How to Join the Wind Sector Value Chain in Mexico

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The purpose of these case studies is for INE to share its work in the region, the problems and challenges it encountered, and the lessons it learned. *How to Join the Wind Sector Value Chain in Mexico* was written by Jesús Tejeda, María Julia Molina, José Antonio Urteaga and Christiaan Gischler of the IDB Energy Division, Marco Borja, former INEEL staff member, and Andrés Duque and Benedicte de Waziers, consultants. *Infrastructure for Development* is led by Olga Morales. It was launched by Tomas Serebrisky and Ancor Suárez-Alemán.

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How to Join the Wind Sector Value Chain in Mexico

Wind power

Wind is one of the most remarkable phenomena on Earth. It comes from the planet's rotations and movements and temperature changes in the atmosphere, which cause changes in pressure and the resulting movement of air masses. Wind has always influenced mankind in one way or another. In Greek mythology, Aeolus was the god of the winds. In Mesoamerica, the Aztec god of wind Ehécatl "gave life to all that was lifeless." The Egyptians called on the know-how of the shipwrights[1], who, by understanding wind conditions, designed and built vessels that sailed the Nile on wind power.

In the seventh century, the Persians developed rudimentary windmills for their farms. France and England adopted this technology for their own use in the twelfth century, and in the sixteenth century, the Spanish made significant advancements the use of windmills, a technology they had inherited during the Roman conquest and perfected with the help of Arab engineers. This is how they were able to master the techniques necessary to generate energy from wind. It is no coincidence that Miguel De Cervantes spoke of those "giants" that he confused with windmills in Don Quijote de la Mancha, published in 1605.

With the advent of the Industrial Revolution and the introduction of the steam engine in the nineteenth century, the dynamo was invented, which paved the way for the first turbine that could generate electricity. Although wind turbines didn't arrive in Latin America and the Caribbean (LAC) until the end of that century, the dynamo was already helping to produce electricity in Santiago de Chile and Rio de Janiero, followed soon after by Costa Rica, which opted for hydropower.

The global oil crisis in 1973 led to renewed interest in renewable energy in developed countries. The technological advances made during that time motivated countries like Mexico and Brazil to explore the beginnings of a Latin American wind sector in the 1980s. In fact, a 1994 pilot program in Mexico tested options with seven wind turbines (see Box I: Wind power and wind turbines), the foundation of the country's first wind energy plant. It was determined that some regions were more promising that others, such as the Isthmus of Tehuantepec in Oaxaca, where wind speeds make it an ideal location for a wind farm. This was the first step in establishing what is today Mexico's most important wind corridor, and one of the world's largest.

Today, more than half of Latin America's wind power capacity is in Brazil, which leads the region in this kind of development. According to the Global Wind Energy Council (GWEC), it added 2 GW (gigawatts) in 2016, for a total installed capacity of 10.7 GW. Mexico is in second place, having added 454 MW (megawatts) in 2016 for a total of 3.7 GW. Its capacity grew by 27.6% between 2017 and 2018, reaching 4.8 GW in 2018.

Diversifying the energy mix: more renewable energy

In modern times, Mexico has always produced more energy than it consumes thanks to the country's oil and water resources. The beginning of the twenty-first century saw a decline in investment in oil and natural gas production, which was too low to meet domestic demand. Crude reserves dropped and extraction became more expensive. Meanwhile, international prices were increasingly volatile. This situation has intensified in recent years due to a sustained increase in fuel imports. Mexico recorded its first energy deficit[2] in 2015 (3%), which then rose sharply in 2017 (to 24%).

In LAC in 2017 and 2018, an average of 25% of energy produced came from renewable sources. For Mexico, that number is just 8%. Wind energy emerged as one of the most interesting options for diversifying energy sources because it offered competitive advantages over other alternatives in certain regions. The need for renewable and sustainable energy, ensuring that it could meet the country's energy demand and fulfill promises made to the international community to reduce greenhouse gas emissions[3], became a high priority for the Mexican government.

2 The energy deficit is recorded as the energy security index, which is the relationship between total energy consumption and primary energy production. This first emerged as an issue in 2017 when it was recorded as 0.97. It was 0.84 in 2016, and 0.76 in 2017.

3 In its National Greenhouse Gas Inventory, the National Institute of Ecology and Climate Change reported that Mexico emitted 683 million tons of carbon dioxide in 2015, making it the 12th largest emitter in the world. The Energy Transition Act was passed that same year, declaring that 35% of domestic energy production must come from renewable sources by 2024.

BOX 1

Wind power and wind turbines

Wind power is the use of wind to generate energy, where the movement of air is converted into electricity. It is an excellent renewable resource that can offer competitive advantages over alternatives in some areas.

The machines that convert wind power into electricity are called wind turbines. They can be installed alone or in groups, on a wind farm or at a wind power plant.

The most common kind of wind turbine has a rotor with three blades, where the speed of rotation is relatively slow. Gearboxes can increase their speed to feed traditional electrical generators. There are also gearless wind turbines with multipole electrical generators. A wind turbine may have more than 8,000 parts, but all of them have the following essential elements: (i) the blades, which are typically made of fiberglass, capture the wind's kinetic energy and turn it into mechanical energy that they transfer to the rotor hub; (ii) the hub is where the blades come together; (iii) inside the nacelle is a powertrain made up of a main shaft, a gearbox (if applicable) and a generator, all mounted on a frame with a mechanism that allows the rotor to be pointed in the direction of the wind; (iv) the tower supports the turbine and transfers the dynamic load toward a reinforced concrete base. Today's wind turbine blades can measure a few meters long for small turbines, up to more than 60 meters for large ones. The towers can range from 20 meters to 100 meters in height. Wind turbines must meet several requirements: they must operate safely, reliably, and efficiently, for as little money as possible for at least 20 years.

Mexican Wind Machine (MEM)*

Parts (MEM)

1. Tower

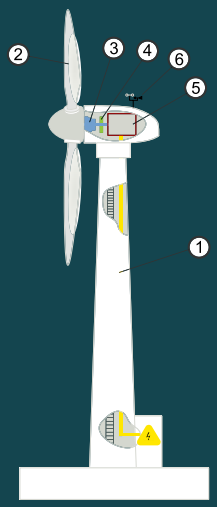
2. Blades

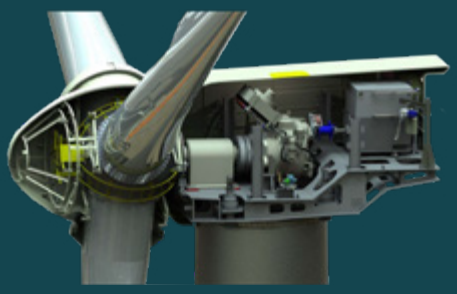
3. Turbine support

4. Gearbox

5. Generator

6. System for capturing the wind's speed and direction





Detail view of powertrain: Rotor and navelle

Reference images

Addressing the issue

The Mexican government delegated the task of finding and implementing energy solutions to INEEL (National Institute of Electricity and Clean Energy), which had been working on an action plan to remove obstacles to wind power development in Mexico since 2004. Even back then, it was understood that developing and manufacturing wind turbines in Mexico was feasible. The idea was to install systems that were adapted to the electrical grid and reduce the costs of transporting and maintaining equipment manufactured in other countries, with a focus on domestic job creation.

The Special Program for Renewable Energy Use, launched in 2009 by SENER[4] (the Secretariat of Energy), also provided a platform for the government to commit to increasing installed capacity and energy generation from renewable sources, including wind power. The program enabled necessary conditions to build wind farms, and the country's laws and regulations created a nurturing environment for their development.

However, at that time, development policy was largely designed to facilitate foreign investment, and not the local capacity development that would let Mexican businesses and individuals join the wind sector value chain. The short-term challenge was to find one or more ways that Mexico could join this value chain by identifying the best opportunities and building the capacity to take advantage of them.

INEEL and the Inter-American Development Bank determined that distributed generation could be one of these niches because of a pre-existing global trend toward smart mini grids based on renewable energy converter systems and storage methods that interface with each other and the grid. According to international projections, these mini grids are expected to proliferate starting in 2025. In Mexico, the smart grid technology road map has it scheduled for 2030.

4 CENER (National Centre for Renewable Energies) is a Spanish technological institution that does applied research in renewable energies and provides technological support to energy companies and institutions in six areas, including wind power

The first step to reaching this goal was to determine whether Mexico had the technical capabilities and resources to complete a project of this size. The Inter-American Development Bank (IDB) and INEEL carried out joint studies and targeted measures to find out. The studies concluded that there were some public R+D centers and Mexican companies with the potential capacity to handle the proposed project; they had the appropriate infrastructure and capabilities to manufacture and develop the various wind turbine components. But the studies also concluded that many potential designers and manufacturers were unfamiliar with the techniques needed to achieve the final product. This is where Spain's National Centre for Renewable Energies (CENER) came in to consult on building the blades with local technology.

Wind power

The Mexican government and INEEL determined that a significant part of the project would be in the Isthmus of Tehuantepec, specifically in Juchitán de Zaragoza. It has 93 thousand inhabitants, making it the fourth largest city in Oaxaca. Several indigenous groups, including Chontales, Huaves, Mixes, Zapotecas and Zoques, have been settled there for many years.

Mexico currently has 45 wind farms, 23 of which are located on the Isthmus of Tehuantepec. Most of these supply large private companies, while the rest are independent power producers.

Financing

In 2009, the IDB began to hold talks with the Mexican government through the latter's Secretariat of Energy. INEEL was the designated representative and would act as the executing agency once the project began. Later, with the IDB's assistance, In 2009, the IDB began to hold talks with the Mexican government through the latter's Secretariat of Energy. INEEL was the designated representative and would act as the executing agency once the project began. Later, with the IDB's assistance, INEEL formally applied to the Global Environment Fund (GEF) for the financing it needed to start the project. The GEF gave the Mexican government a US5 million investment grant.

On August 15, 2012, with INEEL as the executing agency and the IDB acting as the GEF administrator, the two parties signed an agreement to implement the Promotion and Development of Local Wind Technologies in Mexico (DETELM). The next step was to meet the conditions to receive the first disbursement. INEEL met the eligibility requirements on 20 May 2013 and the DETELM project officially began.

BOX II

Program information

Name: ME-X1011 – Promotion and Development of Local Wind Technologies in Mexico (DETELM)

Borrower: United Mexican States

Grant from GEF: US$ 5 million
Local support: US$ 13.6 million

Project start date: 20 May 2013

The general objective of the project is to enable local development of wind turbines for distributed generation and contribute to enhancing local capacity so that Mexico can be part of the wind sector value chain.

Executing Agency: National Institute for Electricity and Clean Energy (INEEL)

The hidden challenges of innovation

The process of acquiring certain products or services required a lot of time and effort. Despite following the usual procedures and taking the right steps, the results were not always timely. IDB policy says that "those who design a product may not also participate in its construction or manufacture." This is to separate responsibilities and processes and avoid conflicts of interest. There were significant delays because the tenders were so stringent, and it took longer than expected to get responses from potential suppliers The hiring process for the design and manufacture of the blades was a clear example.

The hiring process for the design and manufacture of the blades was a clear example. This had to be done through a tender process where the best proposals would be selected, and it required an enormous effort. The complexity of the design and manufacturing meant that it took almost a year and a half to prepare and publish the terms of reference and examine the proposals, and then none of the bidders met the necessary conditions.

The most effective way to overcome this obstacle without violating any regulations was to choose the right companies through direct contracting. INEEL partnered with two companies with known experience in the field that met the requirements. This process was overseen and endorsed by the IDB Procurement Division, who also established a set of protocols and commitments in which the parties signed a single contract that assigned them joint responsibility, ensuring quality control over the process.

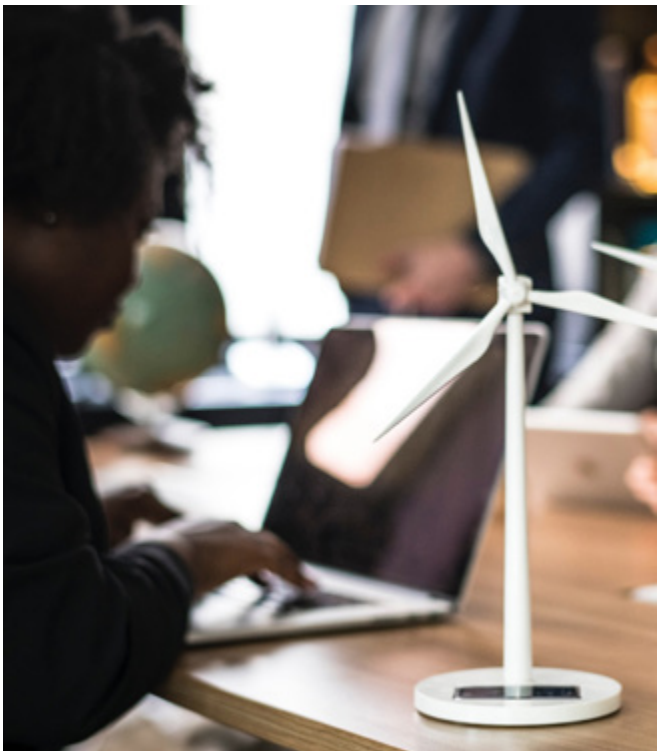
The direct hiring model placed several specialized companies in charge of the knowledge, design feasibility, and development and manufacture of parts, and each organization was assigned tasks based on their experience. They were all under the umbrella of INEEL's partners, who supervised the overall process. This made it easier to join the product value chain while meeting the sector's quality standards.

But the procurement challenges did not end with hiring. They also appeared in routine areas, such as the documentation to validate transactions between the IDB and INEEL. Each organization had their own documents for their own procedures, adapted to international and Mexican regulations, respectively. Often, the parties did not accept or agree on the differences in documentation and coming to an agreement took constant validation. INEEL was concerned about being penalized for using documentation issued by the IDB, and worried that it would lead to audit or internal oversight issues under Mexican law. The parties held several teleconferences and meetings to clear up confusion. Civil servants and relevant departments, such as the legal department and the comptroller, reviewed the documents and verified that they were endorsed by international organizations and conformed to the Mexican government's standards.

Social considerations in the Isthmus of Tehuantepec

But innovation is not the only challenge. Over the years, international companies that have established themselves in Oaxaca have failed to fully understand the communities' cultural traditions and structures. They made promises that went unfulfilled for many, offering economic development that did not materialize at the level residents expected. This affected the trust that locals felt toward new investors and their projects.

The wind sector has made the region's economy more dynamic, moving from personal consumption to a broader market framework. Once the first wind farms were installed, the area saw some isolated benefits that were very gradual and very localized. There are even gaps between residents who benefit from the projects and those who do not get involved due to their opinions or lack of knowledge. This creates tension and disagreements among residents.



BOX III

Ejidos

An ejido is a type of communal property that is directly linked to the preservation of indigenous traditions and customs through land tenure. It gives communities the flexibility to expand their plots or divide them up depending on the population's needs.

Toward the end of the nineteenth century, the government turned the land over to just a few landowners for oil and railroad projects. The 1915 Agrarian Act, largely associated with revolutionary agrarian reform, reversed the situation and reinstated ejidos as collective, undivided land that could not be sold or inherited.

This legislation was altered many times throughout the twentieth century, in line with each government's economic and social goals. One of the most significant changes came from the 1992 Agrarian Act, which determined that, despite the communal nature of ejidos, the General Assembly would have the power to decide which parcels could be granted to an individual, if and when it benefitted the community.

Because of this, INEEL's Regional Wind Technology Center (CERTE), located in the La Ventosa area of Juchitán, Oaxaca, played a central role from the beginning. The wind turbine prototype was placed there for testing, certification, and final approval of its three blades. The local community is familiar CERTE because of its focus on R+D+i programs. It is also home to the Mexican Center for Innovation in Wind Power (CEMIE-Wind) which hosts several R+D+i institutions and some companies. CERTE has a 32-hectare campus and its facilities were built with more support from GEF, as part of a project implemented by INEEL with the help of the United Nations Development Programme.

Setbacks related to changes in government

When a government sets policy, it can encourage projects that are aligned with its strategies or shift the focus away from ones that were designed by a different administration. Shielding these projects from changes of government is a very serious challenge. Mexico's government has cautiously contributed local resources, depending on each administration's renewable energy development strategy.

A new government was installed 1 December 2012, and local resources were frozen. Even though the DETELM project had already started, we had to wait for the government to decide on new renewable energy policies and see how local resources would be directed. In February 2013, the SENER-CONACYT Sustainable Energy Fund.

(FSUE) issued a tender to establish the Mexican Center for Innovation in Wind Power (CEMIE-Wind). INEEL created a consortium to compete in the tender, presenting a proposal with 23 projects. Thirteen of these were approved, one of which was the Mexican Wind Machine (MEM). However, the FSUE only approved 30% of the necessary funds. This mechanism ensured that the project would receive some local resources.

In 2018, another change of government led to another change in strategy. It became clear that the project needed to be protected from new decision makers. On 1 December 2018, new social, energy, and environmental policies were put in place based on the 2018-2024 National Plan. These formed the basis for renewable energy research guidelines that are largely in alignment with the goals of the MEM project, making local support more likely.

Outcomes

The new Mexican industry: Today's innovation and tomorrow's competitiveness

Mexico will celebrate an important milestone with the DETELM project as it will have what it needs to be part of the wind sector value chain. Wind turbine components always had to be imported from other countries, without the benefit of patents, records, or know how. Knowledge transfer was perhaps the greatest, and certainly most valuable achievement of the DETELM project.

As part of the project, Mexico has been training staff and building local industry capacity to design, build, operate, and maintain wind turbines. INEEL holds the patents and records of several prototype components under development. These are examples of innovation within the industry.

The project includes the possibility of transferring technology to investors who want to produce and sell the equipment, with potential support from the development bank, as happened with Nacional Financiera (NAFIN) for the manufacture of the first commercial units. Capitalizing on the acquired knowledge and taking it to other Latin American countries with similar wind conditions is also a possibility. The manufacture and sale of wind turbines will be a tangible project outcome.

The IDB will continue to work alongside INEEL until the project's completion in 2020 when the principal contracts come to an end. By 2032, wind power generation is expected be 4.5 times greater, growing from almost 13,000 GWh today to 62,000 GWh in 2032. This would involve the construction of 107 new wind farms and would mean that 50% of the country's wind capacity would be in Oaxaca. This would help Mexico meet its clean energy goals for electricity generation: 40% of electricity from clean energy by 2035 and 50% by 2050, as laid in the Transition Strategy to Promote the Use of Cleaner Technologies and Fuels.

The project's benefits go beyond the wind turbine prototype to local capacity building with the goal of eventually offering products and services for the distributed generation markets, with a view to implementing smart mini grids. These benefits combine seamlessly with R+D+I goals and the Strategic Plan for CEMIE-Wind supported by FSUE.

Lessons learned

Reducing risks together

Many problems that emerge during an infrastructure project's execution phase can be mitigated with proper planning. It is essential to conduct a detailed assessment to clearly differentiate between participants' real capacity and potential capacity. This will provide a clearer picture of the learning curve. It is also important to have experts who can precisely identify the starting point and scope of projects.

Thoroughly understanding the environment where projects will be implemented is key, as is assessing possible risks and changes. Proper planning in terms of timeline and scope, in line with the financial resources available, is important for success. Coordination and oversight among participants should be intense and objective to avoid omission, delays, deviations, and misunderstandings.

The DETELM development project received a boost in late 2017 and early 2018. A management team made up of different actors (the IDB, INEEL, private sector actors, and others) was responsible for monitoring the project's operations and implementation. They established steps for each tender and activity related to the phases of the program, and identified the risks, bottlenecks, critical path, and consequences of delays. They constantly monitored the project's progress and tracked its different phases with a high degree of detail. Each actor had their own responsibilities, and could report their progress and express their opinions, concerns, and points of view during workshops held for that purpose in order to agree on critical milestones.

One of the tools they used for planning was a results matrix that allowed different actors to align their efforts and share information to create indicators. Workshops were useful for discussing alternatives for project implementation. Based on a risk analysis, they made decisions about the best way to execute the project in the least time possible. In the first quarter of 2018, the project's development was more consistent because all the participants came together in a comprehensive and participatory way. Innovation requires taking calculated risks and having the flexibility to confront adversity. This was the case with the DETELM project, where the project team has faced a constant process of trial and error, taking calculated risks and coming to an agreement on the best ways to get things done.

Being flexible with governments

The DETELM project design is robust and flexible enough to adapt to changes in government. It was not designed for just one government or administration, and certainly not to meet the specific goals of one entity. It has sometimes been subject to slow bureaucratic processes and has continued anyway, thanks to its potential for building the country's capacity to join the wind sector value chain.

From the beginning, the strategy included economic and social development, a commitment to reducing greenhouse gases, support for communities, job creation, and the development of small and medium enterprises, among other issues. These themes let each government work with the project and adapt it to fit their strategies. The DETELM project has been perfectly adapted for social programs and the new development model driven by the new government.

The challenge of sustainability

Continuity and commitment

The right conditions need to be in place to encourage the renewable energy sector, including the following: (i) create a roadmap with the right indicators to measure improved capacity in the wind sector; (ii) pave the way for small businesses so that the financial sector can provide suitable terms; (iii) give incentives to companies that meet quality standards and create jobs; (iv) promote wind sector projects in areas where they can be developed, and more.

According to the Clean Energy Progress Report from SENER, even with current progress, there is still much to do. In 2018, 76% of Mexico's energy came from non-renewable sources, while just 17% came from renewable ones.

Once the project is finished, the Mexican government must use the developed capacity and encourage technology transfer and investment for the sale of direct and indirect products and services, as well as promote continuous improvement and innovation.

BOX IV

How can the wind sector create equitable opportunities for development in Juchitán?

Men and women are treated equally in the Oaxacan region of Juchitán, where women's participation is esteemed and fully respected. The potential for discrimination-free job opportunities is very high in the context of this egalitarian culture. While men farm, raise livestock, and fish, women are responsible for transforming and selling the products that men bring home. Matriarchy in indigenous families is part of daily life and women often manage household finances and participate in ejido assemblies.

Women in Juchitán will play a key role in blade manufacturing. Training both men and women to manufacture wind turbine blades is important, but the local women's manual skill and dedication to local handicrafts is an advantage for the MEM project. Blade manufacturing requires a lot of manual labor and special knowledge and skills that the local women have. Repairing blades for the more than 1,500 wind turbines already installed in the region could provide another possible development opportunity for Juchitán and nearby communities. More than 300 people will have been trained by the end of the project, of whom 60% will be women and 40% men.

This is not the only way women can participate in Juchitán's wind sector. Karla Martinez works in a more complex setting, due to the number of men present. She has worked as a wind turbine maintenance technician for the past five years, repairing the wind turbines on the Isthmus of Tehuantepec.

With engineering coursework and a master's degree, Karla is proud to be the first and, so far, only women doing this job. She has the unconditional support of her husband and daughter, who is surprised that her mother has a job typically held by men. Karla wants to be a source of inspiration for women in the region who want to grow professionally. For now, her ambition is to become a maintenance supervisor.