantaged region in Mexico, the Isthmus of Tehuantepec, with some of the world's highest wind energy potential, but one of the poorest areas in the country and with a large indigenous population. Wind energy development in Mexico has been complex and contentious; the large increase of wind energy in Oaxaca has created social conflicts in Oaxaca, which even might stop further wind project development in the region. Ultimately, local communities need to be considered in the planning and development process of wind power worldwide and the Mexican case shows the need for a national and regional policy, and a comprehensible on-site participatory planning.

Contents

* Corresponding author. Tel.: +49 30 314 29952.
E-mail address: malenahuesca@mailbox.tu-berlin.de (M.E. Huesca-Pérez).

http://dx.doi.org/10.1016/j.rser.2015.12.310
1364-0321/

1. Introduction

Wind is one of the renewable energy sources with major development in the last decades. By mid-2014 wind capacity reached 336 GW worldwide. Latin America has become an emerging wind market mainly because of Brazil's rapid growth (4, 7 GW), followed by Mexico (3 GW) [1–3]. Governments around the world endeavor to stimulate the development of wind energy for several reasons: a) its GHG mitigation potential; b) its facility to increase energy security; c) its capacity for successful integration into existing electric systems in contrast to other intermittent renewable energy technologies; and d) its relative low costs compared to other renewable sources and even conventional ones [4,5].

While wind turbines are increasingly being built, a lack of social acceptance at the local level is also increasing as an important challenge for wind energy diffusion all over the world [6]. Far from the old-fashioned thinking of looking at social acceptance on renewable technologies as a NIMBY (not in my backyard) problem, there is a large number of academic and technical papers that explain that this is an over-simplistic view of people's actual motives [7]. Moreover, the concept of community benefits also results weak because it does not reflect a wide view on environmental justice [8]. From literature review, it becomes clear that information, consultation, and participation are key elements to the success and acceptance of wind farm projects. Therefore, although wind energy has numerous benefits, concerns of the local people have to be taken seriously [9].

Wind energy is a fundamental renewable resource to address climate change mitigation. However, in order to equally address a sustainable path in the social, economical, and environmental context, the technology implemented for sustainable development should not only be reduced to GHG mitigation, but also, to the minimization of other environmental impacts and the maximization of equitable distribution of socio economic benefits [10–14].

The aim of this paper is to review and explore learned lessons on the social impacts of wind power projects that might be transferable within wind energy locations in socially disadvantaged regions. The case study of the Isthmus of Tehuantepec in the state of Oaxaca, Mexico, provides rationale information on important factors of on-site planning mirrored against an international literature review. The main results of Oaxaca's current situation are presented together with a descriptive framework on the general background and international state of research.

Mexico has a huge wind power potential due to its privileged geographic conditions, and most of the current wind generation capacity in Mexico has been developed in Oaxaca, a southern state of Mexico, specifically in the Isthmus of Tehuantepec. By August 2015, the installed capacity just in this area was 2160 MW, over 2000 wind turbines, and it is expected to grow further (already concessions for 2800 MW by 2016 in the Isthmus) [2,15]. Yet, Oaxaca is one of the Mexican states with lowest index of development and highest poverty levels. In 2014, 67% of Oaxaca's inhabitants lived in poverty and 28% in extreme poverty [16]. While the impact of wind power typically focuses on environmental and economic aspects, social implications of wind power deployment are essential in many regions of the world, including Mexico. Despite the fact that wind energy has promoted investment in the state of Oaxaca, local acceptance is the central issue.

The paper is divided in three sections. After the introduction, we present a recent literature review on the social implications of wind energy divided into socio-environmental, socio-economic, socio-cultural, and stakeholder's involvement. The second section gives a review on wind power regulation, installed capacity and future plans in Mexico. In the fourth section, we analyze wind power projects in the Isthmus of Tehuantepec against the background of a literature review of social implications of wind power by following the same categorization of the second section (socio-environmental, socio-economic, socio-cultural, and stakeholder's involvement). In the last section, a Constellation Analysis is provided in order to show empirical results concerning the experience from some of the stakeholders in a specific wind park planning process. Finally, conclusions and recommendations are presented.

2. Social implications of wind energy: an overview

Social impact is understood as the adaptation of a social system to external changes (environment, economic, cultural), including the social and cultural consequences that modify the way of life and the relationships between people in a community [17]. Based on literature review, four different classifications of social implications of wind energy are suggested: Socio-environmental

Table 1
Recent references on social implications of wind energy.

Implications		References
Socio-environmental	Landscape	[17–38]
	Noise	[39–51]
	Shadow flicker	[41–45]
Socio-economic	Employment and local development	[44,47,52–59]
	Ownership, lease agreements, taxes, compensations	[24,52,56,60–66]
	Economic chains	[50,61,67–69]
	Electromagnetic interference	[38–41]
Socio-cultural	Socio-cultural values	[62,70,71]
	Rights of indigenous people	[72,73–82]
	Stakeholder involvement	[37,57,79,83–89]

(landscape, noise, shadow flickering); Socio-economic (employment and local economic development; ownership, lease agreements, property tax and compensations; economic chains and interference); Socio-cultural (socio-cultural values, indigenous peoples rights); and Stakeholders engagement (information, consultation and participation). There are several academic and technical papers on social implications of wind energy, especially on socio-environmental implications; Table 1 presents some of the most recent academic papers on these areas. In the following sections, we present a general review of social concerns to wind energy divided by the areas proposed above.

2.1. Socio-environmental implications

2.1.1. Landscape

Landscape is about the relationship between people and place. People value landscapes for many different reasons, related to aesthetics and scenery and also to their contribution to recreation and health, wildlife and biodiversity, natural resources and geodiversity, and local culture and distinctiveness [18]. Wind farms use large area of land, and therefore, one of the most important social complaints of wind power is its impact on landscape.

In general, public perception on landscape impacts of wind energy may depend on objective geographical conditions such as local population distance to wind turbines [19], density of wind farms [20], daily times people are visually exposed the turbines [21], height of the turbines [22], and aesthetic quality of the landscape [23]. However, many studies illustrate that the diversity of public perceptions depends also on different economic, social and cultural issues [24]. Henningsson, et al [25] and Devine-Wright [26] show for example, that different actors in different social and cultural positions can perceive the same physical landscape in different ways.

This appraisal is avowed by different case studies, which evaluate the variety of perceptions towards impacts of wind farms on landscape, which are related to: a) Socio-demographic characteristics (e.g. Germany) [27], b) both a physical landscape context and socio-economic parameters (e.g. Greece) [28], c) the importance of reducing electricity bills in the wind power acceptance (e.g. US) [29], and d) the importance of strong independent identity on landscape changes perceptions (e.g. The Netherlands) [30]. Negative public opinion regarding impact on landscape is rather high during the planning stage and significantly lower during the implementation stage [31]. Additionally, a notion of 'landscape justice' has been also fostered, which blends elements of deontological, virtue and consequentiality ethics [32].

Acknowledging the complex response of local communities to landscape impact of wind farms, several authors have developed methodologies that help in siting definitions, such as: GIS tool to quantify the visual impact of wind turbines and photovoltaic panels [33], geographical concepts such as place, landscape, distance decay, and territory [34], innovative planning process that includes landscape impacts [35], and the potential for using an analytical property rights framework that cuts across various levels of claims and value statements [36]. Federal and local governments have developed codes and guidelines to mitigate landscape impact of wind farms. Some examples are Scotland and Australia [37,38].

2.1.2. Noise

Noise is one of the more referred disturbances on human health by wind turbines [39–42]. Noise from wind turbines might be disturbing (100 dB on site) but it reduces considerably at a distance from the wind turbine (45–35 dB within a 350–700 m) [43,44]. A similar result was obtained in a recent wind turbine health impact assessment [45], which explains that the sound power level of a typical modern utility scale wind turbine is about 103 dB(A) and at distances larger than 400 m, sound pressure levels for modern wind turbines are less than 40 dB(A), which is below the level associated with annoyance in the epidemiological studies. Despite the relatively moderate level of noise, as compared with the noise from road traffic for example, the annoyance of the wind turbine noise seems to be often more considerable probably because of its frequency [25,46].

Unlike the subjective issues associated with landscape impacts, noise is quantifiable on the decibels scale. However, a great deal of subjectivity is encountered when determining the agreeability of a sound and its degree of annoyance [41], also associated with other factors [47], as it is higher among residents who do not receive benefits from wind turbines [48,49]. Regulations and codes have been developed to mitigate noise and annoyance by wind turbines in different parts of the world [50,51] .

2.1.3. Shadow flicker

Shadow flicker occurs when the rotation of wind turbine blades causes alternating periods of shadow and light. Tabassum-Abbasi et al. [41] and Lima et al. [42] gathered a wide review of literature on undesirable impacts of wind turbine shadow flickering over people living near wind farms. On a clear day, and a little after the sunrise and a little before the sunset, the shadow of a 22 m turbine blade may be visible up to a distance of 4.8 km [42]. However, the nuisance of undesirable shadow is more related to those living near the wind turbine [41,42,44]. An assessment by the Massachusetts Department of Environmental Protection and Public Health addressed the issue of shadow flicker, which encourages Germany's best practices with the recommendation of no more than 30 minutes per day or more than 30 h per year of shadow flicker at a point of concern based on worst case scenarios [45].

2.2. Socio-economic implications

2.2.1. Employment and local economic development

Economic benefits of wind projects to local communities depend on several factors such as: The ownership model and financing plan, the use of local, qualified labor and supplies, and the direct and indirect economic chains that the project is providing [52]. Job creation is one of the positive effects from renewable energy projects [53]. Although the major contribution (in the case of wind energy), is on the construction stage, when local jobs during operation and maintenance are more stable. Kammen et al. [54] estimated that wind can create during construction, manufacturing and installation between 0.43 and 2.51 jobs per MW, and 0.27 jobs per MW during operation, compared to 0.25 and 0.70 per MW in construction and operation respectively for a gas power plant. Furthermore, Henningsson [25] estimated one job per installed MW in the case that the wind farm is owned by local people and financed by local venders. Simas and

Pacca [54] gave higher numbers for Brazil (including turbine manufacturing), and estimated 13.5 persons equivalents for each MW installed during manufacturing and first year of operation of a wind park, and 24.5 persons-year equivalents over the wind park lifetime. In fact, local employment depends on several factors, such as the phase of the wind park, the manufacturing location, the geographical site, region size, and local demand for goods and services [25,55].

In a broader approach, Brown et al. [56] developed an economic analysis of wind farms in US counties and found an aggregate increase in county-level personal income and employment of 0.2% and 0.4% for counties with installed wind power over the same period. Likewise, Swafford and Slattery [57] found that the total lifetime economic activity for the state from the projects equated to more than $1.3 million per MW of installed capacity, and the total economic activity for the local communities was also substantial, to nearly $0.52 million per MW of installed capacity. Slattery et al. [58], based on a large questionnaire, also found that support for wind power in these communities is associated far more with socioeconomic factors than foundational aesthetic or moral values, with wind farms perceived as the vehicle that will reverse economic decline.

Saidur et al. [44] on the other hand, revealed negative economic implications of wind projects on local communities, where nearby wind facilities significantly reduce property values. Munday et al. [59] also question the economic development outcomes for rural areas in Wales from wind generation projects to date, by arguing that revenues from community benefits are low, and instead might be channeled to rural areas through a broader community ownership of wind energy projects.

2.2.2. Ownership, lease agreements, property tax and compensations

There are different experiences of wind development regarding ownership, which varies from large wind companies (e.g. Spain, Scotland and England/Wales), partnership frameworks (e.g. Germany, Denmark and the Netherlands), to local community ownership (e.g. Germany, Denmark) [60]. In many countries, leasing land to wind energy developers continues to be the most common way rural landowners are participating in wind energy. Payments depend on the country, place of installment, lapse of time and technology. The local benefit of lease agreements relies obviously on the fee, but also on the possible displacement of other land uses [56]. There are several guidelines developed in the US to guarantee a fair contract to land owners [61]. It has been documented that the land use fee in rural areas in the US is about US$2700 to US $7000 per MW [54,55,62], or an annual fee of $2000–5000 (US dollars) per turbine [25,62]. In general, locally owned community wind projects create even more of an economic opportunity for those involved than conventional wind farms owned by companies with limited local ties [52,61]. Other possible local benefits are for example, good-neighbor payments provide compensation to individuals who live in the vicinity of the turbines but who do not have a turbine on their property and therefore do not receive landowner lease payments. Community funds may be designed to finance different types of local community activities [61].

2.2.3. Economic chains

Economic benefits from wind projects are larger when they generate economic chains such as indirect jobs and benefits from component and material suppliers [61,67]. For example, in China, the price of wind power has been influenced by technology endorsement, learning-by-doing, local manufacturing, and local economy [63]. In Brazil, local manufacturing has allowed the country being regional leader in wind generation [3,64]. Besides, in the case of small-scale wind projects, local manufacture can improve local economy, by building local capacity and reducing costs [65].

2.2.4. Electromagnetic interference of local TV and radio transmissions

A negative impact of wind turbines can be also the possible interference with transmission signals from radio or television. More studies are needed on this matter but some authors explain that, modern turbines made by synthetic materials have much milder impact on the transmission of electromagnetic radiation [38–41].

2.3. Socio-cultural implications

2.3.1. Socio-cultural values

Socio cultural values represent the (implicitly or explicitly) shared abstract ideas about what is appropriate in a society [70]. It is not the intention of the paper to forth see on this behalf, but to point out that this very complex concept is essential in the local communities' decision to accept or oppose to a large wind farm project. In a study case elaborated in four diverse settings, Pasqualetti [66] found that a major concern from local communities in two of the sites opposing wind projects was that they imply significant challenges to cultural values. Ek and Matti [67] found socio-cultural values as the most important factor of peoples´ disposition to pay for reducing the negative impact associated with large-scale wind farms in Sweden.

2.3.2. Rights of indigenous communities

The UN declaration on the rights of indigenous people sets out the individual and collective rights of indigenous peoples, their rights to culture, identity, language, employment, health and education, as well as the right to maintain and strengthen their own institutions, cultures and traditions, and to pursue their development in keeping with their own needs [68]. The literature shows cases of wind energy projects on indigenous lands with increasing contradictions and in some cases violation to these rights [69–74]. In contrast, there are positive examples of inclusion of indigenous peoples rights in wind energy projects such as the province of Nova Scotia in Canada [75,76] and new approaches towards a more sustainable implementation of projects on this matter [77,78].

There are different international agreement addressing indigenous rights, the fundamental one is the Indigenous and Tribal Peoples Convention, International Labor Organization Convention 169 (ILO-C169), in 1957 and last revision in 1989; which legally promote the rights and recognition of indigenous peoples. The core of this convention is that governments are required to consult indigenous on issues that affect them and to guarantee the principles of consultation and participation in public life [79,80]. To date, 20 countries have signed the ILO-C169, most of them are Latin-American countries [81].

2.4. Stakeholders involvement: information, consultation, and participation

Public attitudes towards wind farms vary across countries and regions. A more integrated approach shows that information, consultation and participation are key to the success of a wind farm project. In the same sense, it is the simplification of the concept of community benefits that according to Cowell et al. [82] obscures other equally important perceptions that engage the role of community benefits in promoting environmental justice.

There are several studies that show that public support for wind farms increases when there is community participation in the planning process [57,83]. Odparlik and Köppel [84], state that

in general, access to Environmental Impact Assessment (EIA) documents is a basic tool for providing information within permitting processes. Likewise, dissemination of information is fundamental for social acceptance along with identifying information and participation as factors for local acceptance, and further considerations regarding ownership of the wind parks [85]. Empirical research in Australia considers that the lacks of prior and clear information, as well as inappropriate participation within the community are perceived as lack of fairness, which reduces legitimacy of the project [86]. Another study on community wind parks in Canada shows the importance of quality of consultation and early communication for increasing social acceptance and reducing conflicts [75].

Some international financing institutions (Inter-American Development Bank and the World Bank) requirements for financing projects promote social sustainability and enhance the process of information, consultation and participation [87]. However, framing an informed consultation and participation program, could be uncertain if the responsibility only falls in project developers [37].

3. Wind power in Mexico

3.1. Regulation

Until December 2013, Mexican regulation classified electricity as a public service provided by the State, allowing private generation (self-generation, cogeneration, and independent producer) to be sold to the stated-owned utility (*Comisión Federal de Electricidad – CFE*), acting as a unique buyer [88]. A legal figure called *self-generation societies* was placed, where private-private and private-public partners set up a society for generation and commercialization of electricity among associates, paying a fee to CFE for the transmission of electricity. The Regulatory Energy Commission (*Comision Reguladora de Energía – CRE*) was the organization that granted permissions for electricity generation (Fig. 1). So far, the majority of the wind energy projects in Mexico are large private investments under the figure of self-generation societies (Table 2).

On one hand, a constitutional reform approved in 2013, establishes that only transmission and distribution of electricity are public services provided by the State. Additionally, it transferred the central control of dispatch from CFE to an autonomous organization and opens the market for larger consumers [89]. Within the secondary laws of this Energy Reform, the Electricity Industry Law (2014) requires now a Social Impact Assessment for electricity projects, as well as an indigenous consultation with international standards [90]. The CRE is the public organism that will continue giving the permissions for new private developers. There is still uncertainty on the new form of renewable power development, but based on different regulations that have been approved, it will be oriented to promote private investment.

On the other hand, there are several regulations in Mexico that promote renewable energy sources (RES), although with conservative goals. The Law of Renewable Energy (*Ley para el aprovechamiento de las energías renovables*) approved in 2008, sets up the goal of 8% for renewables in electricity generation, excluding hydroelectric plants [91]. The General Law of Climate Change (*Ley General de Cambio Climático*), approved in 2012, set up a goal for the year 2024 to produce 35% of electricity by clean energy sources, although clean energy in official documents includes nuclear, coal, and gas with Carbon Capture Storage-CCS [15,92]. There are further incentives for private investments on RES. In 2005 a tax incentive for renewable energy was launched for private developers, which depreciate 100% of investments. And in 2011, the CRE established a special tariff on electricity transmission for renewable energy projects, 70% lower than the tariff on fossil fuel sources [93,94].

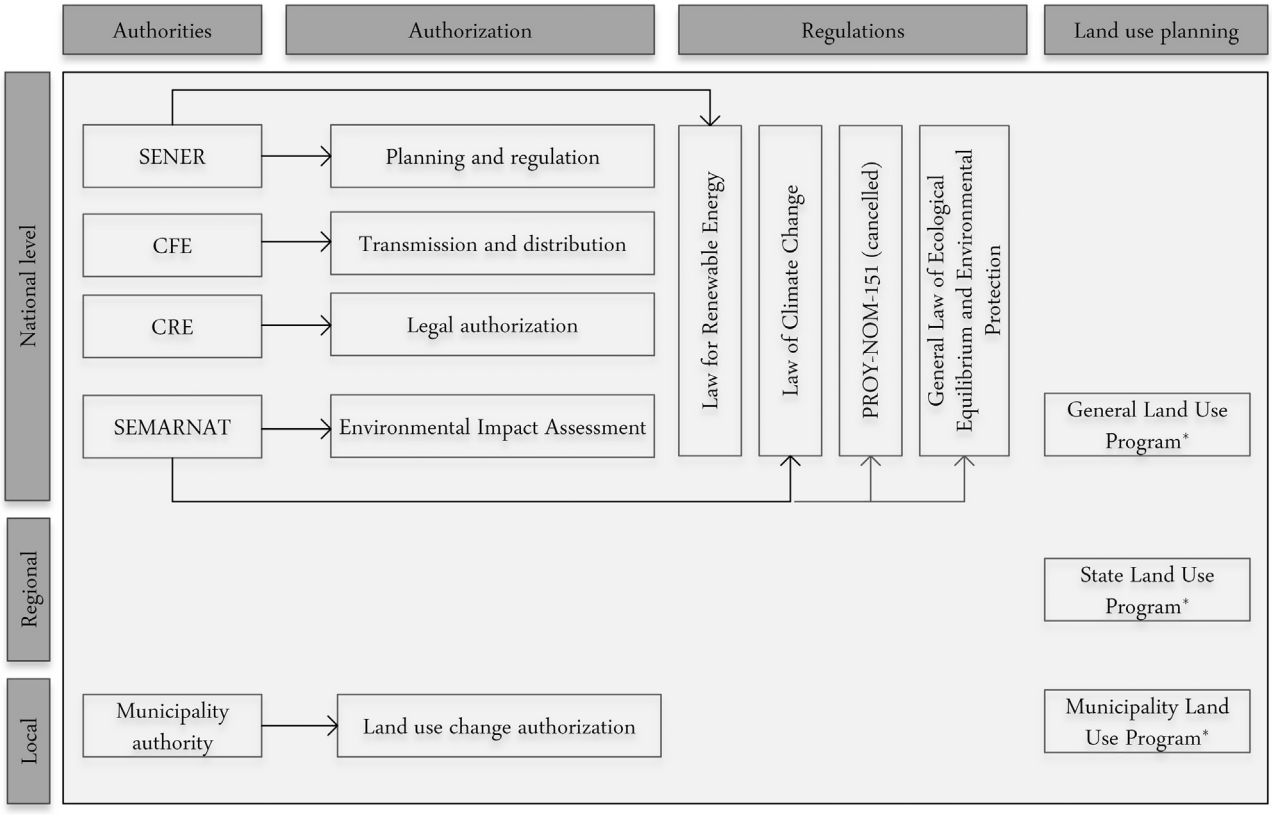

Fig. 1. Diagram of institutions and permits of renewable energy projects in Mexico. *Guidelines for further programs. *Note*: Please compare with the text for abbreviations.

Table 2
Wind installed capacity and under construction in Mexico by August, 2015 (MW).

State	CFE		Self-generation societies		Independent and small producers		Export	Total
	IO	UC	IO	UC	IO	UC		
Oaxaca (25)	86		1529.75	532.50	515.85	102	30	2796.1
Baja California (5)			10	102			457	569
Chiapas (2)			32	20				52
Chihuahua (1)						30		30
Coahuila (7)				1150.60				1150.6
Durango (1)				120.70				120.7
Guanajuato (5)				103		84		187
Hidalgo (1)						30		30
Jalisco (5)			50.4	380				430.4
Nuevo León (6)			22	592				614
Puebla (4)				416.40				416.4
Querétaro (2)				30		30		60
San Luis Potosí (4)			200	199		30		429
Sonora (2)				103.5		2		105.5
Tamaulipas (16)			54	1020.5				1074.5
Veracruz (3)				40				40
Yucatán (6)				262.40		90		352.4
Zacatecas (4)				402.50		30		432.5
Total	86		1898.15	5475.1	515.85	428	487	**8890.1**

Adapted from CRE [2]. IO: In Operation; UC: Under Construction.

Other environmental (e.g. EIA) and land use regulations related to wind power are the mandatory for wind parks with more than 3 MW that have to be approved by the Federal Minister of Environment and the permission of land use issued by municipal governments. Land use planning strategies in Mexico are quite new. Since the year 2000, several governmental institutions have been working on guidelines for land use programs on the national, regional, and local levels, although there are some states in Mexico without a regional land use plan [95].

3.2. Wind power installed capacity in Mexico and future plans

In 2014, the total installed power capacity in Mexico reached 54.3 GW producing 257.8 TWh of which 49.2% was natural gas combined cycle plants, 20.4% oil and gas based thermoelectric plants, 12.3% coal, 10.6% hydro, 4.6% nuclear, 2.4% geothermal, 0.7% wind and 0.005% solar [96].

By the end of 2014, Mexico worldwide rank is the 21st position concerning wind-installed capacity. It has increased from 85 MW in 2008 to 2987 MW by mid 2015, of which 64% are under the so called self-generation societies, 17% under the figure of independent producers, and 16% for exporting [2].. Currently, 5900 MW are under construction and it is expected to reach 8890 MW in 2016 (Table 2). The National prospective estimates 15,500 MW of installed wind power capacity by the year 2027 (out of 21,000 MW from renewable power), which represents a growth rate of 500% compared to 2013. Mexican wind energy potential estimation is around 87 GW [97].

3.3. Wind power in the Isthmus of Tehuantepec

3.3.1. The Tehuantepec Isthmus

The Tehuantepec Isthmus is located at the narrowest distance in Mexico, between the Gulf of Mexico and the Pacific Ocean. Most of the Isthmus is sited in Oaxaca, one of thirty-two states in the Mexican Republic. Oaxaca represents 4.8% of the country's surface with 3.8 million inhabitants (3.3% of the national total) [98]. This state is one of the poorest and most marginalized of the country. According to the National Measures of Poverty in the year 2014 [16,99,100], 67% of Oaxaca's inhabitants live in poverty and 28% in extreme poverty. 27% of Oaxaca's population did not finish primary education, 20% do not have access to health security, and 78% do not have access to social security. There is also a 60% with lack of basic housing services, such as access to water services, sanitation and to electricity. In addition, around 52% of the population lives in rural and isolated areas in small communities with less than 2500 inhabitants, where 53% use fuel wood as the main fuel for cooking, The state's GDP per capita is roughly US $4200 and 60% of the population is living with a daily income of less than US$8.28 [100,101].

Table 3
Moderate to Excellent wind resource at 50 m according to NREL-SENER. *Source:* Elliot et al. [102].

Wind Resource Utility Scale	Wind power at 50 m W/m^2	Wind speed at 50 m m/s	Total area	Percent windy land	Total potential capacity MW
Moderate	300–400	6.1–6.7	2.234	2.4	11,150
Good	400–500	6.7–7.3	2.263	2.5	11,300
Excellent	500–600	7.3–7.7	1.370	1.5	6850
Excellent +	600–700	7.7–8.5	1.756	1.9	8800
Excellent ++	> 800	> 8.5	1.248	1.4	6250
Total			8.870	9.7	44,350

Because of its geographical position, Oaxaca, and especially the Isthmus of Tehuantepec has a very large wind power potential. The US National Renewable Energy laboratory [102] estimation is around 44 GW wind power potential for the region (Table 3).

3.3.2. Current wind power installed capacity in the Isthmus of Tehuantepec

In 1994, CFE began to operate its first wind park in Mexico: *La Venta*, in the municipality of Juchitán de Zaragoza. The park contained seven wind turbines of 225 kW in an area of 1.8 ha [103]. By 2007, the second phase *La Venta II* began operations. This wind project was financed by the World Bank, under the *Wind Umbrella Carbon Finance Project* and consists of 98 wind turbines with a total nominal capacity of 85 MW[1] [104]. Until now, these are the only public owned wind farms in the region. By August 2015, there are over 2000 wind turbines (operating or under construction) in

[1] La Venta I and La Venta II, the only wind parks for public service.

Table 4
Wind projects in operation and under construction in Oaxaca by municipality [2].

Municipality	Number of projects	Number of wind turbines	Capacity MW	Authorized generation GW h/year	Investment Thousand US dollars
Asunción Ixtaltepec[a]	3	214	250	1103	499
El Espinal	3	198	386	1590	772
Ixtepec	1	5	15	42	30
Juchitán de Zaragoza	10	947	1357	4521	2709
Santo Domingo Ingenio[a]	6	421	618	2130	1237
Unión Hidalgo[a]	2	221	228	842	455
Asunción Ixtaltepec[a]	3	214	250	1103	499
Total	25	2006	2854	10,228	5702

[a] Some of the projects share territory with *Juchitán de Zaragoza.*

the Isthmus of Tehuantepec in Oaxaca distributed in seven municipalities, with a total capacity of 2854 MW, and a total investment of almost six million dollars [2] (Table 4).

4. Social implications of wind energy in the Isthmus of Tehuantepec

Wind energy development in Oaxaca has been characterized by different social conflicts since the installation of the first turbines. These problems are found in several notes of national newspapers [105–108], technical reports, and scientific papers [66,103,104,109–127]. In this section, a literature review of social implications of wind projects in the Isthmus of Tehuantepec is developed based on the category division presented in Section 2. Lastly, the literature review is reinforced with Constellation Analysis results.

4.1. Socio-environmental implications

4.1.1. Landscape, noise and shadow flicker

Wind turbines in the region have already become prominent features of the landscape (Fig. 2) and due to the large wind potential this visual effect will increase. According to Pasqualetti [66], the planned development in the Tehuantepec Isthmus in Oaxaca would create the largest concentration of wind turbines in the world, more than 5000 hectares of land have been reserved by 2010 in the windy municipalities of Juchitán de Zaragoza, Union Hidalgo, El Espinal, and San Dionisio del Mar. There is no specific case studies on population perception towards wind turbines in the region so far, but it has been recognized in the literature, as one of the population's concerns [66,116,117,124].

Regarding noise, there is no (public) scientific study on noise annoyance by wind parks in Oaxaca; however, it is also one of the major concerns of local residents about wind energy development [106,108,110]. The Mexican Comission for Dialog with Indigenous Peoples (CDPIM) [110] also reports concerns on noise effects over cattle. The Mexican regulation on noise disturbance considers a limit of 50–55 dB in residential areas, depending on daytime [128].

Concerning shadow flickering, there are no studies or reports on complaints on this matter. However, it is important to highlight that there is no regulation on distance of turbines from residential areas in Mexico. The currently withdrawn guideline project from the Ministry of Environment PROY-NOM-151-SEMARNAT-2006 contained general technical specifications for distances between wind turbines and other land uses (e.g. natural protected areas, aviation and radar facilities) but none from urban areas [129–131].

Fig. 2. Wind park in the Tehuantepec Isthmus. Photo by María Elena Huesca Pérez.

4.2. Socio-economic implications

4.2.1. Economic development and employment

On one hand, economic development and increased employment can mainly observed during construction stage. The operation of 14 wind projects in the Isthmus of Tehuantepec employed approximately 300 people [124], which represents an average of one job per three turbines. According to several authors [113,114,116] employments are small and not well remunerated for local population.

On the other hand, negative economic effects of wind projects in the region have been reported, such as impacts on agriculture and livestock soil due to the construction of roads and platforms, which represents loss of traditional economic activities in the lands like seasonal harvesting [114,124].

Socio-economic indicators of the municipalities with wind development are presented in Table 5 and Fig. 3. El Espinal is the municipality with higher quality social indicators; but, in general, the socio-economic status of the population presents singular deprivations. From 2000 to 2010, the municipalities with wind projects have not reduced their marginality rate; and, in the case of La Ventosa y Santo Domingo Ingenio, the rate increased from middle marginality to high marginality [100,124]. Some authors [114,115,132] also reported that wind projects in the Isthmus of Tehuantepec have created disparity among landowners with lease agreements and those without agreements, and as well with the rest of the local population.

4.2.2. Ownership, land use rights and lease agreements

Private developers set lease agreements with landowners. Most of the land in Mexico, and especially in Oaxaca is based on social ownership called *ejido*. While 54% of the National territory belongs to an *ejido*, this number raises to 91% in the Oaxaca state [133].

Table 5
Socioeconomic indicators of poverty in municipalities with wind energy projects in Oaxaca (2010).
Source: [99,101].

Municipality	Total	In poverty	In Extreme poverty	With educational lag	Without health services	Without social security	Without quality and spaces in dwelling	Without access to basic services	Without enough access to food	With income less than welfare line	With income less than minimum welfare line	No piped water	No electricity	Fuel wood as the main fuel
		%	%	%	%	%	%	%	%	%	%	%	%	%
Asunción Ixtaltepec	14,014	54.4	10.8	30.9	44.6	71.1	16.0	30.1	15.5	56.8	19.9	6.2	2.2	26.1
El Espinal	10,949	32.4	3.8	17.5	20.7	48.9	6.7	7.0	13.6	36.5	9.3	–	2.5	8.0
Juchitán de Zaragoza	79,197	60.2	11.3	27.3	42.3	76.8	25.7	11.1	17.1	62.9	21.4	9.5	1.7	22.1
San Dionisio del Mar	5564	85.9	46.0	40.8	65.0	80.2	32.7	84.3	35.7	86.9	54.8	26.7	8.1	78.8
Santo Domingo Ingenio	7342	60.6	9.5	28.0	35.0	74.8	22.9	22.6	10.5	62.8	19.7	7.7	2.6	23.2
Unión Hidalgo	8332	54.4	11.8	17.8	39.0	63.2	21.8	10.3	15.3	59.5	24.2	8.1	1.2	20.9
Oaxaca (thousand)	3809	67.4	29.8	30.3	39.9	79.7	34.1	58.7	26.6	68.6	36.8	29.2	4.4	49.3
Mexico (thousand)	112,336	46.6	11.3	20.7	29.7	60.7	15.2	22.9	24.8	52.0	19.4		1.8	14.0

The *ejido* is a legal form of community land created after the Mexican Revolution in the year 1917, which states that a group of peasants or *ejidatarios* had the perpetual rights of a specific area for agrarian purposes, but with the prohibition to sell [134]. In 1992, the Mexican Constitution was reformed, and the *ejido* land was allowed to be transformed into individual rights, which permits them to be sold, rented or mortgaged through financial contracts [135–137]. Nevertheless, there are many lands still belongs to the *ejidos*. According to the law, the *ejido* has representatives (*comisariado ejidal*) elected in an Assembly, and decisions on land such as leasing have to be approved by the majority of the members of this Assembly. Some documents report that false Assembles are arranged in order to sign faster lease agreements between the *ejidatarios* and the wind companies, which reveals illegality and corruption [108,110,124,125]. Also, private wind companies have promoted the legal modification of the property rights from *ejido* to private land, in order to facilitate the installation of wind farms [125,138].

In addition, the leasing contracts are in general 30 years term with the expectation to be prolonged, and the fees are substantially low compared with similar projects in other countries. Some lease payments in Oaxaca are estimated annually between US$98 to US$360 per hectare depending on the affectation. Royalties go from 0.025–1.53% of gross income [66,108,115,125]. Public projects fees are similar, such is the specific case of La Venta, where lease payments are between US$114 and US$456 per year per ha[2] [114].

4.2.3. Economic chains and Clean Development Mechanism

Most of the wind projects in the country have been financed by the Clean Development Mechanism (CDM), one of the instruments of the Kyoto Protocol, and in the case of Oaxaca, by the year 2014, 20 out of 23 wind projects are supported through this policy [131]. Contrary to the case of Brazil, where wind turbine manufacturing has created economic chains with positive impacts in the country, México has no wind turbine manufacturing, which permits a high rate of wind technology import [131,139]. According to technology transfer research in wind energy projects supported by CDM, countries with no domestic wind industry have a lower rate of wind power growth [140].

4.3. Socio-cultural

4.3.1. Socio-cultural values and rights of indigenous people

There are 62 ethno-linguistic peoples and communities in the country, and Oaxaca is one of the states with higher indigenous diversity (47%), thirteen indigenous peoples and communities are officially recognized: *Amuzgo, Chatino, Chinanteco, Chocho, Chontal, Cuicateco, Huave, Ixcateco, Mazateco, Mixe, Mixteco, Triqui y Zapoteco* [141]. In 2010, 34% of the state population spoke an indigenous language (*Zapotecas* 40%; *Mixtecas* 28%; *Mazatecos* 19%; *Mixes* 13%). Each community has its own customary law called *usos y costumbres* recognized by the state Constitution where the Assemble is the participatory decision-making foundation. By 2010, Juchitán de Zaragoza (where most wind parks are built) was one of the municipalities with the highest indigenous presence in the country (86%). Besides poverty, education is a critical factor: 25% of indigenous people in Oaxaca are illiterate (while 16% of the total state population), and 16% is monolingual with no Spanish knowledge [141].

In order to guarantee indigenous rights, Mexico undertook ratification in 1990 with the International Labour Organization

[2] Between MXP$1500 and MXP$6000 with exchange currency into US Dollars in 2010 of MXP$13,15.

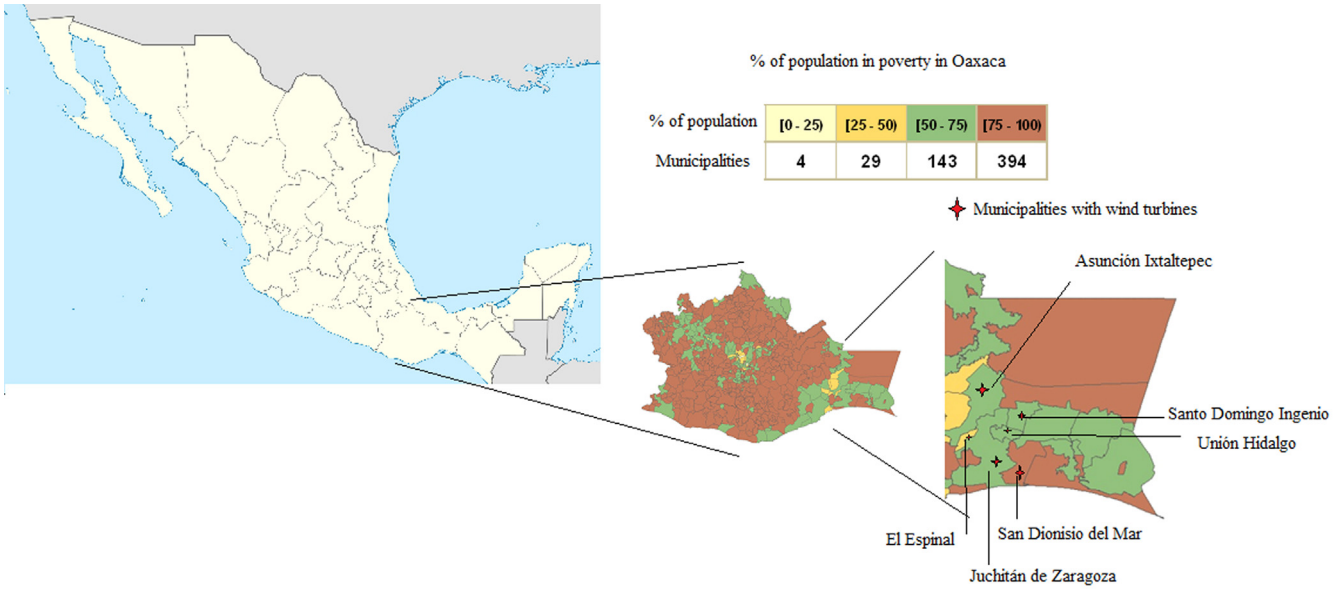

Fig. 3. Municipalities with wind energy turbines in Oaxaca.
Source: [2,101].

(ILO) Convention 169 [79]. In 2004, ILO's supervisory board requested from the Mexican government to ensure full participation of indigenous communities, emphasizing its responsibility to ensure their right to participate in the process of productive land use and resources, as well to ensure the implementation of the Convention [68,142]. In 2001, indigenous rights were introduced in the Mexican Constitution in Article 2, giving more rights to the community, e.g. deciding about their own economical, political and cultural organization, enriching their own language and culture, and preserving and improving their land and natural resources [143].

Conflicts about energy deployment on indigenous territory are very common (e.g. hydro-electrical industry in Oaxaca, Veracruz and Guerrero) [143]. In general, the main issue is due to lack of timely and comprehensive information as well as prior consultation, which contravene the ILO Convention 169 [125]. Opposition to wind farms in Oaxaca has been marked by the importance of socio cultural values related to the indigenous peoples and communities. As Pasqualetti [66] quoted, the discourse of one of the opposition groups has called on its supporters to “defend the land we inherited from our ancestors” and to say “no to the wind energy megaprojects in the Isthmus that desecrate our lands and cultural heritage” [105].

4.4. Stakeholders involvement: information, consultation, and participation

Social conflicts among some population groups and wind farm developers have been created mainly because of an improper framework of information, consultation and participation [124–126].

According to the General Environmental Law (LGEEPA), any person can ask for public consultation and, in case of serious damage of the environment, a public meeting for the project's information can be arranged; unfortunately, the project managers can keep this information due to industrial property reasons [144]. People in the Isthmus of Tehuantepec have argued there are substantial environmental impacts not only on birds and noise, but also on underground water, negative effects on food sources, and wetland destruction [106,115,132]. Concerning access and public participation, the Federal Law of Transparency and Access to Governmental Public Information compel the SEMARNAT to give access to information regarding permissions given throughout EIA. The EIA is an instrument with the potential for public involvement; however, its shortcoming in Mexico is not only because public participation is limited, but also because there is no external monitoring [145].

According to several authors, wind farms in the Isthmus of Tehuantepec have accentuated inequalities and generated a conflict that not only threatens wind development but the social stability in the region [114,124,125].

4.5. Constellation analysis of the “Piedra Larga” Wind Park

The aim of this section is to present a qualitative result of a case study developed in one of wind projects sited in the Isthmus of Tehuantepec. This empirical research shows the conflicts of a wind project from the landowner’s perspective. The case study reinforces and enriches the information presented in this paper, giving a local visualization of a specific wind project in the Isthmus.

The study was based on a park with 11 wind turbines of an installed capacity of 90 MW. The project was financed with the support of the Clean Development Mechanism (CDM) and started operations in 2012. It is sited in a private owned land of 756 hectares (of which, 26 are for infrastructure) in Piedra Larga in the municipality of Union Hidalgo in the Isthmus of Tehuantepec. A second wind park also with CDM support is under construction in the same area [146].

The evaluation was conducted through Constellation Analysis (CA) [147,148] developed on a semi-structured workshop in which participated four of the land-owners who have a lease agreement with the wind company. The data was gathered during the workshop where all the landowners could hear other's comments. The workshop was conducted in March 2014, as part of a wider case study research. Further research work must be done in order to find out other significant aspects of the wind energy development in the region.

The resulting constellation diagram (Fig. 4) summarize the vision of the participants and help to understand the complex field of actors and interactions divided in *social and institutional actors* (yellow), *natural elements* (green), *technical elements* (blue), as well as *system of regulations, incentives, laws, among others* (red). The

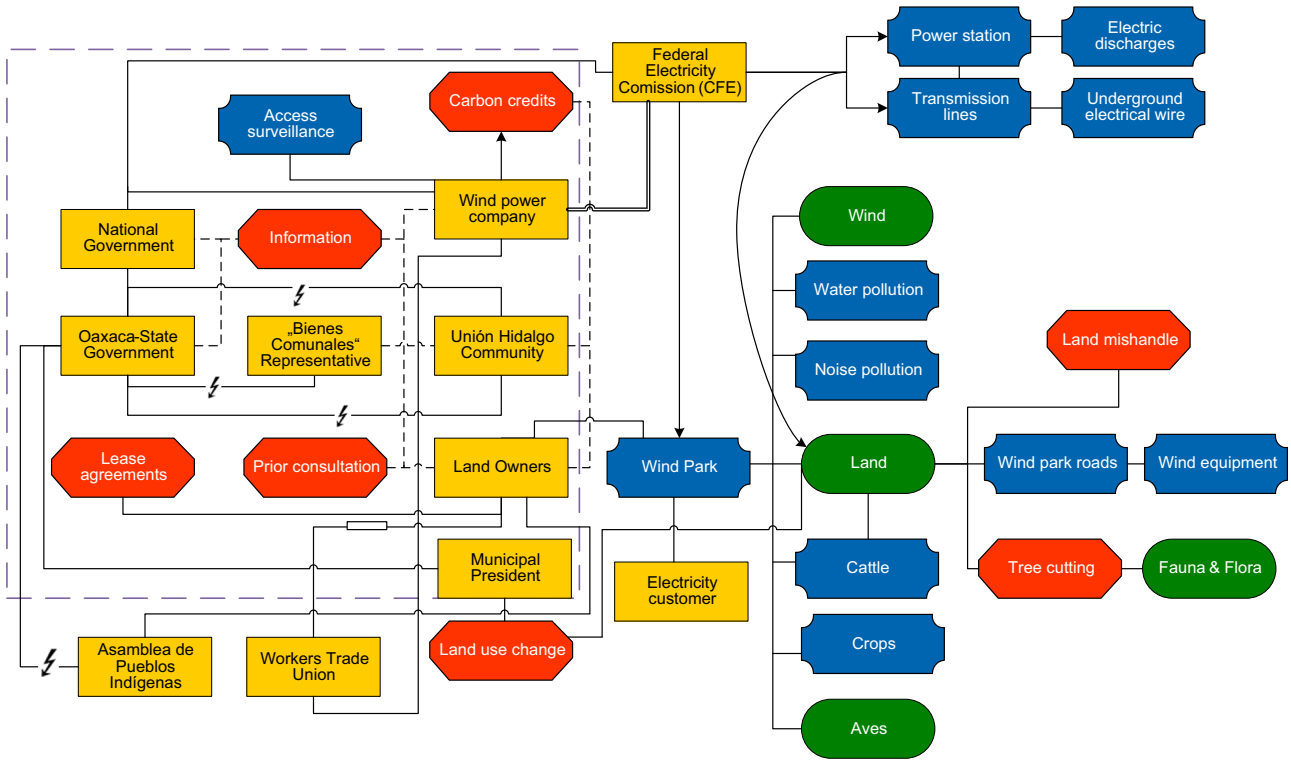

Fig. 4. Constellation analysis diagram.

different elements are characterized by different colors and graphical representations, with their respective relations, as well as the diverse possible interactions, which are differently represented.

The CA diagram (Fig. 4) shows the main considerations from the participants in this evaluation; the analysis is carried out concerning the socio-environmental effects from private large wind parks in the area. The area deals in the last years with different conflicts within the wind energy development, resulting on a growing opposition. In this specific wind park development the conflicts over the project emerged since the very beginning, with the new *wind park roads* and early infrastructure's construction. In general, people from the community got startled to see the first wind turbines, as they argued there was none *information* before the project has started. On one hand, the *multilevel government* in Mexico as well as the multiple stakeholders results in a complex *top-down planning* process of a wind park. (See Section 3.1 Regulation).

The *national government* through *Federal Electricity Commission (CFE)* and CRE are responsible to give the permit to a large *Electricity Customer (for self-generation)* for building a private wind park; however, is the local government, the *Municipal President*, who approves the *land use change* (from agricultural to industrial). There is also a complex process of actors as well as a conflictive relation between all levels of authorities. The *national, regional* and *local government* has a good relation with the *wind company*; in contrast with the civil society, they have not been supportive with the *community* 'concerns and *information* to the local people, who are in majority *indigenous peoples*. In addition, the wind company has placed *surveillance access* to the wind parks 'roads, which has been an upset for the local people in general. Proper *information* and *prior consultation* is essential for the local communities before the project has begun, this basic step has failed, contributing to raise an *opposition* from local residents to the second stage of this wind park and future projects in the area, leaded by the *Asamblea de pueblos indígenas* (officially called Asamblea de Pueblos Indígenas del Istmo de Tehuantepec en defensa de la tierra y el territorio APIITDTT).

On the other hand, the participants consider the *wind* as a local resource to be used for the local benefit. The land owners´ concerns about the *wind park* and land management are mainly concerning the *impacts to the environment*: a) *land mishandle* from the new *roads* infrastructure and *equipment* handling, b) *tree cutting* without prior notice, and therefore local *flora and fauna* affectation, c) *water pollution* due to improper turbines oil waste management, and therefore negative effects on the crops, d) *noise pollution* because of the proximity with urban areas, e) *cattle* disturbance by shadow flickering. Most of the complaints were about the *land* and how it has been used not only for the wind turbines but also for the *transmission lines, underground electrical wire* and *power stations*, which people consider a substantial issue when it comes to the increasing rate of wind parks in the area over the last years and their long-term effects in the future, or cumulative effects (argued as well in the discussion group).

There are also some *impacts on the society/community*, which comprises mainly complains from the *land owners* regarding land property and their respective *lease agreements*. The land lease contracts are perceived with lack of transparency and openness to the landowners and specially the whole *Union Hidalgo community*. According to the discussion group, there are approximately 1000 members of this community, which not all have a land agreement although they are part of the community and they used the leased land. The lease contracts contain assorted conditions and tariffs, which gives the people a perception of an unfair process.

Last but not least, one of the main referred reason of the upcoming wind projects opposition is that the *wind company* and all levels *government* are missing their responsibility of giving *information* and an effective *prior consultation* of the project to the civil society, moreover to the indigenous communities in the area. There is a warning concerning the ILO Convention 169, which

protects indigenous peoples to their rights to participate and to be consulted, then the concept of "'Free, Prior and Informed Consent" is fundamental for indigenous rights in this type of renewable and sustainable projects [80]. This analysis is especially important in the context of international environment policies, specially CDM, which has been widely applied in Oaxaca to finance wind parks. In own words of the participants, the *carbon credits* are not a benefit for the communities but for the companies. As shown in the CA, the top-down planning approach has caused local opposition as a response to the *limited public participation* of stakeholders and all civil society.

Essential findings:

The multilevel government in Mexico as well as the multiple stakeholders result in a complex top-down planning process of a wind park.

Concerning about environmental and social impact, long term effects on the environment (birds, cattle, soil, underwater, noise) as well as on the society/community (land property and lease agreements).

One of the opposition arguments is that the wind company and all levels of governments are missing their responsibility of giving information and provide an effective consultation of the project to the civil society, and to the indigenous communities.

Further considerations:

The role of the Environmental Assessment (EIA & SEA) concerning impacts monitoring, mitigation and compensation measures.

The role of international organizations and their environmental policies to contribute to the sustainable development.

5. Discussion and conclusions

The growth of wind power has been exceptional in the last decade in the world, but it has been accompanied with opposition of local residents. This paper proposes four areas for the evaluation of social impacts of wind power: socio-environmental; socio-economic; socio-cultural and stakeholder involvement. A review of literature on these four areas shows that regulation, guidelines for best practices and institutional involvement are crucial to reduce the social impacts, but an important number of studies also show that even in the cases of landscape and noise annoyance, the perceptions of the local dwellers to wind farms varies depending on the distribution of economic benefits, participation in the decision-making process and ownership.

Wind energy potential in Mexico represents more than twice as much as the current total power installed capacity, so the possibility of an increase of wind farms is very large. Meanwhile, the Isthmus of Tehuantepec has a greater potential, it is also a socially disadvantaged region. Wind energy development in the Isthmus area has been characterized by different social conflicts since the installation of the first turbines. The paper shows that wind projects in this region have grown with lack of sufficient regulation, an absence of institutional mediators, and insufficient instruments that promote a fair distribution of benefits. This has led to an increase of inequalities and has promoted social conflicts in the region [114,124,125].

Engaging participation of the local communities (from economic benefits to decision making) as well as recognizing the cultural values are unavoidable conditions for its development. To promote this participation, the following outlook is under discussion.

5.1. On-site participatory planning

A participatory planning process could lead to a more equitable development [149,150], and might help not only to reduce social conflicts towards wind energy, but to allow understanding the concerns, needs, and even limitations of wind energy in the region. Since the first step of a wind project is site selection, information from the site is mandatory. In the case of the Isthmus region in Mexico, the main issue is regarding participation within stakeholders and civil society, who mainly are indigenous peoples. A special treatment must be done in order to engage all sectors of society, and also to engage to the principles of consultation and participation of the ILO Convention 169. Culturally sensitive consultation is key for engaging indigenous communities [104], with clear and proper information, also in different languages. Such a susceptible topic needs a number of individual resolutions, due to the diversity of indigenous people. Main issues concerning wind parks in the Tehuantepec Isthmus have demonstrated limited participation, which also shows the importance of legal representation through the land lease process [39,151].

5.2. Public policy for sustainable renewable energy development

Mexico needs to build a more comprehensive public policy for renewable energy that considers national, regional and local goals in a more sustainable path of development. Public policies are needed to promote community ownerships, social and public investments, science, technology innovation, economic chains, and policies for regional development that create synergies and respect cultural values, in the vision of green economies promoted by the Rio + 20 UN declaration.

5.3. Governance and regulatory institutions and instruments

The complex and contentious process of wind energy planning in Mexico has been a consequence of a top-down decision with a weak institutional framework. On one hand, the main issue is due to multi-level government and, wind energy planning being held as a complete federal responsibility, while the regional (Oaxaca State) and local authorities (municipalities) have minor or no participation in the process. On the other hand, the state and the municipalities are the ones directly confronted with the social problems at wind parks site. Although there is a national importance of increasing wind power capacity, there is a struggle of suitable regulations on the local level.

There is an urgent need in Mexico to develop mandatory regulations and guidelines that reduce and mitigate social-environmental impacts, a close coordination between all levels of government [125]. For example, regulations that establish minimum distance of wind turbines to populations, density of wind farms, height of the turbines, noise, etc. Other regulations such as land use planning with a participatory planning process are also important as explained above, specially policies that mandates participatory governance across multiple levels for policy implementation [152]. Also, guidelines that provide valid source of information to land owners for fair lease agreements could be highly useful. It is also urgent to create a regional governmental agency that includes different level of governments and guarantees the promotion of sustainable regional development, participatory process and advisory for local communities.

The challenge of environmental assessments such as EIA (as well as Social Impact Assessment and Strategic Environmental Asssessment), as regulatory instruments, is integrating multiple stakeholders and socio-environmental factors within wind power projects as well as diffusion of information outside the project. An adequate and effective application of the current EIA based on local consultations, might anticipate and mitigate conflicts (in a project level). EIA is also important for monitoring the effects of impact assessment, which their effectiveness can then provide

guidance for further wind energy projects and final decision-making [153].

Learning from previous experiences is key to manage future development. Further research on the local level will help to understand public attitudes and performance of social acceptance, as well as to learn lessons from previous experiences within siting wind energy deployment in unprivileged regions, like the Isthmus of Tehuantepec wind corridor.

Acknowledgments

The corresponding author would like to thank the Mexican Science Council (CONACyT) and the German Academic Exchange Service (DAAD) for the PhD research scholarship. Acknowledgment also goes to different colleagues for language editing, and helpful comments.

References

[1] World Wind Energy Association (WWEA). Worldwide Wind Market booming like never before: Wind Capacity over 392 Gigawatt, ⟨http://www.wwindea.org/hyr2015/⟩; 2015 [accessed 26.10.15].
[2] Comisión Reguladora de Energía (CRE). Permisos de Generación e Importación de Energía Eléctrica Administrados al 31 de Agosto de 2015, ⟨http://www.cre.gob.mx/articulo.aspx?id=171⟩; 2015 [accessed 27.10.15].
[3] World Wind Energy Association (WWEA). 2014 Half-year Report; 2014.
[4] Intergovernmental Panel on Climate Change (IPCC). Special report on renewable energy sources and climate change mitigation; 2011.
[5] International Energy Agency (IEA). World energy outlook. 2013.
[6] Agterbosch S, Meertens RM, Vermeulen WJ. The relative importance of social and institutional conditions in the planning of wind power projects. Renew Sustain Energy Rev 2009;13(2):393–405.
[7] Devine-Wright P. Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy. Wind Energy 2005;8(2):125–39.
[8] Richard Cowell, Gill Bristow and Max Munday. Wind energy and justice for disadvantaged communities; 2012.
[9] Horbaty R, Huber S, Ellis G. Large-scale wind deployment, social acceptance. WENE 2012;1(2):194–205.
[10] Fleurbaey M, Kartha S, Bolwig S, Chee YL, Chen Y, Corbera E, Lecocq F, Lutz W, Muylaert MS, Norgaard RB, Okereke C, editor. Sustainable development and equity. In: Climate change 2014: mitigation of climate change. contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; 2014.
[11] Janeiro L, Patel MK. Choosing sustainable technologies. Implications of the underlying sustainability paradigm in the decision-making process. J Clean Prod 2014.
[12] Kaygusuz K. Energy for sustainable development: a case of developing countries. Renew Sustain Energy Rev 2012;16(2):1116–26.
[13] Pasqualetti MJ. Social barriers to renewable energy landscapes. Geogr Rev 2011;101(2):201–23.
[14] Evans A, Strezov V, Evans TJ. Assessment of sustainability indicators for renewable energy technologies. Renew Sustain Energy Rev 2009;13(5):1082–8.
[15] Comisión Federal de Electricidad (CFE). Programa de Obras e Inversiones del Sector Eléctrico POISE 2011–2025; 2014.
[16] Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL). Medición de la pobreza en México y en las Entidades Federativas 2014; 2015.
[17] Barrow CJ. Social impact assessment: an introduction. Arnold; 2000.
[18] Martin J, Farmer A, Porter J, Simpson J. Landscape capacity study for wind energy developments in the South Pennines, January 2010; 2010.
[19] Watson I, Betts S, Rapaport E. Determining appropriate wind turbine setback distances: Perspectives from municipal planners in the Canadian provinces of Nova Scotia, Ontario, and Quebec. Energy Policy 2012;41:782–9.
[20] Sturge D, While A, Howell R. Engineering and energy yield: the missing dimension of wind turbine assessment. Energy Policy 2014;65:245–50.
[21] Ladenburg J, Termansen M, Hasler B. Assessing acceptability of two onshore wind power development schemes: a test of viewshed effects and the cumulative effects of wind turbines. Energy 2013;54:45–54.
[22] Drechsler M, Meyerhoff J, Ohl C. The effect of feed-in tariffs on the production cost and the landscape externalities of wind power generation in West Saxony, Germany. Energy Policy 2012;48:730–6.
[23] Molnarova Kristina, Sklenicka Petr, Stiborek Jiri, Svobodova Kamila, Salek Miroslav, Brabec Elizabeth. Visual preferences for wind turbines: Location, numbers and respondent characteristics. Appl Energy 2012;92:269–78.
[24] Dai K, Bergot A, Liang C, Xiang W, Huang Z. Environmental issues associated with wind energy – a review. Renew Energy 2015;75:911–21.
[25] Henningsson M, Jönsson S, Bengtsson Ryberg J, Bluhm G, Bolin K, Bodén B, Ek K, Hammarlund K, Hannukka I, Johansson C, Mels S, Mels T, Nilsson M, Skärbäck E, Söderholm P, Waldo Ä, Widerström I, Åkerman N. The effects of wind power on human interests. Stockholm, Sweden: Swedish Environmental Protection Agency; 2013.
[26] Devine-Wright P. Energy citizenship: psychological aspects of evolution in sustainable energy technologies, In: Governing technology for sustainability, Earthscan; 2012.
[27] Mariel P, Meyerhoff J, Hess S. Heterogeneous preferences toward landscape externalities of wind turbines – combining choices and attitudes in a hybrid model. Renew Sustain Energy Rev 2015;41:647–57.
[28] Kontogianni A, Tourkolias C, Skourtos M, Damigos D. Planning globally, protesting locally: patterns in community perceptions towards the installation of wind farms. Renew Energy 2014;66:170–7.
[29] Mulvaney KK, Woodson P, Prokopy LS. Different shades of green: a case study of support for wind farms in the rural midwest. Environ Manag 2013;51(5):1012–24.
[30] Langbroek M, Vanclay F. Learning from the social impacts associated with initiating a windfarm near the former island of Urk, The Netherlands. Impact Assess Proj Appraisal, 30; 2012. p. 167–78.
[31] Karydis M. Public attitudes and environmental impacts of wind farms: a review. Global Nest J 2013;15:585–604.
[32] Mason K, Milbourne P. Constructing a 'landscape justice' for windfarm development: the case of Nant Y Moch, Wales. Geoforum 2014;53:104–15.
[33] Minelli A, Marchesini I, Taylor FE, Rosa P, de, Casagrande L, Cenci M. An open source GIS tool to quantify the visual impact of wind turbines and photovoltaic panels. Environ Impact Assess Rev 2014;49:70–8.
[34] Fast S. Social acceptance of renewable energy: trends, concepts, and geographies. Geogr Compass 2013;7(12):853–66.
[35] Nadaï A, Labussière O. Playing with the line, channelling multiplicity: wind power planning in the Narbonnaise (Aude, France). Environ. Plann. D 2013;31(1):116–39.
[36] van der Horst Dan, Vermeylen S. Ownership claims, valuation practices, and the unpacking of energy-landscape conflicts. Int Rev Sociol 2012;22(3):429–45.
[37] University of Newcastle. Visual Assessment of Windfarms: Best Practice: Scottish Natural Heritage Commissioned Report F01AA303A; 2002.
[38] Western Australia Planning Comission. Guidelines for Wind Farm Development: Bulletin 67; May 2004.
[39] Baker SH. Why the IFC's free, prior, and informed consent policy doesn't matter (yet) to indigenous communities affected by development projects. Rochester, NY: Social Science Research Network; 2012.
[40] Møller H, Pedersen CS. Low-frequency noise from large wind turbines. J Acoust Soc Am 2011;129(6):3727–44.
[41] Tabassum-Abbasi, Premalatha M, Abbasi T, Abbasi SA. Wind energy: increasing deployment, rising environmental concerns. Renew Sustain Energy Rev 2014;31:270–88.
[42] Lima F, Ferreira P, Vieira F. Strategic impact management of wind power projects. Renew Sustain Energy Rev 2013;25:277–90.
[43] Katsaprakakis DA. A review of the environmental and human impacts from wind parks. A case study for the Prefecture of Lasithi, Crete. Renew Sustain Energy Rev 2012;16(5):2850–63.
[44] Saidur R, Rahim NA, Islam MR, Solangi KH. Environmental impact of wind energy. Renew Sustain Energy Rev 2011;15(5):2423–30.
[45] Ellenbogen JF, Grace S, Heiger-Bernays WJ, Manwell JF, Mills DA, Sullivan KA, Weisskopf MG. Wind turbine health impact study: report of independent expert panel: prepared for: Massachusetts Department of Environmental Protection Massachusetts Department of Public Health; 2012.
[46] Backalarz C, Pedersen TH, Sondergaard LS. Calculations of indoor low frequency noise from wind turbines: INTER-NOISE and NOISE-CON congress and conference proceedings, InterNoise13, Innsbruck AUSTRIA. Innsbruck AUSTRIA; 2013. p. 5093–916, p. 5845–54(10).
[47] Pedersen E. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. Occup Environ Med 2007;64(7):480–6.
[48] Pedersen E, Berg, Frits van den, Bakker R, Bouma J. Response to noise from modern wind farms in The Netherlands. J Acoust Soc Am 2009;126(2):634–43.
[49] Janssen SA, Vos H, Eisses AR, Pedersen E. A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources. J Acoust Soc Am 2011;130(6):3746–53.
[50] Hessler David M, George F, Hessler JR. Recommended noise level design goals and limits at residential receptors for wind turbine developments in the United States. Noise Control Eng J 2011;59(1):94–104.
[51] Harrison JP. Wind turbine noise. Bull Sci Technol Soc 2011;31(4):256–61.
[52] National Renewable Energy Laboratory (NREL). Community Wind Benefits (Fact Sheet): Wind And Water Power Program; 2012.
[53] The International Renewable Energy Agency (IRENA). Renewable energy and jobs – annual review 2014, ⟨http://www.irena.org/Publications/rejobs-annual-review-2014.pdf⟩; 2014.
[54] Kammen DM, Kapadia K, Fripp M. Putting renewables to work: how many jobs can the clean energy industry generate? Berkeley: University of California; 2004.
[55] Lantz E, Tegen S. Economic development impacts of community wind projects: a review and empirical evaluation: conference paper NREL/CP-500-45555; 2009.

[56] Brown JP, Pender J, Wiser R, Lantz E, Hoen B. Ex post analysis of economic impacts from wind power development in U.S. counties. Energy Econ 2012;34(6):1743–54.
[57] Swofford J, Slattery M. Public attitudes of wind energy in Texas: local communities in close proximity to wind farms and their effect on decision-making. Energy Policy 2010;38(5):2508–19.
[58] Slattery MC, Johnson BL, Swofford JA, Pasqualetti MJ. The predominance of economic development in the support for large-scale wind farms in the U.S. Great Plains. Renew Sustain Energy Rev 2012;16(6):3690–701.
[59] Munday M, Bristow G, Cowell R. Wind farms in rural areas: How far do community benefits from wind farms represent a local economic development opportunity? J Rural Stud 2011;27(1):1–12.
[60] Toke D, Breukers S, Wolsink M. Wind power deployment outcomes: how can we account for the differences? Renew Sustain Energy Rev 2008;12(4):1129–47.
[61] Brower Michael. Wind resource assessment: a practical guide to developing a wind project. Hoboken NJ: Wiley; 2012.
[62] Suzanne Rynne, Larry Flowers, Eric Lantz, Erica Heller. Planning for wind energy: report number 566; 2011.
[63] Qiu Y, Anadon LD. The price of wind power in China during its expansion: technology adoption, learning-by-doing, economies of scale, and manufacturing localization. Energy Econ 2012;34(3):772–85.
[64] Simas M, Pacca S. Assessing employment in renewable energy technologies: a case study for wind power in Brazil. Renew Sustain Energy Rev 2014;31:83–90.
[65] Leary J, While A, Howell R. Locally manufactured wind power technology for sustainable rural electrification. Energy Policy 2012;43:173–83.
[66] Pasqualetti MJ. Opposing wind energy landscapes: a search for common cause. Ann Assoc Am Geogr 2011;101(4):907–17.
[67] Ek K, Matti S. Valuing the local impacts of a large scale wind power establishment in northern Sweden: public and private preferences toward economic, environmental and sociocultural values. J Environ Plan Manag 2014:1–19.
[68] United Nations (UN). Declaration on the Rights of Indigenous Peoples; 2007.
[69] Brown KB. Wind power in northeastern Brazil: local burdens, regional benefits and growing opposition. Clim Dev 2011;3(4):344–60.
[70] Finley-Brook M, Thomas C. Renewable energy and human rights violations: illustrative cases from indigenous territories in Panama. Ann Assoc Am Geogr 2011;101(4):863–72.
[71] Sovacool BK, Bulan LC. Meeting targets, missing people: the energy security implications of the Sarawak Corridor of Renewable Energy (SCORE): contemporary Southeast Asia. J Int Strateg Aff 2011;33:p56.
[72] Patrick Bond. Politics of climate justice: paralysis above, movement below. Presentation paper, 27 May; 2011.
[73] Garcia Santos, Alice Nataraja. National Policy, Local Impacts: Development of Wind Branches in Northeast Brazil: Geographies of Inequality in Latin America 2012; Kieler Geographische Schriften 123 (Sandner Le Gall, V. und R. Wehrhahn):159–87.
[74] Comisión Económica para América Latina y el Caribe (CEPAL). Pueblos indígenas y afrodescendientes de América Latina y el Caribe: información sociodemográfica para políticas y programas. http://www.eclac.cl/cgi-bin/getProd.asp?xml=/publicaciones/xml/0/25730/P25730.xml/xsl=/celade/tpl/p9f.xsl&base=/celade/tpl/top-bottom.xsl; 2014.
[75] Corscadden K, Wile A, Yiridoe E. Social license and consultation criteria for community wind projects. Renew Energy 2012;44:392–7.
[76] CMM Environmental Services. Dalhousie Mountain Mi'kmaq Ecological Knowledge Study: Clydesdale Ridge Wind Farm Final Environmental Assessment Registration; 2008.
[77] Davis Danielle C. Land in the second decade: the evolution of indigenous property rights and the energy industrie in the United States and Brazil. Energy Law J 2013;34:667.
[78] Ely A, Smith A, Stirling A, Leach M, Scoones I. Innovation politics post-Rio+20: hybrid pathways to sustainability? Environ. Plann C 2013;31(6):1063–81.
[79] Feiring B. Indigenous & tribal peoples' rights in practice: a guide to ILO convention. 169th ed. International labour organization; 2009.
[80] Hanna P, Vanclay F. Human rights, indigenous peoples and the concept of free, prior and informed consent. Impact Assess Proj Apprais 2013;31(2):146–57.
[81] International Labour Organization (ILO). Indigenous and Tribal Peoples Convention 169; 02.02.2015.
[82] Cowell R, Bristow G, Munday M. Acceptance, acceptability and environmental justice: the role of community benefits in wind energy development. J Environ Plann Manag 2011;54(4):539–57.
[83] Hoffman SM, High-Pippert A. From private lives to collective action: recruitment and participation incentives for a community energy program. Energy Policy 2010;38(12):7567–74.
[84] Odparlik LF, Köppel J. Access to information and the role of environmental assessment registries for public participation. Impact Assess Project Apprais 2013;31(4):324–31.
[85] Jobert A, Laborgne P, Mimler S. Local acceptance of wind energy: factors of success identified in French and German case studies. Energy Policy 2007;35(5):2751–60.
[86] Gross C. Community perspectives of wind energy in Australia: the application of a justice and community fairness framework to increase social acceptance. Energy Policy 2007;35(5):2727–36.
[87] International Finance Corporation (IFC). Environmental and Social Review Procedures Manual: Environment, Social and Governance Department; 2013.
[88] Janet Ruiz-Mendoza B, Sheinbaum-Pardo C. Electricity sector reforms in four Latin-American countries and their impact on carbon dioxide emissions and renewable energy. Energy Policy 2010;38(11):6755–66.
[89] Diario Oficial de la Federación (DOF). DECRETO por el que se reforman y adicionan diversas disposiciones de la Constitución Política de los Estados Unidos Mexicanos, en Materia de Energía; 20.08.2014.
[90] Diario Oficial de la Federación (DOF). Reglamento de la Ley de la Industria Eléctrica; 2014.
[91] Diario Oficial de la Federación (DOF). Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética; 2008.
[92] Diario Oficial de la Federación (DOF). Ley General de Cambio Climático; 20.08.2014.
[93] Diario Oficial de la Federación (DOF). Metodología contraprestaciones a los generadores que utilicen energías renovables; 2012.
[94] Ramírez-Mariaud R. Evaluación del Programa Especial para el Aprovechamiento de Energías Renovables. Master thesis, Energy Studies; 2013.
[95] Sánchez Salazar MT, Bocco Verdinelli G, Casado Izquierdo JM. La política de ordenamiento territorial en México: De la teoría y la práctica. 1st ed. Centro de Investigaciones en Geografía Ambiental Campus Morelia de la UNAM, Morelia, Michoacán, México, México, D.F; 2013.
[96] Secretaría de Energía (SENER). Sistema de Información Energética, ⟨http://sie.energia.gob.mx/⟩; 2014.
[97] Secretaría de Energía (SENER). Prospectiva de Energías Renovables 2013–2027; 2013.
[98] Instituto Nacional de Estadística y Geografía (INEGI). Anuario Estadístico y Geográfico de los Estados Unidos Mexicanos, 2013, México; 2014.
[99] Instituto Nacional de Estadística y Geografía (INEGI). Censo de Población y Vivienda, 2010, México; 2010.
[100] Comisión Nacional de Población y Vivienda (CONAPO). Índice de marginación por localidad, 2010, México; 2010.
[101] Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL). Report of the results of the poverty measurement of 2012, México, D.F; 2013.
[102] Elliot D, Schwartz M, Scott G, Haymes S, Heimiller D, George R. Wind Energy Resource Atlas of Oaxaca; 2003.
[103] Borja MA, Jaramillo OA, Mimiaga F. Primer Documento del Proyecto Eoloeléctrico del Corredor Eólico del Istmo de Tehuantepec. IIE, ⟨http://www.cie.unam.mx/~ojs/pub/Eolica/LibroProyectoEolico/ProyectoEolico.pdf⟩; 2005.
[104] Ledec GC, Rapp KW, Aiello RG. Greening the wind: environmental and social considerations for wind power development. Washington, DC: World Bank Publications; 2011.
[105] National Wind Watch: National Wind Watch; 2007.
[106] Manzo D; 2012.
[107] Cervantes J. Parques eólicos: La resistencia comunitaria; 2013.
[108] Rojas R.: La Jornada; 2014.
[109] Hernández Avilés, Valeria Olinca. Conflictos territoriales y perspectivas de desarrollo de la energía eólica en el istmo de Tehuantepec. Revista Mexicana de Opinión Pública 2010;9:67–79.
[110] Comisión para el Diálogo de los Pueblos Indígenas de México (CDPIM). La energía eólica en México: Una perspectiva social sobre el valor de la tierra; 2013.
[111] Alvarado López A. Transferencia Tecnológica y Creación de Capacidades Tecnológicas, en el Enfrentamiento al Cambio Climático: El caso de Proyectos MDL en Energía Eólica en México, Argentina; 2011.
[112] Briones F. Social Distribution of risk: A case study in Tehuantepec, Mexico. Perspectives on Social Vulnerability, Hohenkammer, Germany; 2006.
[113] Henestroza R. Desarrollo del proyecto eólico de la región del Istmo de Tehuantepec: Investigación y Ciencia de la Universidad Autónoma de Aguascalientes 2008;42:18–21.
[114] Nahmad S, editor. El impacto social del uso del recurso eólico: Informe Final para el Consejo Oaxaqueño de Ciencia y Tecnología del CONACyT. Centro de Investigaciones y Estudios Superiores en Antropología Social (CIESAS); 2011.
[115] Castillo Jara E. La viabilidad socio ambiental de los parques eólicos del Istmo de Tehuantepec: Tesis de Licenciatura. Facultad de Ciencias Políticas y Sociales, UNAM, México; 2011.
[116] Rueda EC. Eólicos e inversión privada: El caso de San Mateo del Mar, en el Istmo de Tehuantepec Oaxaca. J Latin Am Caribb Anthropol 2011;16(2):257–77.
[117] Howe C. Logics of the wind: development desires over Oaxaca. Anthropol News 2011;52(5):8.
[118] Howe C. Anthropocenic ecoauthority: the winds of Oaxaca. Anthropol Q 2014;87(2):381–404.
[119] Mendoza E, Pérez V. Energías renovables y movimientos sociales en América Latina. Estudios Internacionales 2010;165(165):109–28.
[120] Brodziak F, García AL, Gómez Chow L. Climate Change Impacts on socio-environmental conflicts: Vulnerability in facing Climate Change and social conflicts in Mexico; 2011.
[121] Déniz J, de la Rosa, María, Verona M. El impacto social de las compañías de energía eólica españolas en las comunidades campesinas de Oaxaca y su reflejo en las memorias de sostenibilidad. Proceedings of XVII Congreso Internacional de Contaduría, Administración e Informática, México; 2012.
[122] Simon S. Friction in a Warming World: The Challenges of Green Energy in Rural Oaxaca, Mexico: Peace, Conflict & Development April 2013(20):6–19.
[123] Castillo JE. Conflicto social y energía eólica, ⟨http://mexicosocial.org/index.php/secciones/especial/item/278-conflicto-social-y-energía-eólica.html⟩; 2013.

[124] Juárez-Hernández S, León G. Energía eólica en el Istmo de Tehuantepec: Desarrollo, actores y oposición social. Revista Problemas del Desarrollo 2014;178(45):139–62.
[125] Martínez J, LLaguno Dávila J. Windmills: The face of dispossesion: Land Deal Politics Initiative; 2014(55).
[126] Cordero-Torres J, González-Nolasco J, Hernández-Cortés N. Social responsibility, human rights and wind energy: Oaxaca and Chiapas, Mexico. Int J Humanit Soc Sci 2014;4(11):45–53.
[127] Sellwood SA. Interrupting 'green capital': Transformative political practice at the frontiers of wind energy in Mexico. Thesis, North Carolina, US; 2014.
[128] Diario Oficial de la Federación (DOF). Norma Oficial Mexicana NOM-081-SEMARNAT-1994; 2013.
[129] Diario Oficial de la Federación (DOF). Norma Oficial Mexicana PROY-NOM-151-SEMARNAT-2006; 2006.
[130] Diario Oficial de la Federación (DOF). Cancelación Norma Oficial Mexicana. PROY-NOM-151-SEMARNAT-2006; 2014.
[131] Gartman Victoria, Wichmann Kathrin, Bulling Lea, Huesca-Pérez María Elena, Köppel Johann. Wind of Change or Wind of Challenges: Implementation factors regarding wind energy development, an international perspective. AIMS Energy 2014;2(4):485–504.
[132] Jara Emiliano Castillo. Problemática en torno a la construcción de parques eólicos en el Istmo de Tehuantepec. Revista Desarrollo Local Sostenible 2011;4(12).
[133] Instituto Nacional de Estadística y Geografía (INEGI). Censo Ejidal 2007, ⟨http://www.inegi.org.mx/est/contenidos/proyectos/Agro/ca2007/Resultados_Ejidal/default.aspx⟩; 2007 [accessed 04.12.14].
[134] Zuñiga J, Castillo J. La Revolución de 1910 y el mito del ejido mexicano: Alegatos; 2010(75):497–522.
[135] Calva JL. El modelo de desarrollo agropecuario impulsado mediante la Ley Agraria y el TLC, In: Alternativas para el campo mexicano, UNAM; 1993. p. 15–42.
[136] Jones GA, Ward PM. Privatizing the commons: reforming the ejido and urban development in Mexico. Int J Urban Reg Res 1998;22(1):76–93.
[137] Cornelius WA, Myhre D. The transformation of rural Mexico: reforming the ejido sector. San Diego: Center for U.S.-Mexican Studies, University of California; 1998.
[138] Jorge Pérez: La Jornada; 2013.
[139] Cancino-Solórzano Y, Villicaña-Ortiz E, Gutiérrez-Trashorras AJ, Xiberta-Bernat J. Electricity sector in Mexico: current status. Contribution of renewable energy sources. Renew Sustain Energy Rev 2010;14(1):454–61.
[140] Lema A, Lema R. Technology transfer in the clean development mechanism: Insights from wind power. Glob Environ Change 2013;23(1):301–13.
[141] Comisión Nacional para el Desarrollo de Pueblos Indígenas (CDI). Catalogo de localidades indígenas 2010; 2010.
[142] Food and Agricultural Organization of the United Nations (FAO). Voluntary guidelines on the responsible governance of tenure of land, fisheries and Forests in the context of national food security, Rome; 2012.
[143] Navarrete Linares F. Los pueblos indígenas de México. 1st ed. Comisión Nacional para el Desarrollo de los Pueblos Indígenas; Programa de las Naciones Unidas para el Desarrollo, México, D.F; 2008.
[144] Diario Oficial de la Federación (DOF). Ley General del Equilibrio Ecológico y la Protección al Ambiente; 1996.
[145] Palerm J, Aceves C. Environmental impact assessment in Mexico: an analysis from a 'consolidating democracy' perspective. Impact Assess Proj Apprais 2004;22(2):99–108.
[146] Centre on Energy, Climate and Sustainable Development. CDM pipeline: Project Design Document - PDD Piedra Larga Fase I_ 29.03.2011; 2011 [accessed 05.01.15].
[147] Bruns E, Ohlhorst D, Wenzel B, Köppel J. Renewable energies in Germany's electricity market: a biography of the innovation process. Netherlands, Dordrecht: Springer; 2011.
[148] Susanne Schön, Sylvia Kruse, Martin Meister, Benjamin Nölting, Dörte Ohlhorst. Handbuch Konstellationsanalyse: Ein interdisziplinäres Brückenkonzept für die Nachhaltigkeits- Technik- und Innovationsforschung. oekom, München; 2007.
[149] Aylett A. Participatory planning, justice, and climate change in Durban, South Africa. Environ Plann A 2010;42(1):99–115.
[150] Insitute of development Studies (IDS). The rise of rights: Rights-based approaches to international developmetn; 2003.
[151] International Finance Corporation (IFC). Performance Standards on Environmental and Social Sustainability, ⟨http://www.ifc.org/wps/wcm/connect/c8f524004a73daeca09afdf998895a12/IFC_Performance_Standards.pdf?MOD=AJPERES⟩; 2012.
[152] Newig J, Koontz TM. Multi-level governance, policy implementation and participation: the EU's mandated participatory planning approach to implementing environmental policy. J Eur Public Policy 2013;21(2):248–67.
[153] Geißler G, Köppel J, Gunther P. Wind energy and environmental assessments – a hard look at two forerunners' approaches: Germany and the United States. Renew Energy 2013;51:71–8.