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Renewable Energies Outlook

2017-2031

RENEWABLE ENERGIES OUTLOOK

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Presentation

Throughout the last years, Mexico has undergone a deep restructuration process due to several Structural Reforms aimed to reach a higher economic and social development. In particular, thanks to the Energy Reform, it has been possible to have access to more resources which were no available before and which guarantee greater energy security.

One of the many achievements of the Energy Reform, specifically related to the development and promotion of renewable energies within the energy matrix, is creating a legal and regulatory scheme that enables the transition towards a more reliable, sustainable, and clean energy model. In addition, due to the country's renewable-sources great potential, it has been possible to integrate higher levels of investment into the development of new projects and efficient technologies. Hence the importance of continuing developing financial and technical instruments such as the Clean Energy Certificates (CELs), the National Inventory of Clean Energies (INEL, for its Spanish acronym), or the National Atlas of High-Potential for Clean Energies (AZEL, for its Spanish acronym), which have a fundamental role in promoting renewable energies.

Additionally, after the sector's opening to new participants, the electricity market has been reinforced with a largest share in renewable energies through new projects, given that at international and domestic level there has been a meaningful reduction of generating costs, which otherwise made difficult the integration of renewable energies into the National Electric System (SEN, for its Spanish acronym) planning.

Mexico continues moving forward with the Reforms and maintains it commitment to be more environmentally friendly; thereby, it should carry out a strategic planning to achieve the clean-generation targets established, strengthen the system, and modernize the Mexican electricity sector as well.

Introduction

Nowadays, clean energies play a significant role in electricity generation and the transportation sector. The constant increase of energy consumption throughout the world, along with the climate change mitigation targets, has forced to take into consideration a larger share of renewable energies in the energy matrix to serve the demand with environmentally friendly sources. However, there are still challenges for the integration of renewable energies, such as accessibility to the transmission grid and the development of storing sources which enable the administration of energy as required and thus avoid supply shortage, mainly during the consumption peaks.

The Renewable Energies Outlook 2017-2031 is an energy policy instrument containing historical as well as prospective information of every renewable energy included in the Electric Industry Law, studies and trends of the renewable energies in Mexico, and which will give a broad panorama that will foster their utilization in the strategic decision making on investment, research, or public policy.

The document Renewable Energies Outlook 2017-2031 was elaborated with information from the *Advances Report on Clean Energies in the Energy Matrix* and the *Development Program for the National Electricity System 2017-2031* (PRODESEN, for its Spanish acronym), and has three chapters.

The first chapter refers to the main laws and regulations to which renewable energies are subjected in matter of electricity and share in the transportation sector. The second chapter displays the historical and prospective diagnosis of each of the renewable energies, where it can be observed the growing trend of some energy sources during the last ten years, such as solar and wind power. The third and last chapter presents a series of studies and trends about subject related to different types of renewable energies.

Executive Summary

The Renewable Energies Outlook is aimed to present a historical panorama of the renewable energies behavior in Mexico and how its share is foreseen within the energy matrix. The document is an analytical tool for varied users such as researchers, scholars, State Productive Enterprises, and investors who require general information.

Renewable Energies Legal and Regulatory Frame

The first chapter describes the main laws which foster the use of renewable energies, as well as the energy public policies and their instruments in order to identify the objectives, lines of action, and target that have been set and determine which of them have influence or represent opportunity areas for the participants to foster renewable energy projects.

Renewable Energies Historical and Prospective Diagnosis

In 2016, the total electricity generation capacity with renewable energies at worldwide level was of 2,011,332 MW, an increase by 8.8% regarding 2015. Hydropower remains the predominant source concentrating 60% for the total global installed capacity.

In Mexico, by the end of 2016, renewable energies increased by 10.17% its installed capacity regarding the previous year. In Mexico, 15.4% of the electricity was generated by renewable energies, being solar and wind power the technologies with the largest growths.

By 2017 and 2031 renewable energies are expected to grow at an average annual growth rate (AAGR) of 7.4%, reaching 135,027 GWh by the end of the period, according to the PRODESEN 2017-2031. It is worth mentioning that solar photovoltaic energy will have a larger share within the energy matrix and will grow approximately 3,543% going from 368 GWh[1] in 2017 to 13,396 GWh in 2031.

Renewable Energies Studies and Trends

This third chapter displays a series of studies and trends aimed to foster electricity generation through renewable sources. The importance of shedding light on these studies and trends in this document is to disseminate them and become a reference in future researches and investment developments, as well as for strategic decision making that foster a better utilization of the country's resources.

The first study is the Atlas of Hydropower Potential, a new support and innovation tool which will help identify places with high hydropower potential in the country and shows a significant progress in the framework of tools which contribute and enable consultation within an environment of shared and updated information.

The second and third studies, currently in progress, show the progress made and try to resolve two challenges the National Electricity Sector is currently facing: the integration of renewable energies in Baja California Sur and the integration of renewable energies in the North American region to achieve the regional target in 2025 of 50% electricity generation with clean energies. Finally, the last study is an analysis on the Benefits of Clean Distributed Generation in Mexico.

[1] Source: PRODESEN 2017-2031. Does not consider Distributed Generation.

Legal and Regulatory Framework of Renewable Energies

With the amendment of the constitutional framework and the strengthening of the secondary laws, the public policy in matter of renewable energies has been substantially benefitted. Before the Energy Reform the promotion and share of renewable energies was limited, since they could only be considered for electricity generation through private investment under modalities with restricted intervention. The Energy Reform gives legal certainty to the private participation in generation and the country is opened to the new electricity market. As for the development of biofuels, the new legislation establishes promotion mechanisms aimed to contribute to the reduction of greenhouse gas (GHG) emissions in the motor-carrier sector.

This chapter describes the main laws that promote the use of renewable energies as well as their energy public policies and instruments in order to identify the objectives, action lines, and targets set, at global level, and determine which of them have an influence or represent opportunity areas for the participants to foster renewable-energy projects.

1.1.Strengthening of the Legal and Regulatory Framework

One of the Energy Reform objectives is to reduce the consumption and dependency on fossil fuels, fostering a larger use of renewable energies. Hence, identifying the difference between *Clean Energies* and *Renewable Energies* helps contextualize the scope of this document in fostering them.

The Electric Industry Law[2] (LIE, for its Spanish acronym) define clean energies as:

Article 3, Section XXII, Electric Industry Law:
• *"Energy sources and electricity-generation processes whose emissions or residuals, if the case, do not overpass the thresholds established in the regulatory provisions issued for such purpose".*

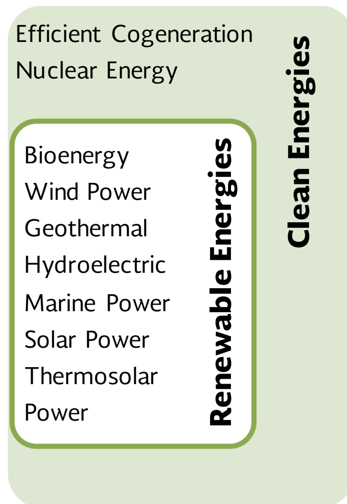
As for the Energy Transition Law[3] (LTE, for its Spanish acronym), it defines renewable energies as:

Article 3, Section XVI, Energy Transition Law:
• *"Those whose source lies in natural phenomena, processes or materials susceptible of being transformed into energy utilizable by humans, which are generated naturally and thus, are continually and periodically available, and do not release pollutant emissions when being generated".*

As it can be observed in Figure 1.1., renewable energies are comprised within clean energies:

[2] For further details, see http://www.dof.gob.mx/nota_detalle.php?codigo=5355986&fecha=11/08/2014
[3] For further details, see http://dof.gob.mx/nota_detalle.php?codigo=5421295&fecha=24/12/2015

FIGURE 1. 1. DIFFERENCE BETWEEN RENEWABLE ENERGIES AND CLEAN ENERGIES



Source: Elaborated by SENER.

1.1.1. Political Constitution of the United Mexican States

The Political Constitution of the United Mexican States [4] (CPEUM, for its Spanish acronym) is the set of laws within the highest hierarchy within the Mexican Legislation and establishes the acting framework of the authorities, through principles, rights, and obligations which govern the rest of the national legal framework.

Within the CEPEUM there are a series of articles related with the implementation of renewable-energy projects, as shown in Figure 1.2.

FIGURE 1. 2. CONSTITUTIONAL FOUNDATIONS IN MATTER OF RENEWABLE ENERGY

Political Constitution of the United Mexican States			
Art. 4.	***Art. 25.***	***Art. 26.***	**Art. 27.**
...Any person has the right to a healthy environment for his/her own development and well-being. The State will guarantee the respect to such right. Environmental damage and deterioration will generate a liability for whoever provokes them in terms of the provisions by the law....	*The State shall command the development of the Nation to: be integral and sustainable; strengthen national sovereignty and democracy; and, through competitiveness, fostering economic growth, employment rates and a fair distribution of income and wealth, to allow the full exercise of liberty and dignity to individuals, groups and social strata, which security is protected by this Constitution...*	*A. The State shall organize a democratic planning system to support national development, which shall provide solidity, dynamism, competitiveness, continuity and equity to economic growth for the political, social and cultural independence and democratization of the nation....*	... The Nation shall exclusively carry out the planning and control over the national electric system, and over the power transmission and distribution utilities. No concession shall be granted in these activities, notwithstanding the power of the State to execute contracts with private parties in accordance with the laws, which shall determine the ways in which private parties may participate in all other activities related to the electric power industry....

Source: Elaborated by SENER.

[4] http://www.diputados.gob.mx/LeyesBiblio/pdf/1_240217.pdf

To guarantee free competency in the energy market, Article 28 of the CEPEUM establishes:

Article 28, Political Constitution of the United Mexican States:

- *"... The functions carried out by the State in an exclusive manner in the following strategic economic sectors shall not be considered monopolistic: post, telegraph, radiotelegraphy; radioactive minerals and nuclear power generation; planning and control of the national power system and the public power transmission and distribution systems; the exploration and exploitation of oil and other hydrocarbons, pursuant to paragraphs six and seven of the 27th Article of this Constitution, as well as any other activity expressly determined by the laws issued by Congress."*

1.2. Secondary Legislation

To comply with this mandate, the Constitution emanates a series of Laws which enable the opening of the electricity supply to private participation with the purpose of a larger promotion of the renewable energies in the energy sector planning.

1.2.1. Organic Law of the Federal Public Administration

The Organic Law of the Federal Public Administration, in its article 33 states that it corresponds to the Secretariat of Energy (SENER, for its Spanish acronym) to establish, lead, and coordinate the country's energy policy. Hence, the SENER should prioritize energy security and diversification, as well as energy saving and environmental protection. This same article, in its Section V[5], determines SENER has the attribution to carry out the energy planning in the medium and long term, activity which should consider criteria of energy sovereignty and security, progressive reduction of the environmental impacts from the consumption and production of energy, a larger participation of renewable energies, energy saving, and the higher efficiency on their production, among other.

1.2.2. Planning Law

Establishes standards and basic principles for conducting the National Development Planning as well as the basis for the functioning of the Democratic Planning National System. Likewise, and according to article 4° of the Law, the Federal Executive is in charge of leading the national development planning.

1.2.3. Law of the Coordinating Regulatory Organs in Energy Matter

The Law of the Coordinating Regulatory Organs in Energy Matter lay the foundations for the organization and operation of the Coordinating Regulatory Organs, which are the National Hydrocarbons Commission (CNH, for its Spanish acronym) and the Energy Regulatory Commission (CRE, for its Spanish acronym). In such way, and in order to promote a competitive and efficient energy sector, the State will exercise its functions as technical and economic regulator in matter of electricity and hydrocarbons through these entities.

[5] For further details, see http://www.diputados.gob.mx/LeyesBiblio/pdf/153_190517.pdf

1.2.4. General Law on Climate Change

On June 6, 2012, the DOF published the General Law on Climate Change (LGCC, for its Spanish acronym) which is aimed to guarantee the right to a healthy environment, sustainable development, as well as the preservation and restoration of the ecological balance. One of the main characteristics of the LGCC is it establishes a group of targets to conduct Mexico's performance towards a low-carbon economy. Regarding the emission of greenhouse effect gases and compounds (GHG), Article Second Transitory of the LGCC assumes an aspirational target of reducing them by 30% regarding the base line; as well as a 50% emissions reduction by 2050 regarding the emissions produced in 2000. Likewise, Article Third Transitory of the LGCC establishes as a target to achieve at least 35% of electricity generation based on clean energies by 2024.

1.2.5. Law of the Electric Industry

The Law of the Electric Industry (LIE, for its Spanish acronym) is born out from the strengthening of the process for Planning the SEN and was decreed on August 11, 2014 as a Regulatory Law of the CPEUM. This law establishes a free-competency regime for generating and trading electricity, besides including the participation of private parties in the public service of transmission and distribution, under new contracting models which consider that, just as in the planning and control of the SEN, such activities are still exclusive of the State.

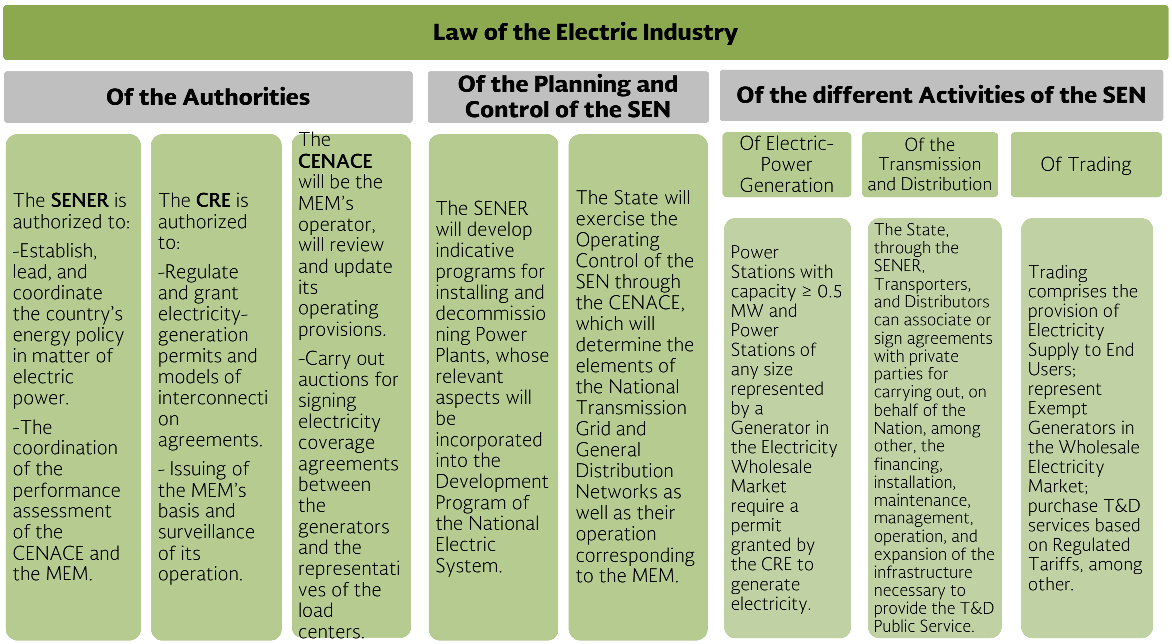
Article 11, Electric Industry Law:

- *"The Secretariat of Energy has the faculty to: … III. Manage the planning and elaboration process of the Development Plan of the National Electric System."*

One of the LIE's objectives is to foster the sustainable development of the electric industry and guarantee its continuous, efficient, and safety operation in the users' benefit, as well as the compliance with the obligations of public and universal service, clean energies, and reduction of pollutant emissions.

The main provisions of the LIE establish the faculties of authorities, Planning and Control of the SEN, and the diverse activities related to the electricity sector, as display in Figure 1.3.

FIGURE 1. 3. MAIN PROVISIONS OF THE LIE



Source: Elaborated by SENER.

1.2.6. Energy Transition Law

The Energy Transition Law (LTE, for its Spanish acronym) was issued on December 24, 2015 in the DOF and is aimed to regulate the sustainable utilization of energy, as well as the obligations in matters of clean energies and reduction of pollutant emissions of the electric industry, maintaining the competitivity of the production sectors (see Figure 1.4).

As supporting mechanisms, the LTE establishes as planning instruments of the energy national policy in matter of clean energies and energy efficiency the Transition Strategy to Promote the Use of Cleaner Technologies and Fuels, the Special Program of Energy Transition, and the National Program for the Sustainable Utilization of Energy (PRONASE, for its Spanish acronym), which should be reviewed annually with the participation of the SENER, CRE, CENACE, and the National Commission for the Efficient Use of Energy (CONUEE ,for its Spanish acronym).

The LTE entrusts the Transition Strategy to Promote the Use of Cleaner Technologies and Fuels, to establish Targets for serving the electricity consumption through a portfolio of alternatives which include Energy Efficiency, and a growing proportion of generation through clean energies under economic-viability conditions.

FIGURE 1. 4. MAIN OBJECTIVES OF THE ENERGY TRANSITION LAW

Energy Transition Law	Foresees the gradual increase of Clean Energies' share in the Electric Industry in order to comply with the targets established in matter of clean-energies generation and emissions reduction.
	Enable the compliance of the Clean-Energies and Energy-Efficiency targets established in this Law in a feasible economic way.
	Establish mechanisms to foster clean energies and pollutant-emissions reduction.
	Reduce, under feasible-economic conditions, the generation of pollutant emissions in electricity generation.
	Reduce, under feasible-economic conditions, the generation of pollutant emissions in electricity generation.

Source: Elaborated by SENER.

1.2.7. Geothermal-Energy Law

The Geothermal Energy Law (LEG, for its Spanish acronym) was published along with the LIE, and is aimed to regulate the reconnaissance, exploration, and exploitation of geothermal resources to utilize the subsoil thermal energy within the national territory limits. Hence, it establishes the rules to record the reconnaissance, issuing of exploration permits, as well as exploitation licenses.

1.2.8. Law of Biofuels Promotion and Development

The Law for the Promotion of Development of Biofuels was enacted on February 1st, 2008 in order to promote the production, trading, and use of biofuels and thus contribute to sustainable development and energy and energy diversification. Specifically, it seeks to promote the production of inputs for biofuels from agricultural and forestry activities, algae, biotechnological and enzymatic processes of the Mexican countryside, without risking the country's food security and foot sovereignty, compliant with what is established in articles 178 and 179 of the Sustainable Rural Development Law.

1.3. Public Energy Policies in Renewable Energies

For carrying out the energy transition, a series of actions, strategies, programs, guidelines, and standards are required to achieve an energy sector based on clean technologies, energetically efficient, and which fosters the productivity, sustainable development, and social equity in the country.

The institutional framework for promoting energy generation through renewable resources was established in a variety of programs and strategies described below.

1.3.1. National Strategy on Climate Change

Planning instrument which defines the long-term vision, and which also governs and leads the national policy and a route which establishes national priorities and define the criteria for identifying regional priorities. It contemplates the country will have a sustainable grow and will foster the sustainable and equitable management of its natural resources, as well as the use of clean and renewable energies which enable a development with low emissions of greenhouse gases and compounds.

1.3.2. Transition Strategy to Promote the Use of Cleaner Technologies and Fuels

This strategy is a planning instrument of the energy national policy in matters of clean energies and energy efficiency that will be subjected to a process of continuous improvement which includes the assessment of its partial results, the identification of barriers to achieve its objectives, the identification of other improvement opportunities, and the adoption of corrective measures in the case that some compliance indicators do not achieve the committed results.

It establishes the clean-generation targets to 35% of the electricity total generation by 2024; of 37.7% by 2030, and of 50.0% by 2050, as well as the energy-efficiency targets of reducing 1.9% the energy intensity by final consumption during 2016-2030, and 3.7% during 2031-2050, with a 2.9% average.

The Strategy should comprise a long-term component for a 30-year period which defines the scenarios suggested to comply with the Clean Energies Targets and the Energy Efficiency Target. It will also include a medium-term planning component for a 15-year period which should be updated every three years, once it has been completed what is established in the previous article regarding the long-term component accordingly.

1.3.3. Programs to Foster Renewable Energies

The production of energy using renewable energies brings great environmental, economic, and social advantages, such as low or null emission of GHG, tariffs reduction, generation of direct employment, or the possibility of bringing electricity to remote communities.

The Programs are aimed to strengthen the national policy to reinforce and foster concrete actions for achieving the energy matrix diversification.

Energy Sectorial Program 2013-2018

The Energy Sectorial Program (PROSENER, for its Spanish acronym) 2013-2018 was published in the DOF on December 13, 2013, and it contains estimates of the resources and decisions related to the varied instruments and entities responsible of its execution.

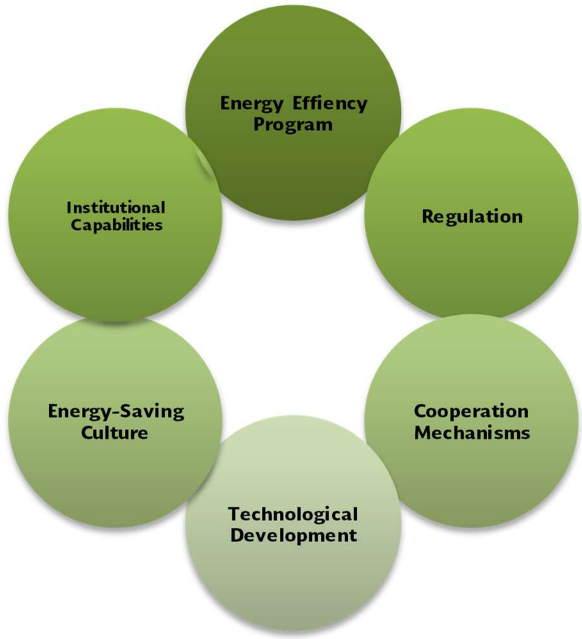
Within the multiple objectives of the PROSENER, there is to expand the use of clean and renewable energies, promoting the energy efficiency and the social and environmental responsibility.

National Program for the Sustainable Utilization of Energy 2014-2018

The National Program for the Sustainable Utilization of Energy (PRONASE, for its Spanish acronym) is developed within the Law for the Sustainable Utilization of Energy compliant with what is established in its second chapter. It establishes the strategies, objectives, actions, and goals which will enable the optimal use of energy in every process and activity from its exploitation, production, transformation, distribution, and final consumption.

To promote and execute the policies focalized in the country's energy; this program takes into account the six substantial elements:

FIGURE 1. 5. SUBSTANTIAL ELEMENTS OF THE PRONASE 2014-2018



Source: Elaborated by SENER.

Special Program for Energy Transition

The Special Program (PETE, for its Spanish acronym) emanates from the LTE, which stipulates it should be elaborated by the SENER as a planning instrument of the national energy policy in matter of clean energies. Its objective is to instrument the actions established in this Strategy for one period of the Federal Public Administration, ensuring its economic feasibility.

The Program is instrumented every year and should pay special attention to the timely expansion of the transmission grid to zones with high potentials for clean energies and its modernization to lead the penetration of growing proportions of clean energies, always under conditions of economic sustainability.

The Program lays out for strategic objectives: i) increase installed capacity and clean-energies generation; ii) expand and modernize infrastructure and increase distributed generation and storage; iii) foster the technological development of talent and value chains; and iv) democratize the access to clean energies.

1.3.4. Electricity Universal Service Fund

The Electricity Universal Service Fund is aimed to expand the electrification of rural communities and marginalized urban zones which have no access to this basic service yet and are far away from the existing grids. In its first stage, the needs of 180 thousand Mexicans will be served, providing lighting, communication, food preservation, and other productive activities which require electricity.

On May 2017, was published the first call[6] for Isolated Systems under the second scheme[7], that is, using photovoltaic solar cells for houses, impacting 898 localities in 11 states, and destining 438 million pesos MXN to install more than 10 thousand systems for the benefit of 45 thousand Mexicans currently lacking electricity.

Isolated Systems are an excellent option, in economic terms, for supplying electricity at a small scale and contribute to the preservation of the environment since they avoid the production of pollutant emissions. Likewise, the communities will be trained on how to keep them, give them maintenance, and make sure the batteries remain working throughout the panels' lifespan.

1.4. Instruments to Promote Renewable Energies

To carry out the energy transition a series of instruments on national policy in matter of obligations on renewable energies and sustainable utilization of energy, in the medium and long terms. The latter, in order to foster a larger share of renewable energies in the sector's planning, diversifying the energy matrix, and reduce – under economic viability criteria – the dependency of the country on fossil fuels as their primary energy source.

As for the reach of the commitment of the maximum utilization of the potential in matter of renewable energies in Mexico, two key instruments were elaborated for the decision making on new investments to produce clean energy and diversify the electricity generating matrix and reduce the dependency of fossil fuels. These instruments are the National Inventory of Clean Energies[8] (INEL, for its Spanish acronym) and the National Atlas of High-Potential Zones for Clean Energy (AZEL, for its Spanish acronym).

1.4.1. Electricity Auctions and Issuing of Clean Energy Certificates

Long-term Electricity Auctions for acquiring new clean-generation capacity are a mechanism to expand the electric power infrastructure and serve the clean-energy supply which Mexico requires. One of the Auctions' objectives is that large energy consumers will be able to obtain electricity from a growing supply from generators and without intermediaries, thus incentivizing competency and the possibility of acquiring better prices.

From the first and second Electricity Auctions, the CENACE[9] reported it was possible to engage an investment of 6,600 million dollars (USD), from which: 34 companies will construct 52 new power stations which will double the solar and wind power infrastructure, adding nearly 5,000 MW of new clean-generation capacity in 15 states of the Mexican Republic which will be benefitted from the results of both Auctions.

From the third Auction, whose verdict was published on November 2017 by the CENACE and the SENER, it was possible to obtain one of the most affordable costs in the world, 20.57 dollars per MWh of solar photovoltaic, and it is expected an investment of nearly 2,400 million dollars for constructing 15 new power stations of clean energies in eight states, adding to the SEN 2,562 MW of electricity generation capacity.

[6] For further details, see http://fsueconvocatoriaaislados.fide.org.mx/
[7] CFE considers two electrification schemes; the first one is conventional and is focused on expanding distribution grids for carrying electricity to communities without it. The second scheme, fostered by the Electricity Universal Service Fund, is the non-conventional electrification through solar panels.
[8] http://inere.energia.gob.mx
[9] For further details, see http://www.cenace.gob.mx/paginas/publicas/MercadoOperacion/SubastasLP.aspx

TABLE 1. 1. TECHNOLOGIES OF THE SELECTED BIDS (PRELIMINARY RESULTS)

Amounts allocated by technology				Share by technology		
Technology	**CEL**	**Energy (MWh)**	**Power (MW-year)**	**CEL**	**Energy**	**Power**
Solar Photovoltaic	3,471,160	3,040,029	10	58.3%	55.3%	1.6%
Wind	2,481,415	2,452,547	83	41.6%	44.6%	13.9%
Gas Turbine	0	0	500			84.4%
Total	**5,952,575**	**5,492,575**	**593**	**100.0%**	**100.0%**	**100.0%**

Source: Elaborated by SENER.

Like in the two first Auctions, CFE will buy Energy, Power, and CELs to the winning generators. However, for the first time, the Auction was opened to different buyers which, as Load Responsible Entities, submitted buying bids in the three electric products.

FIGURE 1. 6. MAIN DIFFERENCES OF THE THIRD AUCTION REGARDING THE PREVIOUS ONES

Third Auction	Creation of the Compensation Chamber, based on what is established in the Transitory Twenty Second of the Energy Transition Law.
	Participation of buyers different to the Basic Services Supplier.
	Values for expected differences by zone.
	The interconnection limits will be "not firm limits" based on the minimum interconnection criteria. The call includes the auction schedule..

Source: Elaborated by SENER.

The CELs are an energy policy instrument implemented to integrate clean energies into the low-cost electricity generation and contribute to formalize long-term contracts between Generators and Mandatory Participants for acquiring CELs under the best possible terms.

In order to foster the energy transition in Mexico towards the clean energy targets established in the LTE, the minimum percentage of clean energy to be consumed by large consumers was gradually increased, in such way that it was fixed in 5% by 2018, 5.8% by 2019; recently, there were established requirements of 7.4% by 2020, 10.9% by 2021, and 13.9% by 2022.

1.4.2. National Inventory of Clean Energies (INEL)

The INEL[10], former National Inventory of Renewable Energies (INERE, for its Spanish acronym) is a technological tool with information about the potential of clean energies, such as solar, tidal, wind, and geothermal power, biomass, and efficient cogeneration, and which can be used to generate electricity.

The INEL, through interactive maps, enable the identification of the existing potential for generating energy, the zones where it is feasible to develop new projects, or even projects currently in development or which have a permit. Information can also be consulted and downloaded from power stations using clean energies currently operating.

[10] For further details, see https://dgel.energia.gob.mx/inere/

FIGURE 1. 7. TYPES OF ELECTRICITY GENERATION POTENTIAL WITH CLEAN ENERGIES

Proved Potential	• Potential based on technical and economic studies which prove the feasibility of their utilization; it can be found in wind and solar powers.
Probable Potential	• Potential based on field studies which prove the presence of the resources, but which are not enough to evaluate the technical and economic feasibility for exploitation; it corresponds to geothermal resources.
Possible Potential	• Theoretical potential of the resources, but which lack of the necessary studies to evaluate the technical feasibility and the possible economic, environmental, and social impacts. In this classification, solar power has the greatest potential, seconded by wind power.

Source: Elaborated by SENER.

The INEL has interactive atlases of high-potential of the renewable sources of energy to enable the identification of feasible zones for the development of projects. In a near future, the Carbon Capture, Utilization and Storage (CCUS) Atlas.

It also has supporting maps which identify the zones with some kind of restriction or condition for developing projects, such as environmental, social, or climatological aspects, or even archaeological zones and historic sites.

1.4.3. National Atlas of High-Potential for Clean Energies (AZEL)

The LTE establishes the annual publishing of the National Atlas of High-Potential for Clean Energies [11] which should include the zones of the country with high potential for clean energies.

The National Atlas of High-Potential for Clean Energies, or AZEL, is a platform which supplements the INEL. The AZEL shows the zone with the highest potential for generating energy through clean sources. Its current version considers solar, wind, geothermal, and biomass energies.

The AZEL enables the identification where is more feasible to develop renewable projects, taking into account technical factors such as: availability of the resource, latitude, altitude, and type of technology to be used. Besides, it can identify possible territorial restrictions related to land-use such as the proximity to urban zones or communities, the existence of historic or archaeological monuments, protected natural areas, hazard-prone zones (floods, earthquakes, volcanic eruptions, etc.). The objectives of the AZEL are: become a supporting instrument for investments in the planning of clean-generation projects and an input for elaborating indicative plans to expand and modernize the National Transmission Network (RNT, for its Spanish acronym) and the General Distribution Grids (RGD, for its Spanish acronym).

The following institutions participated in developing this tool: SENER, Secretariat of Environment and Natural Resources (SEMARNAT, for its Spanish acronym), CFE, Secretariat of Communications and Transportation (SCT, for its Spanish acronym), Management of Civil Engineering Studies (GEIC, for its Spanish acronym), the National Forestry Commission (CONAFOR, for its Spanish acronym), National Institute of Statistics and Geography (INEGI, for its Spanish acronym), National Autonomous University of Mexico (UNAM, for its Spanish acronym), National Institute of Anthropology and History (INAH, for its Spanish acronym), the National Renewable Energy Laboratory (NREL), and VESTAS.

The AZEL also considers the competitivity of renewable energy sources regarding other supplying sources, in terms of the degree of technological matureness and their impact on investment and operational costs; as well

[11] For further details, see https://dgel.energia.gob.mx/AZEL/

as the availability of the interconnection to the grid. The estimate of the potential for each source takes into account the following technologies: fixed photovoltaic and 1-axis tracking flat plat photovoltaic, axial-flux aerogenerator, binary cycle for geothermal, biogas motor generator, and Rankine cycle for direct combustion of residuals.

One of the AZEL's characteristics is having four Scenarios that enable the identification of the projects' feasibility. Each scenario considers a different distance to the National Transmission Network; hence, it is related to different ranges of installed capacity for projects since this distance is a determinant in the construction and recovery costs of a project. AZEL can also analyze zones qualified with high potential, defined as zones far away from the network but which have high density potential for solar and wind power, which will be useful for the planning of the General Transmission Networks and new development regions. Additionally, the AZEL includes informative and restrictive layers for the installation of generating stations, and it even calculates that in the lands for wind and solar power, only between 25% and 3.5% of the surface area, respectively, can be utilized.

The next updates, considered for the AZEL, are: evaluate other sources of clean energy such as hydropower, tidal power, efficient cogeneration, and CCUS, as well as to integrate other variables like the grid capacity (node-level congestion), future transmission/distribution grids, generating-electric costs by technology per node/region; and relevant aspects of political, social, and/or environmental character. The AZEL is expected to be improved through the identification of qualified and/or priority zones for the federal and local governments; zones of interest with developers which can strengthen the expansion and modernization plans for the RNT and which add value to the definition of clean-energies auctions.

1.4.4. Online Renewable Energies (ENRELmx)

The ENRELmx is an effort of the SENER to integrate all the procedures for constructing a renewable-energies projects in the website GOB.MX, through a digital platform which will enable the management of the governmental services at any time (24/7), from any place and device. This will help to increase transparency and reduce discretion and time for obtaining permits, aligned with the objectives of the Program for a Close, Modern Government and the National Digital Strategy.

ENRELmx is aimed to support the development of renewable-energies projects through simplifying the requirements and procedures requested to the developers. This mechanism is designed and constructed to enable management processes to investors for installing new electricity generation projects.

This platform includes procedures related to clean energies of the SENER, the SEMARNAT, the SCT, the CRE, the CENACE, the CONAGUA, and the INAH. The platform is in testing phase and it is expected to have it in productive by the first quarter of 2018.

The ENRELmx has a guide of 38 procedures for wind and solar-photovoltaic power, hydropower, biogas, and geothermal power technologies (exploration and exploitation). The tool contains a critical path that identifies all the necessary procedures and also shows the ones that can be performed simultaneously, reducing thus the average time for the execution of all the project's procedures.

ENRELmx enables investors to enter their procedures online and to follow up the progress of each of their projects and their respective procedures. The progress is displayed in a flow Table where the developer can consult the progress status reported by the organ in charge.

FIGURE 1. 8. FEATURES OF THE ONLINE RENEWABLE ENERGIES PLATFORM (ENRELMX)

- Interoperability and information exchange of the institutions of the Federal Public Administration.
- Provide communication between the federal government and citizens interested in developing renewable-energies projects.
- Trigger the development of projects for increasing electricity generation with renewable sources.
- Speed up the procedures to start up power stations with renewable technology.
- Increase the interoperability and information exchange of the institutions of the Federal Public Administration to speed up management procedures.
- Facilitate the communication between the government and investors interested in developing renewable-energies projects.

Source: Elaborated by SENER.

1.4.5. Interconnection Manual for Generating Stations with a capacity below 0.5 MW

One of the objectives of the Energy Transition is to foster clean distributed generation so users can produce their own electricity, with an outstanding use of photovoltaic systems, due to the high solar radiation potential of the country and to the low international costs of this technology.

In this sense, the Interconnection Manual for Generating Stations with a capacity below 0.5 MW, issued by the SENER, establishes the new technical and administrative guidelines to be followed by the small generators for interconnecting their power plants to the distribution grid.

This instrument grants the access to users and gives them clarity about the interconnection process, and it also simplifies the procedures and reduces the response time of requests to a maximum interval of 18 days.

1.4.6. Amendment to the NOM 016

In 2016, after the NOM-016-CRE-2016[12] was issued, it was authorized the use of anhydrous ethanol in a 5.8% proportion in the zone named Rest of the Country, in order to contribute to the energy matrix diversification. In 2017 it is intended to amend it allow the use of anhydrous ethanol in a 10% in the zone Rest

[12] For further details, see http://www.dof.gob.mx/nota_detalle.php?codigo=5450011&fecha=29/08/2016

of the Country, and field studies are being carried out to assess the possibility of expanding its use in the metropolitan zones.

Additionally, and closely related to this standard, there is a diagnosis for biodiesel made by the SENER in cooperation with the Inter-American Development Bank[13]. This study includes the development of the policy scenarios for its implementation. Likewise, a regulation is being elaborated for establishing the quality of the pure liquid biofuels which will be used to regulate the biofuel that will be used in the Official Mexican Standard referred to.

[13] For further details, see Renewable Energies Outlook 2016-2030

Historical and Prospective Diagnosis of Renewable Energies

The new models of energy markets throughout the world demand a larger use of renewable energies, and nowadays, Mexico is in the avant-garde. In the face of achieving an electricity sector completely diversified, clean, and economically viable, it has been possible to implement a competitive market that fosters the use of renewable energies, as it could be observed in the results of the three long-term Auctions.

One of the challenges of renewable energies, beyond the frequency of electricity generation in the face of the resources instability, is the potential dispersion of the productive zones, which have a large energy consumption. Hence the importance of integrating the renewable-energies generating centers into the transmission networks and to have power-backup centers which guarantee the system's stability.

The present chapter displays the behavior of renewable energies during the last decade in Mexico, and the prospective horizon to 15 years for each of them. In addition, it presents the studies of the renewable energies potentials made throughout the country and which are available in the INEL and the AZEL.

2.1. Renewable Energies International Context

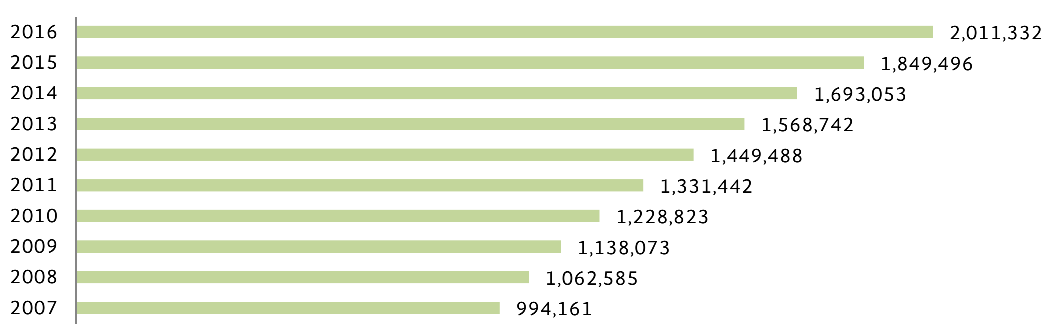
Worldwide, year after year, renewable energies have a relevant development, and 2016 was not the exception since the population demand lays more challenges and have given them a relevant position in the electricity generation matrix.

Factors such as an increase in the installed electricity generation capacity with renewable energies, the reduction in the use of coal, and improvements in energy efficiency in every sector, at global level, have contributed significantly to reduce the emissions of GHG.

Moreover, thanks to the policies of developing economies it has been possible to access funds which enable the incorporation of a totally updated, efficient, and environmentally respectful energy system. Thus, the cost of renewable energies has significantly reduced, allowing a greater inclusion of them in electricity generation.

According to what is reported in the *Renewable Energy Statistics 2017*, published by the International Renewable Energies Agency (IRENA), in 2016 the total electricity generation capacity with renewable energies was of 2,011,332 MW, an increase by 8.8% regarding 2015 (see Figure 2.1).

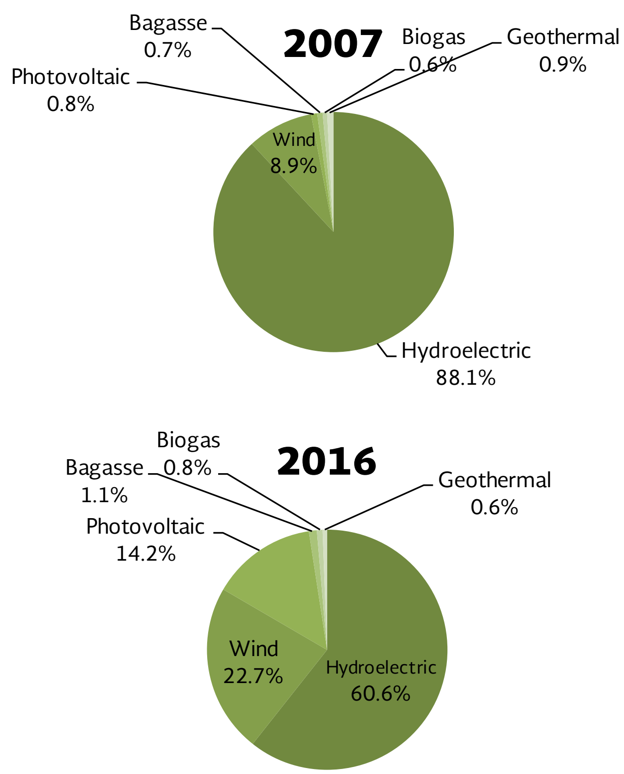
FIGURE 2. 1. TOTAL ELECTRICITY GENERATION CAPACITY WORLDWIDE, 2007-2016
(MW)



Source: Elaborated by SENER, with information from *Renewable Energy Statistics 2017*.

Between 2007 and 2016 the energy matrix has been meaningfully modernized, and even when hydropower remains predominant, other technologies like wind and photovoltaic power have gained ground, as shown in the following figure:

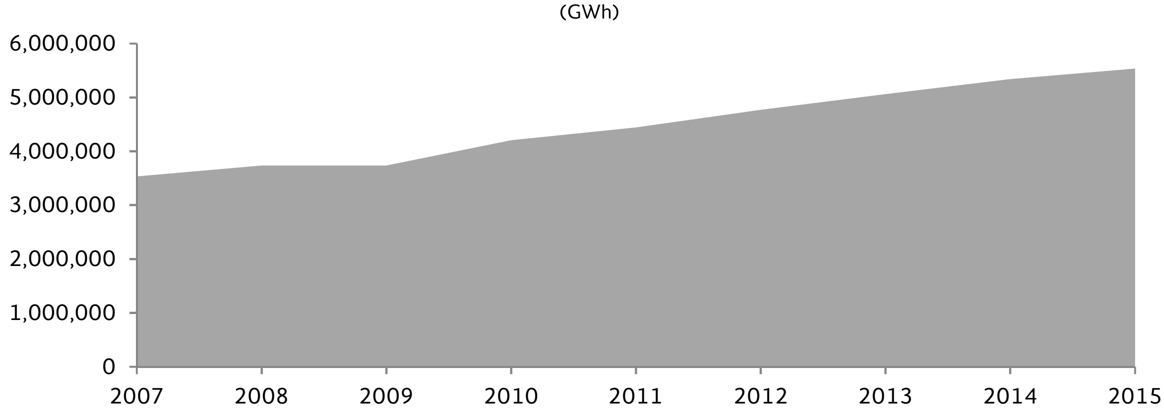
FIGURE 2. 2. SHARE OF RENEWABLE ENERGIES IN THE WORLDWIDE INSTALLED CAPACITY, 2007 AND 2016
(Percentage)



Source: Elaborated by SENER, with information from *Renewable Energy Statistics 2017*.

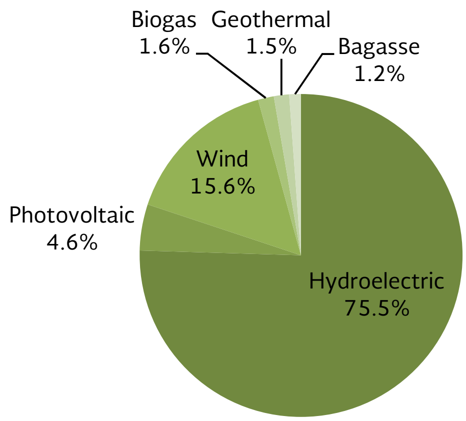
As for electricity generation, it has grown at an AAGR of 5.8% during the past years, being hydropower the one with the largest share, achieving 75.4% of the total renewable share by 2015 (see Figure 2.3 and 2.4).

FIGURE 2. 3. BEHAVIOR OF THE WORLDWIDE ELECTRICITY GENERATION WITH RENEWABLE ENERGIES, 2007-2015
(GWh)



Source: Elaborated by SENER, with information from *Renewable Energy Statistics 2017*.

FIGURE 2. 4. SHARE IN THE WORLDWIDE ELECTRICITY GENERATION WITH RENEWABLE ENERGIES, 2015
(Percentage)



Source: Elaborated by SENER, with information from *Renewable Energy Statistics 2017*.

2.2. Diagnosis of the Mexican Economy

A historical analysis of the main variables of Mexican economy becomes a reference for future behaviors and how these will influence the planning of the electricity sector. Moreover, in the face of a transition panorama towards a more intensive use of renewable energies in the electricity sector, along with the identification of a positive economic environment, enables a larger participation of the private sector which will foster investments in renewable energies.

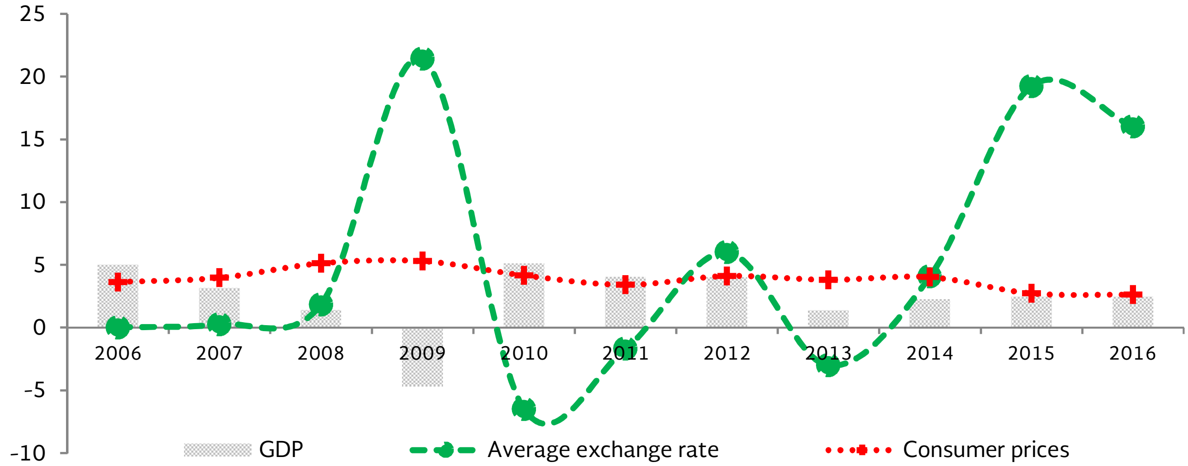
By the end of 2016, the global economy showed recovery and the influence of the acceleration of the American economic activity has also enabled the foreign trade recovery, particularly, Mexican manufacturing. Between 2006 and 2016, the Gross Domestic Product (GDP) grew at an AAGR of 2.4%, while the population growth rate remained in 1.2%, as shown in Table 2.1 and Figure 2.5.

TABLE 2. 1. MAIN MACROECONOMIC VARIABLES OF MEXICO, 2006-2016
(Different units)

Macroeconomic Variable	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Population (thousand persons)	106.0	107.2	108.4	109.8	111.3	112.9	114.3	115.7	117.1	118.4	119.7	121.0	122.3
GDP (thousand pesos 2008)	10,832.0	11,160.5	11,718.7	12,087.6	12,256.9	11,680.7	12,277.7	12,774.2	13,287.5	13,468.3	13,770.7	14,110.1	14,455.2
Average exchange rate (pesos per dollar)	11.3	10.9	10.9	10.9	11.1	13.5	12.6	12.4	13.2	12.8	13.3	15.8	18.4
Consumer prices (average annual percentage variation)	4.7	4.0	3.6	4.0	5.1	5.3	4.2	3.4	4.1	3.8	4.0	2.7	2.6

Source: Elaborated by SENER with information from INEGI.

FIGURE 2. 5. MAIN MACROECONOMIC VARIABLES OF MEXICO, 2006-2016
(Annual Variation)

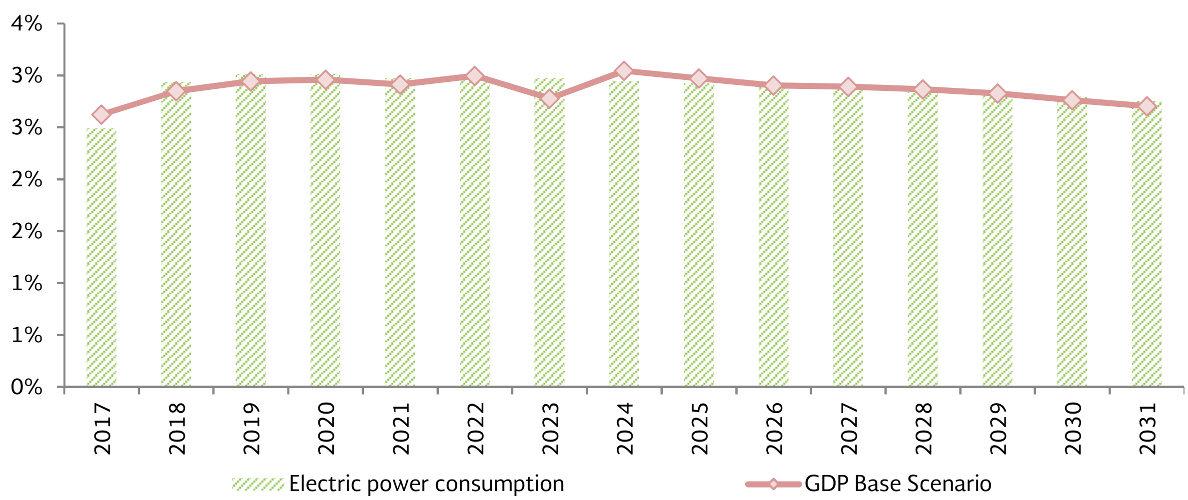


Source: Elaborated by SENER with information from INEGI.

Thanks to the positive performance of the domestic market, resulting from the implementation of structural reforms, among other, which have fostered economic efficiency, productivity, and competence within the main economic sectors, it is expected the economic panorama becomes more favorable, mainly for investments in energy infrastructure.

For the macroeconomic framework of the planning exercise 2017-2031, it is estimated an annual growth of 2.9%, the same as the expected growth of the electric power (see Figure 2.6).

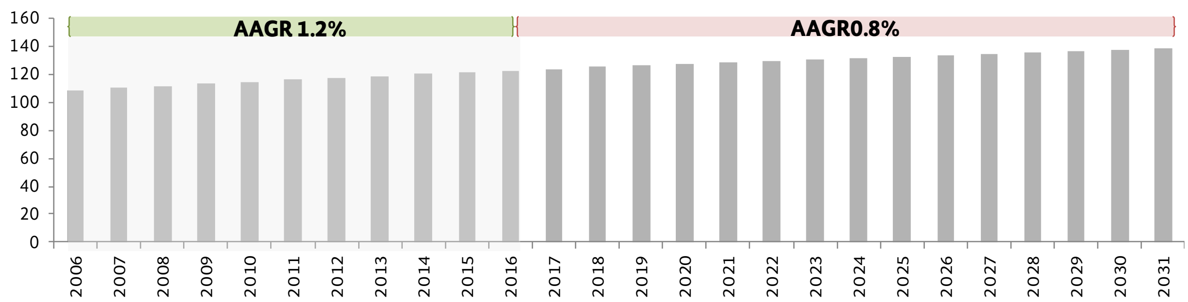
FIGURE 2. 6. TREND OF THE ELECTRICITY CONSUMPTION AND GDP, 2017-2031
(Annual Variation)



Source: Elaborated by SENER with information from Oxford Economics.

Population growth is an important indicator for measuring the country's future needs in energy matter. Throughout 10 years, this growth was of 1.2%, and it is expected to display an annual decrease of 0.8% for the next 15 years (see Figure 2.7).

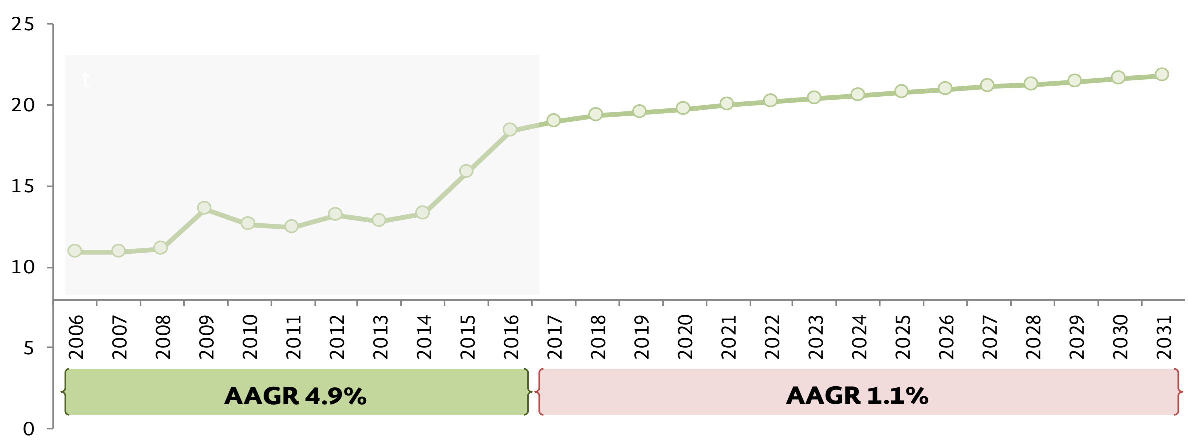
FIGURE 2. 7. BEHAVIOR AND TREND OF POPULATION IN MEXICO, 2006-2031
(Million people)



AAGR: Average Annual Growth Rate.
Source: Elaborated by SENER with information from CONAPO and Oxford Economics

Between 2006 and 2016 the exchange rate of dollar (USD) regarding Mexican peso (MXN), grew at an average annual rate of 4.9%. It is foreseen a small appreciation of the dollar and an annual increase by 1.1% during the planning period considered (see Figure 2.8).

FIGURE 2. 8. BEHAVIOR AND TREND OF THE EXCHANGE RATE IN MEXICO, 2006-2031
(Dollar-Peso)



Source: Source: Elaborated by SENER with information from INEGI and Oxford Economics.

2.3. Potential of Renewable Energies in Mexico

With the support of the INEL and the AZEL tools it is possible to identify zones with high potential for clean energies, helping thus in the decision making of investors and make them a relevant input for planning the transmission and distribution grids of the country.

TABLE 2. 2. ELECTRICITY GENERATION POTENTIAL WITH RENEWABLE ENERGIES IN MEXICO, 2016
(GWh/a)

Resources	Geothermal	Hydraulic	Wind	Solar	Biomass	Marine
Proved	2,610	4,920	20,104	25,052	3,326	-
Probable	45,207	23,028	-	-	680	1,057
Poszible	52,013	44,180	87,600	6,500,000	11,485	-

Source: Elaborated by SENER with information from INEL.

The assessment of the probable potential takes into account technical factors such as the availability of the resources, temperature, latitude, altitude, among other, as well as territorial restrictions related with the land use, and it can also include studies direct from field; but it does not have enough studies which prove its technical and economic viability. From the identified zones it can be assumed that only a fraction of the territory is utilizable, hence assuming a utilization factor of 25% of the areas available for wind power, and only 3.5% for solar power.

Considering the environmental, social, and technological restrictions, the AZEL defines 4 scenarios which would enable the country to take advantage of renewable and clean resources in the short, medium, and long terms. Scenario 1 identifies zones with high potential for developing electricity generation projects based on clean energies, without taking into account the proximity to the general transmission networks. This scenario presents a probable installable capacity of 2,593,889 MW, and a probable generation potential of 5,695,580 GW/h (see Table 2.3).

TABLE 2. 3. PROBABLE CAPACITY AND GENERATION POTENTIALS FOR SCENARIO 1
(MW, GWh/a)

Energy	Installable Capacity (MW)	Generation Power (GWh/a)
Fixed solar	1,171,881	2,121,803
Solar tracker	837,537	2,077,997
Wind	583,200	1,486,713
Geothermal	174	1,373
Biomass	1,097	7,694
Total	2,593,889	5,695,580

Source: Elaborated by SENER with information from AZEL.

Scenario 2 identifies the zone with high potential for developing electricity generation projects taking into account the proximity to general transmission networks of less or equal to 20 km. This scenario projects a probable installable capacity of 1,381,945 MW and a generation potential of 3,024,235 GW/h (see Table 2.4).

TABLE 2. 4. PROBABLE CAPACITY AND GENERATION POTENTIAL FOR SCENARIO 2
(MW, GWh)

Energy	Installable Capacity (MW)	Generation Power (GWh/a)
Fixed solar	639,420	1,156,286
Solar tracker	450,646	1,115,840
Wind	290,249	740,332
Geothermal	399	3,146
Biomass	1,231	8,631
Total	1,381,945	3,024,235

Source: Elaborated by SENER with information from AZEL.

Scenario 3, like the previous scenario, identifies zones with high potential for developing electricity generation projects taking into account the proximity to general transmission networks of less or equal to 10 km. This scenario projects a probable installable capacity of 397,020 MW and a generation potential of 912,913 GW/h (see Table 2.5).

TABLE 2. 5. PROBABLE CAPACITY AND GENERATION POTENTIAL FOR SCENARIO 3
(MW, GWh)

Energy	Installable Capacity (MW)	Generation Power (GWh/a)
Fixed solar	139, 000	252, 545
Solar tracker	97, 669	242, 647
Wind	158,302	402,847
Geothermal	571	4,509
Biomass	1,478	10,365
Total	397, 020	912, 913

Source: Elaborated by SENER with information from AZEL.

Scenario 4, like the previous scenario, identifies zones with high potential for developing electricity generation projects far from general transmission networks (>20 km). This scenario projects a probable installable capacity of 1,093,979 MW and a generation potential of 2,424,762 GW/h (see Table 2.6).

TABLE 2. 6. PROBABLE CAPACITY AND GENERATION POTENTIAL FOR SCENARIO 4
(MW, GWh)

Energy	Installable Capacity (MW)	Generation Power (GWh/a)
Fixed solar	462, 279	837, 560
Solar tracker	334, 131	836, 030
Wind	297,444	750,186
Geothermal	125	986
Biomass	-	-
Total	1,093,979	2,424,762

Source: Elaborated by SENER with information from AZEL.

2.4. Diagnosis of Renewable Energies

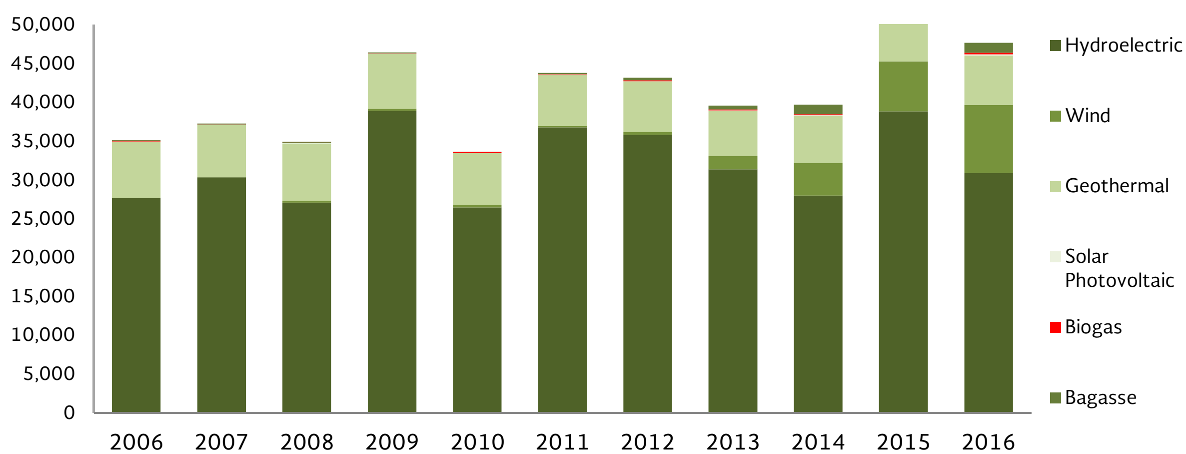
For the historical period 2006-2016, the installed generating capacity grew at an AAGR of 4.3%. In this period, solar and wind power presented a growth of 33.6% and 110.3%, respectively (see Figure 2.9).

FIGURE 2. 9. BEHAVIOR OF THE GENERATION CAPACITY WITH RENEWABLE ENERGIES 2006-2016
(MW)

Solar includes Distributed Generation
Source: Elaborated by SENER.

The average annual growth of electricity generation for the group of renewable energies during 2006-2016 was of 2.8%, standing out wind-power generation with a growth of 72.5%. By percentage in the share, hydropower concentrated 76.1% of the total, becoming the main renewable energy in the country, as shown in Figure 2.10.

FIGURE 2. 10. BEHAVIOR OF ELECTRICITY GENERATION WITH RENEWABLE ENERGIES 2006-2016
(MW)



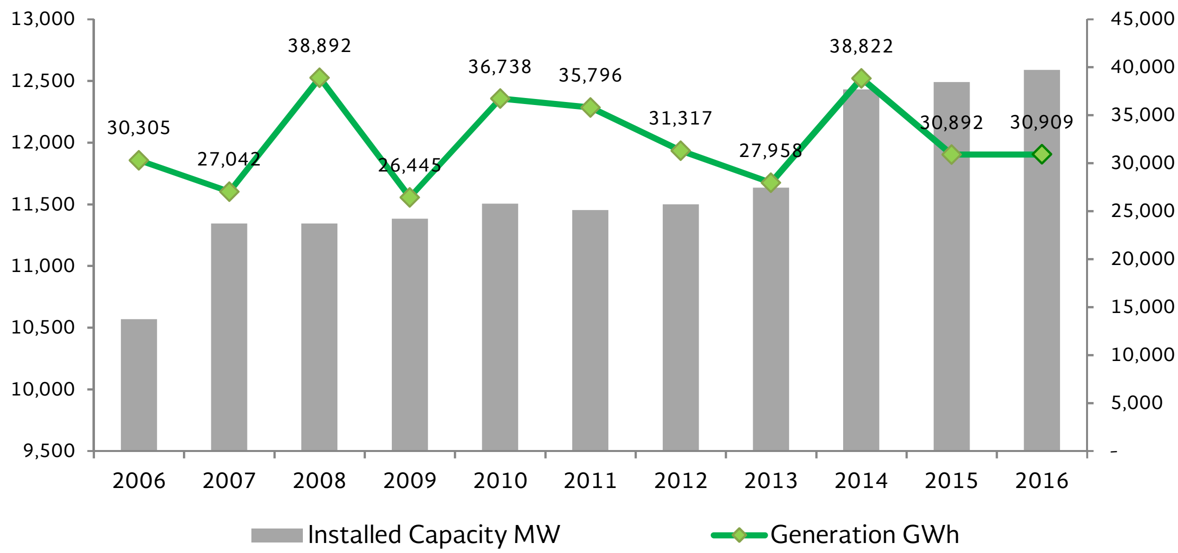
Solar includes Distributed Generation
Source: Elaborated by SENER.

2.4.1. Hydroelectric Power

Between 2006 and 2016, hydropower grew its generating capacity at a rate of 1.8%. For electricity generation, this annual growth was of 0.2% (see Figure 2.11).

During the last two years, hydropower generation has decreased due to climatic effects, given that when resources are scarce in big reservoirs, they prioritize its usage for agricultural and human consumption. Nonetheless, it is still one of the best alternatives for clean base generation and concentrated 17.1%[14] of the total generation.

FIGURE 2. 11. BEHAVIOR OF THE HYDROPOWER CAPACITY AND GENERATION, 2006-2016
(MW, GWh)



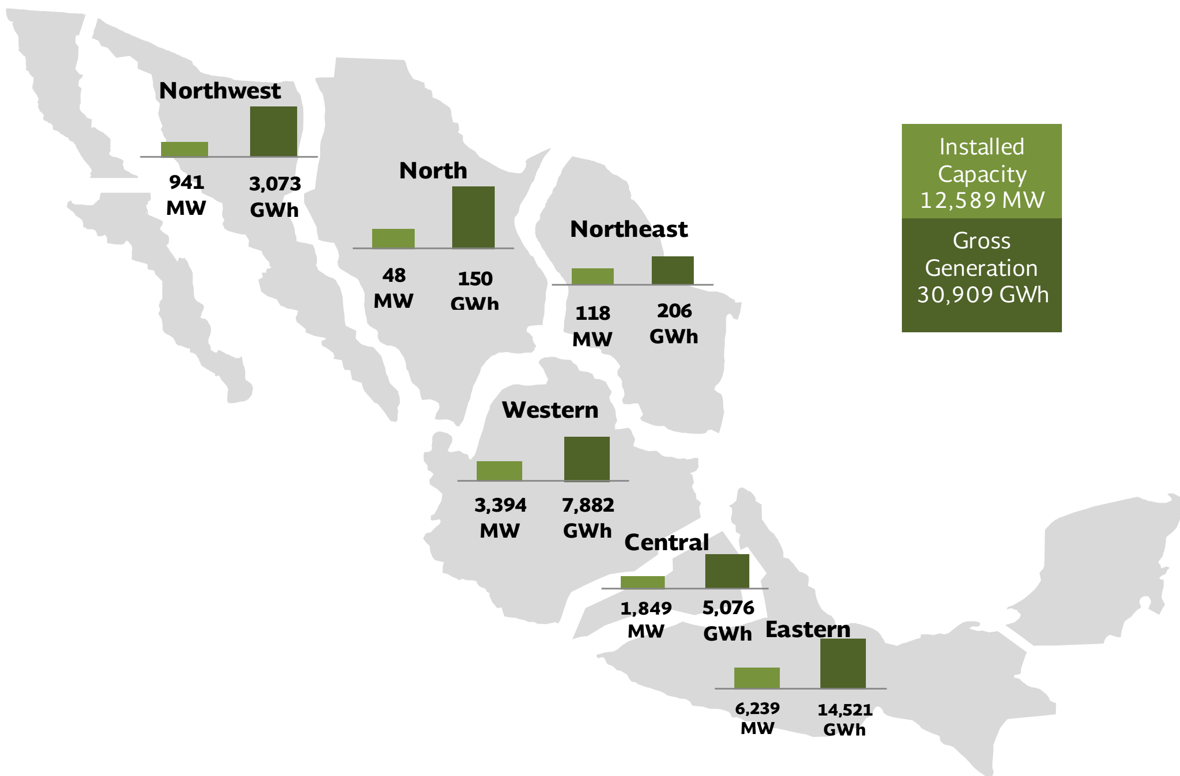
Source: Elaborated by SENER.

By the end of 2016, 85 hydropower stations were recorded with a total generating capacity of 12,588.99 MW and a power generation of 30,909.3 GWh.

The region with the largest number of power plants installed is the Western, with 31 and where the three main statins are located: Chicoasén (2,400 MW), Malpaso (1,080 MW) and Angostura (900 MW), all of them located in the state of Chiapas and with a total generation of 9,021 GWh (see Figure 2.12 and Table A.1 in the Statistical Annex).

[14] For further details, see la Electricity Sector Outlook2017-2031.

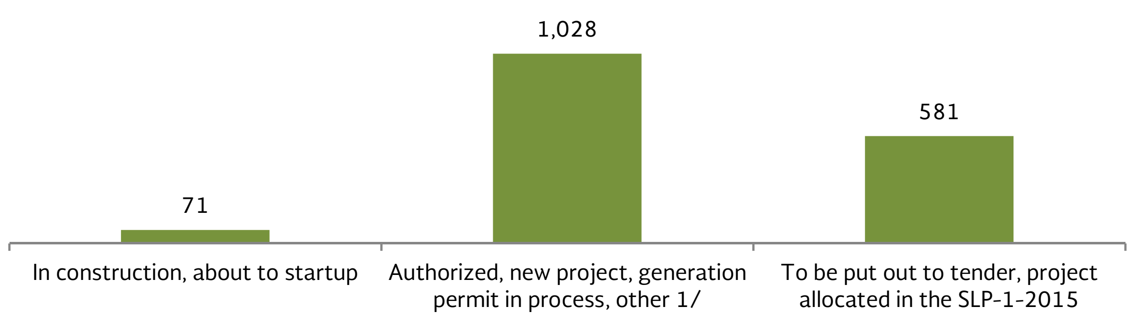
FIGURE 2. 12. CAPACITY AND GENERATION OF HYDROPOWER STATIONS BY CONTROL REGION 2016
(MW, GWh)



Source: Elaborated by SENER with information from PRODESEN 2017-2031.

For the period 2017-2031 it is foreseen to add 1,681.2 MW of new capacity to be installed of hydropower stations, from which more than 61.2% is classified as authorized projects, new ones, or with generating permits in process (see Figure 2.13).

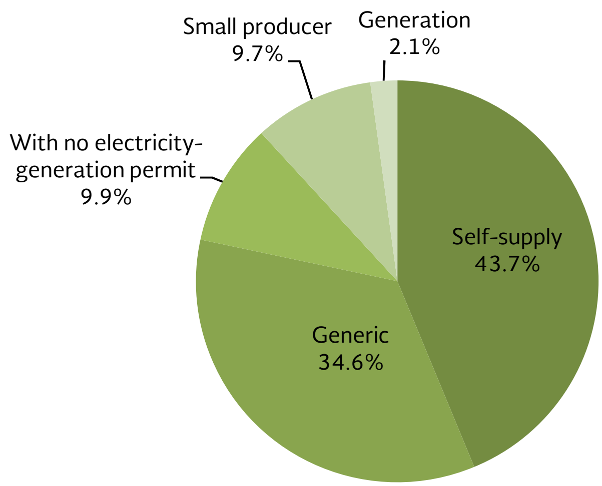
FIGURE 2. 13. ADDITIONAL CAPACITY BY PROJECT STATUS OF HYDROPOWER STATIONS, 2017-2031
(MW)



1/Includes generation projects with status: Conditioned, cancelled in PEF 2016, with progress in the interconnection process for CENACE, and suspended.
2/ Due to rounding, totals may not add up.
Source: Elaborated by SENER with data from PRODESEN 2017-2031.

By modality of the generator, from the new 34 new stations foreseen in the planning exercise to be installed, self-supply will concentrate 43.7% of new capacity, equivalent to 735.4 MW, as shown in Figure 2.14.

FIGURE 2. 14. ADDITIONAL CAPACITY BY MODALITY OF HYDROELECTRIC GENERATION
(Percentage)

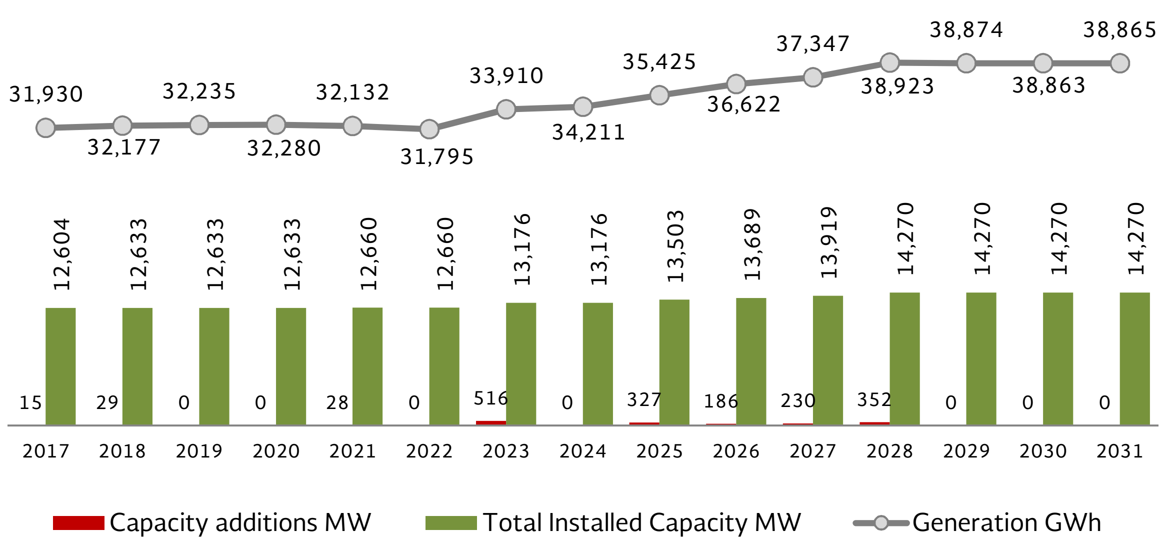


Source: Elaborated by SENER with data from PRODESEN 2017-2031.

Thus, taking into account the existing capacity and the one to be installed, between 2017 and 2031 the total installed capacity of hydropower generation will raise from 12,604 MW to 14,270 MW.

Regarding hydropower generation, it will increase 6,935 GWh throughout the 15 years projected and will have a share of 8.5% of the total generation matrix by the end of the period.

FIGURE 2. 15. BEHAVIOR OF CAPACITY ADDITIONS, CAPACITY TO BE INSTALLED, AND HYDROPOWER GENERATION, 2017-2031
(MW, GWh)

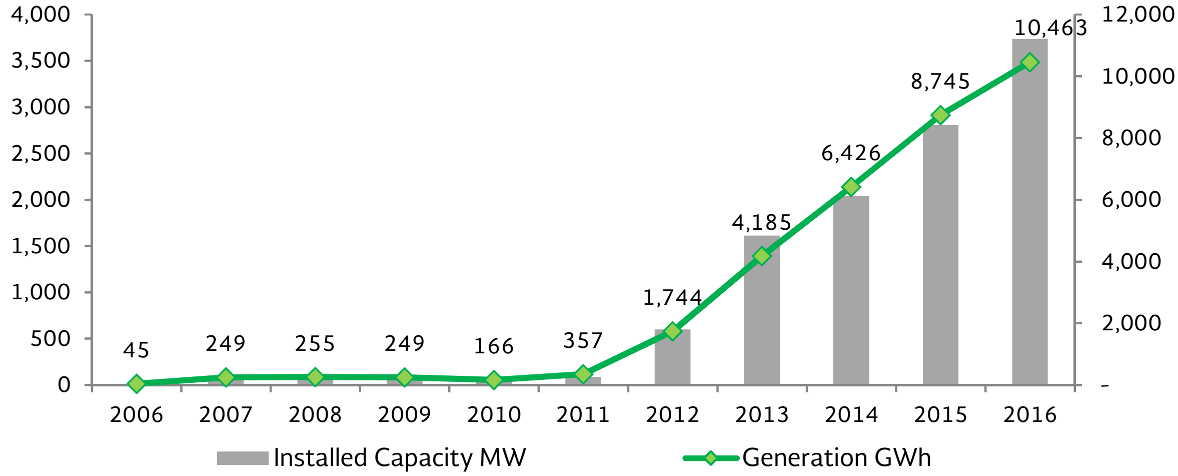


Source: Elaborated by SENER with data from PRODESEN 2017-2031.

2.4.2. Wind Power

Wind power has rallied during the last years thanks to the country's high potential, to the growing interest of the private sector, and to the reforms carried out along with public policies directed to reduce the existing barriers and which brings about larger investments. As a result, wind power generating capacity increased at an AAGR of 72.5%, reaching 10,462.6 MW in 2016. Likewise, electricity generation increased at an AAGR of 110.3% in the last 10 years, as shown in Figure 2.16.

FIGURE 2. 16. BEHAVIOR OF THE WIND POWER CAPACITY AND GENERATION, 2006-2016
(MW, GWh)



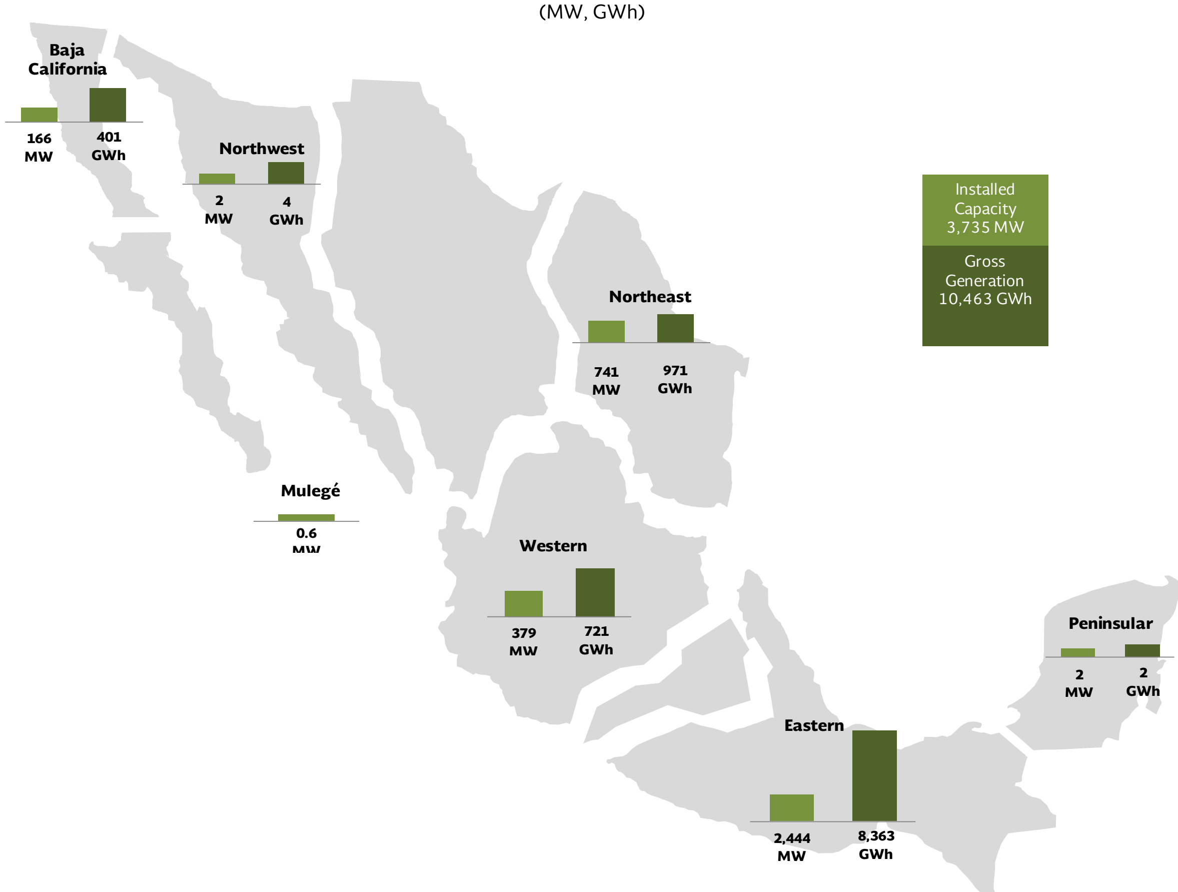
Source: Elaborated by SENER.

From the 41 wind power plants recorded in 2016 and located in 13 states of the Mexican Republic, most of them are located in the Western Region (23 in Oaxaca), and jointly generated 8,363 GWh (see Figure 2.17).

The main modalities of these plants are: self-supply, small production, IPP, and the ones corresponding to CFE[15].

[15] For further details, see Table A.2 in Statistical Annex.

FIGURE 2. 17. CAPACITY AND GENERATION OF WIND POWER STATIONS BY CONTROL REGION 2016
(MW, GWh)



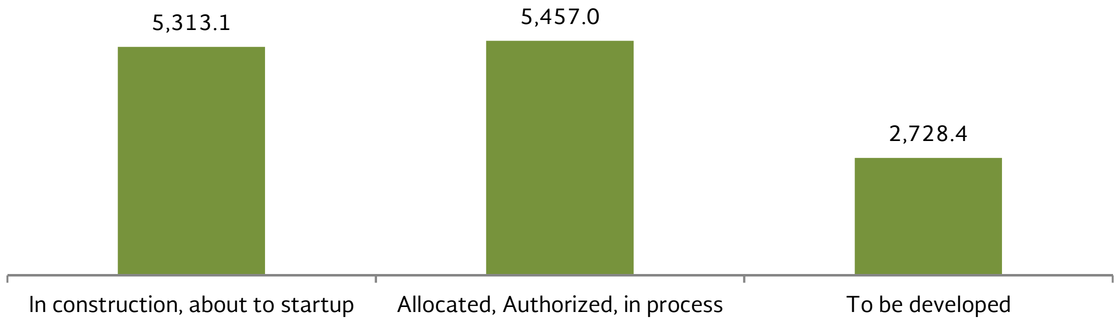
Source: Elaborated by SENER with data from PRODESEN 2017-2031.

The two Long-Term Auctions were an effective instrument to increase the penetration of clean energies. Hence, wind power will generate 25.7% of the contracted energy, and the auctions will provide 2,718 MW between 2017-2019[16]. Thus, during the prospected period it is expected a capacity addition of 13,498 MW[17] from wind power, from which 39.4% (5,313 MW) are projects in construction or about to begin works (see Figure 2.18).

As a result of the third auction, and additional 2,040,029 MWh/year will be added. These projects will start up between July 2019 and June 2020.

[16] http://www.cenace.gob.mx/Paginas/Publicas/MercadoOperacion/SubastasLP.aspx
[17] El PRODESEN 2017-2031 no considera las adiciones de generación y capacidades resultantes de la tercera subasta.

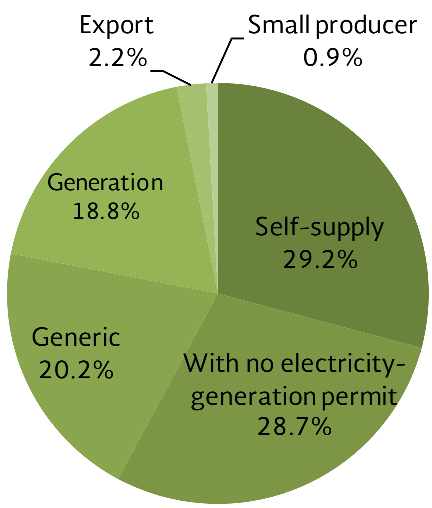
FIGURE 2. 18. ADDITIONAL CAPACITY BY PROJECT STATUS OF THE WIND-POWER STATIONS, 2017-2031
(MW)



Source: Elaborated by SENER with data from PRODESEN 2017-2031.

Regarding generation modalities, self-supply concentrates most of the share of the new capacity to be installed, as shown in the following figure.

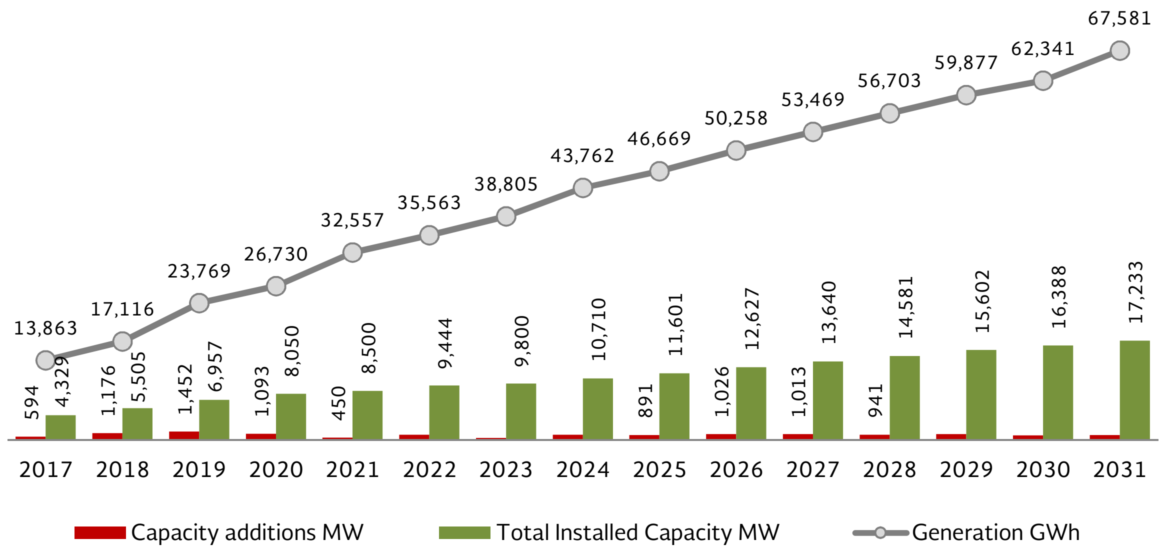
FIGURE 2. 19. ADDITIONAL CAPACITY BY MODALITY OF WIND-POWER GENERATION
(Percentage)



Source: Elaborated by SENER with data from PRODESEN 2017-2031.

Thanks to its high competitivity, mainly due to its low costs and country's high potential, wind power is estimated to increase its electricity generation in 387.5% between 2017 and 2031 (see Figure 2.20).

FIGURE 2. 20. BEHAVIOR OF WIND-POWER CAPACITY ADDITIONS, CAPACITY TO BE INSTALLED, AND GENERATION 2017-2031
(MW, GWh)



Source: Elaborated by SENER with data from PRODESEN 2017-2031.

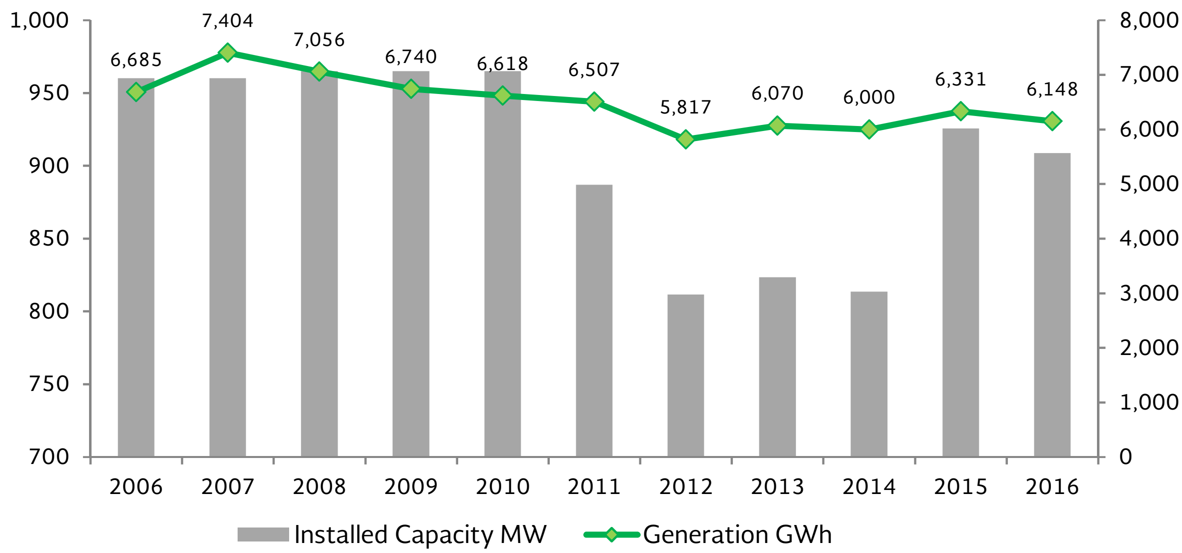
2.4.3. Geothermal-Power

By the end of 2016, the SENER granted 21 permits for geothermal exploration, in addition to two new exploitation licenses during 2015, which guarantees significant growths for geothermal power in the medium term.

The geothermal power installed capacity has decreased 0.5% per year during the decade 2006-2016. There are 8 geothermal power stations which represent 1.2% of the country's total installed capacity (909 MW). Additionally, it has a proved potential of 2,610 GWh, a probable of 45,207 GWh, and a possible of 52,013 GWh, according to what was reported by the INEL in 2016.

Geothermal power, which provides base-charge generation[18], has decreased its share in the electricity generation matrix reaching 6,148 GWh by the end of 2016, 183 GWh less than what was reported in 2015 (see Figure 2.21).

FIGURE 2. 21. BEHAVIOR OF THE GEOTHERMAL POWER CAPACITY AND GENERATION, 2006-2016
(MW, GWh)

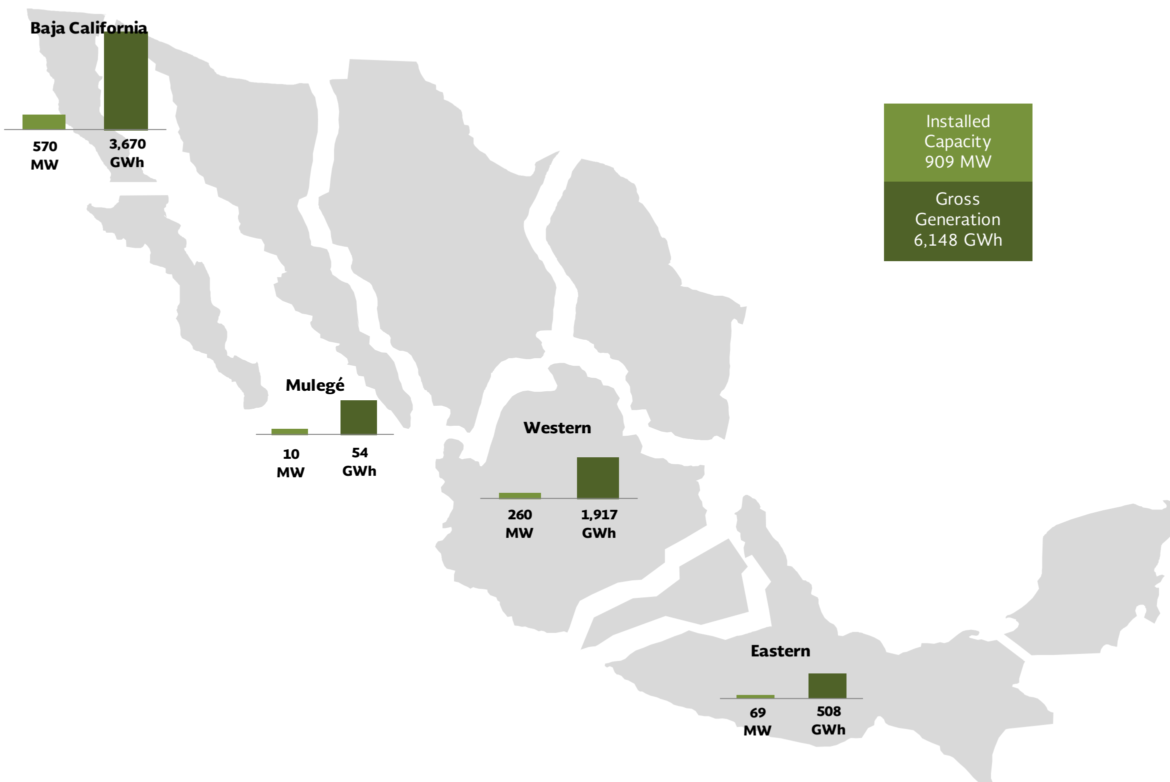


Source: Elaborated by SENER.

There are varied geothermal fields located in the states of Baja California, Baja California Sur (Mulege), Nayarit, Michoacán, and Puebla. For the case of Baja California Sur, this region has the largest share of electricity generation by geothermal technology, 60% of the total in the country with the Stations Cerro Prieto I, II, III, and IV (see Figure 2.22 and Table A.3 in the Statistical Annex).

[18] It is considered as base generation because its operation is not affected by climatological or seasonal variations.

FIGURE 2. 22. GEOTHERMAL POWER STATIONS CAPACITY AND GENERATION BY CONTROL REGION 2016
(MW, GWh)

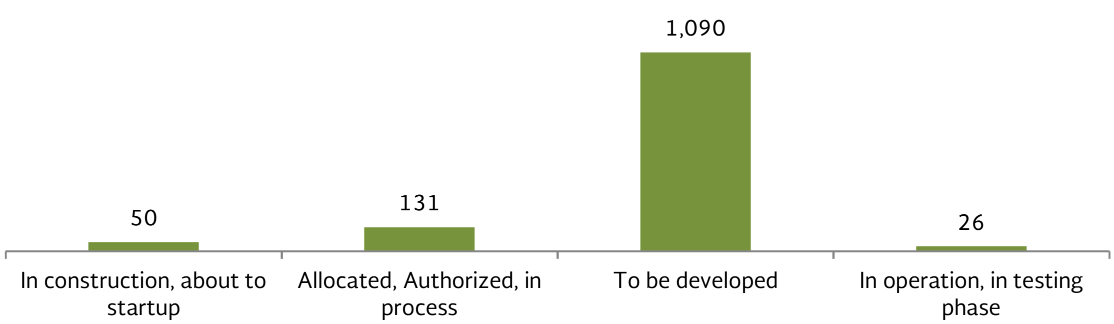


Source: Elaborated by SENER with data from PRODESEN 2017-2031.

With the entry into force of the new LEG, the industry has been renovated by the interest in the development and utilization of the country's geothermal resources, through the reconnaissance, exploration, and exploitation of geothermal reservoirs.

For the SEN's planning exercise 2017-2031 it is foreseen the installation of 1,298 MW of new generation capacity, from which 84% are projects to be developed (see Figure 2.23).

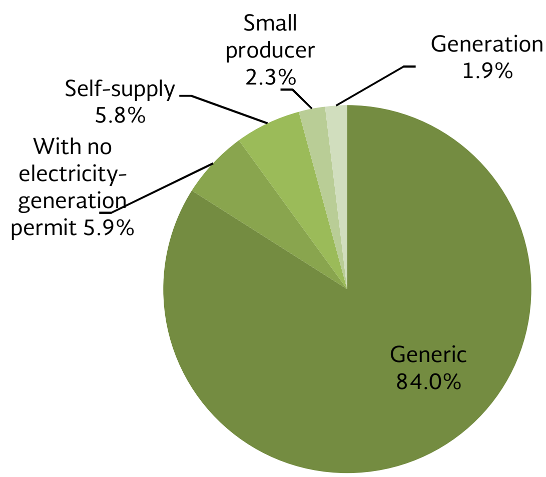
FIGURE 2. 23. ADDITIONAL CAPACITY BY PROJECT STATUS OF GEOTHERMAL-POWER STATIONS, 2017-2031
(MW)



Includes generation projects with status: Conditioned, Cancelled in PEF 2016, with progress in the interconnection process for CENACE, and suspended
Source: Elaborated by SENER with data from PRODESEN 2017-2031.

Under the new generators' scheme, it is foreseen that 84% of the additional capacity comes from the modality of generic generator (1,090 MW), from which it is expected a large share from the private sector and CFE's new projects, as the winner of the second Electric Auction "Los Azufres III, Phase II".

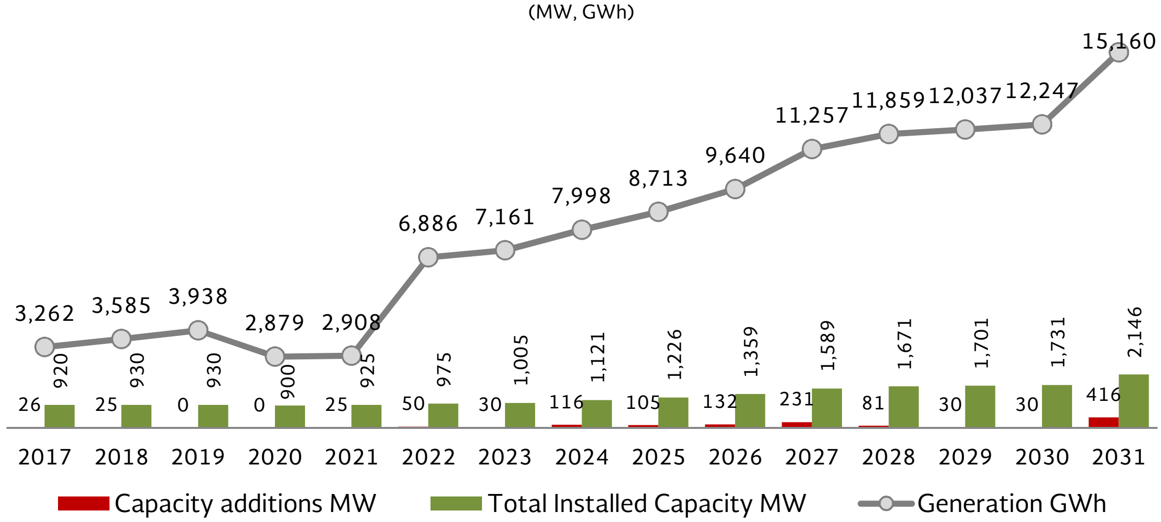
FIGURE 2. 24. ADDITIONAL CAPACITY BY GEOTHERMAL GENERATION MODALITY
(Percentage)



Source: Elaborated by SENER with data from PRODESEN 2017-2031.

Between 2017 and 2031, according to what was published in the PRODESEN 2017-2031, it is expected a capacity withdrawal of 30 MW from the stations: Los Humeros U3, U6, and U8; Los Azufres U2, U6, and U10; and Cerro Prieto. To comply with the target of electricity generation with clean energies, it is expected that by 2024 there is an installed capacity of 1,121 MW of geothermal power. Hence, and taking into account a plant factor of 80%, between 2017 and 2031, it is expected that geothermal electricity generation will increase 364.8%, reaching 15,160 GWh by the end of the prospective period, as shown in the following figure:

FIGURE 2. 25. BEHAVIOR OF THE CAPACITY ADDITIONS, CAPACITY TO BE INSTALLED, AND GEOTHERMAL GENERATION 2017-2031
(MW, GWh)

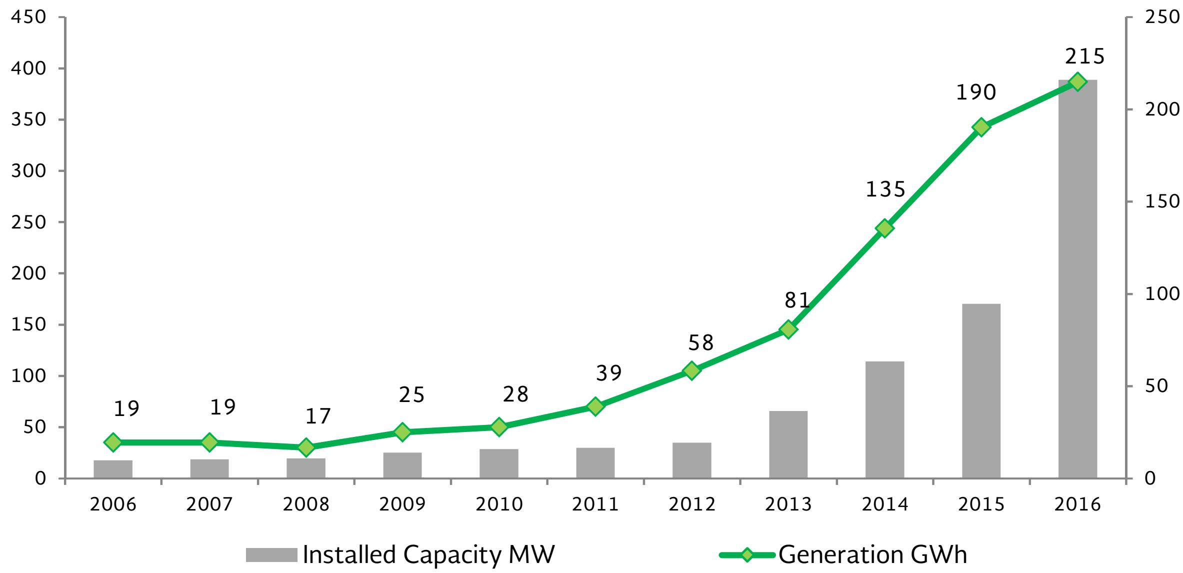


Source: Elaborated by SENER with data from PRODESEN 2017-2031.

2.4.4. Solar Photovoltaic Power

Solar Photovoltaic Power is the source with the largest growth worldwide. In Mexico, the installed capacity with solar technology grew an average of 36.3% per year during the last decade, going from 17.6 MW in 2006 to 388.6 MW in 2016. Likewise, electricity generation with solar power grew at an AAGR of 27.1%, as shown in Figure 2.26.

FIGURE 2. 26. BEHAVIOR OF THE SOLAR-PHOTOVOLTAIC POWER CAPACITY AND GENERATION, 2006-2016
(MW, GWh)

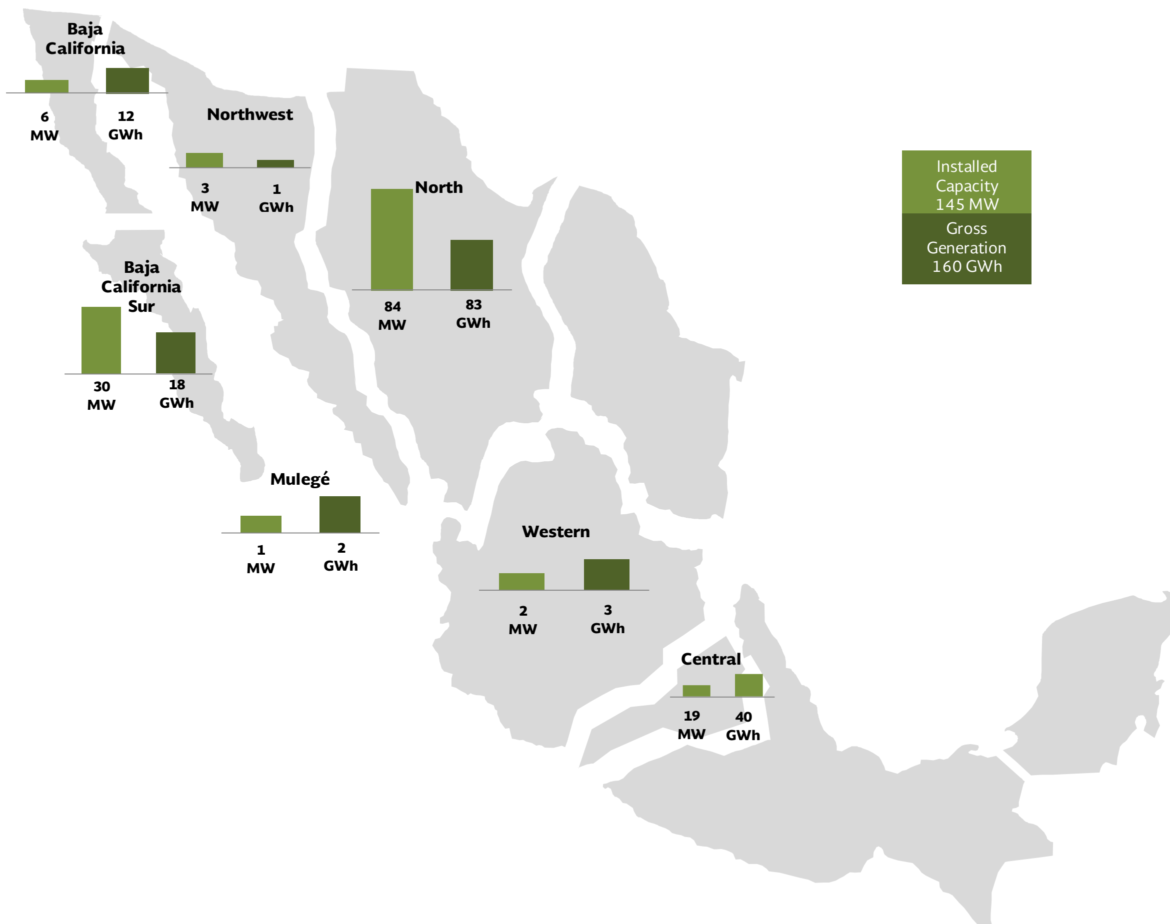


*Includes Distributed Solar Energy
Source: Elaborated by SENER.

By the end of 2016, 17 power stations, located in 8 states of the Republic were recorded. The North Region had the largest level of electricity capacity and generation, as shown in Figure 2.23, with the share of 5 stations under the modality of small producer and 1 of self-supply[19].

[19] For further details, see el Table A.4 in the Statistical Annex.

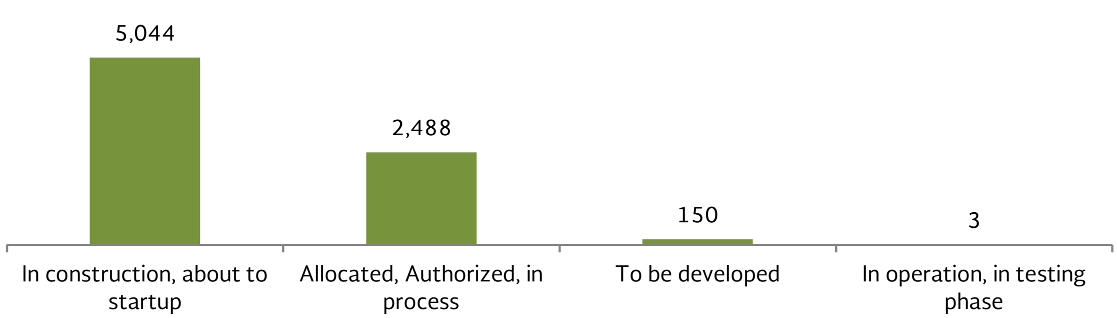
FIGURE 2. 27. SOLAR-POWER STATIONS CAPACITY AND GENERATION BY CONTROL REGION 2016
(MW, GWh)



Does not include Distributed Solar Energy
Source: Elaborated by SENER with information from PRODESEN 217-2031.

Due to the results from the two first Electric Auctions, it has been considered the installation of more than 5,400 thousand MW of new solar capacity during 2017-2019, and the planning exercise estimates to add a total of 7,685 MW, from which 65.4% are projects in construction or about to begin works (see Figure 2.28).

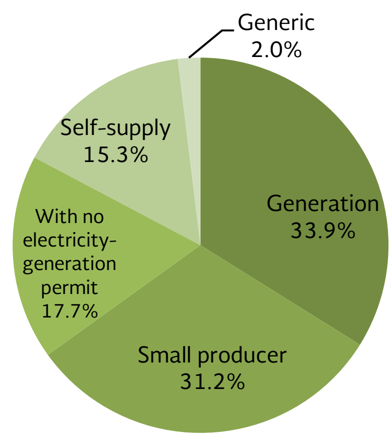
FIGURE 2. 28. ADDITIONAL CAPACITY BY PROJECT STATUS OF THE SOLAR POWER, 2017-2031
(MW)



Source: Elaborated by SENER with information from PRODESEN 217-2031.

From the additional capacity by modality, 65.1% will come from the schemes Generation and Small Producer, as shown in the following figure:

FIGURE 2. 29. ADDITIONAL CAPACITY BY SOLAR-GENERATION MODALITY, 2017-2031
(Percentage)



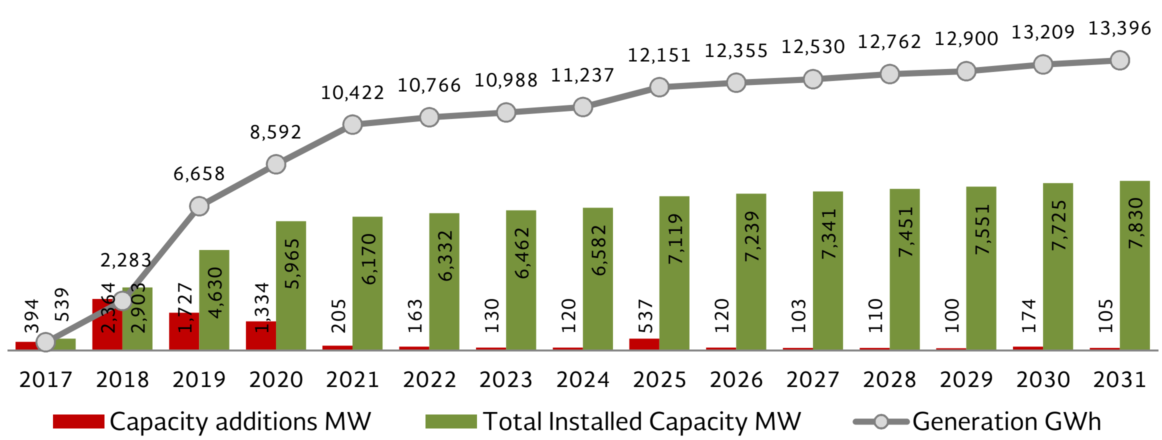
Source: Elaborated by SENER with information from PRODESEN 217-2031.

Between 2017 and 2031 it is expected an average annual growth of 21.1% of generation capacity to be installed, going from 539 MW in 2017 to 7,830 MW in 2031. It is worth mentioning that between 2017 and 2020, it is expected to install 5,820 MW of capacity; the winners of the two first Long-Term Electric Auctions[20] are considered for this same period.

As a result of the winning projects of the third auction, an additional 3,040,029 MWh/year will be added. These projects will start up between July 2019 and June 2020.

Electricity generation with solar technology will increase at an AAGR of 29.3%, reaching 150,618 GWh in 2031 and a share of 2.9% within the energy matrix (see Figure 2.30).

FIGURE 2. 30. BEHAVIOR OF THE CAPACITY ADDITIONS, CAPACITY TO BE INSTALLED, AND SOLAR GENERATION 2017-2031
(MW, GWh)



Source: Elaborated by SENER with information from PRODESEN 217-2031.

[20] The PRODESEN 2017-2031 does not consider the winners of the third Long-Term Auction.

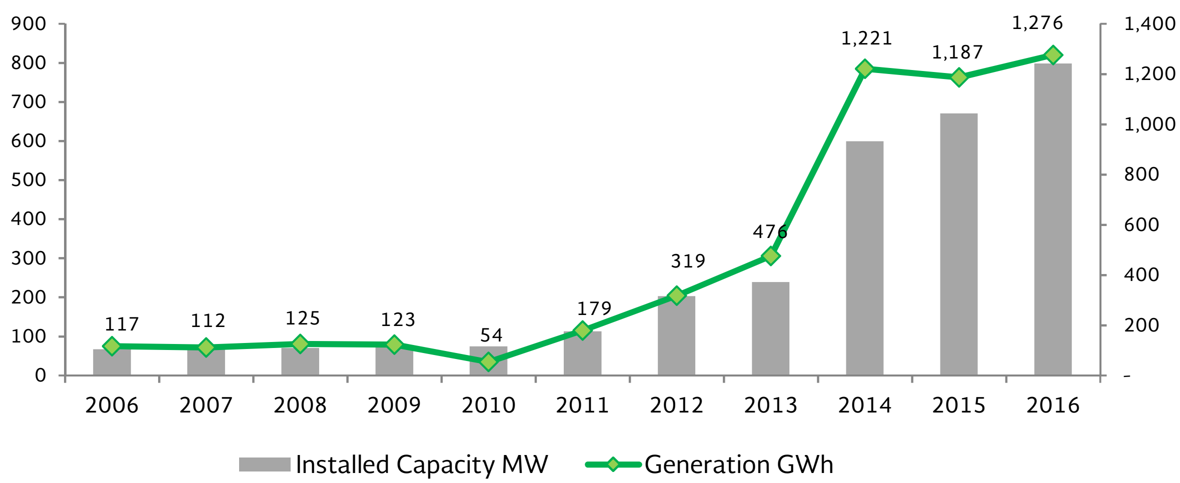
2.4.5. Bioenergy

In Mexico, organic residues, and biomass in general, has a meaningful biogas generation potential for producing electricity, for vehicles, or to inject it into a natural gas network as biomethane; similarly, forest biomass can be used for manufacturing pellets to generate heat or electricity.

In 2016, the installed capacity of biofuels was of 1.2% of the total, equivalent to 881.5 MW, from which 798.3 MW correspond to sugarcane bagasse and 83.1% to biogas, with a 1.09% and 0.11%, respectively, of installed capacity.

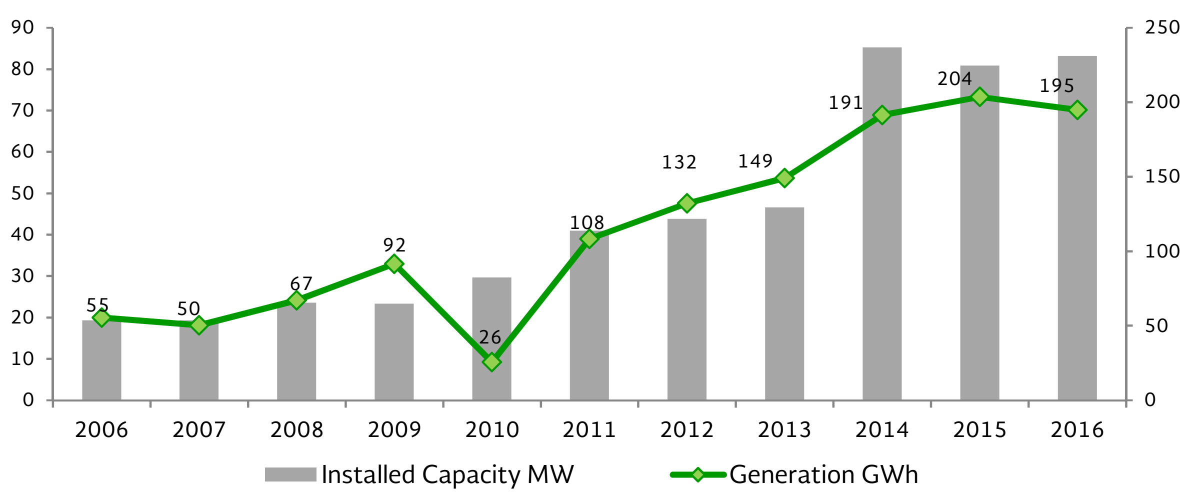
The share of Bioenergy in the electricity generation matrix was of 0.46% in 2016, equivalent to 1,471 GWh, from which 1,276.4 GWh correspond sugarcane bagasse and 194.8 GWh to biogas (see Figure 2.31 y 2.32).

FIGURE 2. 31. BEHAVIOR OF THE CAPACITY AND GENERATION OF ELECTRICITY WITH BAGASSE, 2006-2016
(MW, GWh)



Source: Elaborated by SENER.

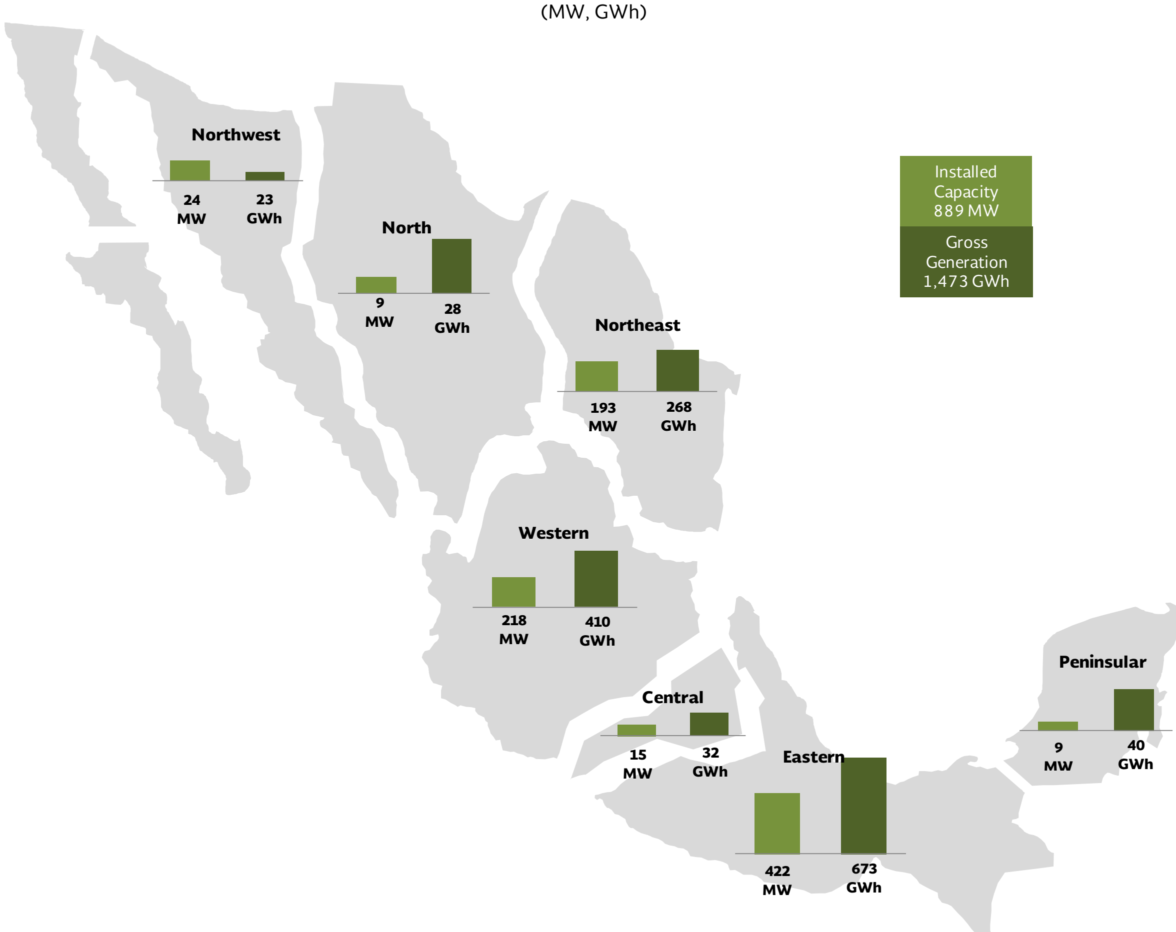
FIGURE 2. 32. BEHAVIOR OF THE CAPACITY AND GENERATION OF ELECTRICITY WITH BIOGAS, 2006-2016
(MW, GWh)



Source: Elaborated by SENER.

As of the end of 2016, 75 bioenergy power stations were recorded within the SIN [21], where the Western region had the largest share of installed capacity and electricity generation, with 47.5 and 45.7%, respectively, as it is shown in the following figure:

FIGURE 2. 33. CAPACITY AND GENERATION OF BIOENERGY POWER STATIONS BY CONTROL REGION 2016
(MW, GWh)

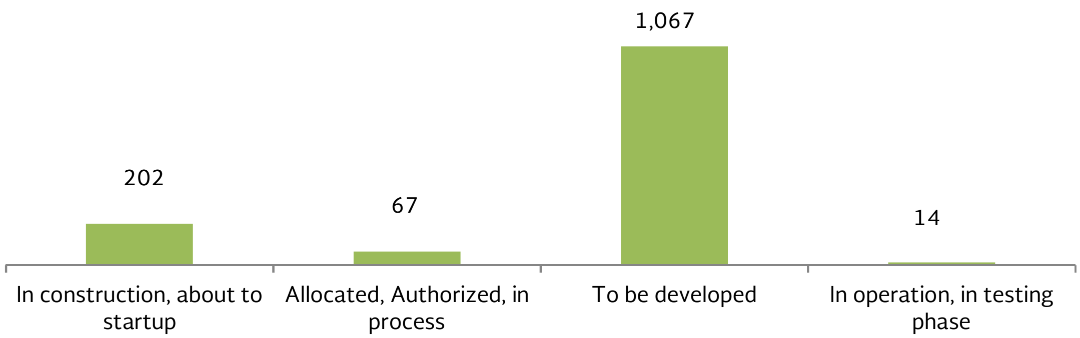


Includes biogas, biomass, and black liquor.
Source: Elaborated by SENER, with information from PRODESEN 2017-2031.

Between 2017 and 2031, it is expected an increase by 1,348 MW of capacity with 36 new power stations, from which 79.1% are projects to be developed, and 15% are in construction or about to begin works (see Figure 2.34 and 2.35).

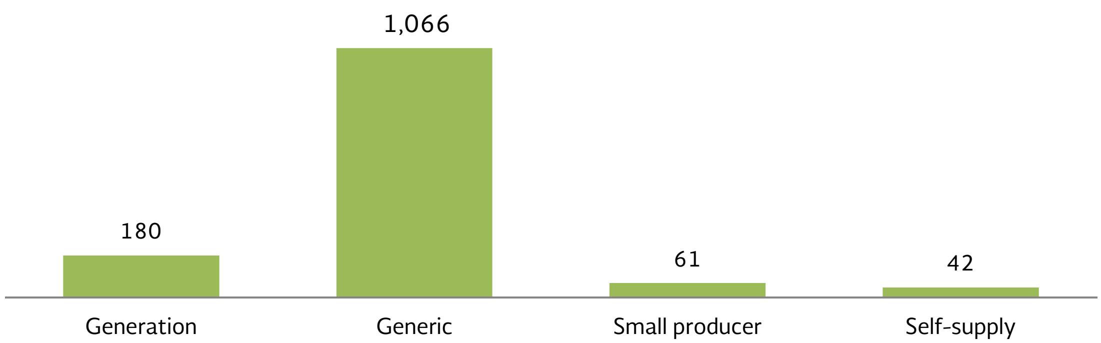
[21] For further details, see Table A.5 in the Statistical Annex.

FIGURE 2. 34. ADDITIONAL CAPACITY BY PROJECT STATUS OF BIOENERGY POWER STATIONS 2017-2031
(MW)



Source: Elaborated by SENER, with information from PRODESEN 2017-2031.

FIGURE 2. 35. ADDITIONAL CAPACITY BY BIOENERGY MODALITY 2017-2031
(MW)

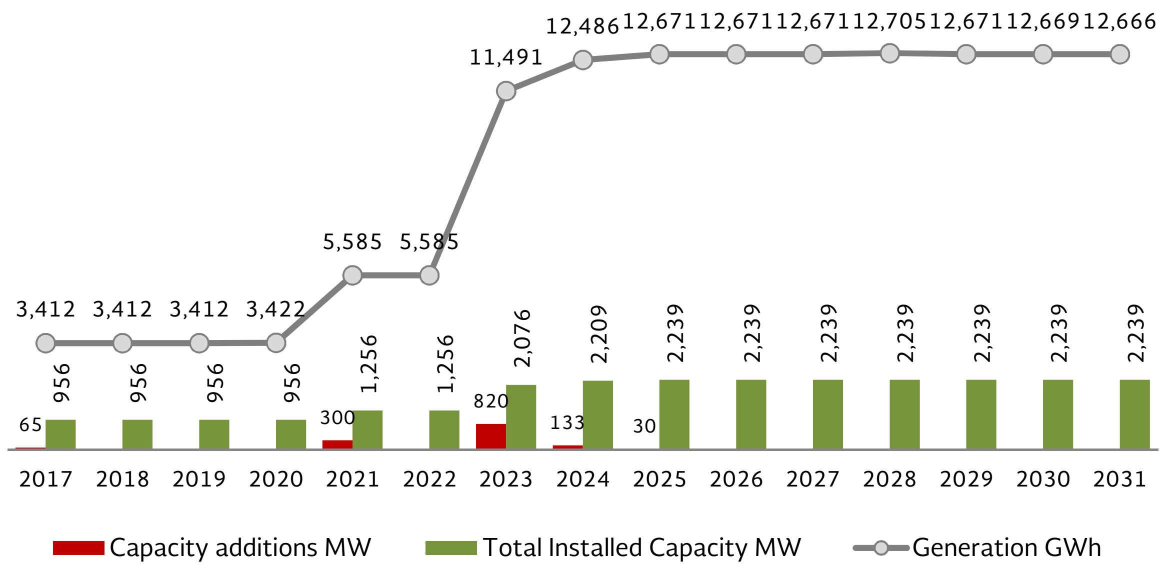


Source: Elaborated by SENER, with information from PRODESEN 2017-2031.

Between 2017 and 2031, the electricity generation capacity with bioenergy is expected to increase in 6.3% annually, reaching 2,239 MW installed by the end of the same period.

It is expected a larger share of bioenergy within the electricity generation matrix, going from 3,412 GWh in 2017 to 12,666 GWh in 2031, which represents a share of 2.8% of the total generation.

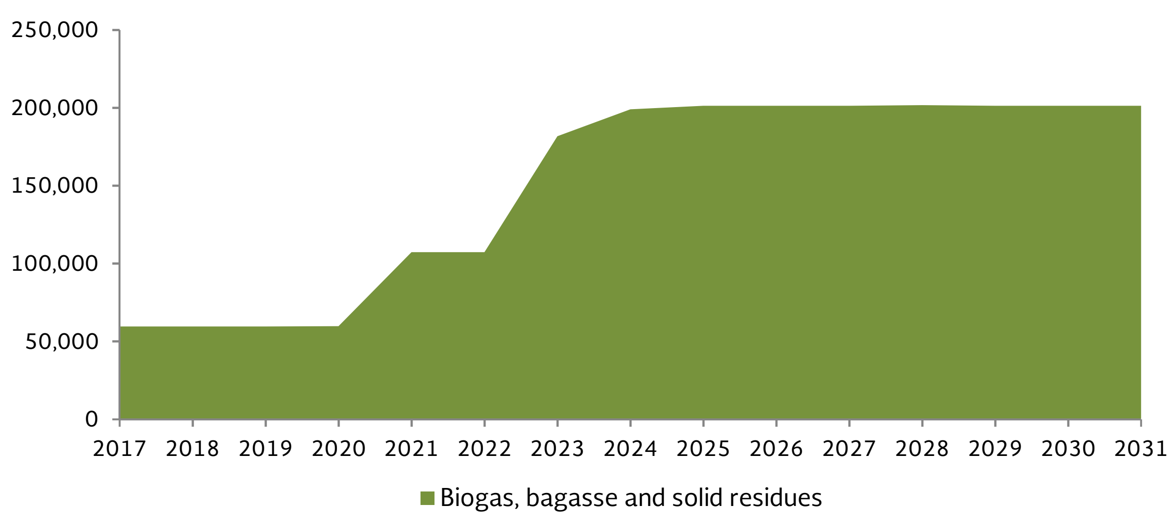
FIGURE 2. 36. BEHAVIOR OF THE CAPACITY ADDITIONS, CAPACITY TO BE INSTALLED, AND GENERATION WITH BIOENERGY 2017-2031
(MW, GWh)



Source: Elaborated by SENER, with information from PRODESEN 2017-2031.

To cover the estimated electricity generation, it is foreseen an increase on fuels from biogas, bagasse, and solid residues of 141,668 TJ between 2017 and 2031, an increase of 238%, as shown in Figure 2.37.

FIGURE 2. 37. FUEL CONSUMPTION 2017-2031
(Terajoule)



Source: Elaborated by SENER, with information from PRODESEN 2017-2031.

2.5. Clean-Energies Transmission Infrastructure

One of the objectives of the Program of Expansion and Modernization of the National Transmission Network (RNT, for its Spanish acronym), and included in the planning exercise of the PRODESEN 2017-2031, is to include clean-energy power stations in the RNT; to do so, it also includes an Interconnection project Southeast-Peninsular, the expansion and refurbishment of the electricity transmission system in zones with high potential for Clean Energy through the projects described below.

2.5.1. Project Transmission Grid to Interconnect the Northeast, North, and Western of the Country

This project consists in the construction of 3,806.8 km-c of transmission lines in 400 km, transformation of 5,000 MVA, and compensation of 4,042.3 MVAr with technology of Alternating Current (AC) for incorporating the high potential of wind and solar resources to foster the installation of wind and solar photovoltaic farms in Sonora, Chihuahua and Coahuila, Aguascalientes, Queretaro and San Luis Potosi, and the corridor Laguna-Saltillo.

2.5.2. Project Transmission Grid to Interconnect the Northwest and Center of the Country

The project consists in constructing 1,400 km-c of Direct Current (DC) and 1,203.4 km-c of Alternating Current in 400 kV, transformation for 9,575 MVA, and compensation of 1,483.3 MVAr to incorporate power stations whose primary source is wind power from the northern zones of Coahuila, the zone Laguna-Saltillo, and the state of Tamaulipas; and to integrate conventional electric power stations whose primary source is natural gas from the Northeast, for combined cycles as well as cogeneration.

The projects of the Northwest, North, Western, Northeast, and Center are considered in studying process in the PRODESEN 2017-2031, they will be in review by the CENACE, the CRE, and the SENER for analyzing: i) additional probable capacity for renewable projects, particularly wind and solar during 2017-2024; ii) the criteria for determining the potential zones and integration capacities of solar and wind generation; iii) plant factors for simulating accurate power-flow conditions of wind and solar power; iv) the possible determination of the varied power zones in the SIN; and v) the existing and programmed infrastructure of gas pipelines, among other.

Renewable Energies Studies and Trends

Mexico has a high potential for using renewable energies, hence the importance of taking advantage of its privileged geographic condition; and even when fossil fuels are still playing a meaningful role in the energy matrix, their share is expected to decrease.

This chapter presents a series of studies and trends derived from the Energy Reform for moving forward to a clean and sustainable economy through the promotion of electricity generation with renewable energies. The importance of publishing these studies and trends in the Renewable Energies Outlook 2017-2031 is for them to become a reference for future research and investment development, as well as for strategic decision making that will foster the better utilization of the country's resources.

It is worth noting that some of the studies presented here are currently in elaboration, so they could be or not considered within the energy sector planning; likewise, some of them are already published in different information platforms.

3.1. Hydroelectric Power Atlas

Since the second half of 2017, the INEL counts on the Hydroelectric Power Atlas. This new supporting and technologically innovative tool supplements the INEL by identifying locations in the country with high hydroelectric potential and shows a considerable progress within the framework of the tools which provide consultation in an environment of shared and updated information.

The Atlas was developed based on data obtained from 1,594 hydrometric stations registered by the National Water Commission (CONAGUA, for its Spanish acronym) and the Surface Water National Databank (BANDAS, for its Spanish acronym). To manage the Atlas, the 20-year data from hydrometric stations, for the period 1994-2013 and a value over 0.3 m^3/s, for a permanency of 85% of the time.

The tool enables consultations on information about the potential of the 67 most important hydrographic basins of the country and represent 85% of the national hydric resource. These basins occupy 45% of the national territory and have the largest density of operating hydrometric stations.

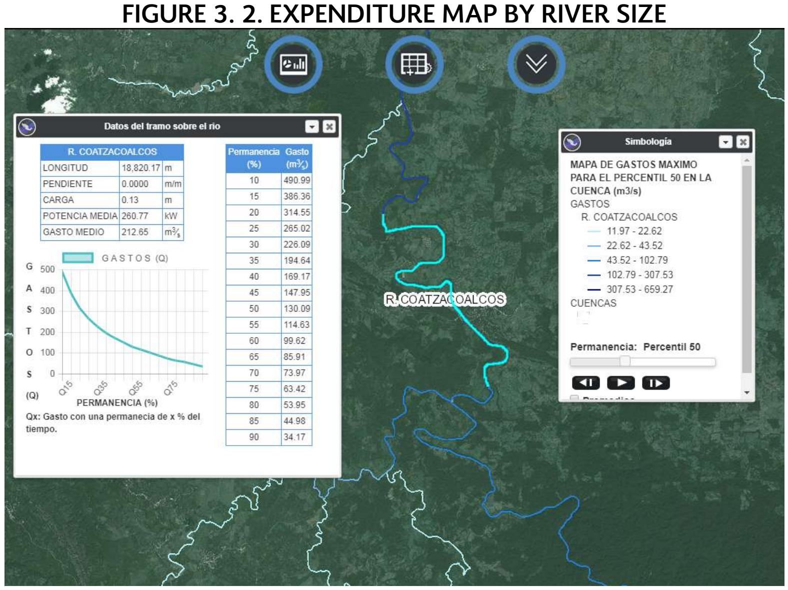
The platform has 46 thematic maps divided into two types of scales:

- **Physiographic-Hydrologic Map:** These maps are divided by hydrographic basins at national level (Figure 3.1); and at regional level, they show the main natural parameters of the riverbeds (Figure 3.2).

FIGURE 3. 1. NATIONWIDE MAPS OF SLOPES, EXPENDITURES, LOADS, AND POWERS[22]

Source: SENER.

FIGURE 3. 2. EXPENDITURE MAP BY RIVER SIZE



Source: SENER.

- **Hydrologic-Anthropogenic Map.** Represents the main human factors weighted to define a strategy for elaborating projects.

The Atlas of hydroelectric potential includes the characterization of the rivers by section and enables to differentiate the type of projects that could be developed in each section, whereas one project's type and size or a combination of these, through evaluating the physiographic and hydraulic characteristics. It also enables the potential analysis considering parameters such as load and volume of flow for 20 water stability times in each section of the river.

[22] For further details, see https://dgel.energia.gob.mx/atlashidro/

With the results of the potential assessment of 67 hydrographic basis, the INEL estimates an installable potential capacity at national level of a bit more than 28 GW and a generation estimated in 247,053 GWh/a.

Most of the potential is estimated for low-scale projects, of less or equal to 30 MW, and it only identifies 24 large-scale projects, as shown in the following table:

TABLE 3. 1. SUMMARY OF THE POTENTIAL OF HYDROELECTRIC PROJECTS
(MW, GWh)

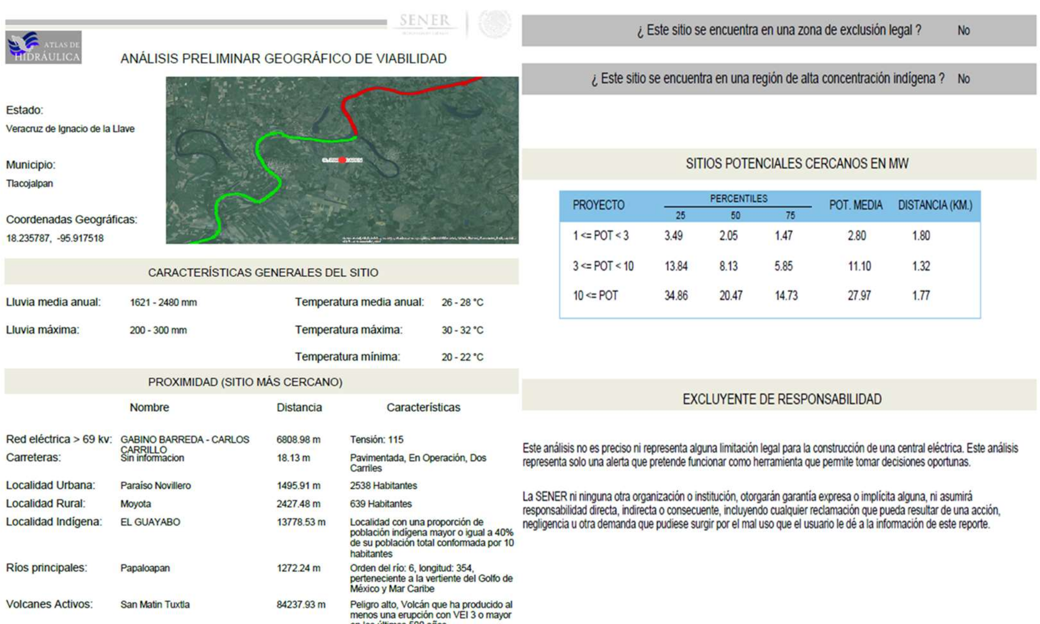
Hydraulic Atlas				
Low-Load Factor Projects				
Type of Project	Size MW	Total	Power Total of Projects (MW)	Total Generation of Projects (GWh)
All the proyects		100,008	28,202	247,054
Hydroelectric	> 30	24	1,145	10,026
Small Hydroelectric	1 > 30	611	5,616	49,194
Mini Hydroelectric	0.01 > 1	4,443	8,633	75,629
Micro Hydroelectric	< 0.01	94,930	12,809	112,204

Source: SENER.

The Atlas can also identify the developmental potential of projects from two different perspectives:

a) The user defines a center, region, or population which requires electricity, and which could be served from a hydroelectric station, the tool provides the closes possible locations with three different powers (see Figure 3.3).

FIGURE 3. 3. EXAMPLE OF THE ANALYSIS OF LOCATIONS NEAR TO A CHOSEN SITE



SENER
ATLAS DE HIDRÁULICA
ANÁLISIS PRELIMINAR GEOGRÁFICO DE VIABILIDAD

Estado:
Veracruz de Ignacio de la Llave

Municipio:
Tlacojalpan

Coordenadas Geográficas:
18.235787, -95.917518

CARACTERÍSTICAS GENERALES DEL SITIO

Lluvia media anual:	1621 - 2480 mm	Temperatura media anual:	26 - 28 °C
Lluvia máxima:	200 - 300 mm	Temperatura máxima:	30 - 32 °C
		Temperatura mínima:	20 - 22 °C

PROXIMIDAD (SITIO MÁS CERCANO)

	Nombre	Distancia	Características
Red eléctrica > 69 kv:	GABINO BARREDA - CARLOS CARRILLO	6808.98 m	Tensión: 115
Carreteras:	Sin informacion	18.13 m	Pavimentada, En Operación, Dos Carriles
Localidad Urbana:	Paraíso Novillero	1495.91 m	2538 Habitantes
Localidad Rural:	Moyota	2427.48 m	639 Habitantes
Localidad Indígena:	EL GUAYABO	13778.53 m	Localidad con una proporción de población indígena mayor o igual a 40% de su población total conformada por 10 habitantes
Ríos principales:	Papaloapan	1272.24 m	Orden del río: 6, longitud: 354, perteneciente a la vertiente del Golfo de México y Mar Caribe
Volcanes Activos:	San Matin Tuxtla	84237.93 m	Peligro alto, Volcán que ha producido al menos una erupción con VEI 3 o mayor en los últimos 500 años

¿ Este sitio se encuentra en una zona de exclusión legal ? No

¿ Este sitio se encuentra en una región de alta concentración indígena ? No

SITIOS POTENCIALES CERCANOS EN MW

PROYECTO	PERCENTILES 25	50	75	POT. MEDIA	DISTANCIA (KM.)
1 <= POT < 3	3.49	2.05	1.47	2.80	1.80
3 <= POT < 10	13.84	8.13	5.85	11.10	1.32
10 <= POT	34.86	20.47	14.73	27.97	1.77

EXCLUYENTE DE RESPONSABILIDAD

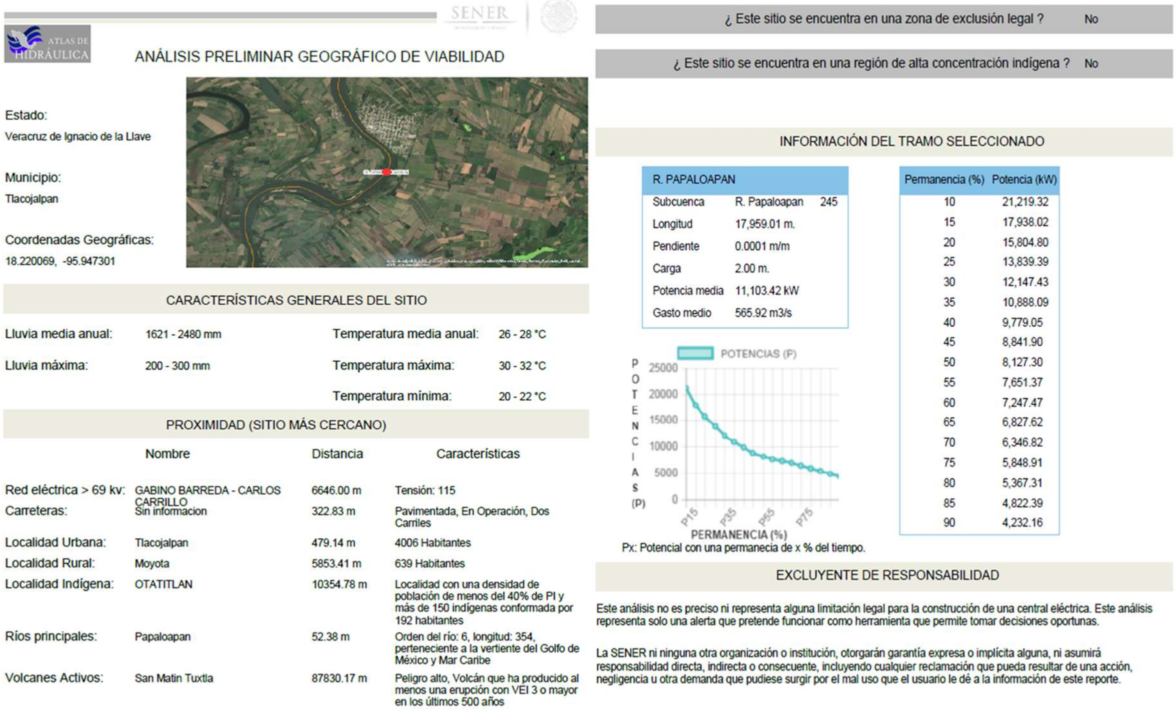
Este análisis no es preciso ni representa alguna limitación legal para la construcción de una central eléctrica. Este análisis representa solo una alerta que pretende funcionar como herramienta que permite tomar decisiones oportunas.

La SENER ni ninguna otra organización o institución, otorgarán garantía expresa o implícita alguna, ni asumirá responsabilidad directa, indirecta o consecuente, incluyendo cualquier reclamación que pueda resultar de una acción, negligencia u otra demanda que pudiese surgir por el mal uso que el usuario le dé a la información de este reporte.

Source: SENER.

b) The user has previously identified a particular location and is interested in performing prefeasibility studies. In this case, the tool is a support that provides information about the economic, social, and environmental factors of the zone, as well as the hydroelectric potential of the location (see Figure 3.4).

FIGURE 3. 4. EXAMPLE OF A GEOGRAPHIC ANALYSIS OF FEASIBILITY


ATLAS DE HIDRÁULICA

ANÁLISIS PRELIMINAR GEOGRÁFICO DE VIABILIDAD

Estado:
Veracruz de Ignacio de la Llave

Municipio:
Tlacojalpan

Coordenadas Geográficas:
18.220069, -95.947301

CARACTERÍSTICAS GENERALES DEL SITIO

Lluvia media anual:	1621 - 2480 mm	Temperatura media anual:	26 - 28 °C
Lluvia máxima:	200 - 300 mm	Temperatura máxima:	30 - 32 °C
		Temperatura mínima:	20 - 22 °C

PROXIMIDAD (SITIO MÁS CERCANO)

	Nombre	Distancia	Características
Red eléctrica > 69 kv:	GABINO BARREDA - CARLOS CARRILLO	6646.00 m	Tensión: 115
Carreteras:	Sin información	322.83 m	Pavimentada, En Operación, Dos Carriles
Localidad Urbana:	Tlacojalpan	479.14 m	4006 Habitantes
Localidad Rural:	Moyota	5853.41 m	639 Habitantes
Localidad Indígena:	OTATITLAN	10354.78 m	Localidad con una densidad de población de menos del 40% de PI y más de 150 indígenas conformada por 192 habitantes
Ríos principales:	Papaloapan	52.38 m	Orden del río: 6, longitud: 354, perteneciente a la vertiente del Golfo de México y Mar Caribe
Volcanes Activos:	San Matin Tuxtla	87830.17 m	Peligro alto, Volcán que ha producido al menos una erupción con VEI 3 o mayor en los últimos 500 años

¿ Este sitio se encuentra en una zona de exclusión legal ? No

¿ Este sitio se encuentra en una región de alta concentración indígena ? No

INFORMACIÓN DEL TRAMO SELECCIONADO

R. PAPALOAPAN	
Subcuenca	R. Papaloapan 245
Longitud	17,959.01 m.
Pendiente	0.0001 m/m
Carga	2.00 m.
Potencia media	11,103.42 kW
Gasto medio	565.92 m3/s

Permanencia (%)	Potencia (kW)
10	21,219.32
15	17,938.02
20	15,804.80
25	13,839.39
30	12,147.43
35	10,888.09
40	9,779.05
45	8,841.90
50	8,127.30
55	7,651.37
60	7,247.47
65	6,827.62
70	6,346.82
75	5,848.91
80	5,367.31
85	4,822.39
90	4,232.16

Px: Potencial con una permanecia de x % del tiempo.

EXCLUYENTE DE RESPONSABILIDAD

Este análisis no es preciso ni representa alguna limitación legal para la construcción de una central eléctrica. Este análisis representa solo una alerta que pretende funcionar como herramienta que permite tomar decisiones oportunas.

La SENER ni ninguna otra organización o institución, otorgarán garantía expresa o implícita alguna, ni asumirá responsabilidad directa, indirecta o consecuente, incluyendo cualquier reclamación que pueda resultar de una acción, negligencia u otra demanda que pudiese surgir por el mal uso que el usuario le dé a la información de este reporte.

Source: SENER.

Additionally, the Atlas displays the total hydraulic potential by political divisions (states and municipalities) and hydrographic divisions (Basins and Subbasins), which makes it an excellent planning and development tool for local governments, non-governmental organizations, and private companies.

The information of the Hydroelectric Power Atlas can be consulted openly and for free from any part of the country and the world in the following weblink:

https://dgel.energia.gob.mx/atlashidro/

3.2. Study on the Integration of Renewable Energies in Baja California Sur

Baja California Sur (BCS) is relevant for studying the impact of the renewable energies integration since this is an isolated system whose most electricity is produced burning fossil fuels (fuel oil and diesel), making it the electricity system with the highest generation costs and also the most polluting one. Besides, its electricity-demand average growth is forecasted in 3.8% and it has a very attractive potential for renewable resources of wind power and, specially, for solar power.

3.2.1. Background

This study was carried out by the NREL as part of the technical assistance provided to Mexico within the 21st Century Power Partnership (21CPP) Alliance, an initiative from the Clean Energy Ministerial (CEM). The study was funded by the Children's Investment Fund Foundation (CIFF) and was supervised and advised by the CENACE, the SENER, the CRE, and the National Institute of Electricity and Clean Energy (INEEL, for its Spanish acronym).

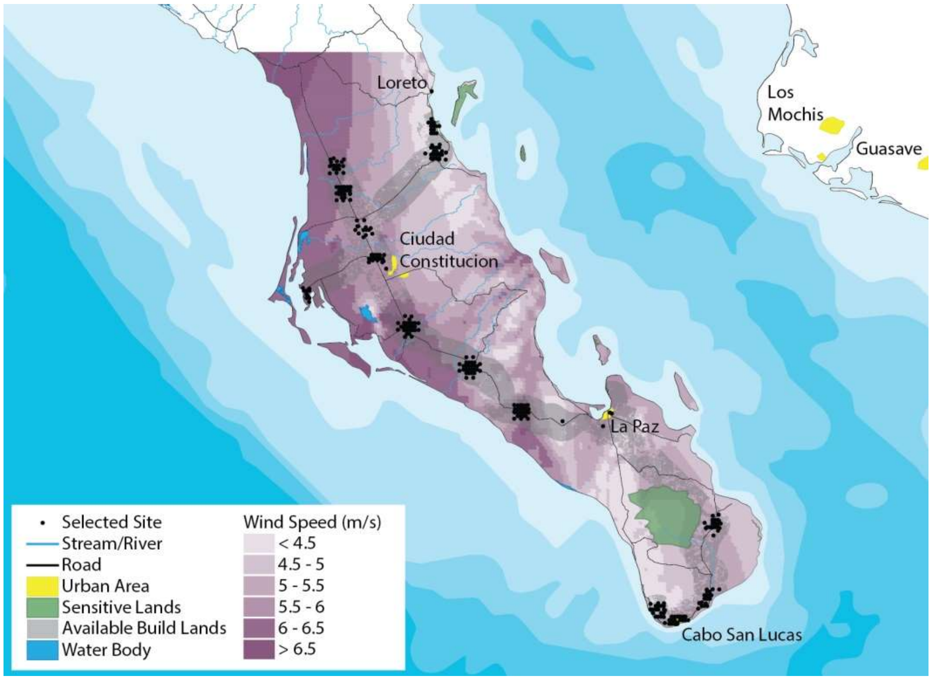
3.2.2. Objective and Methodology of the Study

The BAJA-RIS is aimed to assess the potential impact on the production costs of the growing shares of wind and solar power in the isolated operation of the BCS electricity system by 2024. Studying the impact of wind and solar power in the operation and reliability of the electricity system is imperative due to the variable and uncertain nature of these resources.

The scope of this study does not include the analysis of the dynamic behavior of electric variables and System's stability, as a result of intermittence of renewable generation, reduction of kinetic energy after replacing conventional generation sources with wind and solar generation, and in the occurrence of contingencies.

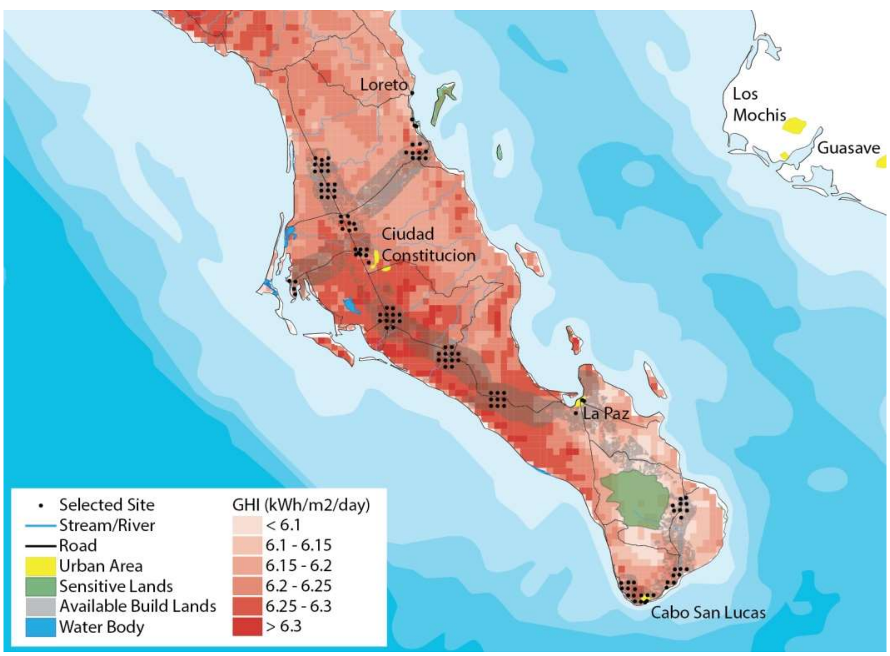
The study will be carried out using PLEXOS©, a commercial tool for modelling production costs. This tool is used for developing a dispatch and commitment generation model which simulates the hourly operation of the BCS isolated electricity system during a year, under different scenarios of renewable energies participation, wind and solar. Likewise, it considers the different restrictions of generation, transmission, and demand, as well as the different operating restrictions to maintain the system's reliability and stability. These include electricity flow constraints between zones (Villa Constitucion, La Paz, and Los Cabos), an instant maximum renewable share equal to 50% of the instant electricity demand, and a dynamic requirement of operating reserve. The model was constructed using real generation and demand data of 2013, provided by the Baja California Regional Control Management and the La Paz Control Sub-Management of the CENACE; as well as other estimates provided by the CENACE's Deputy Directorate of Planning and the SENER. For developing the potential scenarios with growing participations of wind and solar power, two NREL's solar and wind resources databases are used, the National Solar Radiation Database (NSRDB) and the WIND Toolkit. The quality of the wind and solar resource and a subgroup of potential places for renewable projects (from which some are chosen to build different scenarios) are shown in Figures 3.5 and 3.6.

FIGURE 3. 5. WIND RESOURCE IN EN BCS



Source: Elaborated by NREL with information from WIND Toolkit.

FIGURE 3. 6. SOLAR RESOURCE IN BCS



Source: Elaborated by NREL with information from NSRDB.

3.2.3. Scenarios Description

As of 2024, six different scenarios were constructed with growing participations of renewable energies ranging from 3.5% to 40.1% of the total electricity generation. These scenarios share the same thermal generators, the same transmission network, the same electricity demand, and same solar-photovoltaic generation capacity under schemes of distributed generation (15 MW)[23]. The sole difference between these scenarios is the capacities of the wind and solar generators connected to the transmission network, and which range from an installed solar capacity of 60 MW in Scenario 1, to 323 MW and 250 MW capacity in large-scale solar and wind power projects in Scenario, respectively (see Table 3.1). The maximum demand foreseen for the system is of 586 MW and corresponds to the base demand by substation in 2013, projected with an increase equivalent to a growth rate per substation between 2013 and 2024[24].

TABLA 3. 1. SCENARIOS OF RENEWABLE ENERGIES PARTICIPATION IN BCS

Renewable Share (% - Generation)	Installed Solar Power Capacity (MW)	Installed Wind Power Capacity (MW)	Installed Renewable Capacity (MW)	Renewable Penetration (% - installed capacity)	Renewable Penetration (% - maximum demand)
3.5	60.0	0.0	75.0	9.4	12.8
9.5	83.0	50.0	148.0	17.0	25.3
15.4	103.0	100.0	218.0	23.2	37.2
23.6	168.0	150.0	333.0	31.6	56.8
32.5	245.0	200.0	460.0	38.9	78.5
40.1	323.0	250.0	588.0	44.9	100.3

Source: Elaborated by NREL.

As it can be observed in Table 3.2. the thermal generators in the model have an installed capacity of 722 MW (464 MW of fuel oil and 258 MW of diesel) and are an approximate representation of the thermal generation in BCS by 2024. The data were provided by the La Paz Control Sub-Management of the CENACE and are part of the information in the 2016 and 2017 editions of the PRODESEN. This last version does no longer consider investments on NG for the BCS system in the period of analysis. For the thermal generators, the following fuels prices are considered (in MXN of 2016 per MBTUs): 216 for fuel oil and 517 for diesel[25].

TABLE 3. 2. THERMAL GENERATING STATIONS INCLUDED IN THE STUDY
(MW)

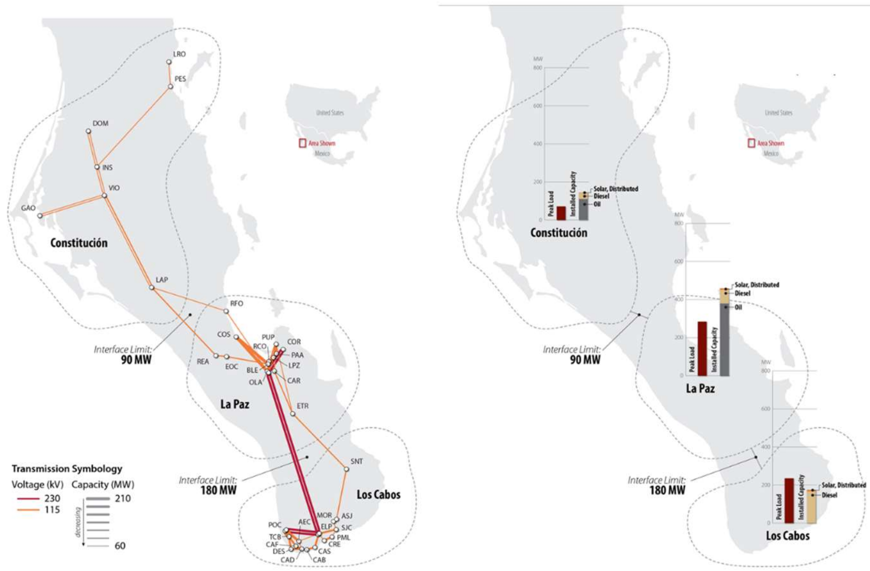
Diesel Generation		Generation with Fuel oil	
Location	Capacity (MW)	Location	Capacity (MW)
La Paz	26.0	La Paz	37.0
La Paz	18.0	La Paz	41.9
La Paz	25.0	La Paz	41.9
Los Cabos	30.0	La Paz	41.9
Los Cabos	23.7	La Paz	41.9
Los Cabos	27.0	La Paz	41.9
Los Cabos	26.0	Constitución	32.0
Los Cabos	26.0	Constitución	32.0
Los Cabos	26.0	Constitución	41.1
Constitución	30.0	La Paz	37.5
-	-	La Paz	37.5
-	-	La Paz	37.5
Total	257.7	Total	464.1

[23] Assumption agreed by the CENACE for elaborating this study based on 2016 estimates.
[24] The series of demand per substation for 2024 were provided by the CENACE.
[25] Prices scenario provided by the SENER based on information contained in COPAR 2015 of CFE.

Source: Elaborated by NREL with information from la Control Sub-Management La Paz of the CENACE.

Figure 3.7 shows the BCS electricity system, as well as the thermal generators and solar-photovoltaic generation under schemes of distributed generation, common to all the scenarios.

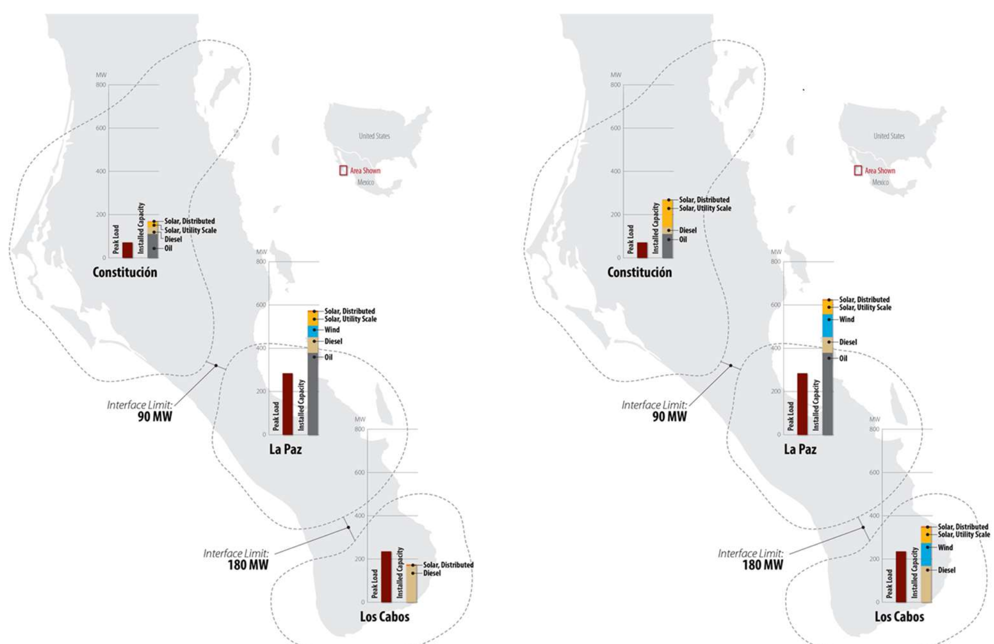
FIGURE 3. 7. TRANSMISSION NETWORK AND THERMAL AND SOLAR GENERATION UNDER SCHEMES OF DISTRIBUTED GENERATION COMMON TO ALL THE SCENARIOS



Source: Elaborated by NREL.

Figure 3.8. shows detailed maps of the scenarios with renewable energies participation of 9.5% and 32.5%.

FIGURE 3. 8. SCENARIOS WITH RENEWABLE ENERGIES PARTICIPATION IN BCS: 9.5% AND 32.5%



Source: Elaborated by NREL.

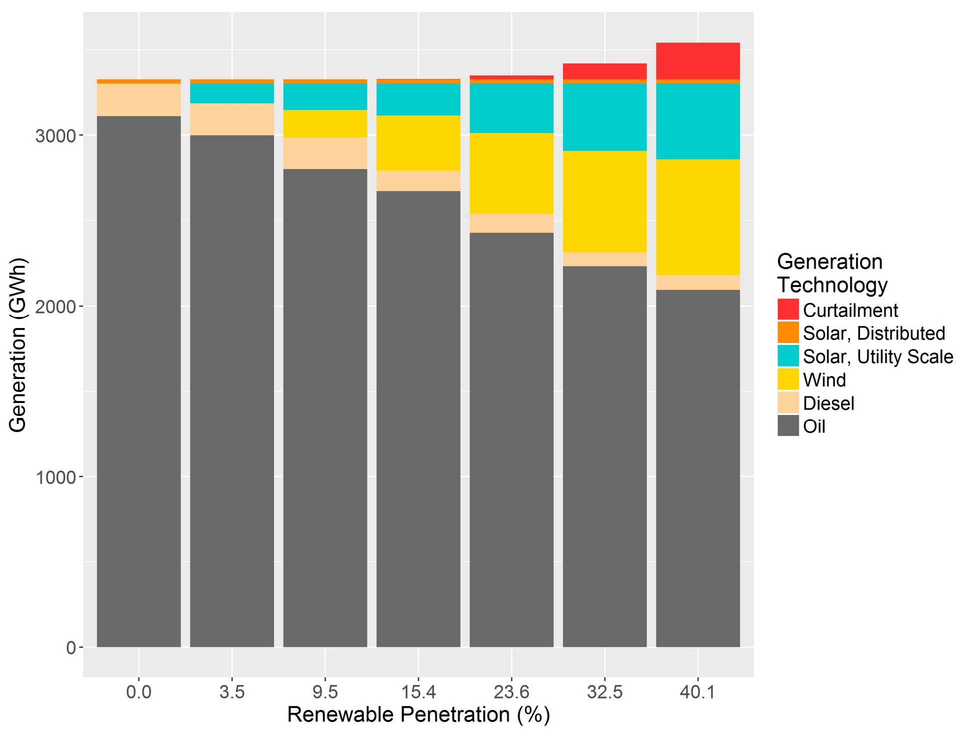
3.2.4. Summary of Results and Conclusions of the Study

From an approach of and study on production costs, the results suggest that towards 2024, the BCS isolated system (not considering the afore planned interconnection to the SIN) could supply the demand and comply with the requirements of operational reserve during every hour of the year under different scenarios with growing participations of wind and solar power connected to the transmission network.

The impacts of a larger participation of wind and solar power within the electricity system operation can be observed in Figure 3.9, which includes, among other: reduction of the electricity generation using fuel oil and diesel; increase of the number of thermal machines startups; reduction of the total variable costs of the system; reduction of CO_2 emissions; and the increase of the necessary downsizes to wind and solar power.

As for the decrease of fuel-oil based electricity generation, it is reduced between 3.56% and 32.65% in a scenario with a renewable-energies share of 3.5% and 40.1% of the total generation, respectively. Regarding diesel-based generation, this is reduced between 2.59% and 54.92% in a scenario with a renewable-energies participation of 3.5% and 40.1% of the total generation, respectively.

FIGURE 3. 9. IMPACT OF THE GROWING LEVELS OF RENEWABLE ENERGIES SHARE IN THE ELECTRICITY GENERATION IN BCS



Source: Elaborated by NREL.

Integrating renewable energies into the BCS isolated system significantly reduces the total variable operational and maintenance costs, and the startup costs of thermal generators. The latter increase with the growing participations of wind and solar power but correspond to a very small percentage of the total variable costs of the system's operation.

With higher levels of renewable-energies participation, the total operational variable costs decrease, mainly, due to increasing the need to curtail solar and wind generation. This generation curtailment is done with the renewable generation is larger than the energy consumption and cannot be stored or absorbed by the electricity system. For example, a renewable share of 15.4% reduces the total variable operational costs in 20.4%; on the other hand, a share of 40.1% reduces costs only by 37.9%. This happens because the generation curtailments needed to keep the balance between the supply and demand of electricity would make it necessary to reduce the generation from wind and solar power to a share of only 33.7% of the total generation. Hence, the optimum level of power utilization is when there are no curtailments. Similar to the total variable operational costs, the reduction of CO_2 emissions decreases with larger shares of wind and solar power.

These results also show the BCS operation with a renewable-share of 32.5% would require a curtail of solar and wind power by 8.5%, reducing their gross share to 29.7%. The renewable energy curtailment grows exponentially with higher levels of participation. With a 23.6% share, it would only be of 2.7%, while with a 40.1% share, the curtail would be of 16%. With these levels, the energy curtail assumes only a small percentage of the annual generation. Besides, if wind and solar participants were allowed to participate in the reserves, these will be benefitted, as well as the system in general due to a reduction in the variable operational costs.

3.2.5. Additional Considerations

This study does not analyze the sub-hourly operational challenges, but it does consider the operational restrictions defined by the CENACE, such as limiting the instant participation of renewable energy to 50% of the instant electricity demand, to make sure the system operates within the limits which guarantee its reliability. In the future, a dynamic simulation study could be very useful to evaluate how would the system behave with a high share of wind and solar power after a high-impact failure. Besides, studying the stability and frequency response with high levels of wind and solar participation would be very valuable for determining in which cases the 50% restriction on instant participation is sufficient or necessary.

A study about the impact of different requirements of operational reserve in the system's production costs and reliability would be very useful to assess the interconnection requirements for generators with renewable energies, e.g. the requirement of installing 15-minute storage to batteries, equivalent to a percentage of the installed capacity of the wind or solar power station.

As part of the Program of Expansion of the National Transmission and Distribution Grid, included in the PRODESEN 2017-2031, it is planned the installation of a submarine wire which connects the BCS with the SIN. This interconnection will entail a reduction in the total operational variable costs; besides, it will also be useful for integrating wind and solar power into the BCS, reducing the necessity of curtailing renewable energies, among other positive impacts in the system. In the future, it would be interesting to assess the challenges and solutions for the integration of renewable energies into the BCS, taking into account the interconnection to the SIN.

3.3. North American Renewable Integration Study to achieve the 2015 target

The objective of the North American Renewable Integration Study (NARIS) is to provide elements to the entities in charge of making the electricity systems planning, to system's operators, governmental agencies, legislators, and regulators about the challenges and opportunities of a larger participation of electricity generated through wind, solar, or hydroelectric power stations in North America, as well as the necessary tools for carrying out this integration in the most effective possible way.

Likewise, this integration study will bring about a deeper understanding on what is the share of the renewable energies to be reliably integrated into the network, under which infrastructure scenarios, as well as the amount of GHS that could be reduced, and at which cost.

3.3.1. Background

During the Eighth North American Leaders Summit (NALS), held on June 2016 in Ottawa, Canada, the then presidents of Mexico, Enrique Peña Nieto, of the USA, Barack Obama, and the Prime Minister of Canada, Justin Trudeau, announced the target of increasing electricity generation with clean energies in the region to reaching 50% in 2025.

By the end of the NALS, it was announced the Action Plan of North American Climate, Clean Energy, and Environment Partnership. In matter of clean and secure energy the following commitments[26] stand out:

- The regional target of clean energies will be achieved through the use of renewable and nuclear energies, technologies of carbon capture and storage, as well as through energy-efficiency measures, under the premise that the actions carried out individually will comply with their conditions, specific legal frameworks, and national targets of clean energy.
- Support the development of cross-border transmission projects, including renewable electricity. The three countries recognize the significant role cross-border transmission lines have in cleaning and increasing the reliability and flexibility of the electricity system of the region.
- Elaborate the NARIS to jointly analyze the planning and operational impacts in the light of a scenario which considers a large integration of renewable energies in the region.

3.3.2. Clean-Energies Electricity Generation in North America

Based on the information available in the PRODESEN 2016-2030, published by the SENER, and in statistical information of the EIA and the NRCan (National Resources Canada), Table 3.3 shows the share of clean energies in generating electricity individually in Mexico, the USA, and Canada, and in the North American region in 2015.

26 For further details, visit the website: https://www.gob.mx/presidencia/documentos/clan2016-plan-de-accion-de-america-del-norte-sobre-la-alianza-del-clima-energia-limpia-y-medio-ambiente?idiom=es

TABLE 3. 3. SHARE OF CLEAN ENERGIES IN GENERATING ELECTRICITY IN THE NORTH AMERICAN REGION, 2015

		Canada	Mexico	USA	Region
2015	Total Generation (TWh/year)	639.0	309.5	4,087.0	5,035.5
	Clean Generation (TWh/year)	514.4	63.0	1,348.0	1,925.4
	Clean Energy %	80.5%	20.3%	32.9%	
	Share of each country in the total of clean energy in the region %	26.7%	3.3%	70.0%	38.2%

Source: Own elaboration with information from SENER, EIA and NRCan.

In 2015, the largest share of clean energies in generating electricity in the North American region was recorded in Canada with 80.5% of the total generated in that country, seconded by the USA and Mexico with 32.9% and 20.3%, respectively. Jointly, electricity generation with clean energies in North America reached 38.2% by the end of that same year. USA is the country which mostly contributes to the clean-energies share in the region with 70% of all the electricity generated recorded in the three countries. Canada and Mexico accounted for 26.7% and 3.3%, respectively.

3.3.3. Next steps of the North American Renewable Integration Study

The scope of the study be developed in 36 months and will be carried out by the NREL [27]. The study has resources of about 8 million dollars (USD), from which two million will be given by the SENER through the Energy Sustainability Fund CONACYT-SENER, and the rest by the US DOE and the NRCan.

The startup meeting of the study was held on October 2016 and, to date, the Technical Review Committee (TRC) of the NARIS, which is formed by representatives of the public and private sectors, and scholars of the three countries, has gathered to discuss the advances of the project, once in the USA and another time in Mexico, in the framework of the Dialogs for the Future of Energy Mexico 2017 (DEMEX).

During 2018 it is foreseen to present the first results of the participation scenarios of renewable energies in the electricity systems, individually for each country and also as a region. Towards the last year of the devise of this study (2019), it is considered the presentation of the final results, as well as the recommendations for each of the three countries.

3.4. Benefits of Distributed Clean Energy

In order to analyze the benefits of distributed clean energy in Mexico, two analyses were carried out on the implementation of photovoltaic systems in the residential sector. The first one was focused on a cost-benefit analysis, while the second focused on an analysis from the economic theory perspective which considers the change in the economic and social wellness. Following is a summary with the main elements and results obtained from each of the studies mentioned above.

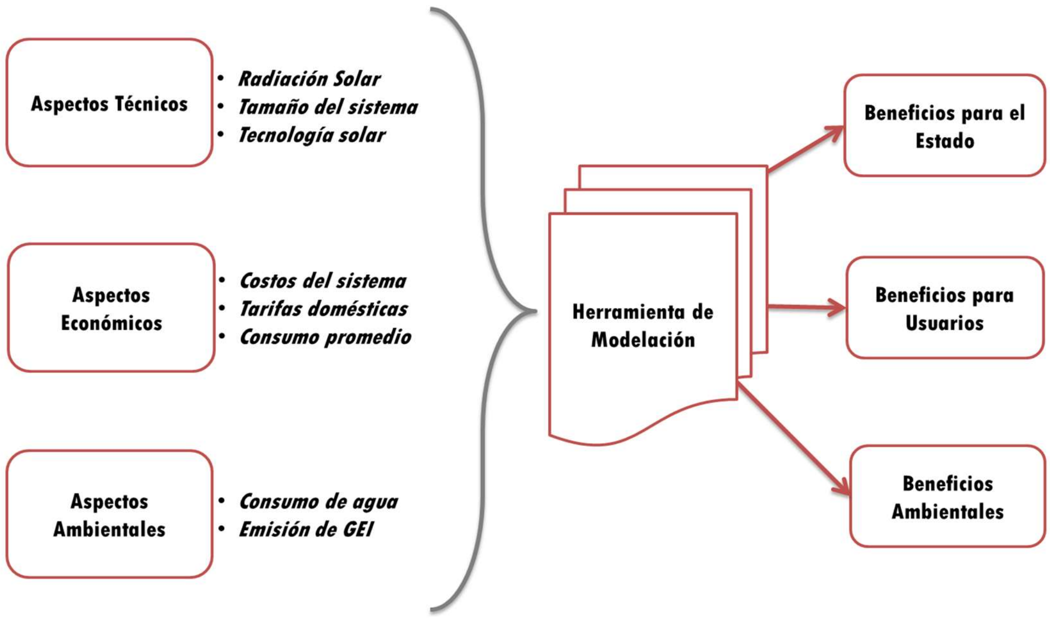
27 For further details, visit the website: https://www.nrel.gov/analysis/naris.html

3.4.1. First analysis of the benefits of implementing solar power in Mexico

The first analysis identified the economic and environmental benefits of implementing solar power in Mexico under schemes of distributed generation[28]. The study was carried out compliant with article Eighteenth Transitory of the LTE and using the model System Advisory Model (SAM), developed by the NREL.

The SAM model incorporates a database with georeferenced solar radiation that estimates each hour and during a whole year the electricity generation served by a Solar Photovoltaic System (SFV, for its Spanish acronym). The potential universe of household users in Mexico is of approximately 35 million households with different characteristics and electricity consumption patterns. To simplify this analysis, average or representative values were used from the different CFE's distribution zones, using data from 2014 and 2015, as shown in the following figure:

FIGURE 3. 10. SIMPLIFIED SCHEME OF THE ANALYSIS OF THE BENEFITS OF THE IMPLEMENTATION OF SOLAR POWER IN MEXICO [29]



Source: SENER.

The results from this analysis suggest that a SFV installed capacity in the household sector equivalent to 1% of the SEN's total would enable the State to have savings for 1,500 million pesos per year in governmental contributions given to users through electricity tariffs during the studied period.

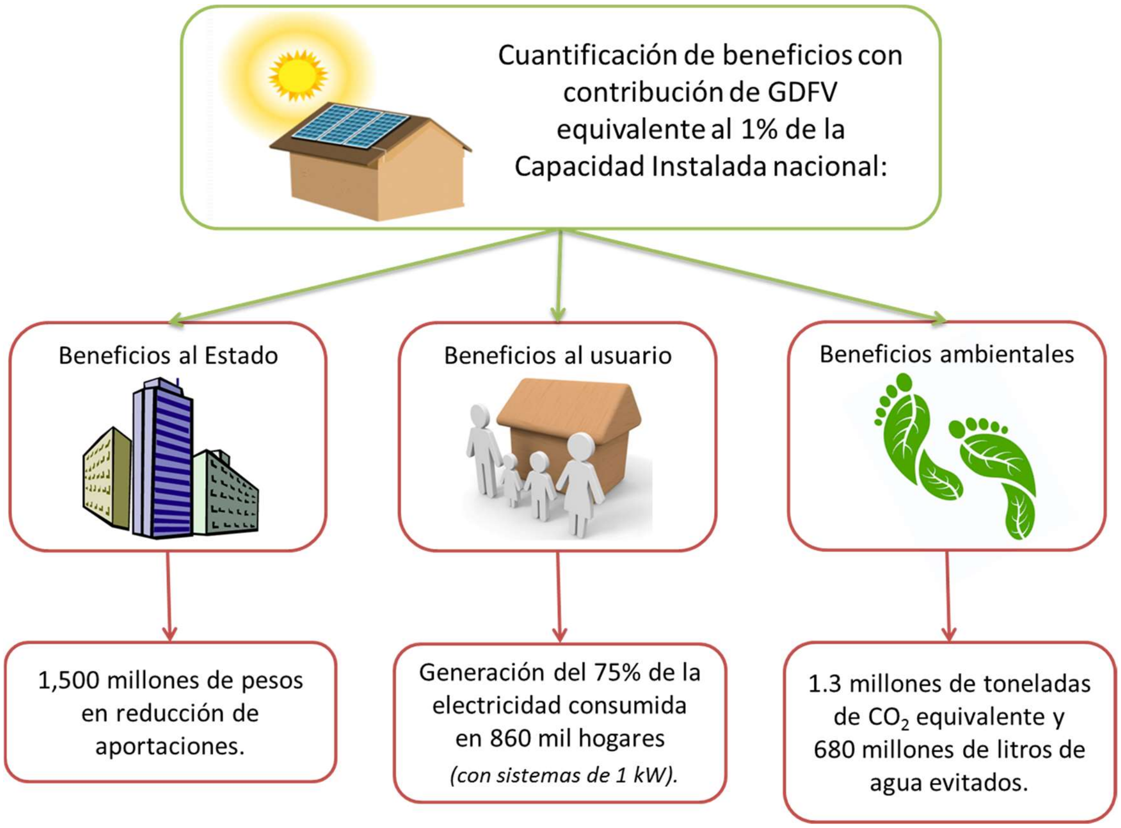
Likewise, it would reduce 1.3 million tons of carbon dioxide equivalent (CO_{2e}) and 961 million liters of water per year, related to the centralized generation with fossil fuels.

Individually, residential-sector users will have savings in their electricity consumption accounting for 75% of the energy used by an average user from the CFE's supply network per year.

[28] In Mexico, distributed generation refers to the electricity generated in a power station of less than 500 kW and interconnected to a distribution circuit. Likewise, distributed clean energy is based on clean energies.

[29] For further details, visit the website: https://www.gob.mx/sener/documentos/beneficios-de-la-generacion-limpia-distribuida-y-la-eficiencia-energetica-en-mexico

FIGURE 3. 11. SUMMARY OF THE BENEFITS EXPECTED FROM ADOPTING SOLAR POWER UNDER SCHEMES OF DISTRIBUTED GENERATION



Source: SENER.

Nonetheless, it is necessary to improve the profitability of implementing SFVs from the users' perspective, given the investment recovery period varies between 15 and 21 years, still a very high value to assume the market could speed up its adoption in the short and medium term.

Hence, new public policies will be needed to foster supporting mechanisms and/or economic stimuli where the State could share its benefits with the uses and thus foster investment in SFVs. A well supported policy could a bridge the gap between the benefits for the State and the benefits for the users. Otherwise, its penetration in the market will be very slow, and the environmental and social benefits would not be observable in the short and medium term.

3.4.2. Analysis of the Social Welfare of Implementing Distributed Solar Energy (DSE) in Mexico

Within the framework of the technical assistance provided to Mexico through the 21CPP, and with the support of the CIFF, the Climate Initiative of Mexico (ICM, for its Spanish acronym), the Center for Research and Teachings in Economics (CIDE, for its Spanish acronym) made an analysis to identify the possibilities, benefits, and challenges of implementing a national program to support the adoption of solar power in Mexico under schemes of distributed solar generation (DSG). This work was aimed mainly to strengthen and supplements the results obtained from the first benefits analysis, presented in the previous sector.

The analysis made by the CIDE[30] is based on the information of the 2014 edition of the National Survey of Household Income and Expenditure (ENIGH, for its Spanish acronym), published by the National Institute of Statistics and Geography (INEGI, for its Spanish acronym), to determine which are the group of users within the residential sector which could install photovoltaic systems in their homes. Afterwards, it was used an econometric model to represent the behavior of a user at the moment of taking a decision about installing a photovoltaic system in his/her home or to continue being served by a supply network. Finally, the changes were obtained, separating the variation in the economic welfare into four parts: 1) change in the welfare of consumers; 2) change in the producers' surplus, for the energy industry as well as for the photovoltaic cells (PV) industry; 3) variation of the governmental incomes from subsidies and taxes related to electricity consumption and to the final purchase of solar panels; and, lastly, 4) variation of the environmental damage.

The results of the analysis gave the maximum number of potential users which could adopt a DSG accounts for 15 million households, which means a consumption of 24.5 million MWh/year. Thus, without considering financing sources for this investment, these households would face a first period of strong negative impact in their welfare due to the initial disbursement[31] for purchasing and operate solar panels. However, during the coming years the initial disbursement would be recovered gradually through the saving on electricity consumption, currently provided by the network.

The average benefit in this 25-year period[32] would be of approximately $2000 MXN per year. The DAC users would be the most benefited since, in average, every household in this category would obtain a benefit of more than $13,000 MXN per year. On the other extreme, households with 1E and 1F tariffs would not obtain any benefit and, therefore, would receive almost no incentives for adopting DSG. The households would need approximately 17 years to recover their investment. However, DAC users would only need 5 years.

From the producer's side, installing PV cells would have a direct impact on the conventional energy producer (CFE), and multiple impacts on the PV panel industry. Assuming the users would install DSG to cover 100% of their household consumption, the CFE would reduce its sales in 24.5 thousand GWh per year. In a scenario where the electricity producer sells its energy at least at average cost, the producer would receive an income of approximately $145 billion MXN per year for the nearly 56 thousand GWh currently dispatched. If the 15 million households mentioned before installed DSG, the conventional energy producer's sales would be reduced to only 31.5 GWh/year. In such case, the CFE could modify its production for using less generators that imply higher costs and thus concentrate in the most efficient ones.

From the PV industry's side, it would benefit from the free competency and its larger profits would be reflected during the term when most of the investment on solar panels installed in households occur. The industry should produce (or import) about 62 million units of 250 watts (or the equivalent to 15.5 thousand MW) during the adoption period. Nowadays, Mexico is a country trying to compete in PV industries similar to the ones in countries like China or Germany. In this context, the country would only generate 20% of the employment and necessary investment (mostly for installation, repairing, and maintenance).

Thus, subtracting the imported panels and inputs, about 12,500 employments would be generated (including the ones of companies already established), and a total investment in capital of $2.5 billion MXN. As for the distribution and installation indicators (which includes installers, sales and administrative personnel, among other), each household's installation would need approximately two persons per day busy in 8-hour workdays, generating about 3,200 employments (including the ones of companies already established), and $110 million MXN of investment in capital.

Finally, regarding environmental impacts, savings would be significative: 70 thousand tons of SO_2, 46 thousand of NO_x, 12 million tons of CO_{2e} (value similar to what was recorded in the California market for 2016-17), and $56 MXN per cubic meter of water (estimates of CONAGUA for 2016), the saving in environmental terms would be of approximately 3,400 million MXN per year.

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[30] A report with the results of this analysis will be published shortly by the SENER.

[31] If these households install a solar-panel system, in average, each household would face an initial investment of $35,000 Mexican pesos (MXN) for each kilowatt installed. The lifespan of a DSG investment is of 25 years.

[32] The operation and maintenance annual cost would be of approximately $70 MXN per kW.

STATISTICAL ANNEX

TABLE A. 1. HYDROELECTRIC GENERATING STATIONS 2016
((MW, GWh)

No.	Name	Federal Entity	Control Region	Scheme[1]/	Total Capacity (MW)	Gross Generation[2]/ (GWh)
1	Cervecería Cuauhtémoc Moctezuma, Planta Orizaba	VER	02-Eastern	SS	10	14
2	Compañía de Energy Mexicana	PUE	02-Eastern	SS	36	235
3	Compañía Eléctrica Carolina	GTO	03-Western	SS	2	5
4	Electricidad del Golfo	VER	02-Eastern	SS	35	106
5	Energy EP	PUE	02-Eastern	SS	0	1
6	Generadora Eléctrica San Rafael	NAY	03-Western	SS	29	96
7	Gobierno del Estado de Michoacán de Ocampo	MICH	03-Western	SS	4	15
8	HydroelectricArco Iris	JAL	03-Western	SS	8	47
9	HydroelectricCajón de Peña	JAL	03-Western	SS	1	7
10	Hidroelectricidad del Pacífico	JAL	03-Western	SS	9	28
11	Hidrorizaba	VER	02-Eastern	SS	2	9
12	Hidrorizaba II	VER	02-Eastern	SS	4	19
13	Ingenio Tamazula, Planta Santa Cruz	JAL	03-Western	SS	1	1
14	Mexicana de Hidroelectricidad Mexhidro	GRO	02-Eastern	SS	30	136
15	Papelera Veracruzana	VER	02-Eastern	SS	1	6
16	Primero Empresa Minera	DGO	05-North	SS	20	58
17	Procesamiento Energético Mexicano	VER	02-Eastern	SS	11	51
18	Proveedora de Electricidad de Occidente	JAL	03-Western	SS	19	50
19	Zagis	VER	02-Eastern	SS	2	11
20	Generadora Fénix, Alameda	MEX	01-Central	GEN	7	5
21	Generadora Fénix, Lerma (Tepuxtepec)	MICH	01-Central	GEN	57	229
22	Generadora Fénix, Necaxa	PUE	01-Central	GEN	109	395
23	Generadora Fénix, Patla	PUE	01-Central	GEN	45	139
24	Generadora Fénix, Tepexic	PUE	01-Central	GEN	45	99
25	Agua Prieta (Valentín Gómez Farías)	JAL	03-Western	GEN-CFE	240	241
26	Aguamilpa Solidaridad	NAY	03-Western	GEN-CFE	960	1,998
27	Angostura (Belisario Domínguez)	CHIS	02-Eastern	GEN-CFE	900	2,030
28	Bacurato	SIN	04-Northwest	GEN-CFE	92	266
29	Bartolinas	MICH	03-Western	GEN-CFE	0.8	2
30	Bombaná	CHIS	02-Eastern	GEN-CFE	5	23
31	Boquilla	CHIH	05-North	GEN-CFE	25	82
32	Botello	MICH	03-Western	GEN-CFE	18	67
33	Caracol (Carlos Ramírez Ulloa)	GRO	02-Eastern	GEN-CFE	600	1,262
34	Chicoasén (Manuel Moreno Torres)	CHIS	02-Eastern	GEN-CFE	2,400	4,513
35	Chilapan	VER	02-Eastern	GEN-CFE	26	112
36	Cóbano	MICH	03-Western	GEN-CFE	60	269

37	Colimilla	JAL	03-Western	GEN-CFE	51	88
38	Colina	CHIH	05-North	GEN-CFE	3	9
39	Colotlipa	GRO	02-Eastern	GEN-CFE	8	33
40	Comedero (Raúl J. Marsal)	SIN	04-Northwest	GEN-CFE	100	342
41	Cupatitzio	MICH	03-Western	GEN-CFE	80	467
42	El Cajón (Leonardo Rodríguez Al.)	NAY	03-Western	GEN-CFE	750	1,149
43	El Fuerte (27 de Septiembre)	SIN	04-Northwest	GEN-CFE	59	366
44	El Novillo (Plutarco Elías Calles)	SON	04-Northwest	GEN-CFE	135	531
45	El Retiro (José Cecilio del Valle)	CHIS	02-Eastern	GEN-CFE	21	80
46	El Salto (Camilo Arriaga)	SLP	06-Northeast	GEN-CFE	18	87
47	Electroquímica	SLP	06-Northeast	GEN-CFE	1	10
48	Encanto	VER	02-Eastern	GEN-CFE	10	17
49	Falcón	TAMS	06-Northeast	GEN-CFE	32	57
50	Huites (Luis Donaldo Colosio)	SIN	04-Northwest	GEN-CFE	422	1,062
51	Humaya	SIN	04-Northwest	GEN-CFE	90	267
52	Infiernillo	GRO	01-Central	GEN-CFE	1,200	2,813
53	Intermedia (Luis M. Rojas)	JAL	03-Western	GEN-CFE	5	14
54	Itzícuaro	MICH	03-Western	GEN-CFE	1	2
55	Ixtaczoquitlán	VER	02-Eastern	GEN-CFE	2	13
56	Jumatán	NAY	03-Western	GEN-CFE	2	13
57	La Amistad	COAH	06-Northeast	GEN-CFE	66	49
58	La Venta (Ambrosio Figueroa)	GRO	02-Eastern	GEN-CFE	ND	1
59	La Yesca (Alfredo Elias Ayub)	NAY	03-Western	GEN-CFE	750	1,059
60	Malpaso	CHIS	02-Eastern	GEN-CFE	1,080	2,477
61	Mazatepec	PUE	02-Eastern	GEN-CFE	220	593
62	Micos	SLP	06-Northeast	GEN-CFE	1	3
63	Minas	VER	02-Eastern	GEN-CFE	15	85
64	Mocúzari	SON	04-Northwest	GEN-CFE	10	49
65	Oviachic	SON	04-Northwest	GEN-CFE	19	119
66	Peñitas (Ángel Albino Corzo)	CHIS	02-Eastern	GEN-CFE	420	1,309
67	Platanal	MICH	03-Western	GEN-CFE	13	41
68	Portezuelo I	PUE	02-Eastern	GEN-CFE	2	9
69	Portezuelo II	PUE	02-Eastern	GEN-CFE	2	4
70	Puente Grande	JAL	03-Western	GEN-CFE	9	34
71	San Pedro Porúas	MICH	03-Western	GEN-CFE	3	5

72	Sanalona (Salvador Alvarado)	SIN	04-Northwest	GEN-CFE	14	71
73	Santa Bárbara	MEX	01-Central	GEN-CFE	23	33
74	Santa Rosa (General Manuel M. Diéguez)	JAL	03-Western	GEN-CFE	70	277
75	Schpoiná	CHIS	02-Eastern	GEN-CFE	2	8
76	Tamazulapan	OAX	02-Eastern	GEN-CFE	2	6
77	Temascal y Ampliación Temascal	OAX	02-Eastern	GEN-CFE	354	1,214
78	Texolo	VER	02-Eastern	GEN-CFE	2	12
79	Tingambato	MEX	01-Central	GEN-CFE	42	85
80	Tirio	MICH	03-Western	GEN-CFE	1	3
81	Tuxpango	VER	02-Eastern	GEN-CFE	36	131
82	Villita (José María Morelos)	MICH	01-Central	GEN-CFE	320	1,278
83	Zimapán (Fernando Hiriart Balderrama)	HGO	03-Western	GEN-CFE	292	1,848
84	Zumpimito	MICH	03-Western	GEN-CFE	8	51
85	Hidroeléctrica Trigomil	JAL	03-Western	P.P.	8	8
				Total[3/]	**12,589**	**30,909**

1/ SS: Self-Supply; GEN: Generation; GEN-CFE: Federal Electricity Commission Generation; SP: Small Production. 2/ Includes the generation reported by the power station La Venta (Ambrosio Figueroa) temporary out of service by the end of 2016. 3/ Due to rounding, totals may not add up. Preliminary information by the end of 2016.
Source: Elaborated by SENER with information from CFE, CRE and CENACE.

TABLE A. 2. WIND-POWER GENERATING STATIONS 2016

(MW, GWh)

No.	Name	Federal Entity	Control Region	Scheme1/	Total Capacity (MW)	Gross Generation2/ (GWh)
1	Bii Nee Stipa Energy Wind	OAX	02-Eastern	SS	26	91
2	Compañía Wind de Tamaulipas	TAMS	06-Northeast	SS	54	169
3	Compañía Eoloeléctrica de Ciudad Victoria	TAMS	06-Northeast	SS	50	19
4	Desarrollos Eólicos Mexicanos de Oaxaca 1	OAX	02-Eastern	SS	90	304
5	Desarrollos Eólicos Mexicanos de Oaxaca 2, Piedra Larga Fase 2	OAX	02-Eastern	SS	138	491
6	Dominica Energía Limpia	SLP	03-Western	SS	200	489
7	Eléctrica del Valle de México	OAX	02-Eastern	SS	68	191
8	Energía Limpia de Palo Alto	JAL	03-Western	SS	129	48
9	Eólica del Istmo	OAX	02-Eastern	SS	164	545
10	Eólica del Pacífico	OAX	02-Eastern	SS	160	640
11	Eólica de Arriaga	CHIS	02-Eastern	SS	32	90
12	Eólica de Coahuila	COAH	06-Northeast	SS	201	7
13	Eólica Dos Arbolitos	OAX	02-Eastern	SS	70	225
14	Eólica El Retiro	OAX	02-Eastern	SS	74	143
15	Eólica Los Altos	JAL	03-Western	SS	50	183
16	Eólica Santa Catarina	NL	06-Northeast	SS	22	37
17	Eólica Tres Mesas	TAMS	06-Northeast	SS	63	11
18	Eólica Zopiloapan	OAX	02-Eastern	SS	70.0	261
19	Eurus, Juchitán de Zaragoza Oaxaca	OAX	02-Eastern	SS	251	964
20	Fuerza Eólica Del Istmo	OAX	02-Eastern	SS	80	190
21	Fuerza y Energía Bii Hioxo	OAX	02-Eastern	SS	234	802
22	Municipio de Mexicali	BC	08-Baja California	SS	10	24
23	Parques Ecológicos de México	OAX	02-Eastern	SS	102	250
24	PE Ingenio	OAX	02-Eastern	SS	50	184
25	Pier II Quecholac Felipe Ángeles	PUE	02-Eastern	SS	66	253
26	Stipa Nayaa	OAX	02-Eastern	SS	74	279
27	Ventika	NL	06-Northeast	SS	126	333
28	Ventika II	NL	06-Northeast	SS	126	357
29	Vientos del Altiplano	ZAC	06-Northeast	SS	100	40
30	Energy Sierra Juárez	BC	08-Baja California	EXP	156	377
31	La Venta I-II	OAX	02-Eastern	GEN-CFE	84	185
32	Puerto Viejo (Guerrero Negro)	BCS	10-Mulegé	GEN-CFE	1	0
33	Yuumil´iik	QR	07-Peninsular	GEN-CFE	2	2
34	Energía Sonora PPE	SON	04-Northwest	P.P.	2	4
35	Instituto de Investigaciones Electricas	OAX	02-Eastern	P.P.	0	0
36	CE Oaxaca Cuatro, Oaxaca IV	OAX	02-Eastern	IPP	102	469
37	CE Oaxaca Dos, Oaxaca II	OAX	02-Eastern	IPP	102	420
38	CE Oaxaca Tres, Oaxaca III	OAX	02-Eastern	IPP	102	371
39	Energías Ambientales de Oaxaca, Oaxaca I	OAX	02-Eastern	IPP	102	317
40	Energías Renovables La Mata, La Mata (Sureste I fase II)	OAX	02-Eastern	IPP	102	398
41	Energías Renovables Venta III, La Venta III	OAX	02-Eastern	IPP	103	299
				Total3/	3,735	10,463

1/ SS: Self-Supply; GEN: Generation; GEN-CFE: Federal Electricity Commission Generation; SP: Small Production. 2/ Includes the generation reported by the power station La Venta (Ambrosio Figueroa) temporary out of service by the end of 2016. 3/ Due to rounding, totals may not add up. Preliminary information by the end of 2016.
Source: Elaborated by SENER with information from CFE, CRE and CENACE.

TABLE A. 3. GEOTHERMAL-POWER GENERATING STATIONS 2016

(MW, GWh)

No.	Name	Federal Entity	Control Region	Scheme[1]/	Total Capacity (MW)	Gross Generation[2]/ (GWh)
1	Geothermal for development, Domo de San Pedro	NAY	03-Western	SS	35	115
2	Cerro Prieto I	BC	08-Baja California	GEN-CFE	30	241
3	Cerro Prieto II	BC	08-Baja California	GEN-CFE	220	1,536
4	Cerro Prieto III	BC	08-Baja California	GEN-CFE	220	1,098
5	Cerro Prieto IV	BC	08-Baja California	GEN-CFE	100	797
6	Los Azufres	MICH	03-Western	GEN-CFE	225	1,801
7	Los Humeros	PUE	02-Eastern	GEN-CFE	69	508
8	Tres Vírgenes	BCS	10-Mulegé	GEN-CFE	10	54
				Total[3/]	**909**	**6,148**

1/ SS: Self-Supply; GEN: Generation; GEN-CFE: Federal Electricity Commission Generation; SP: Small Production. 2/ Includes the generation reported by the power station La Venta (Ambrosio Figueroa) temporary out of service by the end of 2016. 3/ Due to rounding, totals may not add up. Preliminary information by the end of 2016.
Source: Elaborated by SENER with information from CFE, CRE and CENACE.

TABLE A. 4. SOLAR-POWER GENERATING STATIONS 2016

(MW, GWh)

No.	Name	Federal Entity	Control Region	Scheme1/	Total Capacity (MW)	Gross Generation2/ (GWh)
1	Autoabastecimiento Renovable	AGS	03-Western	SS	1	3
2	Coppel	SON	04-Northwest	SS	1	1
3	Generadora Solar Apaseo	GTO	03-Western	SS	1	0
4	Iusasol 1	MEX	01-Central	SS	18	39
5	Iusasol Base	MEX	01-Central	SS	1	1
6	Oomapas Nogales	SON	04-Northwest	SS	1	0
7	Plamex	BC	08-Baja California	SS	1	2
8	Los Santos Solar I	CHIH	05-North	SS	20	-
9	Productora Yoreme	SON	04-Northwest	GEN	1	0
10	Cerro Prieto	BC	08-Baja California	GEN-CFE	5	10
11	Sta. Rosalía (Tres Vírgenes)	BCS	10-Mulegé	GEN-CFE	1	2
12	Servicios Comerciales de Energy	BCS	09-Baja California Sur	P.P.	30	18
13	Tai Durango Cinco	DGO	05-North	P.P.	30	39
14	Tai Durango Cuatro	DGO	05-North	P.P.	6	8
15	Tai Durango Dos	DGO	05-North	P.P.	6	8
16	Tai Durango Tres	DGO	05-North	P.P.	6	5
17	Tai Durango Uno	DGO	05-North	P.P.	16	24
	Total[2/]				**145**	**160**

1/ SS: Self-Supply; GEN: Generation; GEN-CFE: Federal Electricity Commission Generation; SM: Small Production. 2/ Includes the generation reported by power stations under testing phase. 3/ Due to rounding, totals may not add up. Preliminary information by the end of 2016.
Source: Elaborated by SENER with information from CFE, CRE and CENACE.

TABLE A. 5. GENERATING STATIONS WITH BIOENERGY
(MW, GWh)

No.	Name	Federal Entity	Control Region	Scheme1/	Total Capacity (MW)	Gross Generation2/ (GWh)
1	Azsuremex	TAB	02-Eastern	SS	3	3
2	BSM Energía de Veracruz	VER	02-Eastern	SS	13	28
3	Compañía Azucarera de Los Mochis	SIN	04-Northwest	SS	14	17
4	Compañía Azucarera del Río Guayalejo	TAMS	06-Northeast	SS	46	17
5	Compañía Azucarera La Fé	CHIS	02-Eastern	SS	13	24
6	Cooperativa La Cruz Azul	AGS	03-Western	SS	1	0
7	Ecosys III	GTO	03-Western	SS	2	1
8	Empacadora San Marcos	PUE	02-Eastern	SS	1	0
9	Energy Láctea	CHIH	05-North	SS	1	0
10	Fideicomiso Ingenio Emiliano Zapata	MOR	01-Central	SS	9	19
11	Fideicomiso Ingenio Plan de San Luis	SLP	06-Northeast	SS	9	27
12	Grupo Azucarero San Pedro	VER	02-Eastern	SS	10	33
13	Impulsora de la Cuenca del Papaloapan	VER	02-Eastern	SS	24	53
14	Ingenio Adolfo López Mateos	OAX	02-Eastern	SS	14	31
15	Ingenio Alianza Popular	SLP	06-Northeast	SS	6	20
16	Ingenio El Higo	VER	06-Northeast	SS	22	38
17	Ingenio El Mante	TAMS	06-Northeast	SS	6	10
18	Ingenio El Molino	NAY	03-Western	SS	10	14
19	Ingenio Eldorado	SIN	04-Northwest	SS	10	5
20	Ingenio Melchor Ocampo	JAL	03-Western	SS	6	27
21	Ingenio Nuevo San Francisco	VER	02-Eastern	SS	7	13
22	Ingenio Presidente Benito Juárez	TAB	02-Eastern	SS	14	23
23	Ingenio San Francisco Ameca_SS	JAL	03-Western	SS	5	14
24	Ingenio San Miguelito	VER	02-Eastern	SS	5	7
25	Ingenio San Rafael de Pucté	QR	07-Peninsular	SS	9	40
26	Ingenio Tala	JAL	03-Western	SS	12	1

27	Ingenio Tamazula	JAL	03-Western	SS	10	36
28	Ingenio Tres Valles	VER	02-Eastern	SS	12	0
29	Kimberly-Clark de México	VER	02-Eastern	SS	10	0
30	Lorean Energy Group	COAH	06-Northeast	SS	2	9
31	Servicios de Agua y Drenaje de Monterrey, Gobierno del Estado de Nuevo León, Planta Dulces Names	NL	06-Northeast	SS	9	0
32	Servicios de Agua y Drenaje de Monterrey Gobierno del Estado de Nuevo León, Planta North	NL	06-Northeast	SS	2	0
33	Sociedad Autoabastecedora de Energy Verde de Aguascalientes	AGS	03-Western	SS	3	8
34	TMQ Generation Energy Renovable	QRO	03-Western	SS	1	4
35	Transformadora de Energandéctrica de Juárez	CHIH	05-North	SS	6	27
36	Alcoholera de Zapopan	VER	02-Eastern	COG	8	7
37	Atlatec	QRO	03-Western	COG	1	6
38	Atlatec, Planta El Ahogado	JAL	03-Western	COG	3	6
39	Bio Pappel, Planta Atenquique	JAL	03-Western	COG	16	38
40	Bioeléctrica de Occidente	NAY	03-Western	COG	35	2
41	BioEnergy de Nuevo León	NL	06-Northeast	COG	17	81
42	Conservas La Costeña y Jugomex	MEX	01-Central	COG	1	8
43	Energy Renovable de Cuautla	MOR	01-Central	COG	1	0
44	GAT Energy	VER	02-Eastern	COG	45	14
45	Huixtla Energy	CHIS	02-Eastern	COG	12	27
46	Ideal Saneamiento de Saltillo	COAH	06-Northeast	COG	1	5
47	Piasa Cogeneration	VER	02-Eastern	COG	40	156
48	Tala Electric	JAL	03-Western	COG	25	106
49	Tampico Renewable Energy	VER	06-Northeast	COG	40	17
50	Energreen Energy PI	MEX	01-Central	GEN	1	0
51	Ingenio Lázaro Cárdenas	MICH	03-Western	GEN	6	10
52	Ingenio San Francisco Ameca_GEN	JAL	03-Western	GEN	8	3
53	Renova Atlatec	JAL	03-Western	GEN	11	0
54	Ener-G	DGO	05-North	P.P.	2	1

55	Central Motzorongo	VER	02-Eastern	COU	20	20
56	Compañía Azucarera La Concepción	VER	02-Eastern	COU	4	1
57	Compañía Industrial Azucarera	VER	02-Eastern	COU	6	13
58	Fideicomiso Ingenio Atencingo	PUE	02-Eastern	COU	15	19
59	Fideicomiso Ingenio Casasano	MOR	01-Central	COU	3	5
60	Fideicomiso Ingenio La Providencia	VER	02-Eastern	COU	7	9
61	Ingenio El Carmen	VER	02-Eastern	COU	7	7
62	Ingenio El Modelo	VER	02-Eastern	COU	9	15
63	Ingenio El Potrero	VER	02-Eastern	COU	10	22
64	Ingenio El Refugio	OAX	02-Eastern	COU	4	0
65	Ingenio La Gloria	VER	02-Eastern	COU	53	36
66	Ingenio La Margarita	OAX	02-Eastern	COU	7	28
67	Ingenio Mahuixtlán	VER	02-Eastern	COU	3	5
68	Ingenio Pánuco	VER	06-Northeast	COU	18	32
69	Ingenio Plan de Ayala	SLP	06-Northeast	COU	16	14
70	Ingenio Quesería	COL	03-Western	COU	6	24
71	Ingenio San José de Abajo	VER	02-Eastern	COU	8	14
72	Ingenio San Miguel del Naranjo	SLP	03-Western	COU	49	95
73	Ingenio San Nicolás	VER	02-Eastern	COU	14	42
74	Ingenio Santa Clara	MICH	03-Western	COU	9	13
75	Santa Rosalia de La Chontalpa	TAB	02-Eastern	COU	25	20
				Total[3/]	**889**	**1,471**

1/ SS: Self-Supply; COG: Cogeneration; GEN: Generation; SM: Small Production; COU; Continuous Own Uses. 2/ Includes the generation reported by power stations under testing phase. 3/ Due to rounding, totals may not add up. Preliminary information by the end of 2016.
Source: Elaborated by SENER with information from CFE, CRE and CENACE.

GLOSSARY

Capacity	Maximum power at which energy can be supplied to a generating unit, a power plant, or an electric device, and is specified by the manufacturer of the user.
CFE power plant	Power plant which, with the entry into force of the Law for the Electric Industry. It is owned by the bodies, entities, or state enterprises and is under operating conditions, or whose construction and delivery is included in the Expenditure Budget of the Federation under the modality of direct investment.
Charge	Power required by consumption devices which is measured in electrical units (watts); each time a user turns on a switch for connecting or disconnecting an electric appliance produces a variation in its electricity demands.
Clean Energies Certificate	Certificate issued by the CRE which appoints the generation of a defined amount of electricity through renewable sources or clean technologies and which is used to comply with the mandatory requirements related to the consumption of Load Centers.
Cogeneration	Procedure through which one can simultaneously obtain electric power and useful thermal power (steam, hot water, etc.). As a modality, it is the jointly generation of electric power with steam and/or secondary thermal power of other kind. It can be the direct or indirect electric power generation from residual thermal energy coming from processes using fuels, or vice versa.
Demand	Power to which the needed electricity shall be supplied in a given instant. The average value within a given interval is equal to the energy needed between the numbers of time units of the interval (MWh/h).
Emissions	Release of GHG or its precursors, and sprays into the atmosphere, including greenhouse compounds, in a defined zone and period.
Energy Consumption (GWh)	Total annual sales of power, remote self-supply, sales associated to the reduction of non-technical losses, and own uses.

Export (modality)

Electricity destined to foreign trade through projects like cogeneration, independent production, and small production complying with the legal and ruling provisions applicable in each case.

Permit holders in this modality are not allowed to dispose of the electricity that has been generated within the national territory, unless they are granted a permit from the CRE for performing such activity under another modality.

Final Consumption (GWh)

Total annual sales of electric power and remote self-supply consumed by end users of the electricity sector.

Firm-Energy Project

Generation projects not subjected to the optimization of the planning model; hence, they are installed in the date indicated by the Generators, as long as they comply with the following criteria:

a) Have an Interconnection Agreement and a Generation Permit which considers its startup after January 1st, 2016.

b) That the CENACE has instructed the Transporter of the Distributor to sign an Interconnection Agreement.

c) To have finished the facilities' study and have paid the financial guarantee for the projects chosen to be included as part of the planning process.

d) To have submitted a compliance guarantee for the projects assigned in the Long-Term Auctions, timely.

Generator

Permit granted under the LIE for generating electricity in power stations with a capacity beyond 0.5 MW, or agreement of Market Participant for representing these stations in the MEM, or, authorized by the CRE, to power stations located abroad.

Generic-Generation Project

Possible power stations candidates allocated to the different transmission region according to the available generation potential and development feasibility for achieving the Clean Energy Targets and send market signals to the project developers interested in production investments within the electricity sector, subjected the optimization of the planning model.

Grid	Group of elements interconnected for the transmission, transformation, and compensation of energy transportation.
Gross Domestic Product (GDP)	Annual value of the production of goods and services of the country.
Import (modality)	Purchase of energy from generating plants abroad through legal acts signed between the electricity supplier and its consumer.
Independent Production	Electricity generation coming from a power plant with a capacity for over 30 MW, exclusively destined to be sold to CFE or - if permitted by the Secretariat of Energy under the terms of the Electric Power Public Service Law -, for exports.
Interconnected National System	Regional electrical systems which share through their connections their resources of capacity, and their economic, trustable, and efficient operation as a group.
Megawatt (MW)	Unit of power equal to 1,000,000 Watts.
Megawatt hour (MWh)	Unit of power. In electricity, it is the power consumed by a one MW load during an hour.
National Electrical System (SEN, for its Spanish acronym)	Integrated by public and private participants connected to the electricity national grid and which intervene in the generation, transmission, and distribution of electricity.
Natural Gas (NG)	Hydrocarbons blend mainly formed by the methane found in the fields as a solution or in a gas phase with crude oil, or in oil-free fields.
Net Generation	Electricity delivered to a transmission grid and which is equal to the gross generation minus the energy used for the plant's own uses.
Net Power	Total power delivered into the grid, and which equals the gross generation from the system's power plants plus the imported power from other electric systems, plus the powered purchased from self-suppliers and co-generators.

Operating-Generation Project	Power stations of the SEN which operated regularly or began operating during 2016, according to information from the CFE, the CENACE, and the CRE.
Optimization-Generation Project	Generation projects which do not comply with the “firm” category; might have or not, a generation permit from the CRE, subjected to the optimization of the planning models.
Own Uses	Amount of electric power consumed by auxiliary equipment in the generating units.
Photovoltaic Solar Power (Photovoltaics)	It is defined from the "photovoltaic effect", which refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current.
Plant Factor	Indicates the degree of usage of the generating units’ capacity during a given period. It is calculated by dividing the average generation between its effective capacities.
Power Plant	Facilities and equipment which, in a specific site, enables the generation of electricity and related products.
Projects by private parties	It replaces the figure of permit holders when the Electric Industry Law came into force.
Renewable Energies Potential	Renewable and clean sources which can be used for generating electricity through the development of projects on power stations, as long as they are economically viable.
Self-supply	Supply of the electricity requirements from members of a private association through a power generating plant of their own. As a modality defined by CFE it is understood as: electricity generation for self-supply consumption provided that such energy is destined to meet the needs of individuals or legal entities and result in no damage to the country.
Self-supply project	Development of a generating unit constructed by private parties, in order to supply its own electricity requirements or those between the members of an association of individuals.

Small production	Electric power generation destined to be totally sold to CFE, and whose projects cannot have a total capacity bigger than 30 MW within a given are; or to the self-supply of small rural communities or isolated areas that are not served, and whose projects cannot exceed 1 MW; or to exports, within the maximum limit of 30 MW.
Solar Photovoltaic Energy	It is defined based on the "photovoltaic effect", which happens with the photons of the sunlight excite energy levels higher than the "loose" electrons of the atoms from the semiconductor material it is having incidence. When this light's property is combined with the properties of those materials, the electrons flow through an interface and creates a power differential.
Solar thermal energy	Produces electricity concentrating solar radiation to heat and produce water steam that goes through a turbine, just as it happens in a thermal or combined cycle plant.
Stored Power	Potential power susceptible to become electricity in a hydroelectric plant, regarding the useful volume of stored water and the specific consumption for energy conversion.
Thermal Solar Power	Thermal solar technology produces power by concentrating solar array for heating and producing water steam which goes through a turbine, just in the same way it is done in a thermal or combined cycle power plant.

ACRONYMS AND ABBREVIATIONS

21CPP	21st Century Power Partnership
SS	Self-Supply
AZEL	National Atlas of High-Potential Zones for Clean Energy
BANDAS	Surface Water National Databank
BCS	Baja California Sur
CELs	Clean Energy Certificates
CENACE	National Energy Control Center
CEM	Clean Energy Ministry
CFE	Federal Electricity Commission
CIDE	Center for Research and Teachings in Economics
CIFF	Children's Investment Fund Foundation
CONAGUA	National Water Commission
CO_2	Carbon Dioxide
CONAFOR	National Forestry Commission
CONUEE	National Commission for the Efficient Use of Energy
CRE	Energy Regulatory Commission
DOF	Official Journal of the Federation
EIA	Energy Information Agency
EOL	Wind-Power
GHG	Greenhouse Gases
GEIC	Management of Civil Engineering Studies
GEN	Generation
GEN-CFE	Federal Electricity Commission Generation
GEO	Geothermoelectric
GPG	Geothermoelectric Projects Management
GW	Gigawatt

GWh	Gigawatt-hour
HID	Hydroelectric
INAH	National Institute of Anthropology and History
INEGI	National Institute of Statistics and Geography
INEL	National Inventory of Clean Energies
INEEL	National Institute of Electricity and Clean Energy
INPC	National Consumer Price Index
IRENA	International Renewable Energy Agency
km-c	Kilometer-circuit
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour
LIE	Electric Industry Law
LTE	Energy Transition Law
LOAPF	Organic Law of the Federal Public Administration
MMCFD	Million cubic feet per day
MV	Medium Voltage
MVA	Megavolt ampere
MW	Megawatt
MWe	Megawatt electric
MWh	Megawatt-hour
n.a.	Not available
NARIS	North American Renewable Integration Study
NRCan	National Resources Canada
NREL	National Renewable Energy Laboratory
NOM	Official Mexican Standard
PRODESEN	Development Program for the National Electricity System
PRONASE	National Program for the Sustainable Utilization of Energy

GPD	Gross Domestic Product
IPP	Independent Power Producer
SP	Small Production
RNT	National Transmission Network
SCT	Secretariat of Communications and Transportation
SEN	National Electric System
SENER	Secretariat of Energy
SEMARNAT	Secretariat of Environment and Natural Resources
PVS	Photovoltaic System
SIN	National Interconnected System
AAGR	Average Annual Growth Rate
TWh	Terawatt-hour
UNAM	National Autonomous University of Mexico
VER	One-Stop-Shop for Renewable Energies

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https://dgel.energia.gob.mx/azel/	Atlas of High-Potential Zones for Clean Energies
http://inere.energia.gob.mx	National Inventory of Clean Energies
https://www.gob.mx/sener	Secretariat of Energy
http://www.nrel.gov	National Renewable Energy Laboratory

Explanatory Notes:

- The total up of the numerical or percentage data within the text, tables, charts, or figures may not add up due to rounding.
- The information corresponding to the last historical year is subjected to subsequent reviews.
- Likewise, regarding the sum of the figures, the manual estimation of the average annual growth rates may not coincide accurately with the values reported due to rounding.
- In the modality of Independent Power Producer (IPP), the figures reported under the concept of "authorized capacity" and "operating capacity" do not necessarily coincide with the figures reported under the concept of "gross capacity hired by the CFE".

References for comments

For those interested in provide their observations, suggestions, or make any questions, please contact:

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