2018
2032

PRODESEN

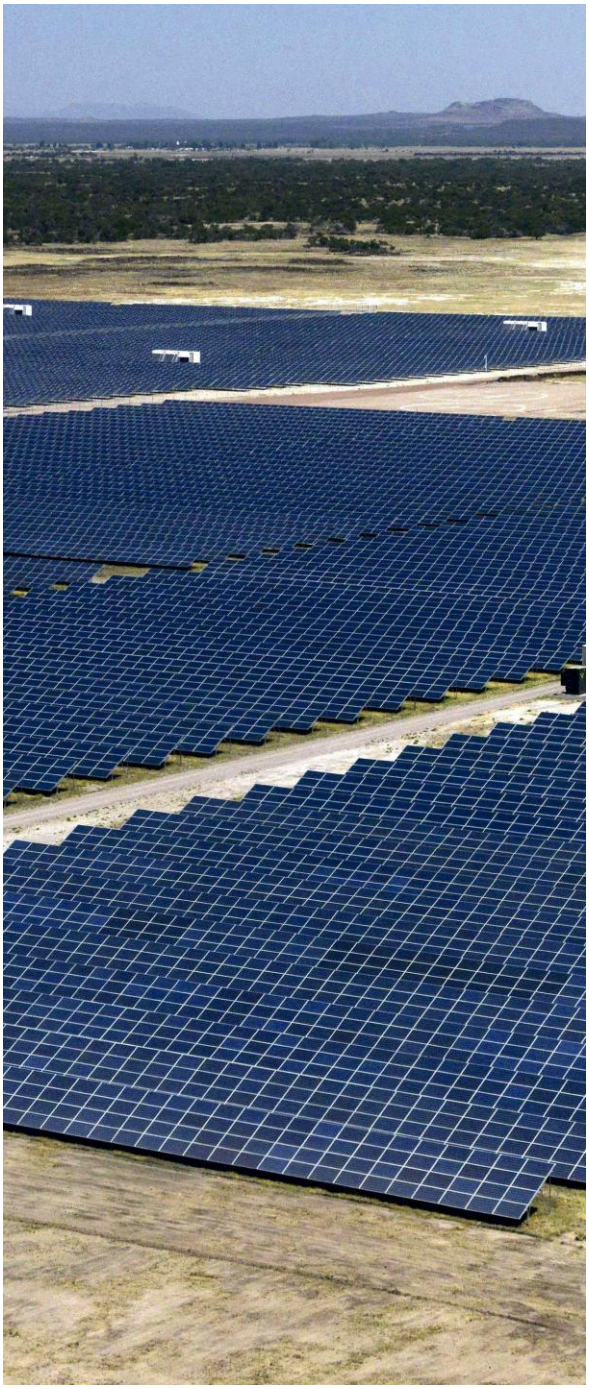
PROGRAMA DE DESARROLLO DEL SISTEMA ELÉCTRICO NACIONAL

Executive Summary

SENER
SECRETARÍA DE ENERGÍA

ESTADOS UNIDOS MEXICANOS

INTRODUCTION



The Political Constitution of the United Mexican States mandates the federal government to develop the planning for the National Electric System (SEN). The Electric Industry Law (LIE) established that such planning shall be conducted by the Ministry of Energy (SENER). Under this framework, SENER published the Development Program for the National Electric System (PRODESEN) 2018-2032, which is the main planning instrument regarding generation, transmission and distribution of electricity in Mexico.

The PRODESEN comprises the planning of SEN and the most significant elements of:

a) **Indicative Program for the Commissioning and Decommissioning of Power Plants (PIIRCE)**

   Outlines the generation capacity required to satisfy the demand forecast and clean energy goals.

b) **Program for the Expansion and Modernization of the National Transmission Grid (PAMRNT)**

   These two programs are the result of the centralized planning carried out by the Independent System Operator (CENACE) and the Distribution Company (CFE Distribución) respectively. These include the expansion and modernization projects needed to minimize the cost of electricity supply, reduce transmission congestion costs and encourage efficient generation capacity expansion meeting the criteria of quality, reliability, continuity and safety of the grid.

PRODESEN includes the necessary transmission and distribution projects to be developed by the transmission company and the distribution company, respectively, prior instruction by SENER.

PROGRESS AND RESULTS OF THE ENERGY REFORM IN ELECTRICITY DURING 2017 AND 2018

SENER tender for transmission BC-SIN project

On February 2nd, 2018, SENER, through the National Electric System and Nuclear Policy Unit, published the Call for the International Public Tender N° LT / SENER-01-2018 in the National Gazette (DOF), to award the Management and Operation Contract of the Electric Transmission Infrastructure for the interconnection between the Baja California Electric System (BC) and the National Interconnected System (SIN).

According to the Bid terms, the awarded bidder will be the one who submits the lowest constant annual contract payment, and whose technical proposal has complied with the requirements established in the terms.

CFE Transmisión tender for Ixtepec-Yautepec transmission project

On February 8, 2018, CFE Transmission company (CFE Transmisión) responsible unit, the Deputy-direction of Project Structuration of the Corporate Direction of Engineering and Infrastructure Projects, published in the CFE's Microsite of Tenders, the Bid Terms N° CFE-0036-CASOA-0001-2018 to award the contract for the Project 303 LT in Direct Current from the Substation Ixtepec (Oaxaca) to the Substation Yautepec (Morelos).

Mid-Term Electricity Auctions

According to the Market Rules, the Mid-term Electricity Auctions are designed for Basic Service Suppliers as well as for Entities Responsible for Load to secure energy and capacity contracts with generators and traders in lengths from one to three years.

On March 5, 2018, CENACE published the official results of the first Mid-term electricity auction, assigning 3.98% of the total capacity, with not awards for energy. Capacity providers were registered Market Participants, on the Generator mode: Subsidiary Productive Enterprise (CFE Generación VI), GPG Energía México and Energía Azteca. The winning bid corresponds to GPG Energía México with a 50 MW-year power to be delivered in 2018.

Long Term Electricity Auctions

So far, three Long-term Electricity Auctions have concluded with successful results. These have resulted in international recognition because of low and decreasing prices offered, even compared with other Latin-American countries like Brazil, Chile and Peru.
The first Long-term electricity auction (SLP-1/2015) closed on March 30, 2016, assigning 84.9% of the power required by CFE, as Basic Service Supplier and 84.6% of the Clean Energy Certificates (CEL). The average price was 47.7 USD for (MWh + CEL).

The awarded projects represent investments of 2.6 billion USD from 11 companies from Canada, China, Spain, United States of America, France, Italy and Mexico. These projects will be located in the states of Aguascalientes, Baja California Sur, Coahuila, Guanajuato, Hidalgo, Jalisco, Tamaulipas y Yucatán, and will increase the national installed capacity by 2.8% compared to 2017. This represent 2,085 MW to generate clean energy. As a whole, the contracts awarded amount to 1.6% of total generation of the National Electric System in 2017.

The second Long-term electricity auction (SLP-1/2016) closed on September 28, 2016, assigning 83.8% of the power, 87.3% of the CEL and 80.1% of capacity required by CFE as Basic Service Supplier. The average price was 33.7 USD for (MWh + CEL), 30% lower than in the first Long-term electricity auction and one of the lowest in the World.

The awarded contracts in the SLP-1/2016 represent investments of 4 billion USD, by 23 companies from China, South Korea, United States of America, Spain, France, Italy, Mexico, the Netherlands, Portugal and the United Kingdom. These projects will be located in the states of Aguascalientes, Baja California, Chihuahua, Coahuila, Guanajuato, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, San Luis Potosí, Sonora y Tamaulipas, and will increase the installed capacity by 3.8% compared to 2017.

The third Long-term electricity auction (SLP-1/2017) closed on November 22, 2017, assigning 90.2% of the power, 97.8% of the CEL and 41.9% of capacity required. This auction allowed other buyers in addition to CFE as Basic Service Supplier to present offers to purchase these products. In order to incorporate these new buyers a Clearing House was established to act as the counterpart in the contracts.

The 16 awarded projects represent investments of 2.4 billion USD, by companies from Mexico, Spain, France, Italy, Canada, United States of America, China and Japan. The average price was 20.57 USD for (MWh + CEL), 38.5% lower than in the second long-term electricity auction and once again one of the lowest in the World.

As a result of the third Long-term electricity auction, 14 new power plants will be built over the next three years which represent 2,012 MW of new clean generation capacity to be located in the Mexican States of Tlaxcala, Aguascalientes, Zacatecas, Tamaulipas, Nuevo León, Coahuila, Chihuahua and Sonora.

On March 2018, CENACE published the call and terms for the fourth Long-term electricity auction (SLP-1/2018), which shall close on November 2018.

Clean Energy Certificates Market

Clean Energy Certificates (CEL) are the primary mechanism that Mexico has implemented to integrate clean energy generation at the lowest cost, promote the investment in new clean generation projects and encourage the execution of long-term contracts between Generators and Obligated Participants to acquire CELs under the best possible conditions.

According to the LIE, the Ministry of Energy established the requirements for acquisition of CELs that will be applicable in 2018 and 2019, 5% and 5.8%, respectively. These requirements were the key element for the first two Long-term auctions which assigned 14.7 million CELs in total, this value represents 39% and 56% of the whole obligation for 2018 and 2019, respectively.

SENER established the requirements for acquisition of CELs for 2020, 2021 and 2022, 7.4%, 10.9% y 13.9%, respectively. These values allow Obligated Participants to plan their CELs requirements, while clean energy developers have more incentives to materialize their investments and to participate in the CELs Market that started operations in 2018.

On March 29, 2018, SENER published the Requirement for acquisition of CELs in 2021, re-affirming the obligation of 10.9%.

SENER handed first Market Rules to CRE

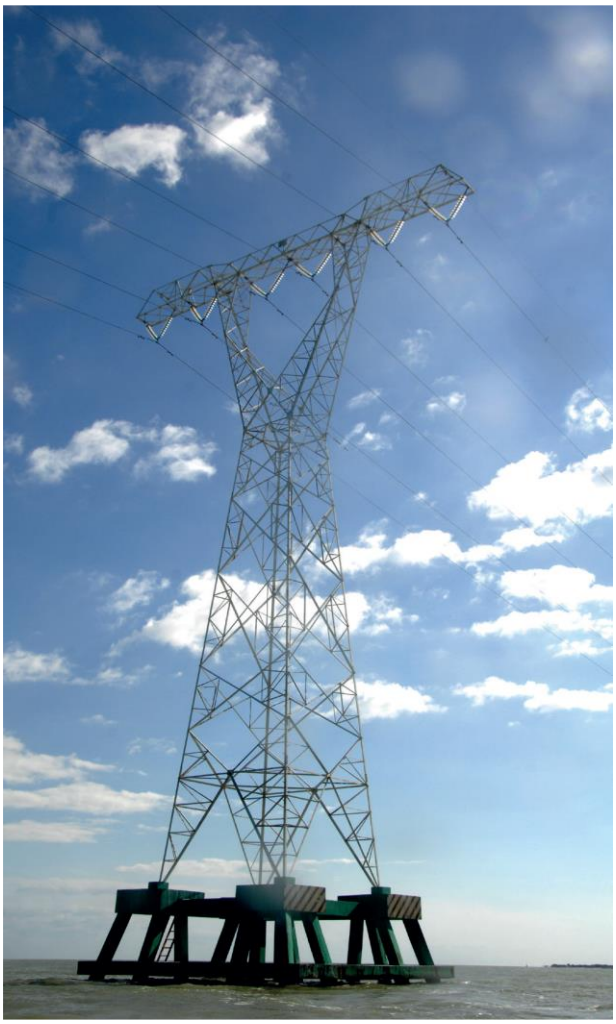
On December 20, 2017, in fulfillment of the third transitory article from LIE, SENER handed over the first Market Rules to the Energy Regulatory Commission (CRE).

The first Market Rules encompass the framework rules, the Bases of the Wholesale Electricity Market, 27 manuals and one operative guideline. In the future CRE will be responsible for evaluating and eventually changing the Market Rules as well as updating them based on the performance of the market.

Operation of the Wholesale Electricity Market

The Wholesale Electricity Market has operated for two years already. There are 82 Market Participants, 39 Generators, 28 Qualified Service Suppliers, 11 Non-suppliers Retailers, one Intermediation Generator, one Qualified User, one Last Resource Supplier and one Basic Service Supplier.

CURRENT SITUATION OF THE NATIONAL ELECTRIC SYSTEM



Installed Capacity

As of 2017, the operating capacity in the SEN was 75,685 MW. 70.5% corresponds to conventional power plants and 29.5% to power plants with clean technologies. The operating capacity increased 3% compared to 2016. Combined cycle power plants have the highest share of conventional technologies while hydroelectric power plants do for clean energy technologies (see Table 1).

57.2% of the operating capacity in the country corresponds to CFE's power plants, 17.5% to power plants of Independent Power Producers (PIE), the remaining 25.3% corresponds to private power plants under the following schemes: generator, self-supply, cogeneration, small-scale production, export, distributed generation or rural systems not interconnected to the grid supported by the Shared Risk Trust Fund (FIRCO).

38.5% of the installed capacity is located in five states: Veracruz, Tamaulipas, Chiapas, Baja California and Nuevo León. In contrast, 1.6% of the total capacity is located in the following five states: Aguascalientes, Tlaxcala, Zacatecas, Mexico City and Quintana Roo.

Electricity Generation

In 2017, electricity generation was 329,162 GWh, 3.1% higher than 2016. Generation from conventional technologies represented 78.9% (259,766 GWh), combined cycle power plants contributed the most. 21.1% (69,397 GWh) came from clean technologies. Hydroelectric power plants contributed the most followed by the nuclear and wind power plants. Generation from clean sources grew 7% (4,529 GWh) compared to 2016 (see table 2).

TABLE 1

INSTALLED CAPACITY BY TECHNOLOGY
(Megawatt)

Technology	Capacity 2016[1/]	Capacity 2017[2/]	AGR (%)[3/]	No. of power plants
Conventional energies	**52,331**	**53,358**	**2.0**	**526**
Combined cycle	27,274	28,084	3.0	83
Conventional thermoelectric	12,594	12,546	-0.4	59
Coal Fuel	5,378	5,378	0.0	3
Turbogas[4/]	5,052	5,136	1.7	131
Internal combustion	1,453	1,634	12.5	248
Fluidized bed combustion	580	580	0.0	2
Clean energies	**21,179**	**22,327**	**5.4**	**271**
Renewable	18,529	19,462	5.0	239
Hydroelectric	12,589	12,642	0.4	86
Wind power	3,735	4,199	12.4	45
Geothermal	909	926	1.9	8
Solar PV	145	214	47.4	23
Bioenergy [5/]	889	1,007	13.3	77
Distributed Generation (GD)[6/]	248	434	75.3	
FIRCO[7/]	14	40	182.2	
Others	2,651	2,865	8.1	32
Nuclear	1,608	1,608	0.0	1
Efficient cogeneration	1,036	1,251	20.7	30
Regenerative brakes	6.61	6.61	0.0	1
Total[8/]	**73,510**	**75,685**	**3.0**	**797**

1/ Revised data. 2/ Preliminary information. 3/ AGR: Annual Growth Rate. 4/ Includes mobile plants. 5/ Includes biomass, bagasse of cane, biogas and black liquor such as fuels according to Ley de Promoción y Desarrollo de los Bioenergéticos. 6/ Includes several technologies. 7/ Fideicomiso de Riesgo Compartido (FIRCO).8/ Totals may not match due to rounding. Preliminary information 2017. Source: Elaborated by SENER with CFE, CRE, CENACE data.

CFE power plants represented 52% of total generation in 2017. PIEs or IPPs generated 26.7% and the remaining 21.3% was generated by private power plants under the following schemes: generator, self-supply, cogeneration, small-scale production, export, distributed generation or rural systems not interconnected to the grid supported by the FIRCO.

The five states with the most electricity generation were: Veracruz, Tamaulipas, Nuevo Leon, Baja California and Guerrero, which together contributed 42.6% of the electricity generation in the country. In contrast, the states of Aguascalientes, Morelos, Quintana Roo, Zacatecas and Tlaxcala contributed with only 0.4%.

TABLE 2

ELECTRICITY GENERATION
(Gigawatt-hour)

Tecnology	Generation 2016[1/]	Generation 2017[2/]	AGR (%)[3/]
Conventional energies	**254,496**	**259,766**	**2.1**
Combined cycle	160,378	165,245	3.0
Conventional thermoelectric	40,343	42,780	6.0
Coal Fuel	34,208	30,557	-10.7
Turbogas[4/]	12,600	12,849	2.0
Internal combustion	3,140	4,006	27.6
Fluidized bed combustion	3,826	4,329	13.1
Clean energies	**64,868**	**69,397**	**7.0**
Renewable	49,244	51,578	4.7
Hydroelectric	30,909	31,848	3.0
Wind Power	10,463	10,620	1.5
Geothermal	6,148	6,041	-1.7
Solar PV	160	344	114.8
Bioenergy[5/]	1,471	1,884	28.0
Distributed Generation (GD)[6/]	56	760	1,246.7
FIRCO[7/]	36	82	127.3
Others	**15,624**	**17,818**	**14.0**
Nuclear	10,567.2	10,883	3.0
Cogeneration	5,053	6,932	37.2
Regenerative brakes	4	4	0.0
Total[8/]	**319,364**	**329,162**	**3.1**

1/ Revised data. 2/ Preliminary information. 3/ AGR: Annual Growth Rate. 4/ Includes mobile plants. 5/ Includes biomass, bagasse of cane, biogas and black liquor such as fuels according to Ley de Promoción y Desarrollo de los Bioenergéticos. 6/ Includes several technologies. 7/ Fideicomiso de Riesgo Compartido (FIRCO).8/ Totals may not match due to rounding. Preliminary information 2017. Source: Elaborated by SENER with CFE, CRE, CENACE data.

Transmission

In 2017, the transmission capacity of the links in the 53 regions was 76,697 MW, representing an increase of 3.4% over the previous year. The highest transmission capacity was concentrated in the Northeast control region with 24.7% of the total. The Northwest control region had the greatest increase in transmission capacity with 895 MW, which represented an annual growth of 14.8% (see map 1).

In 2017, the length of the transmission lines (230 and 400 kV) (CFE and others) was 53,842 kilometers, 1% more than 2016 in total and 1.8% more for 230 kV lines.

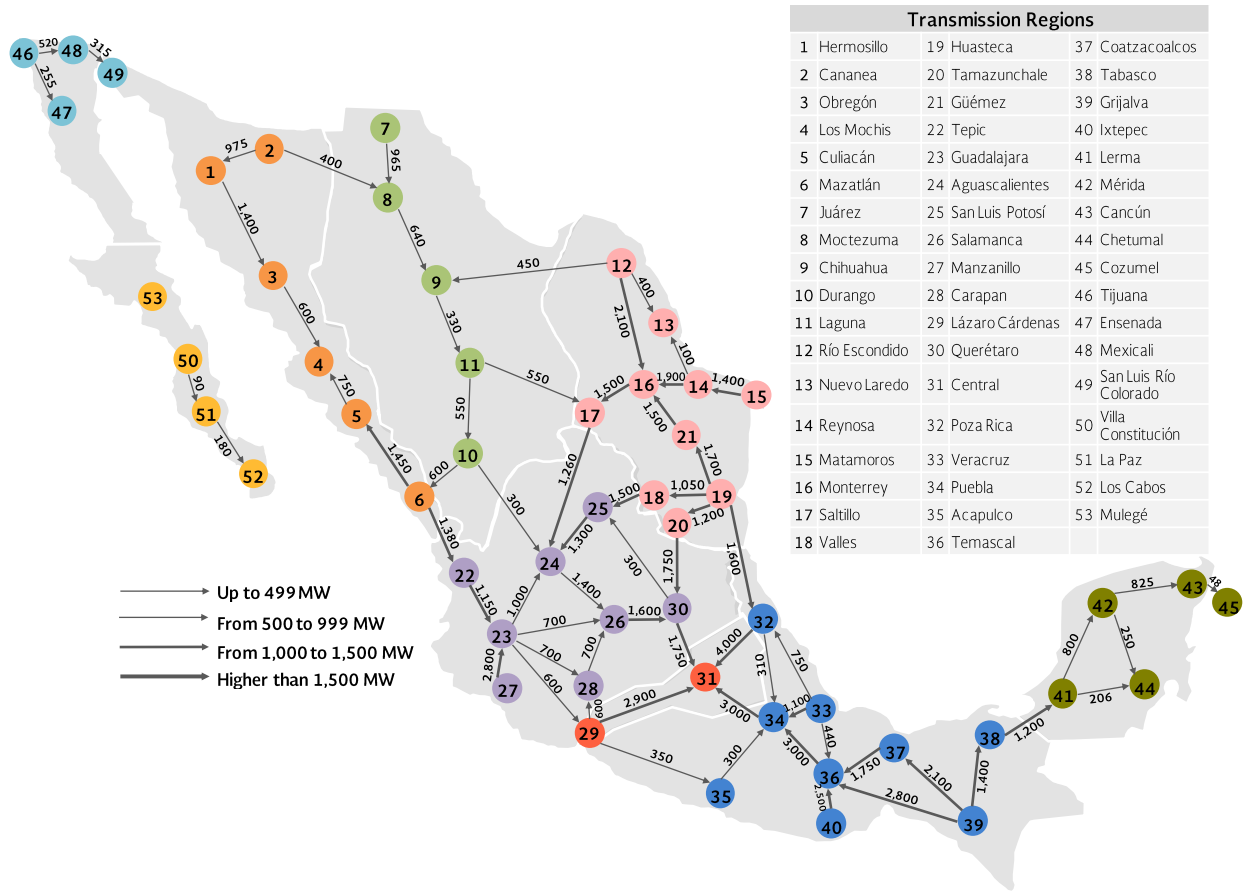
The states with more transmission grid extension are Sonora, Veracruz and Chihuahua with 13,377 kilometers (24.8% of the national total). Whereas, the states with the lowest length of the Transmission

Grid are Baja California Sur, Morelos and Colima, below 500 kilometers each.

On the other hand, in 2017 the transformation capacity of substations was 158,035 MVA, 28.8% less than 2016.

MAP 1

53 TRANSMISSION REGIONS – 2017
(Megawatt)



Transmission Regions					
1	Hermosillo	19	Huasteca	37	Coatzacoalcos
2	Cananea	20	Tamazunchale	38	Tabasco
3	Obregón	21	Güémez	39	Grijalva
4	Los Mochis	22	Tepic	40	Ixtepec
5	Culiacán	23	Guadalajara	41	Lerma
6	Mazatlán	24	Aguascalientes	42	Mérida
7	Juárez	25	San Luis Potosí	43	Cancún
8	Moctezuma	26	Salamanca	44	Cheturnal
9	Chihuahua	27	Manzanillo	45	Cozumel
10	Durango	28	Carapan	46	Tijuana
11	Laguna	29	Lázaro Cárdenas	47	Ensenada
12	Río Escondido	30	Querétaro	48	Mexicali
13	Nuevo Laredo	31	Central	49	San Luis Río Colorado
14	Reynosa	32	Poza Rica	50	Villa Constitución
15	Matamoros	33	Veracruz	51	La Paz
16	Monterrey	34	Puebla	52	Los Cabos
17	Saltillo	35	Acapulco	53	Mulegé
18	Valles	36	Temascal		

Source: Elaborated by SENER with CENACE data.

Distribution

In 2017 the capacity of installed substations for distribution was 74,133 MVA, 7.5% higher than 2016. The total number of transformers from medium to low operating voltage for the distribution service was increased by 22 thousand transformers to reach a total of 1.4 million, with a total capacity of 54,366 MVA.

In 2017, the total length of the distribution lines was 829,925 km. 61.1% corresponds to medium voltage and 38.9% to low voltage, 9.6% and 1.9% more respectively in comparison to 2016.

ELECTRICITY CONSUMPTION AND DEMAND BEHAVIOR

Gross Consumption

Gross consumption of electricity in 2017 (309,727 GWh) grew 3.7% from 2016. More than the half of gross consumption (59%) was concentrated in the Western, Central and Northeast areas (see Table 3). The six months between May to October accounted for 54.1% of gross consumption, while the remaining months accounted for 45.9%.

The main grid, the Interconnected National System (SIN) concentrates 94.6% of the country's gross consumption.

TABLE 3

GROSS CONSUMPTION OF ELECTRICAL POWER BY OPERATIONAL AREA
(Gigawatt-hour)

Region of control	Consumption 2016[1/]	Consumption 2017[2/]	AGR (%)[3/]
Central	59,103	60,685	2.7
Eastern	47,642	48,583	2.0
Western	63,407	66,696	5.2
Northwest	23,389	24,293	3.9
North	24,696	25,949	5.1
Northeast	52,297	54,423	4.1
Peninsular	12,129	12,498	3.0
SIN	**282,662**	**293,127**	**3.7**
Baja California	13,438	13,825	2.9
Baja California Sur[4/]	2,541	2,622	3.2
Mulegé	151	152	0.8
SEN	**298,792**	**309,727**	**3.7**

1/Revised data. 2/Preliminary information. 3/ AGR: Annual Growth Rate. 4/ Sistema La Paz. Totals may not match due to rounding. Source: SENER with information from CENACE.

Demand

On January and December, the minimum annual demands were registered in the SIN. The minimum annual demand occurred on January 1, 2017 at 9:00 hours, at 18,800 MWh/h. On the other hand, on June 23, 2017 at 16:00 and 17:00 hours the maximum demand level was recorded at 43,319 MWh/h, this was 5.9% more than in 2016. The North and Western areas registered the greatest increases in their maximum demands, growing 8.2% and 5.3% respectively.

In the Northern area, the maximum demand was recorded on June 23 at 16:00 hours with a value 4,608 MWh/h and in the Occidental area it was

recorded on June 23 at 14:00 hours with a value 9,842 MWh/h (see Table 4).

In the Central region, the maximum demand was recorded in the winter season on February 8 at 20:00 hours mainly due to the greater use of lighting systems for decorative purposes in residential and commercial areas, use of lighting systems, heating and longer residential lighting at night.

Between 2015-2016 the maximum demands in the SIN were registered on August 14 and July 8, both at 17:00 hours, in contrast in June 23, 2017 the maximum demand occurred in two consecutive hours, at 16:00 hours and 17:00 hours (see Figure 1).

TABLE 4

INTEGRATED MAXIMUM DEMAND BY OPERATIONAL AREA

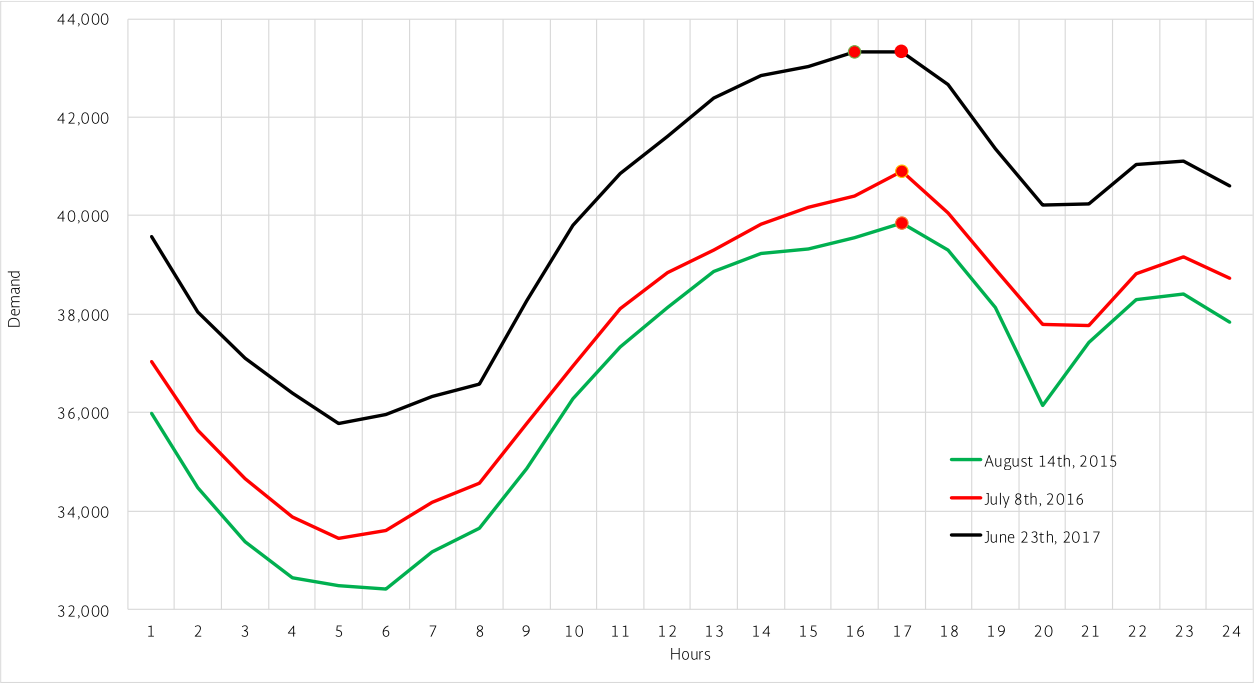
(Megawatt-hora/hora)

Region of Control	Maximum Demand 2016[1/]	Maximum Demand 2017[2/]	AGR (%)[3/]
Central	8,567	8,705	1.6
Eastern	7,128	7,299	2.4
Western	9,351	9,842	5.3
Northwest	4,350	4,582	5.3
North	4,258	4,608	8.2
Northeast	8,710	8,846	1.6
Peninsular	1,893	1,955	3.3
SIN	**40,893**	**43,319**	**5.9**
Baja California	2,621	2,699	3.0
Baja California Sur[4/]	442	484	9.5
Mulegé	28	29	3.6

1/Revised data. 2/Preliminary information. 3/ AGR: Annual Growth Rate. 4/ Sistema La Paz. Totals may not match due to rounding. Source: SENER with information from CENACE.

FIGURE 1

MAXIMUM DEMANDS IN THE SIN 2015, 2016 y 2017
(Megawatt-hour/hour)



Source: Elaborated by SENER with CENACE data.

Forecast of consumption and demand 2018-2032

The electricity consumption and demand forecasts are the initial input for the elaboration of PIIRCE and the RNT Expansion and Modernization Program, carried out by SENER and CENACE.

According to the planning scenario, the electricity consumption of the SEN projects an average annual growth of 3.1% between 2018 and 2032. The operational areas with the highest growth rates in consumption will be Mulegé and Peninsular (3.9% each) and Baja California Sur (3.7%).

With the forecasts of the planning scenario, the integrated maximum demand of the SIN forecasts an average annual growth of 3.2% between 2018 and 2032. It is estimated that the areas with the highest growth rates in their integrated maximum demand will be, Peninsular (3.9%) and Mulegé (3.8%) and Baja California Sur (3.7%).

Indicative Program for the Commissioning and Decommissioning of Power Plants 2018-2032

The Indicative Program for the Commissioning and Decommissioning of Power Plants (PIIRCE) 2018-2032 aims to promote the commissioning of sufficient resources to meet the SEN demand as well as the Clean Energy objectives.

This Program provides the total costs minimum present value system solution (investment, operation and not supplied energy) in the planning horizon. The optimization model solution shows the type, size and location of the power plants that must be commissioned, along with their operation date.

It also presents the minimum cost solution for the transmission network expansion, which guarantees the integration of the new electricity generation, and it comprises the generation units or power plants notified by the generators indicative decommissioning plan.

Generation expansion

To supply the SEN electricity demand during the period 2018-20132 and to meet the clean energy objectives, the planning exercise indicates that 66,912 MW of additional capacity will be required, which means a 1.7 trillion pesos investment in the next 15 years.

The additional capacity will be integrated 45% by conventional technologies and 55% by clean technologies. Within the conventional technologies, combined cycle projects predominate with 28,105 MW, while in the clean technologies group, a diversified portfolio of projects is expected, of which, wind, solar, nuclear and efficient cogeneration will have a greater participation with respect to the rest of the clean technologies (see table 5).

TABLE 5

CAPACITY COMMISSIONING EVOLUTION BY TECHNOLOGY 2018-2032

(Megawatt)

Technology	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total[1/]
Conventional energies	**2,268**	**3,752**	**1,656**	**985**	**2,041**	**4,315**	**1,350**	**1,326**	**2,169**	**1,068**	**2,256**	**2,255**	**812**	**1,801**	**2,155**	**30,207**
Combined cycle	2,268	3,601	766	874	1,941	3,956	889	1,326	2,139	1,068	2,256	2,255	812	1,801	2,155	28,105
Coal Fuel	0	129	0	0	0	0	0	0	0	0	0	0	0	0	0	129
Turbogas	0	0	890	0	100	317	0	0	30	0	0	0	0	0	0	1,337
Internal combustion	0	22	0	111	0	43	0	0	0	0	0	0	0	0	0	176
Fluidized bed combustion	0	0	0	0	0	0	461	0	0	0	0	0	0	0	0	461
Clean energies	**3,165**	**4,200**	**2,740**	**2,699**	**2,810**	**1,856**	**3,029**	**1,541**	**1,266**	**1,872**	**1,342**	**2,843**	**2,959**	**2,576**	**1,805**	**36,705**
Renewable	2,483	4,199	2,740	2,659	2,569	1,487	2,760	1,541	710	1,492	1,218	821	1,599	1,216	1,805	29,301
Hydroelectric	0	29	0	0	0	0	464	63	0	46	432	71	646	0	463	2,213
Wind power	677	1,716	1,537	734	2,369	1,187	1,997	1,116	220	850	303	400	353	611	750	14,819
Geothermal	25	0	0	0	0	0	0	26	150	250	133	0	100	105	53	842
Solar PV	1,767	2,455	1,203	1,925	200	300	300	336	340	346	350	350	500	500	540	11,413
Thermosolar	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Others	**682**	**1**	**0**	**40**	**241**	**370**	**268**	**0**	**556**	**380**	**124**	**2,022**	**1,360**	**1,360**	**0**	**7,404**
Bioenergy	3	0	0	40	241	286	148	0	98	0	124	0	0	0	0	940
Cogeneration	679	1	0	0	0	84	120	0	457	380	0	662	0	0	0	2,383
Nuclear	0	0	0	0	0	0	0	0	0	0	0	1,360	1,360	1,360	0	4,081
Total [1/]	**5,433**	**7,952**	**4,396**	**3,684**	**4,852**	**6,171**	**4,378**	**2,867**	**3,435**	**2,940**	**3,598**	**5,098**	**3,771**	**4,377**	**3,960**	**66,912**

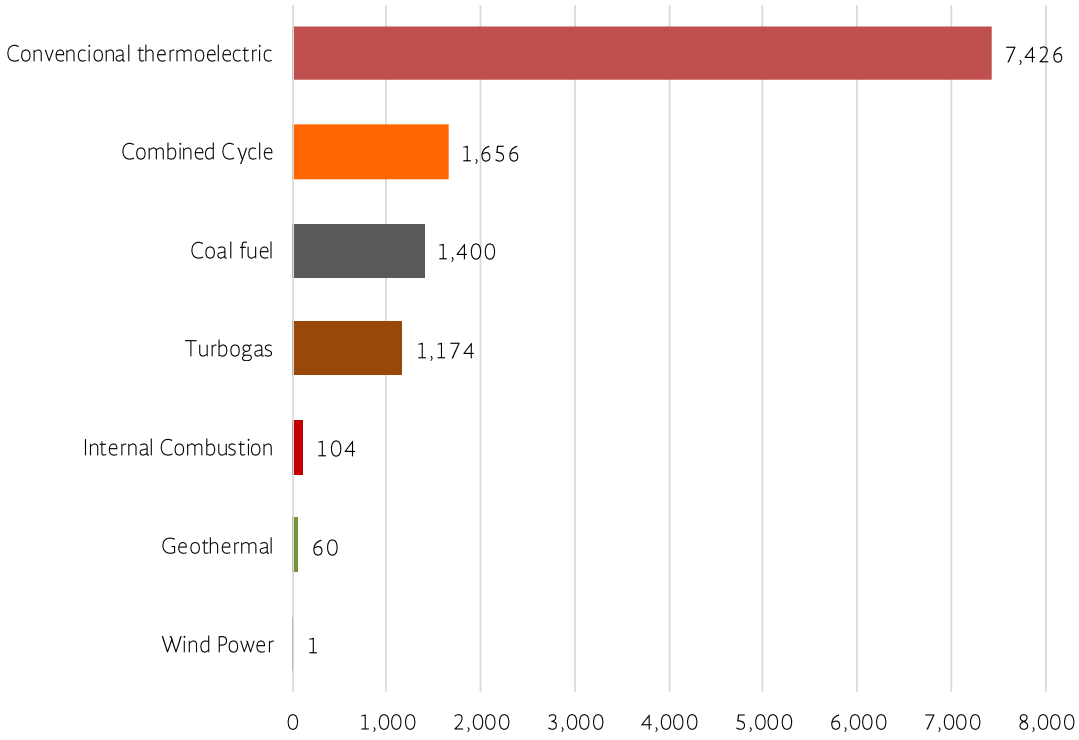
1/ Totals may not match due to rounding. Source: Elaborated by SENER with CFE, CRE and CENACE data.

The Northeast and Eastern regions concentrate 43% of the total additional capacity with 28,849 MW. Likewise, it is estimated that power plants will be installed in most of the country's states in order to meet regional needs. The states of Veracruz, Tamaulipas, Nuevo Leon, Sonora, Oaxaca, Sinaloa and Coahuila will concentrate 50% of the new additional capacity to be developed in the next 15 years.

It is foreseen that 115 power units with a total capacity of 11,821 MW will be decommissioned within 2018-2032. These units are located in 18 states in the country. 62.8% of this capacity corresponds to conventional thermoelectric technology (see figure 2).

FIGURE 2

CAPACITY DECOMMISSIONING BY TECHNOLOGY 2018-2032
(Megawatt)



Source: Elaborated by SENER with CENACE and CFE data.

Installed capacity and electricity generation evolution

As a result of the electricity system expansion, it is estimated that in 2032 the total installed capacity will be 130,292 MW, considering the annual evolution of the commissioning and decommissioning of generating units of the SEN. It is expected that between 2018-2032, the installed capacity will increase by 73% compared to the capacity in operation as of December 31, 2017.

According to the forecasts, the installed capacity will be composed of 55% conventional technologies and the additional 45% will be clean energy. Combined cycles as well as wind and hydroelectric plants will dominate the country's electricity generation infrastructure.

The estimated power generation for 2032 will be equivalent to 484,788 GWh, which is 47% higher than the generation observed in 2017. It is expected that conventional energy will account for 60% of the generation mix and clean energy will account for 40% (See figure 3).

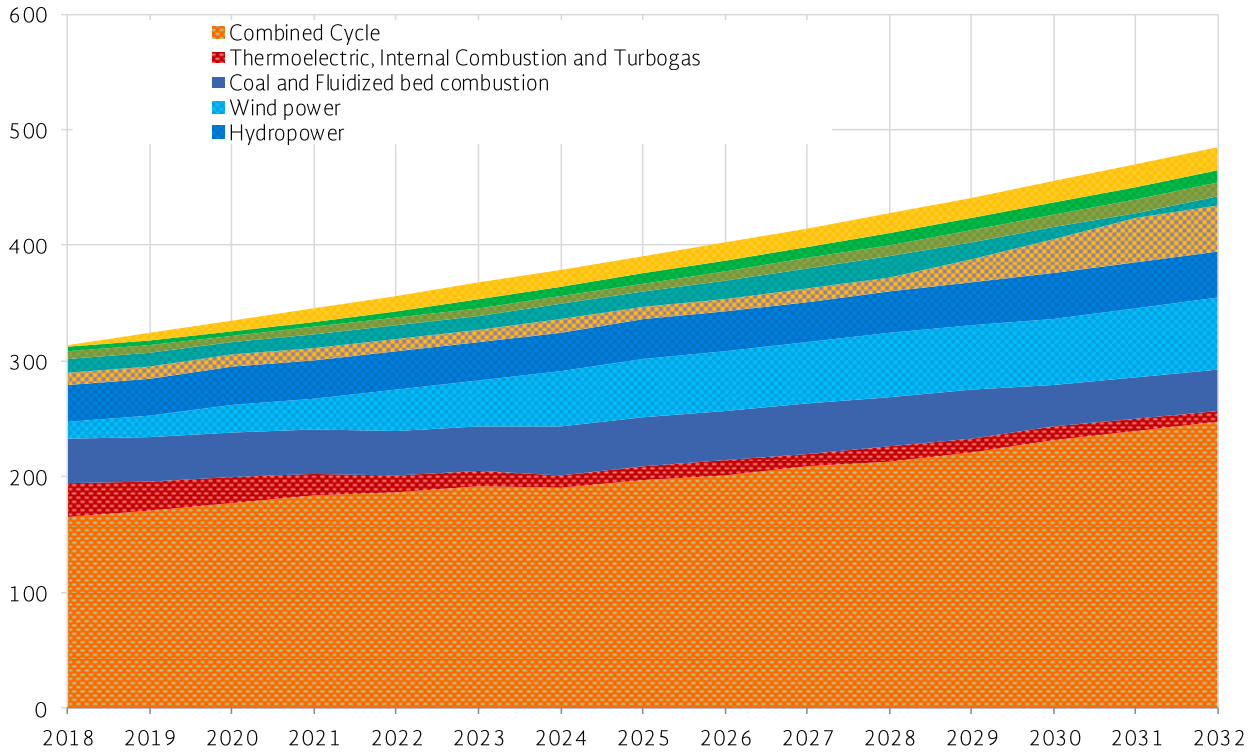
Regarding conventional technologies, energy from thermoelectric and gas turbine plants will decrease steadily at an annual rate of 8% and 11% respectively. This is explained by the programmed decommissions throughout the planning period. An increase in the energy generated by coal fired power plants is estimated starting in 2019 due to the commissioning of capacity.

Clean energy technologies generation will increase at an 6.4% annual rate. Photovoltaic and wind energy will represent the greatest growth in the period, with annual growth rates of 22% and 11% respectively. On

the other hand, a moderate growth in hydroelectric generation is estimated, on average of 2% per year, due to the lower participation in the composition of the generation mix during the period of study.

FIGURE 3

ELECTRICITY GENERATION EVOLUTION 2018-2032
(Terawatt-hour)



Note: Estimated generation according to CENACE's consumption and demand forecasts and PIIRCE's technical parameters. It does not include imports, exports, local self-supply, distributed generation and FIRCO. Source: Elaborated by SENER.

Fuel Consumption

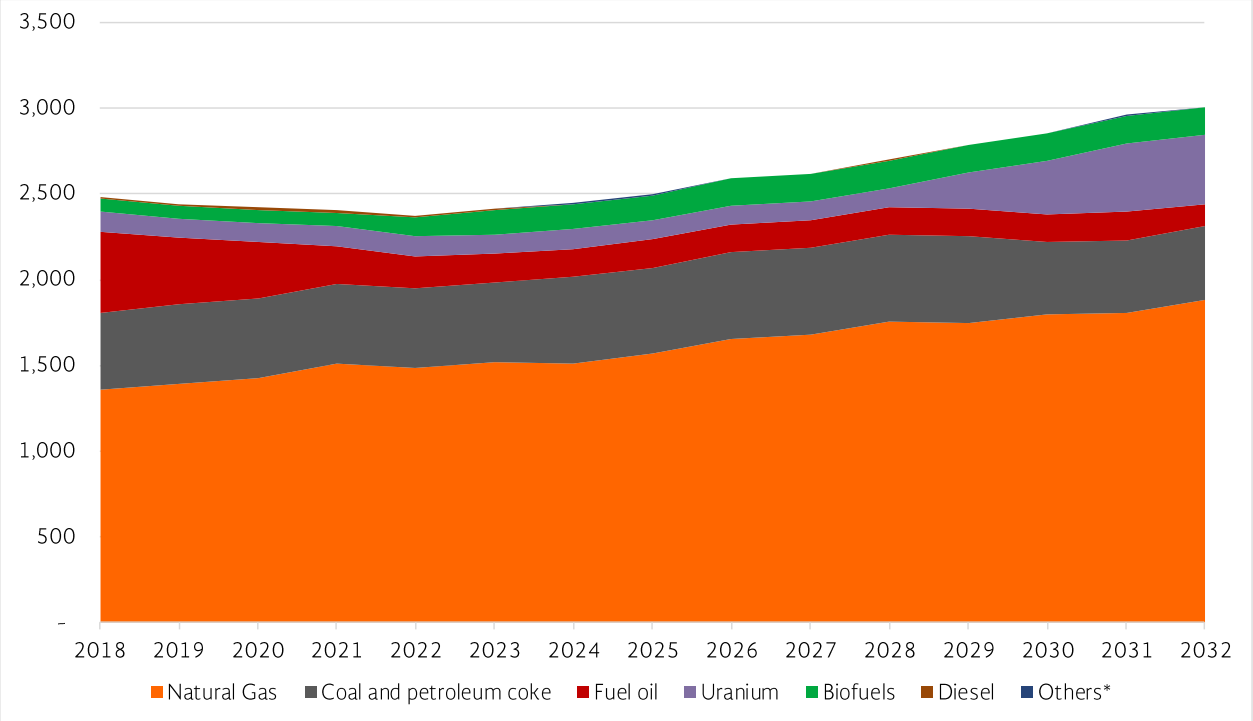
Fuel oil consumption will decrease at a 9% average rate per year. This is due to the 4.1 GW programmed decommission and to the 1.3 GW thermoelectric power plants conversion to dual systems, in order to reduce and replace fuel oil consumption by natural gas.

Biofuels consumption will increase its participation in the electricity generation mix. The commissioning of bioenergy power plants will add 940 MW of installed capacity, representing 5.5% of the total fuel consumption for electricity generation.

Diesel consumption for electricity generation will represent 0.1% of the total consumption at the end of the planning frame. The consumption of this fuel will decrease at an 11.4% annual average rate. This is mainly explained by the 1.2 GW diesel based installed capacity programmed decommission (See figure 4).

FIGURE 4

FUEL CONSUMPTION 2018-2032
(Petajoules)



*Includes residual gas and steam. Source: Elaborated by SENER.

Emissions

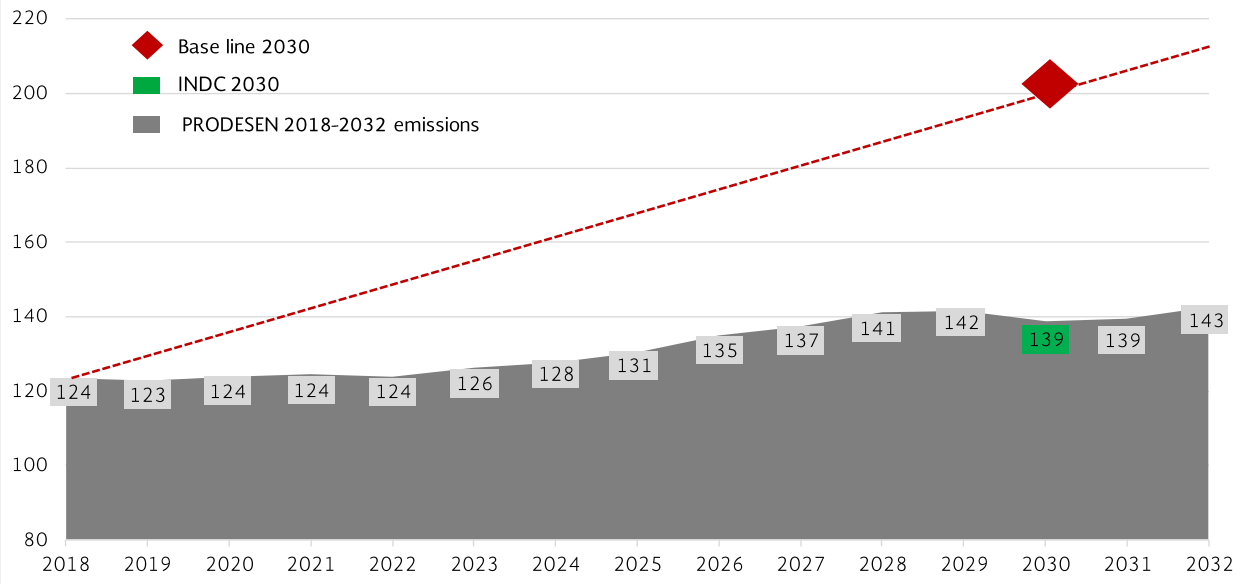
The electricity sector is the second activity with the greatest contribution to the Greenhouse Gas (GHG) emissions in Mexico. This is just below the transport sector, according to the National Inventory of Greenhouse Gases and Compounds Emissions 2015.

The result in the emissions of the electricity generation forecast 2018-2032, shows a 138.7 MTCO2e level. Lower than the defined level in the INDC commitment, which consists of reducing its GHG emissions to a level not higher than 139 MTCO2e by 2030.

This level of emissions is achieved through the 36.7 GW clean energy power plants addition, the 11.7 GW of conventional units decommissioning, the thermoelectric plants conversion to dual, and the implementation of cutting-edge technologies in new electricity infrastructure. Such changes contribute to reducing highly polluting fuels such as fuel oil and diesel consumption, improving the power plants efficiency and promoting the carbon capture and storage in the case of thermal power plants (see figure 5).

FIGURE 5

ELECTRIC SECTOR EMISSIONS 2018-2032
(MTCO2e)



Source: Elaborated by SENER.

National Electric System Costs

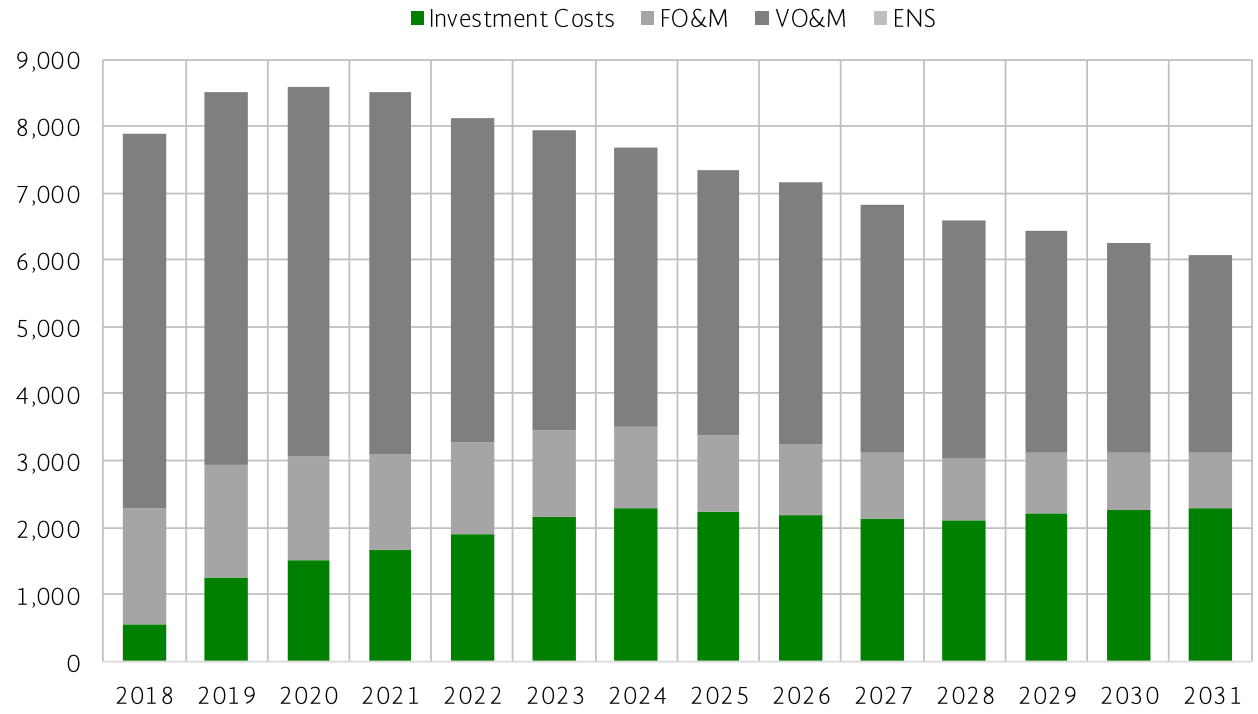
The electricity generation projects that will be carried out in the next 15 years will have an estimated total cost of 167,041 million dollars. The operation and investment costs will represent 54% and 30% respectively, while the cost of the not supplied energy will incorporate less than 1% to the total costs.

The total costs of the NES are distributed between 6 and 8 billion dollars per year. Although the investment is greater every year, the annual total cost is lower. This is due to the reduction of fixed and variable costs, which decrease at an annual average rate of 5.4% and 4.8% respectively (See figure 6).

This behavior is explained by the electricity generation mix diversification, which promotes the incorporation of renewable and clean sources, as well as by the integration of technologies with greater innovation and development which improve the power plants performance and efficiency. Such effects imply fuel consumption savings and lower investment and operating costs.

FIGURE 6

NATIONAL ELECTRIC SYSTEM COSTS 2018-2032
(millions of dollars)



Source: Elaborated by SENER.

Sensitivity analysis

In this version of PRODESEN, sensitivity scenarios were analyzed in key variables such as additional capacity, generation of clean energies, electricity system costs, generation investment projects and GHG emissions. All compared to the base or planning scenario.

Additional capacity

The commissioning of new electric capacity is highly sensitive to changes in electricity demand. For example, considering the high demand scenario, the additional capacity grows 12%. This analysis highlights a greater share of clean technologies such as solar photovoltaic, bioenergy and efficient cogeneration. While lower demand growth generates a drop in expected additions of 18%, mainly in combined cycle and geothermal power plants.

On the other hand, the additional capacity increases by 5% as fuel prices increase, there is a 25% growth in new capacity of clean energy technologies, mainly solar photovoltaic and geothermal.

Clean energy generation

External factors that hinder the development of clean technology projects in the southeastern region of the country, such as the presence of environmental, social, logistical and financial restrictions, will diminish the diversification of the energy mix. This will result in a 26% drop in the new clean technology capacity construction and there would be a substitution effect, which would cause 14% increase in the commissioning of conventional technologies, mainly combined cycle power plants, gas turbine and internal combustion.

An absence of energy transition instruments such as the Clean Energy Goals would boost the generation of conventional power plants, growing 9%, mainly those

of combined cycle, while clean generation would fall by 17%.

Electric System Costs

The sensitivity analysis shows that if the low energy demand scenario is considered, the electric system costs can decrease up to 8%, and up to 7% if fuel prices have a decreasing tendency in relation to the baseline scenario. On the other hand, the cost of the system increases in the scenarios where demand and fuel prices have an upward trajectory, which is explained by the increase in costs associated with higher fuel consumption, fixed operating costs and maintenance and investment costs in generation and transmission, which are related to the development of new infrastructure in the electrical system.

Generation projects investment

Generation projects investment could fall by 16% in the presence of external factors that hinder the development of clean technology projects in the southeastern region of the country. Likewise, with a lower electricity demand, the investment could decrease 14%. Consequently, investment in generation projects responds greatly to growing trajectories in demand. In order to satisfy a greater demand, the system would require more generation capacity of both conventional and clean power plants, so it would be an 8% investment increase.

In a high fuel price scenario, a greater integration of plants with clean technologies is required, mainly solar, wind and efficient cogeneration, resulting in a 5% increase in investment.

GHG emissions

GHG emissions could increase 8% with respect to the baseline scenario, if there are exogenous factors that limit the development of clean technology projects and 7% due to greater dynamism in electricity demand. Similarly, if the Clean Energy Goals were not set, the greater participation of conventional technologies in the generation of electric power would be encouraged, thus increasing GHG emissions by 4%.

A less polluting scenario is achieved by reducing the consumption of electricity and when there is a scenario of high fuel prices. In both cases, the drop in GHG emissions are of the order of 4% and 2% respectively.

Expansion and modernization Program for the National Transmission grid (PAMRNT) 2018-2032

The planning process for the expansion and modernization of the National Transmission Grid (RNT) starts from the SEN operational diagnosis of the previous year. It identifies problems, like transmission grid congestion, overloads in transformation banks, low and high voltage levels, forced outputs of some element and the operational reserve margin behavior. Once all the elements of this diagnosis are identified, elements of expansion and modernization of the RNT are proposed, in order to guarantee the reliability and security of the National Electric System.

Identified Projects 2018-2032

The expansion and modernization program 2018-2032 defines 40 expansion projects.

The total amount of investments for the expansion projects approaches to $ 14,289 million pesos in works that will be carried out from 2018 to 2024. These projects are integrated in turn, by transmission, transformation and/or compensation works according to the characteristics and objectives of each of them:

- Transmission: 50 works representing 1,196 km-c.
- Transformation: 18 works representing 3,716 MVA.
- Compensation: 39 works representing 923 MVAr.

In terms of modernization, the PAMRNT 2018-2032 includes 6 projects with an estimated investment of $1,361 million pesos from 2020 to 2023 (see table 6).

These projects are:

1. Substitution of 8 static VAr compensators.
2. Replacement of 400 kV conductors and circuits towers representing a total of 40 km-L.
3. The 115 kV electrical substation "Cerro del Mercado" adequacy.
4. 3rd stage of bus elevation in the 115 kV substation Nizuc.
5. Replacement of switches in several substations.
6. Construction of a 115 kV feeder bay.

TABLE 6
EXPANSION IDENTIFIED PROJECTS 2018-2032

Region	Amount (millions of mexican pesos)	Number of projects	Number of works	Lenght Km-c	Transformation capacity MVA	Compensation capacity MVAr
Baja California	$484.00	4	4	22	300	0
Baja California Sur	$124.00	5	5	0	20	30
Northwest	$13.00	1	1	0	0	15
North	$436.00	3	5	0	700	30
Northeast	$4,720.00	5	16	367	412	354
Western	$2,281.00	13	43	179	924	366
Central	$178.00	2	2	44	0	0
Eastern	$3,137.00	4	19	430	1,000	75
Peninsular	$2,912.00	3	12	153	359	51
TOTAL	**$14,289.00**	**40**	**107**	**1,196**	**3,716**	**923**

Totals may not match due to rounding. Source: Elaborated by SENER.

2015, 2016 and 2017 Projects tracking

Between 2015 and 2017, SENER has instructed the Transporter (CFE-Transmission) 30 expansion and modernization projects, which were included in the PAMRNT authorized versions.

From the projects instructed in 2015, "Compensación Capacitiva Occidente" is currently in tender process by CFE Transmission, with an estimated investment of 135 million pesos and the project "Compensación Capacitiva Baja California - Baja California Sur-Noreste" 169 million pesos in investment. In addition, 27 more projects are in process to begin tenders.

Tender for Direct Current Transmission Line Yautepec – Ixtepec

One of the projects that will have the greatest impact on the expansion and modernization of the RNT is the Direct Current Transmission Line, Yautepec - Ixtepec. With this project, the electric power transport capacity will be significantly increased between the southeast and the center of the country, generated from renewable sources, mainly wind power and hydroelectric.

This project consists of the construction, modernization, operation and maintenance of 3,000 MW, 1,221 kilometers-circuit 500 kV voltage transmission line in a from Ixtepec, Oaxaca, to Yautepec, Morelos.

Baja California-SIN Interconnection

Another major project is the Interconnection of Baja California with the SIN, which will allow the incorporation of the Baja California area, which currently operates in isolation.

The project consists of a bipolar point-to-point direct current transmission line with a design capacity of 1,500 MW, at a voltage level of ± 500 kV. It will connect from Cucapah in Mexicali, to Seri in Hermosillo, with an estimated length of 700 km-linear. Also, the construction of two converter stations with HVDC VSC technology is considered.

Investments in transmission 2018-2032

It is estimated a total of investments in infrastructure for the provision of electricity service for 173 billion pesos, which is integrated as follows:

1. 80% for identified projects 2015, 2016, 2017 and 2018 and indicative projects[1], the latter are defined as those that continue in the process of analysis in order to confirm that they constitute the best technical and economic alternative for the system, so that they have not yet been integrated into PRODESEN.
2. 9% Financed Public Works that refer to the projects authorized by SHCP prior to the LIE,
3. 10% Medium and long term works, which include the requirements of the grid to supply the growth of demand.
4. 1% for works with own resources.

[1] The Macro Grid investments are not included because the project is still under analysis.

Program for the Expansion and Modernization of General Distribution Networks (PAMRGD) 2018-2032

Between 2018 and 2022, a number of action will be conducted to satisfy the demand for electricity, improving the efficiency of distribution, increasing the quality, reliability and security of the General Distribution Grid (RGD) and moving towards an Intelligent Electricity Network (REI).

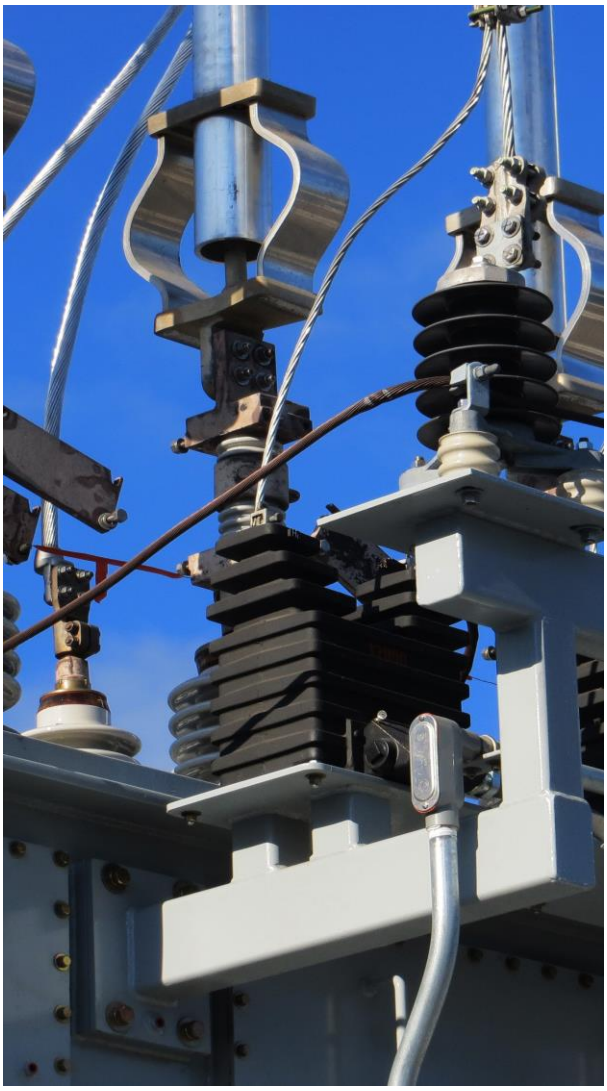
Satisfy the demand

In order to meet the growth in electricity demand, it is planned to expand and modernize the RGD through the following projects:

- Installation of connections and meters: during the planning period it is estimated to make 13.5 million connections, 7.0 million disconnections and 4.4 million modifications, thus, 285,105 kilometers of conductor for connections and 12.1 million meters will be required. The project will represent an estimated investment of 19,788 million pesos.

- Interconnection of Holbox Island, Quintana Roo: in order to supply the increase in demand for electricity, derived from the development of tourism infrastructure on the island, the construction of a 60 km 34.5 kV air circuit is planned, including fiber optics, from the Popolnah Electric Substation to the town of Chiquilá and a submarine circuit of 10.5 km from said population to the future Holbox Electric Substation; likewise, the distribution grid of the island will be adapted and modernized. The project will require an investment of 280 million pesos.

- Electrification of rural communities and marginalized urban areas: through the Universal Electric Service Fund (FSUE), resources are channeled for electrification works. In 2017, 134 thousand inhabitants were given access to the electricity supply by extending the Distribution Grid; by 2018 it is planned to give access to 520 thousand inhabitants, 73.6% of the access will be made by extending the grid and the rest with isolated systems (photovoltaic modules).



Increase efficiency

The reduction of losses of electrical energy, technical and non-technical, is a priority action to achieve improvements in the efficiency of the electric power

distribution process. In order to reach the established goal of a comparable level of losses with international standards of 8% from 2024, the following projects are planned:

- Installation of equipment: in 2018 it is planned to install 54 medium voltage feeders, capacitors in the medium voltage grid with a capacity of 2.7 Mvar, build 2,902 km of medium voltage lines and 1,969 km of low voltage lines, recalibrate 16,838 km of medium voltage line and 7.227 km in low voltage. It is estimated that the investment will amount to 5,320 million pesos.

- Regularization of the electric power service: between 2018 and 2022 it is planned to regularize 40.9 thousand users who make use of the electric power service in an irregular manner.

- Implementation of new measurement technologies: in the planning period of this Program, the modernization of 5.7 million meters is planned (2.7 million electronic self-management meters will be scaled up to achieve some characteristics of Advanced Metering Infrastructure (AMI) and will be acquired will install 3 million meters with radiofrequency card). It is estimated that the amount of the investment will be around 8.413 billion pesos.

- Replacement of measurement equipment: during the planning period, it is planned to replace 5.3 million meters that are damaged or that have already reached the end of their useful life, the investment will amount to 7,051 million pesos.

Increase reliability and security in the supply

The main faults that impact the supply and affect the reliability of the RGD are mainly due to the presence of objects on the lines (trees, branches, animals, etc.), as well as to faults in devices and equipment. In order to solve this type of incidents, the following actions are planned during the period:

- Installation and replacement of equipment: to increase the reliability of the RGD, it is planned to install and replace 93,006 insulators, 22,110 short fuses, 20,627 arresters, reinforce the base of 5,875 posts, among others. Likewise, the installation of 4,857 Protection and Sectioning Equipment (EPROSEC) is considered. An investment of 2,599 million pesos is estimated in these activities.

- Modernization of distribution substations: during 2018 it is planned to replace 32 power transformers that form part of the RGD, the amount of the investment amounts to 453 million pesos. During the planning period, an investment of 1,510 million pesos is estimated for the development of this type of activity.

- Replacement of power switches and distribution transformers.

- Modernization of the electricity grid of Paseo de la Reforma Avenue, Mexico City: the demand for electricity in this area shows a constant growth derived from the construction and modernization of buildings, developments of corporate offices, shopping centers, hotels and complexes residential, in order to address the problem is developing a project consisting of civil works, electromechanical work and replacement of the measurement. The project is scheduled to conclude in 2018 and it is estimated that the investment will amount to 1,678 million pesos.

- Replacement of submarine cable in Isla Mujeres, Quintana Roo: because the island's electricity supply is provided with an underground conductor, suitable for use as submarine cable, as well as the weather conditions of the region and the transit of vessels. This conductor is subject to a large amount of mechanical and electrical stress, which causes frequent failures that affect the quality and reliability of the service. In order to address this problem, it is expected to replace the underground conductor with an underwater driver that is suited to the conditions of the area. The investment of the project amounts to 280 million pesos.

Meet the requirements of the electricity market

In order to secure a reliable measurement for the liquidation process of all the Participants of the Wholesale Electricity Market, in accordance with the provisions of article 37 of the LIE and base 16 of the Bases of the Wholesale Electricity Market, it is required to measure the energy balance in the exchange points of the so-called Load Zones and energy exchange between zones, so it is necessary to

develop infrastructure and software to perform said measurement. During the planning period, the following actions are planned:

- Conditioning 1,207 measuring points in the distribution circuits, which will require an investment of around 540.5 million pesos.

- Conditioning 14,153 measuring points inside power substations with an investment of 6,475.5 million pesos.

Transition to an Intelligent Electrical Network

The Smart Electric Network (REI) project seeks to improve the efficiency, reliability, quality and safety of the SEN with the use of advanced measurement, monitoring, communication and operation technologies to ensure open access to the grid as well as higher integration of renewables. Between 2018 and 2022, the following actions are planned:

- Implement a pilot project to evaluate the capabilities of an Advanced Distribution Management System (ADMS), which includes a system for the management of interruptions (OMS). It will be developed in two phases of study and three phases of demonstration. The investment estimated is 203 million pesos.

- Perform field surveys of geospatial data and develop applications to streamline operational and business decision making in order to unify the different geographical and electrical information technologies of the RGD that belong to CFE distribution, through a Geographic Information System that allows it to integrate these technologies and have the capacity to share and exchange spatial information of the distribution system infrastructure. The estimated investment is 53 million pesos.

- Installation of intercommunicating meters with computerized management system capable of managing commercial activities automatically and remotely. This requires the development of computer applications and communication systems needed to exploit the functionalities of these systems, directed towards the REI and the client, for example, a system of administration of meter records (MDM), which is under evaluation to be developed in the following years. During the planning period, 121 thousand AMI meters will be installed with an approximate investment of 340 billion pesos.

PRODESEN

PROGRAMA DE DESARROLLO DEL SISTEMA
ELÉCTRICO NACIONAL

2018 - 2032