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Regulations for Bat Protection in Mexico's Wind Farms

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Abstract: Wind energy development has expanded the fastest globally among all renewable sources during the last 20 years. However, wind farms have documented adverse impacts on bats, including mortality from collisions with turbine blades and disruptions to habitat and behavior. As the world's sixth most attractive economy for renewables, with 70 operating wind farms, Mexico and its bats now face escalating threats from the country's burgeoning wind industry. Despite this rapid growth, few studies have analyzed Mexico's regulatory framework to prevent, evaluate, and mitigate wind farm effects on bats. In this study, we reviewed Mexican laws and treaties that facilitate wind farm permitting, construction, operation, and decommissioning, and searched for guidelines that specifically address bat conservation. We found eight international pacts that promote wind power adoption along with three relevant articles in Mexico's Constitution. The General Law of Ecological Balance and Environmental Protection proved most pertinent for impact management. Supplementary guidelines from the Ministry of Environment and Natural Resources offer general strategies for evaluating wind farm impacts on bats, but adherence remains voluntary. Given expanding wind power investments across Mexico, we highlight the need for more stringent national standards that require preventative and corrective measures to protect bat populations. Tighter legislation and enforcement offer pathways toward environmentally sustainable wind energy development in Mexico.

Keywords: environmental impact; guidelines; wildlife; bats; wind energy.

Introduction

The generation of greenhouse gases into the atmosphere as a result of energy production from fossil fuels has been recognized as a significant driver of climate change. These gases trap heat in the Earth's atmosphere, leading to global warming (IPCC, 2014). Besides the rising temperatures, there have been alterations in precipitation patterns as well as an uptick in the occurrence and severity of extreme events like heatwaves, droughts, and wildfires (Allan *et al.*, 2021). This has led to climate change being currently considered one of the main threats to biodiversity (Schmittner and Galbraith, 2008; Wolkovich *et al.*, 2014)

Bats are expected to be one of the most impacted groups by climate change, according to Burns *et al.* (2003). Extreme weather events linked to climate change, such as heatwaves and wildfires, can result in the destruction of bat roosts and higher, abnormal mortality rates. This has been observed in at least eight species of bats, as reported by Reusch *et al.* (2019) and Dey *et al.* (2015).

According to Sachanowicz *et al.* (2006), certain species in Europe have extended their range to the north because of increasing temperatures. Additionally, as noted by Ibañez (1997), some species are now giving birth earlier than usual, potentially leading to an increased risk of starvation if food is not readily available during this time. Climate change could also lead to decrease water availability, making survival more challenging (Festa *et al.*, 2022).

Wind power represents an alternative energy source to curb climate change effects as it prevents the emission of millions of tons of carbon dioxide, one of the main greenhouse gases associated with global warming (Asociación Empresarial Eólica, 2024).

Over the last two decades, wind energy development has shown the fastest expansion among renewable sources globally (Renewable Energy Network, 2018). However, an unanticipated trade-off has emerged between wind farm development and biodiversity conservation (Köppel *et al.*, 2019). Construction and operation of wind farms have

documented negative impacts on wildlife, especially birds and bats. Wind turbine collisions directly cause fatalities, while habitat loss, noise, vibrations, and other disruptions can alter species' behaviors related to reproduction, feeding, and migration (Hötker *et al.*, 2006; Kunz *et al.*, 2007; Arnett, 2008; Morrison *et al.*, 2009). Bat mortality estimates reach 888,000 annually at U.S. wind farms (Smallwood, 2013), with population declines likely increasing extinction risks for heavily impacted species like the hoary bat (*Aeorestes cinereus*) (Frick *et al.*, 2017).

In Mexico at least 33 species of bats have been recorded to have suffered mortality due to collision with wind turbines (Villegas, 2013; Bolívar-Cime *et al.*, 2016; Cabrera *et al.*, 2020). This represents mortality in 22% of the total bat species in the country (138 species). Of these species, one is listed as Near Threatened on the International Union for Conservation of Nature Red List; the lesser long-nosed bat (*Leptonycteris yerbabuena*) and the southern long-nosed bat (*Leptonycteris curasoae*), and, are included as vulnerable in the International Union for Conservation of Nature Red List (IUCN, 2024) and as threatened in the Mexican legislation (NOM-059-SEMARNAT-2010). These mortality records come from only three wind farms, so the precise impact of mortality on bats is still unknown.

With a prime geographic location, Mexico ranks sixth globally in renewable energy potential and currently hosts 70 operating wind farms with 3,247 turbines that account for 7,317 MW across 15 states (AMDEE, 2023). The areas with the greatest wind potential are in the states of Oaxaca, Chiapas, Veracruz, Tabasco, Coahuila, Tamaulipas, Nuevo León, and Baja California; these regions could generate 15 times the estimated demand of Mexico by 2024 (NREL, 2022).

Despite the country's wind power expansion, there are no studies that have examined Mexico's regulatory framework for assessing, preventing, and mitigating wind farm impacts specifically on bats. In some works, certain Legal requirements concerning bats are mentioned, but they are not thoroughly analyzed, as the focus is more broadly on examining the regulatory framework for wind energy in Mexico (Llano, 2023). Other studies such as that of Zárate-Toledo and collaborators (2021) focus their analysis on the environmental impact assessment procedure in wind farms in Yucatán and identify some technical deficiencies and gaps in regulation, including some referring to bats.

For this reason, in this work we focused on searching for Mexican laws governing wind farm permitting, operation, and decommissioning, with a focus on bat protections. The analysis establishes a baseline to identify existing gaps in the regulation of wind farms and their impacts on bats in Mexico.

Materials and Methods

Based on Mexico's regulatory hierarchy, we conducted a review of all legal instruments that promote or regulate the permitting, construction, operation, and decommissioning of wind farms in Mexico. The analysis began with Mexico's Political Constitution, followed by a review of relevant treaties, federal laws, and local regulations. We then examined existing guidelines for monitoring, assessing, preventing, and mitigating wind farm impacts on bats. To that end, we reviewed bat-specific protocols from Mexico's Ministry of Environment and Natural Resources (SEMARNAT) at both the particular and regional modalities. Additionally, we searched for all operating wind power projects in Mexico and accessed their Environmental Impact Statement codes via the Ministry's procedure tracking portal. This allowed us to download corresponding Environmental Impact Statements and Resolutions to identify required conditions related to wind farm effects on bats.

In a complementary manner, we searched for environmental policy instruments that included some criteria for the regulation of wind farms and bats. To this end, we reviewed the Territorial Planning and Urban Development Programs for all the States of Mexico by searching for the key words: renewable energy, wind energy, wind farms and bats (Table 1).

Table 1. Revised documents on the promotion and regulation of wind energy and its impacts on bats in Mexico

	Name	Year of publication	Authors
Political Constitution of the United Mexican States (1917)	Articles 25	Article reformed in 1992	Chamber of Deputies of the H. Congress of the Union
	Article 27	Last modification in 2014	
	Article 28	Last modification in 2011	
International/regional treaties, agreements, and conventions	Paris Agreement to the United Nations Framework Convention on Climate Change	2015	United Nations
	Kyoto Protocol to the United Nations Framework Convention on Climate Change	1998	United Nations
	Rio Declaration on Environment and Development	1992	United Nations
	Convention on Biological Diversity	1992	United Nations
	Convention on International Trade in Endangered Species of Fauna and Wild Flora	1973	CITES
	Red List of Threatened Species	1964	International Union for Conservation of Nature
	Convention between the United Mexican States and the United States of America on Cooperation for the Protection and Improvement of the Environment in the Area	1983	Government of the United Mexican States and the Government of the United States of America
	Agreement of Environmental Cooperation North America	1993	Governments of the United Mexican States, United States of America and Canada
General Laws	General Law of Climate Change	2012	The Congress of the Union of Mexico
	General Law of Ecological Balance and Environmental Protection	1988	The Congress of the Union of Mexico
	General Law of Wildlife	2000	The Congress of the Union of Mexico
Federal laws	Energy Transition Law	2015	Governments of the United Mexican States
	Electrical Industry Law	2014	Federal Government, with the Ministry of Energy
	Law for the Sustainable Use of Energy	2008	The Congress of the Union of Mexico
	Law for the Use of Renewable Energies and the Financing of the Energy Transition	2008	The Congress of the Union of Mexico

Table 1 Continued. Revised documents on the promotion and regulation of wind energy and its impacts on bats in Mexico

	Name	Year of publication	Authors
Regulations	Regulation of the General Law of Ecological Balance and Environmental Protection Regarding Environmental Impact Assessment	2000	Chamber of Deputies of the H. Congress of the Union
	Regulation of the Law for the Use of Renewable Energies and Financing of the Energy Transition	2009	Chamber of Deputies of the H. Congress of the Union
	Regulation of the Law for the Sustainable Use of Energy	2009	Chamber of Deputies of the H. Congress of the Union
Official Mexican Standards	NOM-059-SEMARNAT-2010	2010	Ministry of Environment and Natural Resources of Mexico
	NOM-081-SEMARNAT-1994	2013	Ministry of Environment and Natural Resources of Mexico
State laws	Renewable Energy Law for the State of Baja California	2012	Congress of the State of Baja California
	Law for the Promotion of Renewable Energy and Energy Efficiency for the State of Colima	2014	Congress of the State of Colima
	Law for the Promotion, Use, and Development of Energy Efficiency and Renewable Energies for the State of Chihuahua	2013	Congress of the State of Chihuahua
	Law for the Promotion, Use and Exploitation of Renewable Energy Sources in the state of Durango and its Municipalities	2010	Congress of the State of Durango
	Coordination Law for the Promotion of Sustainable Use of Renewable Energy Sources in the State of Oaxaca	2010	Congress of the State of Oaxaca
Guides for the preparation of environmental impact statements	Guide for the presentation of the environmental manifestation of the electricity sector Type: Particular	2002	Ministry of Environment and Natural Resources of Mexico
	Guide for the preparation of the Regional Environmental Impact Assessment	2022	Ministry of Environment and Natural Resources of Mexico
Territorial Planning and Urban Development Programs	Baja California State Ecological Zoning Program	2014	Government of the state of Baja California Secretary of Environmental Protection
	Summary of the Regional Ecological Planning Program of the Territory of the State of Oaxaca	2016	Government of the state of Oaxaca
	Regional Ecological Planning Program for the Territory of the State of Tabasco	2019	Government of the state of Tabasco
	Ecological Planning Program for the Coastal Territory of the State of Yucatán	2014	Government of the state of Yucatán

Results and Discussion

The Mexican Political Constitution outlines the regulation of the electricity sector primarily in articles 25, 27, and 28 (Cámara de Diputados, 2023a). Article 25 stipulates the federal government's mandate to safeguard the ownership, control, transmission, and distribution of the National Electric System. Article 26 delineates the exclusive responsibility of the federal government concerning the generation, distribution, and provision of energy as a public service. Finally, article 28 clarifies that while the State retains exclusive control over planning and managing the national electrical system, along with the public service of transmitting and distributing electrical energy, these functions are not deemed monopolies.

These constitutional articles have as their guiding axis the modernization of Mexico's energy sector without privatizing public companies dedicated to the production and use of hydrocarbons and electricity (Gobierno de la República, 2023); however, they do not incorporate to renewable energy, nor do they consider the negative effects on the environment that are not implicit in the costs of production of energy (CEMDA, 2023).

In terms of international and regional treaties, agreements, and conventions, the latest commitments made in the United Nations Framework Convention on Climate Change stand out. The Mexican government set the goal of voluntarily reducing greenhouse gas emissions by 22% and black carbon emissions by 51% by 2030, compared to the trend scenario (Gobierno de Mexico, 2020). To meet these objectives, one of the main strategies is the use of renewable energy, such as wind power.

Regarding the regulations that were found for wildlife, one of the initiatives arises from the International Union for Conservation of Nature that created the Red List of Threatened Species. This list provides information about range, population size, habitat, and ecology, use and/or trade, and threats; it is a powerful tool to inform government agencies, wildlife departments, nongovernmental organizations, natural resource planners, educational organizations, and the business community about actions needed for biodiversity conservation and policy change, which are critical to protecting the natural resources.

Of the species of bats that are distributed in Mexico, two are on the Red list of Threatened Species, primarily due to the impacts from production of wind energy. The tri-colored bat (*Perimyotis subflavus*) is in vulnerable species status and the Little Brown bat (*Myotis lucifugus*) is endangered (IUCN, 2024). However, in the environmental evaluation procedure in Mexico these lists are not considered; only the species that are in some risk category in the Official Mexican Standard (NOM-059-SEMARNAT-2010) are considered.

Among general laws, the General Law of Ecological Balance and Environmental Protection holds great significance as it substantiates the Environmental Impact Assessment process, mandatory for all wind projects (Ley General de Equilibrio Ecológico y Protección al Ambiente, 2023). At the federal level, four laws stand out as they were created to promote the use of renewable energies in Mexico: The Energy Transition Law (Ley de Transición Energética, 2015), the Electrical Industry Law (Ley de la Industria Eléctrica, 2014), the Law for Sustainable Energy Use (Ley para el Aprovechamiento Sustentable de la Energía, 2008), and the Law for the promotion of renewable energies and financing of the energy transition (Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética, 2008).

A particularly relevant aspect for the establishment of wind farms is mentioned in the Energy Transition Law. This law states that, the Ministry of Environment and Natural Resources, supported by specialized public and educational entities, must prepare regional strategic environmental assessment studies for projects developed in areas for high potential for clean energy. The studies must determine the relevant characteristics of the ecosystem(s) potentially affected by the projects, regionally assess the potential environmental impacts, and dictate prevention and control measures that project developers must adhere to (Ley de Transición Energética, 2015).

Moreover, one of the Official Mexican Standards, specifically NOM-059-SEMARNAT-2010, aims to identify and ensure care for endangered flora and fauna species in Mexico. The species listed in this standard must be reported in the Environmental Impact Assessment of Wind Farms accompanied by proposed actions to avoid or mitigate the negative impacts on the species. Another standard that must be complied with is the NOM-081-SEMARNAT-1994, which

establishes the maximum permissible limits of noise emission from fixed sources (including wind turbines) and specifies the emission measurement method.

Because of the possible impact on birds and bats due to the noise generated during the construction and operation of wind farms, promoters must adhere to the provisions of the NOM-081-SEMARNAT-1994. However, the noise limits in this standard were established based on the values of maximum permissible concentration for humans of pollutants in the environment, which were determined by the Health Secretary (Ley General de Equilibrio Ecológico y Protección al Ambiente, 2023).

In terms of state laws, five regions—Baja California, Colima, Chihuahua, Durango, and Oaxaca—have specific legislation addressing renewable energy (Cámara de Diputados, 2023b) (Table 1). All these laws aim to promote the use and development of renewable energy in a manner compatible with the society and the environment; however, they do not contain any specific regulation to evaluate, prevent, or mitigate the impacts of wind farms on flying fauna.

Note that despite Tamaulipas and Yucatán ranking among Mexico's top five wind energy producers, these states lack specific legislation concerning wind farm development.

To facilitate the preparation of environmental impact statements that wind farm promoters must present, the Ministry of Environment and Natural Resources offers two guides; whose content is based on what is requested in articles 12 and 13 of the regulations of the General Law of Ecological Balance and Environmental Protection (Reglamento de la Ley General del Equilibrio Ecológico y la Protección al Ambiente en Materia de Evaluación del Impacto Ambiental, 2000). These guides provide general recommendations to facilitate a more systematic, efficient, and comprehensive integration of study outcomes that assess the environmental impact of wind farm installations.

One of the guides offered is particular and the other is regional. The regional guide is applicable to projects that meet one or more of the following criteria: 1) projects which surface is greater than 500 hectares, 2) projects which works or activities are included in a partial urban development or ecological planning plan or program. ; 3) projects that intend to be carried out in a specific ecological region; and/or 4) projects that intend to be developed in places where, due to their interaction with the different regional environmental components, cumulative, synergistic or residual impacts are expected to cause the destruction, isolation or fragmentation of ecosystems. In all other cases, the particular type guide should be used (Reglamento de la ley general del equilibrio ecológico y la protección al ambiente en materia de evaluación del impacto ambiental, 2014).

These guides request a description of the state of the fauna present on the site before the development of the wind farm; they also request the identification of possible impacts on the fauna derived from preparation, construction, operation, and abandonment activities. Finally, the guides request the proposal of measures for prevention and mitigation of negative impacts.

Based on the review of the resolutions of the wind projects, Table 2 shows the main conditions requested by the Ministry of Environment and Natural Resources from the promoters to protect bats in wind farms (Secretaría del Medio Ambiente y Recursos Naturales, 2023).

In addition to the environmental impact assessment, other environmental policy instruments include the Ecological Territorial Planning (Programa de Ordenamiento Ecológico del Territorio). This instrument's objective is to regulate or induce the use of land and productive activities to achieve environmental protection and sustainable use of natural resources. In this sense, it was found that four federal entities in Mexico have some ecological regulation criteria for wind farms and bats in their ecological territorial planning (Table 3).

Table 2. Conditions requested by the Ministry of Environment and Natural Resources regarding bats in wind farms.

Description of bats
Diversity of resident, and migratory bats throughout the study cycle Distribution and abundance by species throughout the study cycle Flight behavior (arrival, flight height, flight directions) Nesting, feeding, or roosting areas in the zone and area of influence of the project
Identification of impacts
Estimation of the risk of collisions with wind turbines and analysis of consequences at the level of bat populations and communities
Measures
Presentation of a Monitoring Program for Birds, Bats and Butterflies, where they must establish the appropriate methodology for monitoring these groups and the corresponding results Proposal of actions to minimize the impacts on individuals of bat species that could be affected Record of collisions in wind turbines for each species, resident or migratory, wind turbine number, and analysis of the consequences at the level of populations and communities Reestablish and/or restore nesting, shelter and feeding areas that were affected by the project Noise study (day and night) focused on determining the alteration that wind turbines create in the behavior of bat species Implement a system capable of detecting large flocks of bats early, allowing wind turbines to be stopped to avoid collisions Present biannual reports on bat monitoring during the preparation, operation and maintenance stage to know the behavior and flight heights in order to implement, where appropriate, additional measures to prevent and reduce collisions in the operation stage

Table 3. Regulation criteria for wind farms and bats in Ecological Territorial Planning

Federal entities	Ecological criteria	Description
Baja California	EOL 01	The installation of wind farms should be avoided in Natural Protected Areas, Ramsar sites, and Important Bird Area (IBA), as well as in areas where they alter or put at risk the migratory corridors and routes of birds and bats ¹
	EOL 02	Specific measures must be established to avoid, prevent, mitigate or minimize the potential risks of collisions of birds and bats with wind turbine blades during their operation ¹
	EOL 03	To know the current status of bird and bat populations, prospective studies should be carried out to monitor the populations of resident and migratory birds and bats ¹

Table 3 Continued. Regulation criteria for wind farms and bats in Ecological Territorial Planning

Federal entities	Ecological criteria	Description
Oaxaca	C-047	The negative effects caused by the installation of wind generators on wildlife and their environment should be prevented and, where appropriate, repaired ²
Tabasco	ER1	The installation of wind farms, cogeneration fields and other renewable energy activities must have an environmental impact assessment and authorization from the competent authority ³
	ER2	The establishment of wind farms should be avoided in Natural Protected Areas, Ramsar sites, and Important Bird Area (IBA), as well as in areas where they alter or put at risk the migratory corridors and routes of birds and bats ³
	GN18	Restrict the establishment of thermoelectric plants, hydroelectric plants, wind farms and refineries in conservation environmental management units (UGA), priority conservation and coastal protection areas, prior technical justification and corresponding authorization ³
Yucatán	No.65	For the development of the wind industry, an environmental impact study must be presented and detailed studies of the site on geology, hydrogeology, topography, geophysics and geotechnics will be required, as well as the evaluation of at least one year on the populations of felines, bats, birds and migratory routes within a 50 km radius. Likewise, evaluations will be carried out on noise and visual impact. The wind industry will preferably be established on agricultural land ⁴

¹ Programa de Ordenamiento Ecológico del Estado de Baja California, México. 3 de julio de 2014. Periódico Oficial del Estado de Baja California. Tomo CXXI, No. 34.

² Resumen del Programa de Ordenamiento Ecológico Regional del Territorio del Estado de Oaxaca. 27 de febrero de 2016. Periódico Oficial del Estado de Oaxaca.

³ Programa de Ordenamiento Ecológico Regional del Territorio del Estado de Tabasco. 14 de febrero de 2019. Periódico Oficial del Estado de Tabasco. No. 138.

⁴ Programa de Ordenamiento Ecológico del Territorio Costero del Estado de Yucatán. 20 de marzo de 2014. Diario Oficial del Estado de Yucatán. Decreto 160/2014.

The ecological criteria that are included in territorial planning vary from some that are very general to others that are more specific. For example, in the case of Oaxaca, the state with the greatest wind development in Mexico at this time, there is no specific criterion to prevent or mitigate the impacts of wind farms on bats. Yucatán is another state with notable development of wind energy. It is the only state in the country that specifies the minimum duration of bat population evaluations that must be conducted before the installation of wind farms.

Finally, a tool proposed by bat specialists, through the Latin American and Caribbean Network for the Conservation of Bats is the decree of Areas and Sites of Importance for the Conservation of Bats (AICOMs and SICOMs respectively). The objective of this initiative is to protect bats from certain threats, such as the installation of wind farms. Currently Mexico has thirty areas and one site of importance for the conservation of bats (RELCOM, 2024) (Figure 1); however, the declaration of these areas has no legal weight so the establishment of wind farms on these sites does not violate any law.

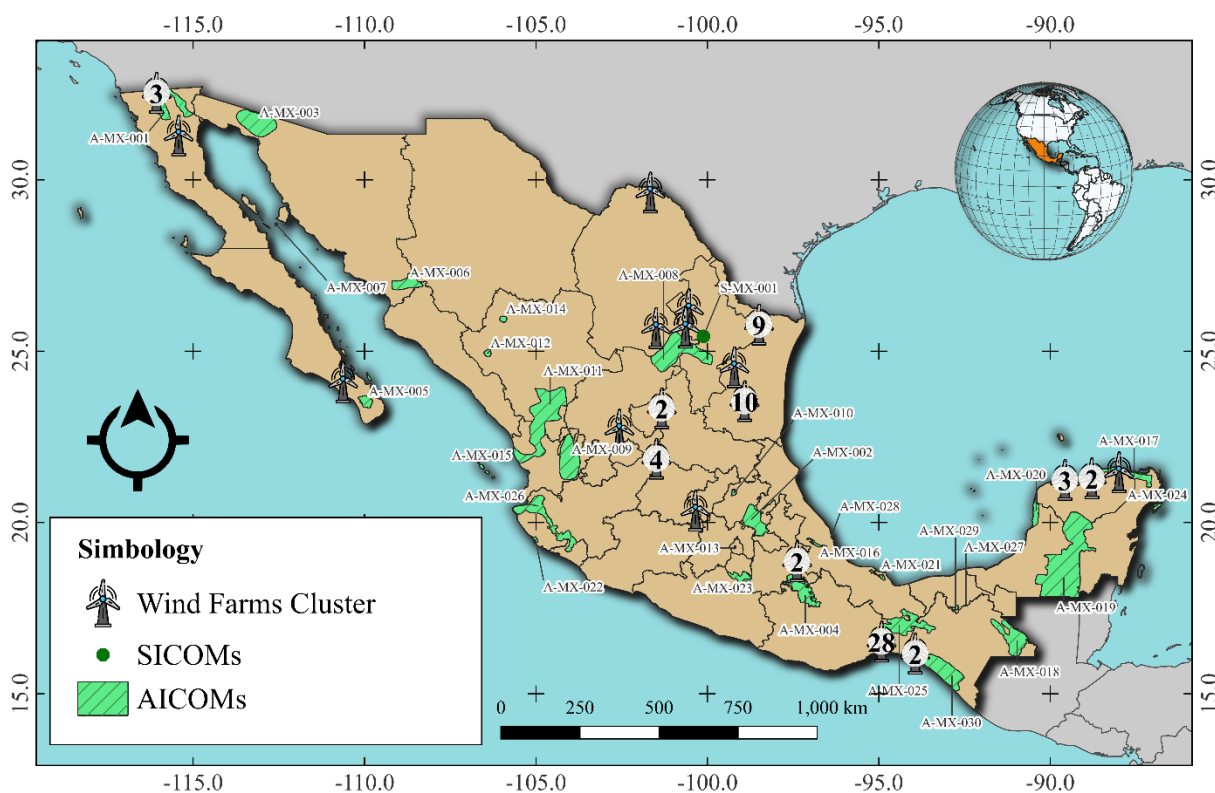


Figure 1. Areas and Sites of Importance for the Conservation of Bats and Wind Farms in operation in Mexico

Conclusions

The impacts of climate change and the heavy reliance on fossil fuels in our current energy model have highlighted the necessity of developing or adapting legal frameworks to transition towards cleaner energy models that incorporate renewable sources, such as wind energy.

Internationally, this commitment is demonstrated through the signing of treaties, agreements, and conventions. For Mexico, key undertakings to decrease greenhouse gas emissions and promote renewable energy include joining the Paris Agreement, the Kyoto Protocol, and the Rio Declaration.

On the other hand, the modernization of the electricity sector is evident in the recent changes made to articles 25, 27, and 28 of the Political Constitution of the United Mexican States. These articles govern the energy sector in Mexico and were revised to prevent the privatization of companies involved in energy production and consumption.

Also in the Mexican legislative framework, the changes that are taking place in the renewable energy and energy efficiency sector have been reflected with the relatively recent publication of the Energy Transition Law (2015), the Electrical Industry Law (2014), the Law for Sustainable Energy Use (2008), and the Law for the Promotion of Renewable Energies and Financing of the Energy Transition (2008).

It was revealed that only the state governments of Baja California, Colima, Chihuahua, Durango, and Oaxaca have specific legislation regarding renewable energy at the state level. However, none of these laws address the potential impact of wind farm operations on bat populations.

When it comes to regulating the impact that the construction and operation of wind farms have on bats, it has been found that the key mechanism is the preparation of Environmental Impact Statements, as outlined in the General Law of Ecological Balance and Environmental Protection. However, the guidelines provided by the Ministry of the

Environment and Natural Resources for these statements do not contain specific criteria for assessing the impact on bats. Furthermore, compliance with these guidelines is voluntary.

In the conditions of the Ministry of Environment and Natural Resources, the promoters are requested to describe the bats present in the area where the wind farms will be installed and identify the possible impacts on them and measures to minimize them, nevertheless it is not specified which methods should be used to study bats or the minimum duration that these studies should have.

The most important regulation for the protection of bats in Mexican wind farms is the NOM-059-SEMARNAT-2010. If any species listed in this norm is found in the construction area of a wind farm, an assessment of the potential impact on these species and proposed measures to minimize the impact must be conducted.

Finally, it was found that the Ecological Territorial Planning of only four states of Mexico, do include criteria to consider the selection of the site where it is intended to install wind farms, considering the sites of importance for bats. In no legal instrument was there any mention of areas of importance for bats that have been officially decreed, however The Latin American and Caribbean Network for the Conservation of Bats made a proposal of 30 areas and one site of importance for the conservation of bats in Mexico. By spatially locating the wind farms that are currently in operation, it was observed that some were built in these areas of importance for bat conservation.

Taking into account the findings of this study, it can be concluded that the existing regulatory framework has propelled wind energy development in Mexico and globally. However, there is a significant scarcity of specific instruments within Mexico that are geared towards averting or lessening the effects of wind farms on bat populations. This scarcity is observed at all scales, particularly in official Mexican standards and state laws.

This work provides an initial approach to analyzing existing regulations in Mexico for wind farms and bats, through which it was possible to identify areas of opportunity. Because wind energy is expected to continue being developed in Mexico, conducting an in-depth analysis to ascertain the adequacy of these guidelines in addressing and mitigating the impact of wind farms on bats in Mexico is strongly recommended.

Future work

Although there is a regulatory framework in Mexico to prevent, evaluate and mitigate the impacts of the operation of wind farms on bats, the development of more specific guides is recommended to help wind farm developers in the preparation of environmental impact statements.

For example, these guidelines should contain the recommended methods for studying bats, as well as the minimum suggested duration of these studies. The inclusion of these methodologies would help to more accurately evaluate the impacts of the operation of wind farms on bats, in addition to helping obtain data comparable with other projects in the country and in the world. Other aspect that it is necessary to incorporate in these guidelines are the methods for the evaluation of cumulative and synergistic impacts as part of the Strategic Environmental Assessment.

Besides, the declaration of Areas and Sites of Importance for the Conservation of Bats can be a valuable tool for decision-making sectors. These environmental policy instruments can help standardize criteria to evaluate the viability of the development of wind projects by considering the potential impact on bats. For this purpose, it is important that these areas are incorporated into Mexican legislation in laws such as the General Wildlife Law.

To ensure the protection of the bat species most affected by the operation of wind farms, it is necessary that the results of mortality findings in wind farms be documented and published. Based on these data, it will be possible to assess whether the regulations of NOM-059-SEMARNAT 2010 are sufficient to protect these species.

Additionally, studies are required on how bats are affected by the noise of wind turbines in order to adjust the maximum permitted limits of noise emitted by wind turbines established in the NOM -081- SEMARNAT.

Finally, it is recommended to work together with researchers, environmental consultants, wind farm promoters and environmental organizations to further analyze the existing guidelines for the protection of bats in wind farms and be able to make a proposal for more specific and appropriate guidelines according to the context in Mexico.

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