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Barriers to Developing Solar Energy in Mexico and Egypt

PhD. Dissertation

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Chapter 1

Introduction

1.1 Introduction

Nowadays, the leading role of renewable energies as an essential tool for the contribution to sustainable economic development of the planet, enabling the transition towards a new low-emission energy model is no in longer question. Accordingly, a massive development in renewable energies is being called upon to play a decisive role in the fight against global warming and climate change (International Renewable Energy Agency, 2020).

Renewable energies, in addition to their obvious environmental advantages, present the uniqueness that they are accessible to all countries, since their resources, in any of its forms (sun, wind, water, agriculture, heat), are available, to a greater or lesser extent, in every country, unlike the very limited availability of other conventional energy resources (oil, gas and coal), which are concentrated in very specific territories and are under the control of a very small number of countries (International Renewable Energy Agency, 2020).

Therefore, the development of renewable energy is, on the one hand, a necessity and, on the other, it represents a great opportunity. In fact, after the energy crises of the 1970s and the most recent financial crises that the world has suffered, the economies of developed countries have focused a large part of their recovery efforts on promoting renewable energy (International Renewable Energy Agency, 2020).

Nevertheless, although developed countries have become aware of this need and of the opportunity to promote renewable energies, the question we must ask ourselves is whether developing countries also have this awareness and if so, are they capable, on an economic, industrial, legislative, regulatory, or technical level, to join this global environmental effort and take advantage of this opportunity (Acemoglu and Robinson, 2013)

Until now, the developed world's support for the economic growth of poor or developing countries has been more theoretical than real, since, although if we are asked about the need to help developing countries, the answer of course would be affirmative and further, that it should be a pressing priority; later in our day-to-day lives the problem will be seen from a distance and the information that reaches us is biased and scarce. Moreover, the fact that there are millions of human beings in economic difficulties, safe of course from the awareness of whatever commitment and social solidarity that we may have, does not directly affect our daily way of life.

However, when considering the problem of global warming and the risk of climate change, the perspective changes completely. Its effects seem terrifying to us and above all remarkably close. Moreover, the temperature of the planet does not distinguish between rich and poor countries and the winds and sea currents that transmit pollution from one part of the globe to another do not understand border controls. Hence the importance that the developed world understands clearly that the determined push for renewable energies and the fight against climate change must be led by countries and economies with the capacity for investment and innovation but has to be implemented at a global level. Because whatever effort is made in the small percentage of the world's population with the capacity to implement renewable energies, it will be of no use and will not produce a change at the global level if the developing countries do not make an equivalent effort.

The truth is that these developing countries, almost all of them with a much higher rate of demographic increase than developed countries, have the right to aspire to energy consumption that allows them a level of development and well-being comparable to those of other developed countries. But if we continue using energy models based on the consumption of conventional fuels, the consequences will be catastrophic for the planet, both due to the depletion of fossil resources and the unsustainable increase in emissions.

In this scenario, the importance of this thesis is critical, since it aims to identify the barriers and obstacles that prevent these developing countries from joining the global effort to promote renewable energies and tries to provide answers and practical solutions to help overcome those difficulties.

Any renewable energy project must go through a series of phases: evaluation, development, financing, construction, and operation, and in each and every one of these phases there are very diverse and very different barriers. Thus, such a project is faced with a wide range of limitations, different in each country; by way of example: electrical systems with very weak interconnection and transport networks, non-existence or uselessness of specific regulatory frameworks, non-existent energy markets, small or not very transparent, public energy monopolies that limit the competition and free participation of private investors, weak local financial institutions, a low-skilled local workforce and poorly developed local industry.[1]

In this thesis the PhD candidate bases his research not only on an analysis of the official statistics, the most relevant bibliography, reports and the data provided by the different organizations and research centers consulted but also on his own real experience and in the large number of interviews held with representatives of the sector.

The novelty of this research on solar energy is that, in describing clean energy barriers, an original analysis will be presented of the topic, combining the information from the literature and from the EOSOL company's own experience.[2]

The PhD candidate has lived through the entire recent history of renewable energies, since, with his 20 years of experience in the sector, he has participated, through the companies in which he has held positions as a manager or as an investor, in the birth of renewable energies, mainly photovoltaic, in many developed and developing countries. In one way or another he has participated in projects that total more than 45,000 MW around the world, having been a pioneer in countries such as Spain, France, Mexico, Egypt and Chile among others. His professional career has been linked to the growth of the sector throughout the world, having founded several relevant and influential companies. He currently directs the largest renewables engineering company in Spain which with more than 450 employees is one of the reference engineering firms for the main European energy companies.

The thesis focuses on the study of two relevant developing countries, Mexico as a reference for Latin America and Egypt as a reference for the Arab world and the African continent. The reasons for this choice are that:

- Both countries are key players in two of the regions with the greatest short-term development potential in the world, these being Latin America and the African continent.
- They share important characteristics such as each being countries with more than 100 million inhabitants and having undergone sustained demographic growth in recent years and thus having a high global polluting potential which, when their economies and energy consumption develop, will be critical for the world's ecology.
- They exert a truly relevant influence in their regions, since they are the reference points for other countries to which culturally and

[1] For example, Nasirov et al. (2005) present the main barriers and opportunities for renewable energy development in Chile.
[2] For more information about the company, see: EOSOL Company: https://www.grupoeosol.com/

geographically they are close and which endeavor to emulate their policies or decisions.

- The PhD candidate has had the privilege of participating in the promotion and construction of the first photovoltaic power plant that was built in each of these countries, therefore, he not only knows first-hand the history of what happened, but has also encountered the aforementioned barriers and, in most cases, has been the instigator of the solutions required to overcome them successfully and also, on other occasions, has encountered insurmountable barriers that led to the failure of some projects.

At a structural level, the thesis is divided into three chapters, two of them dedicated to the Mexican renewables sector and the other to the Egyptian. The reason for having devoted more attention to the Mexican renewable sector than to the Egyptian one is that Mexico has experienced the birth, rise, and fall of the sector in the record period of just the last 10 years. The PhD candidate considers it necessary to explain the reason for this "premature death" to extract some lessons learned in order to avoid a repetition of this ending, which has thwarted a great opportunity for the renewable energy sector in Mexico. This result is even more painful if one considers that Mexico is the 15th economy on the planet with significant demographic and industrial growth, is intricately connected with the largest and most influential economy on the planet, has enormous potential for renewable resources and has unmet large energy supply needs.

The second chapter analyzes the barriers to the development of renewable energy projects in Mexico, beginning the study with an analysis of the energy sector in general in the country, then going on to an analysis of the photovoltaic sector in particular (Alemán-Nava et al., 2014; Chanona-Robles, 2016). Below and based on the PhD candidate´s experience - who during the study period of the thesis has had a lead role the construction of the first photovoltaic power plant in the country, the first “utility scale” power station of the National Interconnected System, the first photovoltaic power station to start operations the new National Electric Market and has participated in more than 30% of the projects built in the renewables sector in the last decade - the barriers encountered for such development are identified and described. At the end of this chapter, the measures adopted by the successive governments that have led the country during this decade are analyzed in depth, to understand how a sector that did not exist in 2008 became, probably, the most important market worldwide before its eventual demise in 2020.

The third chapter analyzes the influence of fossil fuel prices in determining the final price of electricity rates for the case of Mexico; an analysis that is not possible for Egypt, due to the way in which electricity rates are set.

In the fourth chapter and following the same structure of sections and subsections of the previous chapter, the Egyptian market is analyzed. This analysis is an opportunity to discover the differences between a developing country with many problems in the sector, but a democratic one, and another that, although convinced of the need and convenience not only for the planet, but for its own country and its own economy, is governed by a militarized regime (Khalil et al., 2010).

A fifth and final chapter lays out the main conclusions emerging from the empirical analysis of the barriers to the development of renewable energies in these developing countries.

These conclusions are key to establishing a strategy to promote renewable energies in most of the planet, to develop them in emerging countries and to face up to and win the global battle against climate change.

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1.3 Glossary

AUGC: (*Asignación de Unidades Generadoras por Confiabilidad*) Assignment of Generating Units for Reliability.

BCC: Big Construction Company.

BOO: Build, Own and Operate contract.

BOP: Balance Of Plant.

BRECC: Real Estate Contracting Company.

BTU: British Thermal Unit.

CC: Combined Cycle.

CFE: (*Comisión Federal de Electricidad*) Electric Federal Commission.

CEL: (*Certificado de Energía Limpia*) Clean Energy Certificate.

CENACE: (*Centro Nacional de Control de la Energía*) National Center for Energy Control.

CENAGAS: (*Centro Nacional de Control del Gas*) National Center for Natural Gas Control.

CENAGUA: (*Comisión Nacional de Aguas*) National Water Commission.

CEPAL: (*Comisión Económica Para América Latina y el Caribe*) Economic Commission for Latin America and the Caribbean.

CH: Critical Hours.

COFEMER: (*Comisión Federal de Mejora Regulatoria*) Federal Commission for Regulatory Improvement.

CRE: (*Comisión Reguladora de la Energía*) Energy Regulatory Commission.

CSP: Concentrated Solar Power.

CTCP: (*Costo Total de Corto Plazo*) Short Term Total Cost.

DOF: (*Diario Oficial de la Federación*) Official Journal of the Federation.

EBRD: European Bank for Reconstruction and Development.

EEAA: Egyptian Environmental Affairs Agency.

EEHC: Egyptian Electricity Holding Company.

EEIA: Egyptian Environmental Issues Agency.

EETC: Egyptian Electricity and Transmission Company.

EGP: Egyptian Pound.

EgyptERA: Egyptian Electric Utility and Consumer Protection Regulatory Agency.

EIA: Environmental Impact Approval.

EPA: Energy Purchase Agreement.

EPC: Engineering, Procurement and Construction contract.

EVIS: (*Evaluación de Impacto Social*) Social Impact Evaluation.

FIT: Feed In Tarif.

FO: Fuel Oil.

GENI: Global Energy National Institute.

GDP: Gross Domestic Product.

GEIDCO: Global Energy Interconnection Development and Cooperation Organization.

GVA: Giga Volt Ampere.

GW: Gigawatt.

GWh: Gigawatt per hour.

HFO: Heavy Fuel Oil.

HUB: exchanger, connection point, node.

IFC: International Finance Corporation.

IRENA: International Renewable Energy Agency.

kW: Kilowatt.

kWh: Kilowatt per hour.

kWh/m^2: Kilowatt per hour per square meter.

LIE: (*Ley de la Industria Eléctrica*) Electrical Industry Law.

LSPEE: (*Ley del Servicio Público de la Energía Eléctrica*) Law of the Electric Power Public Service.

LTE: (*Ley de Transición Energética*) Energy Transition Law.

MED-TSO: Mediterranean Transmission System Operators.

MEM: (*Mercado Eléctrico Mayorista*) Wholesale Electricity Market.

MBP: (*Mercado de Balance de Potencia*) Market for the Balance of Power.

MDA: (*Mercado del Día en Adelanto*) Day Ahead Market.

MIA: (*Manifiesto de Impacto Ambiental*) Environmental Impact Study.

MMBTU: Millions British Thermal Unit.

MOERE: Egyptian Ministry of Electricity and Renewable Energies.

MTR: (*Mercado en Tiempo Real*) Real Time Market.

MW: Megawatt.

MWh: Megawatt per hour.

NAFTA: North American Free Trade Agreement

NREA: New and Renewable Energy Authority.

NSPO: National Services Products Organization.

MYMEX: New York Mercantile Exchange.

O&M: Operation and Maintenance.

PEMEX: (*Petróleos Mexicanos*) Mexican Petrol Company.

PC: Personal Computer.

PIE: (*Productor Independiente de Energía*) Independent Power Producers.

PML: (*Precio Marginal Local*) Local Marginal Price.

PPA: Power Purchase Agreement.

PPC: Power Plan Controller.

PR: Performance Ratio.

PRODESEN: (*Programa de Desarrollo del Sector Eléctrico Nacional*) National Electricity Sector Development Program.

PV: Photovoltaic.

PXX: Probability of XX.

RECAI: Renewable Energy Country Country Attractiveness Index.

RID: (*Registro de Instrucciones de Despacho*) Registry of Dispatch Instructions.

SCT: (*Secretaría de Comunicaciones y Transportes*) Communications and Transportation Secretary.

SEDESOL: (*Secretaría Desarrollo Social*) Social Development Secretary.

SEMARNAT: (*Secretaría de Medio Ambiente y Recursos Naturales*) Ministry of the Environment and Natural Resources.

SEN: (*Sistema Eléctrico Nacional*) SEN.

SENER: (*Secretaría Nacional de Energía*) National Energy Secretary.

SIE: (*Sistema de Informción Energécica*) Energy Information System.

SIN: (*Sistema Interconectado Nacional*) Interconnected Electric System.

T-MEC: Mexico-United States-Canada Treaty.

TW: Terawatt.

TWh: Terawatt per hour.

UFM: the Union for the Mediterranean.

USA: United State of America.

USD: United State of America Dollar.

US$: United State of America Dollar.

UV transmission lines: UHV – Ultra High Voltage.

VAR: Vector Autoregressive.

VH: High Voltage.

Chapter 2

Barriers facing the Solar Photovoltaic Sector in Mexico

2.1 Introduction

This chapter examines the energy sector in Mexico, focusing on the photovoltaic sector and the barriers facing the development of large plants between 2009 and 2020. Previous studies that also analyze the Mexican energy sector are Espinasa et al. (2013), International Energy Agency (2016) and Alvarez and Valencia (2015) among others.[3]

This chapter analyzes the sector using the information provided by EOSOL, the sole leading developer in the country from 2009 to 2018. The EOSOL team was the first company to install a utility scale project in Saltillo in 2009 and the first company to connect a utility scale project to the interconnected system in Durango in 2014. EOSOL was also the first company to operate a solar installation under the LIE and it was the company which financed the first two solar installations to sell energy to the market. EOSOL has developed a total of 14 utility scale projects with a total power of 322 MW under operation in the country and it has participated in engineering, operations and maintenance or in the provision of supervisory control and data acquisition systems to at least 30% of the total solar energy installed in Mexico at the end of 2019[4].

This chapter studies the main barriers to the development of large plants using the last 11 years' experience of one the leaders in the sector and it will try to explain why one of the countries with the highest solar resources in the world is not building plants more quickly and why only a few of the projects authorized by the CRE have been built during recent years.

[3] For example, the International Energy Agency (2016) presents data on energy demand and supply in Mexico focusing on the Energy Reform package adopted by the government in 2013.
[4] This information was provided by Eosol based on the Operational Project in Mexico, 2019, currently available in the SENER webpage (https://www.gob.mx/sener).

The structure of the chapter is as follows: Section 2 presents an overview of the energy sector in Mexico. Section 3 describes the photovoltaic sector in Mexico. In Section 4 the main barriers to the development of large plants are analyzed. Section 5 includes some government initiatives relating to the energy sector. Finally, Section 6 presents the main conclusions of the chapter.

2.2 An Overview of the Energy Sector in Mexico

In this section an overview of the energy sector in Mexico is presented. For example, Espinasa et al. (2013) cover a detailed analysis of the evolution of the energy matrix during the period 1971-2009 and the institutional development in the energy sector of Mexico. Mexican Gross Domestic Product per capita was 9,863.1 current US$ in 2019, 12% above the average in Latin American & Caribbean countries (excluding high income) (World Bank, 2020). In relation to the energy sector and, in particular oil production, Mexico in 2017 had an average production of 1,950 million barrels, the second highest in Latin America and the Caribbean after Venezuela (EIA, U.S. Energy Information Administration, 2020). This production was 9.5% less than the previous year. The electricity subsector, in 2016 had a total generation of 319,362 gigawatts-hours, the second highest in Latin America and the Caribbean after Brazil. At the end of 2017, total installed capacity was 75,685 MW, 3% higher than 2016. In 2017 the total generation was 329,162 GWh, which was 3.1% above generation in 2016. (*Prospectivas del Sector Eléctrico*, 2018-2032). Next, the thesis focuses in particular on the regulatory framework of the energy sector in Mexico.

2.2.1 Regulatory Framework

A constitutional reform was passed in Mexico on August 12th, 2013. The initiative was promoted by the former President of the Republic and was approved by the Senate and the Chamber of Deputies. On December 18th, 2013, the reformation was declared as constitutional by the Federal Legislative Power; it was promulgated on December 20th, 2013 and published the following day in the Official Journal of the Federation. In August 2014, the LIE was approved. In February 2015, the Secretariat submitted the Draft of the Electricity Market framework to the Federal Commission on Regulatory Improvement for its review. This process culminated in September 2015 with the approval of the Electricity Market Framework.

Following the constitutional reform and the LIE, a market to generate electric power was created. The state continued to have power over the national electric system (SEN) and the exclusivity to transmit and distribute energy as an essential public service. This reform included the unbundling of the electrical industry (generation, transportation, distribution), the separation of the Federal Electricity Commission into independent companies of generation and distribution (horizontal segmentation), the creation of an independent economic dispatch, centralized planning of the transmission expansion and also enabled large users of this market to take part.

This reform sought to manage the SEN through the CFE and bring private companies under the leadership of the state, in order to reduce costs and increase productivity and the efficiency of the power system, thereby reducing electricity tariffs. The reform underlined the necessity of achieving the vertical disbanding of the generation, transmission, distribution and commercialization processes of electric power. The state would become the organizer of the SEN and energy policies would be carried out by the Federal Executive. Indeed, everything related to system operation would be run by the State.

Within a period of twelve months after the regulatory law of electrical industry came into force, the government had laid the ground for the creation of a public decentralized body named CENACE. CENACE would run the operational control of the system. It determined which power plants would operate at any time as well as their production levels, and instructed the work to be carried out in the transmission and distribution networks to maintain the security, reliability, quality, and continuity as well as the efficiency in production. CENACE is responsible for the electrical wholesaler market, in which public and private electricity generation companies make offers at competitive prices (variable costs); electricity traders can also satisfy the demand. In order to be able to do that, the decentralized public body is making use of market rules to choose the power plants which will satisfy demand at the lowest possible cost.

Moreover, this neutral operator plans the network expansion in such a way as to optimize the infrastructure in favor of users and enables the interconnections to be made with transparency and under no discriminatory conditions.

On August 12, 2013, President Enrique Peña Nieto, enacted an energy reform that was later approved by the Senate and the Chamber of Deputies, becoming constitutional last December 18, 2013. In August 2014, the LIE was approved. Thanks to this energy reform, with which the government was trying to remove entry barriers for new players in the electricity sector, investment in the country could be promoted by fostering transparency that had not existed until now because the electricity sector had been classified as a national security matter.

Moreover, this energy reform was accompanied by the implementation of nine new laws, the modification of a further twelve existing laws and a countless number of new regulations with this same purpose.

The country thus created a new market structure, with a clear distribution of powers: SENER dictated energy policy; the regulatory agencies CRE, National Hydrocarbons Commission, Association of Safety, Energy and Environment regulated compliance with the corresponding policies; CENACE and CENAGAS operators managed the national networks of power and gas lines and power plants respectively.

Further, the former monopolies CFE and PEMEX become new operators in the market, competing with private players.

2.2.2 Electricity Production

Table 1 shows total electricity production and total electricity supply during the period 2007 to 2019 considering different sources of electricity production.

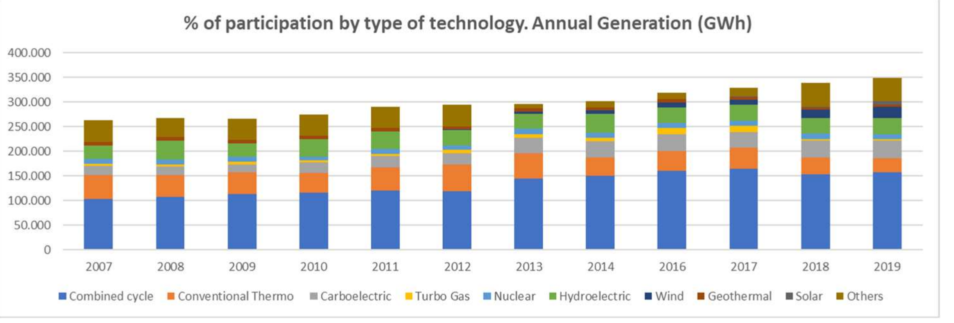
Table 1. Mexican total electricity production, 2007-2019

	2007	2008	2009	2010	2011	2012	2013	2014	2016	2017	2018	2019
Combined cycle	102.674	107.830	113.900	115.865	119.978	119.300	144.182	149.688	160.378	165.245	152.630	157.471
Conventional Thermo	49.482	43.325	43.112	40.570	47.869	53.918	51.861	37.501	40.343	42.780	35.148	29.319
Carboelectric	18.101	17.789	16.886	21.414	22.008	22.744	31.628	33.613	34.208	30.557	34.496	35.294
Turbo Gas	3.805	4.036	4.976	4.638	5.257	7.416	7.345	6.985	12.600	12.849	2.618	2.021
Nuclear	10.421	9.804	10.501	5.879	10.089	8.770	11.800	9.677	10.567	10.883	10.925	10.925
Hydroelectric	27.042	38.892	26.445	36.738	35.796	31.317	29.958	38.822	30.909	31.848	32.177	32.235
Wind	248	255	249	166	106	1.398	4.185	6.426	10.463	10.620	17.116	23.769
Geothermal	7.402	7.056	6.740	6.618	6.507	5.817	6.070	6.000	6.148	6.041	3.585	3.938
Solar	0	0	0	0	0	2	19	85	160	344	2.283	6.658
Others	43.590	38.712	43.773	42.812	43.138	44.147	9.292	12.666	13.586	17.997	48.061	47.580
Electricity Supplied	**262.765**	**267.699**	**266.582**	**274.700**	**290.748**	**294.829**	**296.340**	**301.463**	**319.362**	**329.164**	**339.039**	**349.210**

Source: Own elaboration with SENER data. (Note: 2018&2019 others estimated. No data available)

With regard to the annual figures, total electricity production was 262,765 GWh in 2007 whereas it reached 329,164 GWh in 2017 with a yearly average growth rate of 3%. Furthermore, Mexico experiences a high dependence on combustible fuels. Combustible fuels are the main source of electricity production with 76.38% of the electricity being produced with combustible fuels in 2017. Finally, the percentage of electricity produced from geothermal, wind, solar and other sources was 23,62% in 2017.

Figure 1. Mexican Electric Generation Evolution 2007-2019 (GWh)



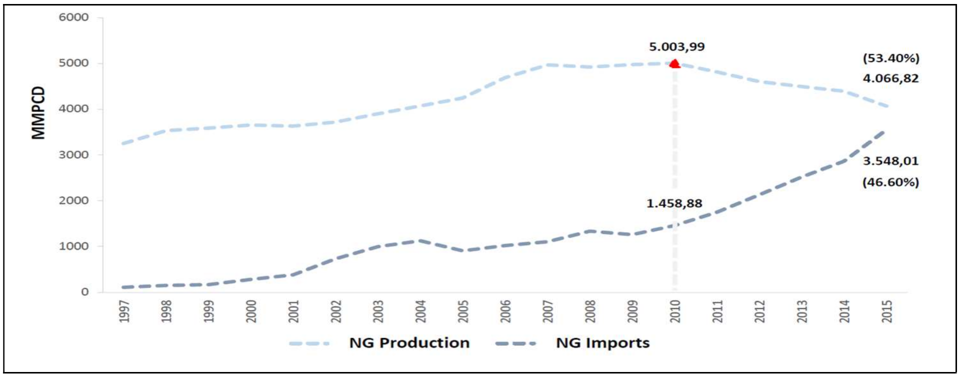
Source: Own elaboration with SENER data.

Mexico is facing an unstable energy future because of several external and internal uncertainties. Mexico's gas demand has grown significantly in recent years, particularly in the electricity sector. Historically, gas demand has been covered mostly with indigenous production and with a lower proportion of gas imports. However, this situation has changed and indigenous production has been decreasing over the last few years due to the combination of the shale gas boom in the USA and more attractive oil prices which have encouraged PEMEX to favor oil production.

Dependency on gas and other fuels from the exterior has always been major as seen in the following Figures 2 and 3.

In Figure 2 it can be seen how gas imports practically equaled Mexico's domestic production in 2015, and from Figure 3 we can see that gasoline imports were almost on a par with national production.

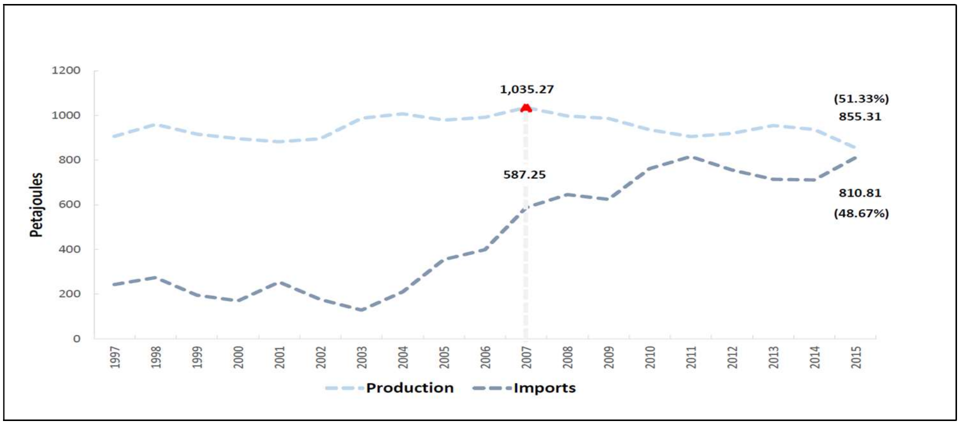
Figure 2. Mexico Gas Importation vs Indigenous production



Source: SIE[5].

[5] For further information please visit: http://sie.energia.gob.mx/

Figure 3. Mexico Gasoline Importation vs Indigenous production



Source: SIE.

Furthermore, electricity demand in the country has been growing at an annual rate of over 2.8% over the last 10 years (*Prospectivas del Sector Eléctrico* 2018-2032). However, the system growth is not able to satisfy the demand.

2.2.3 National Electrical System

At the end of 2017, Mexico had 75,685 MW of installed capacity this being 3% more than at the end 2016, generating approximately 329 GWh/year, 3.1% more than 2016 and a peak demand of 46,025 MWh in the SEN, or 43,319 MWh in the SIN on June 23rd, 2017, 5.6% over the peak demand in 2016 which was 40,893 MWh in the SIN. All this generation was produced with 526 conventional power plants equivalent to 53,358 MW and 270 clean energy power plants equivalent to 23,327 MW, for a total population, at the end of 2017 of 123.5 million habitants (*Prospectivas del Sector Eléctrico*, 2018-2032). Mexico per capita consumption, 2,028 kWh/year, is still far from a developed country such as Spain with 5,087 kWh/year, Germany with 6,454 kWh/year or the USA with 11,888kWh/year[6].

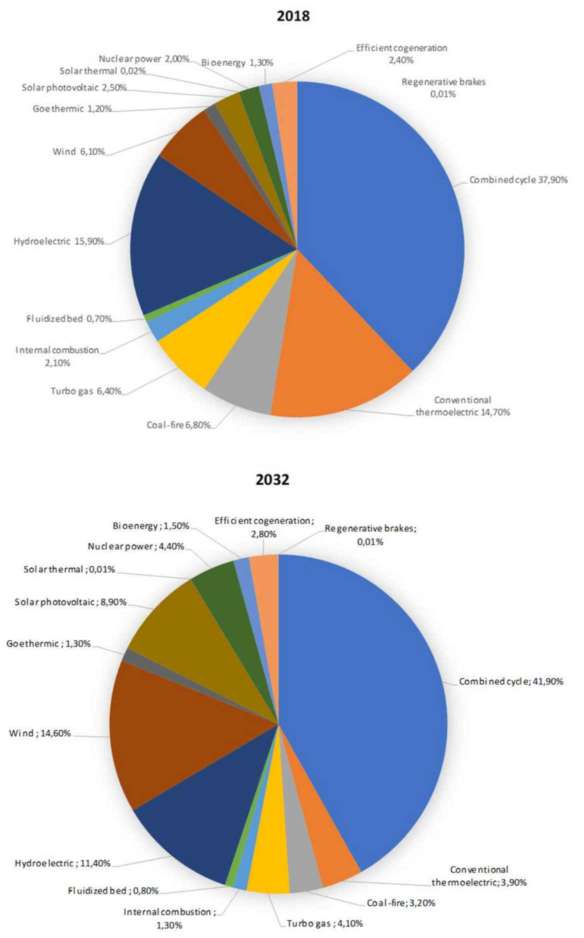
2.2.4 Evolution of grid capacity

Taking in consideration the installed capacity in 2018, the programed decommissioning and installation forecast for public and privet stakeholders, the grid will have a capacity of 130,292 MW by the end of 2032, which represents 64% of total growth. At that moment, natural gas-

[6] Per capital consumption for all countries can be checked on https://www.worlddata.info/

based technologies are expected to constitute 41.9% of the energy mix. A detailed comparison can be seen in the next graph[7].

Figure 4. Mexican Installed Capacity Comparative 2018-2032



Source: Own elaboration with SENER data

The Mexican government estimates that the growth of energy generation needed to meet demand growth in the coming years will exceed 64% (*Prospectivas del Sector Electrico* 2018-2032, SENER).

The country's generation capacity is estimated to reach 130 GW by 2032. For this estimation, the government considers that it will withdraw 11.8 GW from obsolete or low-performance plants and will build 66.2 GW of new, more efficient and environmentally friendly plants, with the solar sector increasing from 4,847 MW in 2017 to 20,641 MW by 2032 (PRODESEN 2019-2033, SENER).

Therefore, thanks to all the regulatory effort that has been made, Mexico is currently well placed to quickly overcome this energy crisis and its

[7] *Prospectiva del Sector Eléctrico* 2018-2032.

dependence on foreign imports. In fact, as of January 2017 1,366 generation permits had been granted by CRE, of which 1,070 are legacy permits (dating from the previous law and which with transitional laws can be built, taking advantage of the best of both the previous government and the current government), eight permits that have already migrated from the government, 161 generation permits already granted to the CFE and another 127 generation permits already granted to private companies (Energy and Sustainability Review 2016, SENER).

Moreover, to encourage the entry of new agents and to generate suitable conditions of competition, the CRE had already granted 140 energy market operation participants and another 68 were in process at the end 2018; 46 are power producers, 17 qualified suppliers and seven are non-supplying traders, leaving the CFE as the only basic supply permit (Energy and Sustainability Review 2019, SENER).

Finally, the CRE has already published all the models of contract for interconnection-connection needed by generators, suppliers, and load centers. Likewise, the models of contract of import of electrical energy have been approved.

The CRE also approved and published the model agreements required between CENACE and the carriers/distributors to carry out the technical and commercial operation of the public electricity transmission service.

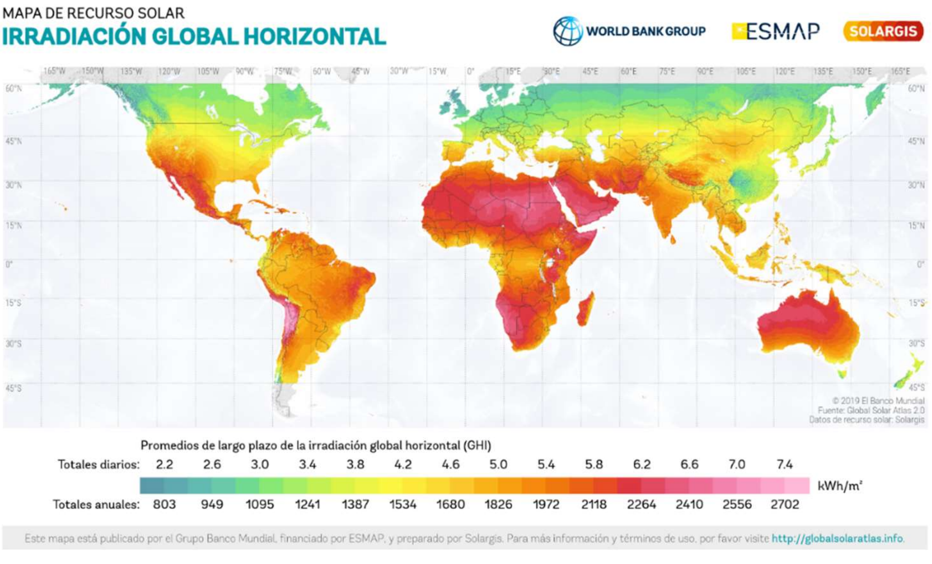
Thanks to new regulatory framework, market participants will be able to interconnect their facilities to the grid and sell their products without delays or surcharges. In addition, the CEL (Certificate of Clean Energy) was introduced with which it is intended to promote the generation of clean energy.

At the level of distributed generation, clean energy generators will be able to sell the energy produced to the CFE or to other customers. The concept of controlled demand was also introduced, which is intended to integrate renewable energies, in addition to requiring fewer requirements regarding firm capacity.

2.3 The Photovoltaic sector in Mexico

Mexico is a country with particularly high levels of solar radiation, belonging to the sun belt and registering around 5.5 kWh/m^2. Moreover, this important radiation is present mainly in sparsely populated states with large tracts of land which are hardly used or in complete disuse.

Figure 5. Horizontal Global Irradiation



Source: SolarGis. https://solargis.com/es/maps-and-gis-data/download/world

This high radiation connected with the considerable rise in Gross Domestic Product (GDP) and high energy prices during the last decade fomented important activity in the development sector. Many projects, adding thousands of solar MW, were submitted to the CRE. As can be seen in Table 2, by December 2016, 70 production permits had already been authorized by the CRE encompassing most of the states of Mexico. Though it should be noted that more than 50% of the projects were for the northern states of Mexico, where solar radiation is higher. The total authorized capacity was more than 2,400 MW by that year. Only four of them were under Self-supply regime, that means that final energy consumers were behind the construction of the installation. All other were under Small Scale Produced, that means that developer plans to sell energy to the CFE at the CTCP price. As will be seen in this article, financial institutions do not provide loans for the Small Scale Produced category and so most of the authorized projects will never be built unless the CRE classifications are modified.

Table 2. Solar Authorized Project in Mexico, 2016

	Company	Plant	Plant Size (MW)	Authorized Energy Production (GWh/year)	Investment (US$ millions)	Arrangement	State
1	Parque Solar Galapago I		30	61,07	60,00	Small-scale Producer	Sonora
2	Cuatro Solar	Caborca	30	60,00	60,00	Small-scale Producer	Sonora
3	Bocas Plantas	Sonora	30	60,00	60,00	Small-scale Producer	Sonora
4	Aleph Solar I		50	96,25	100,00	Self-supply	Sonora
5	SEGH Sonora Energy Group de Hermosillo		30	100,00	60,00	Small-scale Producer	Sonora
6	Solar Carbo I México		30	58,84	60,00	Small-scale Producer	Sonora
7	Cuatro Solar	Hermosillo	30	60,00	60,00	Small-scale Producer	Sonora
8	Nueve Solar	Sonora	30	60,00	60,00	Small-scale Producer	Sonora
9	Solar Wind Baja	Hermosillo	30	60,00	60,00	Small-scale Producer	Sonora
10	Sol de Sonora		30	58,00	60,00	Small-scale Producer	Sonora
11	Garambullo Solar		30	64,49	60,00	Small-scale Producer	Sonora
12	Cuatro Solar	Ciudad Obregón	30	60,00	60,00	Small-scale Producer	Sonora
13	Solar Wind Baja	Navajoa	30	60,00	60,00	Small-scale Producer	Sonora
14	Cuatro Solar	Casas Grandes	30	60,00	60,00	Small-scale Producer	Chihuahua
15	Solar Wind Baja	Ciudad Juarez	30	60,00	60,00	Small-scale Producer	Chihuahua
16	Solar Wind Baja	Samalayuca	30	60,00	60,00	Small-scale Producer	Chihuahua
17	Solar Wind Baja	Chihuahua	30	60,00	60,00	Small-scale Producer	Chihuahua
18	Solar Wind Baja	Camargo	30	60,00	60,00	Small-scale Producer	Chihuahua
19	Cuatro Solar	Parral	30	60,00	60,00	Small-scale Producer	Chihuahua
20	XIII Colima	Torreón	30	60,00	60,00	Small-scale Producer	Coahuila
21	Solar Wind Baja	Torreón	30	60,00	60,00	Small-scale Producer	Coahuila
22	Solar Wind Baja	Monclova	30	60,00	60,00	Small-scale Producer	Coahuila
23	Solar Wind Baja	Sabinas	30	60,00	60,00	Small-scale Producer	Coahuila
24	Solar Wind Baja	Saltillo	30	60,00	60,00	Small-scale Producer	Coahuila
25	Solar Wind Baja	Reynosa	30	60,00	60,00	Small-scale Producer	Tamaulipas
26	Tamaulipas Solar		30	60,00	60,00	Small-scale Producer	Tamaulipas
27	Solar Wind Baja	Güemez	30	60,00	60,00	Small-scale Producer	Tamaulipas
28	Solar Wind Baja	Mante	30	60,00	60,00	Small-scale Producer	Tamaulipas
29	Saferay Solar	La Pasión	30	58,18	60,00	Small-scale Producer	Baja California Sur
30	SEG Sonora Energy Group Caborca-Mexicalli		60	182,00	120,00	Small-scale Producer	Baja California Sur
31	EPC Gea System		30	58,18	60,00	Small-scale Producer	Baja California Sur
32	AEE Energía Renovable de México		30	79,30	60,00	Self-supply	Sinaloa
33	Solar Wind Baja	Los Mochis	30	60,00	60,00	Small-scale Producer	Sinaloa
34	Cuatro Solar	Los Mochis	30	60,00	60,00	Small-scale Producer	Sinaloa
35	Solar Wind Baja	Guasave	30	60,00	60,00	Small-scale Producer	Sinaloa
36	Solar Wind Baja	Guamuchil	30	60,00	60,00	Small-scale Producer	Sinaloa
37	Eneready		30	56,34	60,00	Small-scale Producer	Sinaloa
38	Solar Wind Baja	Costa Rica	30	60,00	60,00	Small-scale Producer	Sinaloa
39	Solar Wind Baja	Mazatlán	30	60,00	60,00	Small-scale Producer	Sinaloa
40	Bocas Plantas-Chihuahua Solar-Solar Wind Baja	Durango	90	180,00	180,00	Small-scale Producer	Durango
41	Cuatro Solar	Fresnillo	30	60,00	60,00	Small-scale Producer	Zacatecas
42	Nueve Solar	Zacatecas	30	60,00	60,00	Small-scale Producer	Zacatecas
43	Solar Wind Baja	Zacatecas	30	60,00	60,00	Small-scale Producer	Zacatecas
44	Zacsol 1		30	66,60	60,00	Small-scale Producer	Zacatecas
45	Solar Energía Altiplano		30	65,01	60,00	Small-scale Producer	San Luis Potosí
46	Cuatro Solar	Peñasco	30	60,00	60,00	Small-scale Producer	San Luis Potosí
47	Bocas Plantas-Cuatro Solar-Querétaro Solar-Solar Wind Baja	San Luis Potosí	120	240,00	240,00	Small-scale Producer	San Luis Potosí
48	Alten Energías renovables México Cinco		120	303,28	240,00	Small-scale Producer	Aguascalientes
49	Comercializadora Capo		30	60,00	60,00	Small-scale Producer	Jalisco
50	Eolia San Julian	San Juan	30	61,50	60,00	Small-scale Producer	Jalisco
51	Solar Wind Baja	Altamira	30	60,00	60,00	Small-scale Producer	Jalisco
52	Solar Wind Baja	Tonalá	30	60,00	60,00	Small-scale Producer	Jalisco
53	Solar Wind Baja	Acatlán	30	60,00	60,00	Small-scale Producer	Jalisco
54	Sonne de Kikp		30	60,00	60,00	Self-supply	Guanajuato
55	FV Mexsolar I y II		60	143,20	120,00	Small-scale Producer	Guanajuato
56	Querétaro Solar	Querétaro	30	60,00	60,00	Small-scale Producer	Querétaro
57	Cuatro Solar	Ezequiel Montes	30	60,00	60,00	Small-scale Producer	Querétaro
58	Cuatro Solar	San Juan del Río	30	60,00	60,00	Small-scale Producer	Querétaro
59	Solar Wind Baja	Calpulalpan	30	60,00	60,00	Small-scale Producer	Estado de México
60	Nueve Solar	Estado de México	30	60,00	60,00	Small-scale Producer	Estado de México
61	Cuatro Solar	Tejepi del Río	30	60,00	60,00	Small-scale Producer	Hidalgo
62	Controladora de Renovables		30	53,17	60,00	Generator	Ciudad de México
63	Solar Wind Baja	Amozoc	30	60,00	60,00	Small-scale Producer	Puebla
64	Solar Wind Baja	Manzanilla	30	60,00	60,00	Small-scale Producer	Colima
65	Solar Wind Baja	Tecomán	30	60,00	60,00	Small-scale Producer	Colima
66	Solar Wind Baja	Chipancingo	30	60,00	60,00	Small-scale Producer	Guerrero
67	Solar Wind Baja	Arriaga	30	60,00	60,00	Small-scale Producer	Chiapas
68	Solar Wind Baja	Macultepec	30	60,00	60,00	Small-scale Producer	Tabasco
69	Solar Wind Baja	Campeche	30	60,00	60,00	Small-scale Producer	Campeche
70	Kiin		30	74,50	60,00	Self-supply	Yucatán

Source: CRE.

If we look at Table 3 next, it can be seen that fewer than 5% of the total number of projects authorized by CRE had been constructed by the end 2018. At the end 2017, the two major projects that were built under the previous law are concentrated in the State of Durango for the case of the 67 MW of the company EOSOL and in the state of Baja California del Sur for the case of the 30 MW of the Aura Solar company.

Table 3. Solar Operational Project in Mexico, 2018

	Company	Plant	Arrangement	Plant S (MW)	Authorized Energy Production (GWh/year)	Investment (US$ millions)	State
1	Plamex		Self-supply	1,04	1,91	2,08	Baja California
2	CFE	Central Cerro Prieto*	Generator	574,85	4009,91	693,70	Baja California
3	CFE	Central Santa Rosalía	Generator	0,97	2,04	1,94	Baja California Sur
4	Servicios Comerciales de Energia		Small-scale producer	30,00	86,00	60,00	Baja California Sur
5	Coppel		Self-supply	0,99	2,30	1,97	Sinaloa
6	Buenavista Renewables	Los Santos Solar I	Self-supply	13,70	40,10	40,00	Chihuahua
7	Eosol	TAI Durango I	Small-scale producer	30,00	57,90	60,00	Durango
8	Eosol	TAI Durango II	Small-scale producer	15,62	32,42	31,25	Durango
9	Eosol	TAI Durango III	Small-scale producer	6,25	12,06	12,50	Durango
10	Eosol	TAI Durango IV	Small-scale producer	6,25	12,06	12,50	Durango
11	Eosol	TAI Durango V	Small-scale producer	3,50	6,75	7,00	Durango
12	Autoabastecimiento Renovable		Self-supply	0,79	1,80	1,57	Aguascalientes
13	Generadora Solar Apaseo		Self-supply	0,98	2,14	1,95	Guanajuato
14	Iusasol		Self-supply	18,30	37,19	36,60	Estado de México
15	Iusasol		Self-supply	0,92	1,86	1,84	Estado de México

Note: Only 5MW of the Cerro Prieto Plant come from solar PV, while the remaining power is produced from geothermal sources.

Source: SENER

Finally, in 2019, thousands of MW were built, making photovoltaic energy an important source of generation in the Mexican energy mix. The success during that year was mainly due to the public auctions that will be studied in this chapter. To understand the main reason for this change the barriers to developing projects in Mexico will be studied in the next section.

2.4 Barriers to the development of photovoltaic plants

There are no doubts about the existence of barriers to develop this new clean energy, even if nowadays alternative sources of energy are needed to reduce pollution. In fact, these barriers exist, not only in the case of solar energy but also for all new alternative sources of energy.

There is abundant literature available that has been developed during recent years on this matter, but to delve more deeply into the literature lies beyond the purposes of our investigation. In a selection of authors, Painuly (2001) offers a general overview on barriers to renewable energy penetration, suggesting measures to overcome them. The existence of barriers is worldwide from pole to pole around the globe. In the case of China, where the solar photovoltaic (PV) industry has developed rapidly (Honghang et al., (2014), an interesting review of solar energy development, including the existence of barriers, is offered by Liu et al. (2010). Negro, Alkemade and Hekkert (2012) present a literature review of studies on the difficult trajectory of different renewable energy technologies, mainly focused on European countries. The paper by Richards et al. (2012) analyzes the case of barriers to renewable energy development in a case study for Canada. In the case of Pakistan "the barriers to development of renewable energy can be broadly classified as policy and regulatory barriers, institutional barriers, fiscal and financial barriers, market-related barriers, technological barriers and information and social barriers" (Mirza et al., 2009).

As far as is known, one of the first documents on barriers in the case of Latin American countries was published in 2003 by the Economic Commission for Latin America and the Caribbean (CEPAL), within the Division of Natural Resources and Infrastructure. The document tries to demonstrate that "there are a number of cultural and institutional reasons for the "relative failure" of sustainable energy development in Latin America. These factors are true not only of Latin America but of the developing world in general" (CEPAL, 2003).

These barriers mentioned above, are already present in Latin American countries, even if some steps forward have been implemented, as in the interesting case of Chile (Nasirov et al. 2016). In fact, we think that these kinds of cultural and institutional barriers, among others, are present in the case of Mexico. The novelty of this chapter on solar energy is that, in describing clean energy barriers, an original analysis of the topic will be presented, combining the information from the literature and from the experiences of EOSOL.

2.4.1 Barriers in the case of Mexico

Among the literature on clean energy barriers for Mexico, I will just mention three important works since I consider these to be the most important with regard to highlighting the experience of EOSOL. First, I want to highlight the work by Huacruz (2005), who distinguishes technical, regulatory, financial, and institutional barriers, trying to look for convenient solutions. Lokey (2009) focuses her research more on institutional barriers, regarding CFE. Alemán-Nava et al. (2014) point out the lack of valorization of the use of renewable energies and the dearth of incentives to encourage private sector participation.

Considering all the barriers analyzed in the papers mentioned above and the experience of EOSOL, a first approach to the barriers could be summarized two categories: those from a logistical standpoint and those from a more institutional point of view.

Regarding the so-called logistical barriers, in Mexico there are a number of peculiarities that render the construction and development of photovoltaic plants particularly arduous. In this sense, one of the first inconveniences stems from the labor market, where there exist important restrictions imposed by labor unions, which are relevant to the hiring process in the country for a Spanish based company such as EOSOL. The country has many specialized unions that force companies to use certain services or personnel that make construction more expensive. These unions, such as transport or electricians, cause numerous delays, even blocking the access to the deliveries of the different subcontractors.

This means that under the frequently used EPC, a contractor must negotiate with its subcontractor so that it includes the services of these unions, having repercussions both on costs and in contract terms[8]. Moreover, when this sector was being launched, the lack of experience of subcontractors resulted in negotiated deadlines and costs not being met since on many occasions the supplier was not able to forecast the real time of execution, incurring costs and delays mainly in assembly and civil works. Then, in EOSOL's own experience, there appeared to be a lack of seriousness with regard to meeting deadlines coupled with low organizational capacity. Additionally, exhaustive controls were not carried out regarding work rates and the capacity of contractors to increase personnel in periods of peak demand was dubious. In short, the cost of fulfilling contractually committed times was high.

[8] EPC is the acronym for *Engineering, Procurement and Construction*, making clear reference to everything included in the contract: the design, the necessary supplies and the construction. A number of additional services will also be included to accomplish these three main objectives of design, supply and construction. For detailed information, see for example, https://www.pwc.com/us/en/industries/capital-projects-infrastructure/library/engineering-procurement-construction-project-intervention-profitability.html.

Apart from the problems concerning labor markets, other more institutional barriers have to be faced. In this sense, a special mention has to be made regarding the lack of experience of the CFE interconnectors. The lack of knowledge regarding photovoltaics, for example on the operation of inverters, caused many delays in the validation of interconnection documentation and excessive demands in terms of protection or security measures. The problem was that the transition from the LSPEE[9] to the new LIE of 2014 required some restructuring in the CFE and in the CENACE. These logistic barriers fortunately have now disappeared, although the labor union is still very important.

In summary, this first examination of the barriers in Mexico, described above, presents an unclear situation in which the challenges in Mexico's electricity sector, including those for clean energies, are huge even in the aftermath of the 2014 energy reform. In fact, "the clean energy definition is broad, which might lead to the favoring of cheaper and reliable natural gas plants over renewable technologies" (Roy and Briones, 2016).

In the subsections below, I will delve a little further into the descriptions of the logistic and institutional barriers in Mexico for the development of a photovoltaic plant.

First, the regulatory framework is outlined, second, other barriers are analyzed and finally the special barrier of financial services is considered.

2.4.2 Barriers to obtaining permits

The barrier considered the most important relating to the development of photovoltaic plants in Mexico is the complicated legal requirements. It could be said that the regulatory framework for operating a power plant is composed of four main, clearly differentiated subjects[10]: management to generate electricity within the transition process of the law (annex 6.1); environmental impact assessment (annex 6.2); local municipal management with the competent authorities (annex 6.3); and procedures related to the social impact of the project (annex 6.4).

Costs and times are supposed to be well defined and clear but, as will be seen in this chapter, due to barrier delays costs could usually be three or even four times higher.

[9] Mexico's energy sector was under a monopoly state company CFE for many years. The law which was managing the rules was the LSPEE can be found in https://www.senado.gob.mx/comisiones/energia/docs/marco_LSPEE.pdf.

[10] In this subsection we describe all four of these barriers, from the regulatory point of view. Since this information comes from the EOSOL's broad experience in implementing photovoltaic plants in Mexico, we offer more concrete data about these barriers in Annexes 6.1, 6.2, 6.3, and 6.4, included at the end of the chapter.

2.4.2.1 Management to generate electricity within the Law Transition Process

The opening of the Mexican energy sector finally materialized when the new LIE [11] was approved on August 5th, 2014 replacing the LSPEE. Several papers about the energy reform have been published and, among them, Rodríguez Padilla (2016) and Chanona Robles (2016) are worthy of mention. Also, many law firms have developed numerous analysis of this matter.[12]

As was indicated in the subsection above, the transition process, even if it provided an opportunity for private business, has been difficult for business with regard to the new clean energies. Under the LSPEE regulatory framework, since pre-feasibility and interconnection feasibility studies were costless, there was much speculation on the part of some companies who requested studies without the intention of carrying out projects, merely to develop and sell the construction permits. As a result, the relevant areas of CFE, in charge of carrying out the technical studies, were saturated with work, causing the response times to be excessively long. The process of transition from the previous law to the new one, and given the restructuring of CFE and CENACE, left a legal gap that brought about the extraordinary and unlikely situation in which CTCPs[13] were not published for months (as far as is known, the last ones published date back to September 2016). It has to be remembered that CTCP is a basic and necessary informative document regarding costs for the development of photovoltaic plants. On February 17th, 2017, the government changed the calculation method of the CTCP to make it equivalent to PML[14].

Currently, the Wholesale Electricity Market is still incipient and there is great uncertainty about its efficient operation and the prices of the different products to be marketed. During the three long-term auctions[15] held to date, contracts awarded to winning companies resulted in incredibly low prices of electric power. Initially, most companies thought that most projects would not be built, but as will be seen in next subsection almost all winning projects finally came to fruition. Probably those which did not eventually become reality was due to the financing.

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[11] See DOF: *Ley de la Industria Eléctrica*, Mexico DF, August 11, 2014.

[12] For instance the interesting study by JATA - J.A. Treviño Abogados S.A. de C.V. 2014. Monterrey and Houston:http://jatabogados.com/publications/articles/Reforma_Energ%C3%A9tica_Ley_de_la_Industria_El%C3%A9ctrica.pdf.

[13] CTCP refers to the total short-term costs of the electrical system and the expected unit costs and costs incurred from freight dispatch, from the public and private power plants that deliver energy to the system for the supply of demand throughout the country. For more information, see http://www.cfe.gob.mx/paginas/Home.aspx.

[14] DOF: 02/03/2017, Resolution Num: RES/143/2017

[15] We will discuss the subject of electricity auctions in next subsection of this chapter.

In addition, the CFE, because of its still monopolistic position in the network, demands infrastructures that are not technically justifiable, and it is very difficult or practically impossible to refute their criteria.[16]

2.4.2.2 Environmental Impact Assessment

Mexico's Environmental Impact Assessment legislation is another legal requirement to receive the permission for building photovoltaic plants. "The EIA procedure begins with the presentation of an environmental impact statement by the developer, known as the MIA. The MIA, together with a permit application is evaluated by SEMARNAT, which may then approve, deny, or conditionally approve the project" (Palerm and Aceves 2004). The problem here is that the MIA does not finish just at SEMARNAT, since to carry out environmental procedures, more requests have to be made at state and local levels, and often the different administrations are badly coordinated and the criteria for the same project are different or contradictory[17].

Despite these legal problems, given that what is being dealt with are electricity generation projects through renewable energy sources with the consequent contribution to the reduction in greenhouse gas emissions to the atmosphere, these projects were supposed to be exempt from the MIA or subject to very reduced requirements. However, this was not the case and currently all projects must present the MIA project. During the first 10 years after Eosol built its first installation, the problem was the lack of experience of this type of project of new photovoltaic plants which were still new for the administration and decision-making took an exceptionally long time as did the outlining of the mitigating criteria of the impacts, if these existed. With the passing of time SEMARNAT has become ever more restrictive and in the near future it is unlikely that any solar installation will be allowed to be installed on arable land. This might have some sense in a country where the extent of non-arable land is vast as it is in Mexico.

There are no doubts that in Mexico some steps forward are needed to be taken in solving legal and practical problems regarding MIA. In this regard, we would like to mention a relatively recent piece of research by Perevochtchikova and André (2013), where the authors include some challenges posed by MIA in Mexico, following the example of the case of Canada.

[16] A good summary of all legal requirements can be found in: Secretaría de Energía (SENER). 2017. Prospectiva del Sector Eléctrico 2017-2031. SENER. Mexico DF.

[17] For more information about the MIA and the requirements at state and local levels, see http://www.semarnat.gob.mx/temas/gestion-ambiental/impacto-ambiental-y-tipos/contenido-de-una-mia.

2.4.2.3 Local municipal procedures previous to submission to the competent authorities

Besides the legal requirements at a local level regarding environmental impact, mentioned above, other legal processes must be also covered at this level. The main difficulty with this type of project with regard to municipal procedures is the amount of fees to be paid. This happens because at the local level, and due to the lack of experience, these types of installations are not regulated in the overall land planning and, therefore, the authorization procedure is not clear.[18] It has to be pointed out that more often than not, the municipalities eventually rule that all land on which a facility of this type is located is industrial, and when occupying very extensive areas, the rates become unaffordable for this type of installation.

Another important problem is that local authorities do not offer authorization for a period longer than the period of validity of the local administration. In Mexico, the local administrations change every three years, therefore, the validity of the authorizations are very short and have to be renewed with new partners, to whom it is necessary to present again all the relevant documentation, to explain the special land planning approval for photovoltaic plants, and, finally more taxes have to be paid to the new local authority.

2.4.2.4 Procedures relating to the social impact of the project

The last legal requirement to be met concerns the social impact. After the implementation of the new LIE in 2014, previously mentioned in this paper, all energy sector projects must past EVIS[19]. Each company is obliged yet again to follow certain specific and complicated norms and observe EVIS, this being another obstacle facing the implantation of long-term programs of photovoltaic plants in Mexico.

The problem of poverty in some Latin American countries, Mexico among them, is nowadays strongly entrenched in society and various social

[18] In fact, official documents do not include these kinds of facilities, for example: "The Political Constitution of Mexico in Art. 115 establishes the attribution of the City Council to administer zoning of the municipal territory and comprises the primary zoning, which are the areas that make up the territory of the municipality, and which are identified as urban areas, areas of conservation and conservation areas, and secondary zoning comprises, uses and destinations compatible in urban districts; the uses determined in the plans are: housing, commercial, service, industrial, open space and infrastructure and destinations: are the road structure, master services networks, equipment (education, culture, health, welfare, recreation, sport, communications, transport and public administration)" (SEDESOL, 2010). Even a recent local government law does not include information on this matter. See: DOF, Diario Oficial de la Federación. *Ley General de Asentamientos Humanos, Ordenamiento Territorial y Desarrollo Urbano*, Mexico DF, November 28, 2016.

[19] For more information about the EVIS and all the approvals regarding social impact, see http://www.gob.mx/sener/articulos/tramite-evaluacion-de-impacto-social-evis.

development plans have been developed by different governments. Nevertheless, this has not been the case until recently, since for decades in these countries the problem has been the existence of extractive economic and political institutions, which instead of fostering better economic conditions for the population, have brought about the impoverishment of their citizens. Of course, these kinds of institutions never favored the implementation of private initiatives to improve development [20]. In the case of Mexico, even if some level of necessary political centralization has been achieved at an institutional level, (see, Acemoglu and Robinson, 2013), the situation of poverty is still worrisome and is not helped by the existence of the kind of disproportionate regulation mentioned in the previous paragraph. In fact, according to last data published by World Bank[21] 46,2% of Mexican population were under the poverty line in 2014.

Indeed, new clean energy projects have been promoted since the first years of the century by international institutions as an instrument to reduce poverty: “in Latin America, energy efficiency and renewable energy offer great potential for reducing the negative effects of the ever-increasing rates of energy consumption associated with economic growth and the move towards more energy-intensive societal models” (CEPAL, 2003). Support has also been coming from national authorities, indicating the importance of these kinds of energies for rural areas: “the contribution of these sources is especially relevant to social development in areas where conventional energy is economically unviable, such as rural areas that are separated from the electricity grid” (SENER, 2006). In sum, there is not much doubt that renewable energies are more effective solutions for rural electrification, given the costs of expanding the grid to supply electricity to remote communities.

Although it is true that emerging innovative programs could trigger more effective solutions to tackle the problem, the truth is that there has never been the required level of continuity, follow-up, consistency, and long-term vision. Such is the case of a program disseminated by the SENER itself during 2009, which aimed to benefit rural communities in the most marginalized municipalities in the country (within the states of Veracruz, Guerrero, Oaxaca and Chiapas).

In this project organizations from the business and government sectors, academics, civil associations, international organizations, and the affected communities all participated. There existed a public-private partnerships approach with the potential to contribute to the reduction of poverty and

[20] See, Acemoglu and Robinson (2013).

[21] For more information, see World Bank. 2017. DataBank. World Development Indicators. http://databank.worldbank.org/data/reports.aspx?Code=SI.POV.NAHC&id=1ff4a498&report_name=Popular-Indicators&populartype=series&ispopular=y.

marginalization rates in the region. The result of this project was the publication of a compendium of more than 100 successful cases of diverse programs implemented, of diverse nature, whose purpose was always the enablement of impoverished communities.

As far as is known, no more projects of this kind have been developed to extend this success to a greater geographical area, and this is a great pity given the potential of clean energy to mitigate poverty in marginal areas.

As a summary of this subsection, it can be said that the biggest barriers that clean energies are facing in Mexico is that the regulatory frameworks are underdeveloped, incomplete, and unclear. There are no correct procedures, and the deadlines are also unclear. This leads to a particularly important level of discretion that encourages clutter and other problems.

The good news is that this situation is reversible, a little political willpower could be sufficient as well as learning from the experiences of other success stories.

2.4.3 Land barriers

After the review of the barriers relating more to legal conditions for the development of clean energy in Mexico, and more precisely for the development of photovoltaic plants, in this subsection other kind of barriers will be reviewed that also exacerbate the hurdles which hinder the process of developing new energies in Mexico.

Previously it has been explained that one of the barriers for building new photovoltaic plants in Mexico is the regulation at local government level, since these types of facilities are not regulated in the general regulations relating to land planning. However, the problem with land in Mexico is further complicated for the development of clean energies, since the installation of new plants must deal with the distribution of land in Mexico, which is especially complicated. I will briefly describe this below.

The Agrarian law of 1915[22] "was the first step taken in Mexico to provide a solution not only revolutionary but institutional to the demands of the people, that is, this law gives a response to the needs of the country with a long-term vision to be consolidated and raised to constitutional level in 1917" (Patiño and Espinoza, 2015). Nowadays, the current Constitution of Mexico [23] still includes these rights for the citizens in Article 27, in

[22] This law was approved in Mexico in January 6, 1915 and was reformed twice in 1992 and recently in 2017. For more information, see: DOF, Diario Oficial de la Federación. *Leyes y reglamentos federales*. http://www.ordenjuridico.gob.mx/leyes.php.
[23] For more information about the Constitution, see: DOF, Diario Oficial de la Federación. *Constitución Política de los Estados Unidos Mexicanos*. http://www.diputados.gob.mx/LeyesBiblio/ref/cpeum.htm.

which refers to a special term known as *ejido*, which appeared for the first time in the Agrarian law of 1915. The *ejido* is a kind of communal land which has special benefits for its owners, according to the Procuraduría Agraria.

The *ejido* "has two connotations, in the first the nucleus of population or person with legal personality and own inheritance is considered; the second refers to lands subject to a special regime of social ownership in land tenure; the Constitution recognizes such personality and protects its patrimony in a special way" (Procuraduría Agraria, 2009). Thus, the origin of the *ejido* dates back to the beginning of last century, within the Constitution of Mexico of 1917, but as an existing concept, some research has been done in recent years. Particular mention should be made of a research paper by Jones and Ward (1998) published after the reform of the Agrarian law in 1992, in which the authors analyze how *ejido* maintains an important role both in rural areas and in the urbanization process. Also, a more recent study by Ruiz (2015) investigates the *ejido*´s organization in rural development in Mexico.

The major problem with the *ejido* with regard to our research is that today they constitute 55% of the cultivated rural areas in Mexico[24], which are generally the places where photovoltaic power plants can be installed. Thus the the possibility of privatizing these areas is essential for this kind of project. All the reforms of the Agrarian law, that took place, as previously mentioned, in 1992 and 2017, did not make any advance regarding privatization of the *ejido*. Regarding the reform of 1992, Jones and Ward commented "reform is not strictly privatization and, to the extent that it does threaten the *ejido*, this may have less to do with the procedures outlined directly in the reform *per se*, but relate more to the accompanying legislation such as the New Human Settlements Law" (Jones and Ward, 1998). Perramond (2008) speaks about a few disperse privatizations, and Haenn points out that "Mexican policy-makers and *ejido* members alike are ambivalent regarding a privatized ejido" (Haenn, 2006).

In sum, "The ejidal ground in Mexico presents, throughout its history, vagueness in its origin, ambiguity in its implementation, lack of definition in its property and confusion in its use. In the latter aspect, mostly from the second half of century XX, of its original and historical communal agrarian sense, one consolidates like merchandise, now for urban use, and that contributes any type of both private and public earnings" (Flores, 2008).

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[24] For a detailed definition, see the definition of *ejido* in https://www.britannica.com/topic/ejido.

Therefore, it could be said that the building of new photovoltaic plants in Mexico faces an important and specific barrier linked to the peculiarities of land use categorization. In fact, the solution to crossing ejidal terrains is often to simply avoid them with the layout of the power lines, which means that time required for the construction of these infrastructures is up to 50% longer. Building installations that need hundreds of kilometers of transmission lines is therefore almost an impossible mission.

Finally, there is yet another problem with land in Mexico in the case of crossing roads, as more permits are needed from State and Federal administrations, although at least in this case the administration levels are better than in the case of *ejido*. The permit for crossing roads often takes years to be processed, leading to a situation in which a considerable number of the line crossings of the CFE do not have these permits. In addition, many of Mexico's highways are under concession, and approval is required before signing an agreement with the concessionaire. These agreements are not regulated and therefore end in a lengthy negotiation that can dramatically increase costs.

2.4.4 Commercial barriers

The legal transition process which enabled the opening of the Mexican energy sector with the approval of the new LIE has previously been described in this research. A prior condition to the law was the Constitutional Reform through the approval of the Decree on energy.[25] This Constitutional Reform brought to an end the state monopoly on the generation and commercialization of electricity and enabled a more direct commitment to renewable energies.[26] This monopoly had been also a barrier that obstructed the take off and deployment of Power Purchase Agreements (PPAs)[27], which are crucial for the development of photovoltaic plants in Mexico.

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[25] DOF, Diario Oficial de la Federación. *Decreto por el que se reforman y adicionan diversas disposiciones de la Constitución Política de los Estados Unidos Mexicanos, en Materia de Energía*, Mexico DF, December 20, 2013.

[26] For more information, see the Energy Agency, http://www.iea.org/policiesandmeasures/pams/mexico/name-148727-en.php.

[27] "A solar power purchase agreement (PPA) is a financial agreement in which a developer arranges for the design, permitting, financing and installation of a solar energy system on a customer's property at little to no cost. The developer sells the power generated to the host customer at a fixed rate that is typically lower than the local utility's retail rate. This lower electricity price serves to offset the customer's purchase of electricity from the grid while the developer receives the income from these sales of electricity as well as any tax credits and other incentives generated from the system. PPAs typically range from 10 to 25 years and the developer remains responsible for the operation and maintenance of the system for the duration of the agreement. At the end of the PPA contract term, a customer may be able to extend the PPA, have the developer remove the system or choose to buy the solar energy system from the developer" (Solar Energy Industries Association, SEIA). Solar Power Purchase Agreements.

http://www.seia.org/sites/default/files/resources/SolarPPAs_fact%20sheet_FINAL%201.pdf)

In fact, throughout the last 10 years, negotiating a PPA contract has been an almost impossible mission in the Mexican electric sector, except for major international utility companies,. Fortunately, in 2019 some PPAs started to take place, but as the commercialization companies were young, project financing loans were now the latest barrier. It must be remembered that this was a regime in which over the last decades, the possibility of negotiating the price of energy was simply impossible. Only large industrial or commercial companies such as Walmart, Bimbo, Coca Cola and others with these levels of solvency and professionalism were developing schemes of self-sufficiency and therefore were able to negotiate with a limited number of suppliers, generally large utilities or developers of wind farms or combined gas cycles, the economic conditions of their energy consumption.

With the inclusion of photovoltaic energy and the entry into the playing field of a great number of small developers and utilities, a common characteristic of companies in the photovoltaic sector throughout the world, the door was opened to medium-sized consumers to negotiate the conditions of its energy supply. The problem is that these medium-sized companies had neither energy departments nor access to professionals with enough knowledge to carry out a thorough analysis of the offers, so many of these companies signed with suppliers who did not have the capacity to execute their projects.

Coupled with this problem in the sale of clean energy, it must be remembered that the aforementioned energy reform had been implemented in an excessively short period and often with little explanation or technical or cost justification of the electricity tariffs in Mexico. Moreover, this was in a period which witnessed thirty consecutive months of reductions in the cost of electricity. This had two effects on consumers. First, no one knew how low the price would fall. Second, the companies that had committed to a new offer to buy energy generally realized that before long the agreed price was superior to that charged by the CFE.

Therefore, in practice the development of PPA contracts was undergoing great difficulties, leading consumers not to sign any offers, due to a lack of knowledge of the real price of what they intended to buy which moreover, sometimes involved a long-term commitment of 15 to 20 years. Indeed, many of those who did signe were involved in litigation to break a contract that was clearly damaging in the short and medium term.

Also a good reference regarding PPA can be found in: World Bank. Power Purchase Agreements (PPAs) and Energy Purchase Agreements (EPAs).

https://ppp.worldbank.org/public-private-partnership/sector/energy/energy-power-agreements/power-purchase-agreements.

In the end, the only consumers who continued to engage with developers in the long term were the large entrepreneurs who did have energy departments and those industries with good professionals who had been negotiating the same terms for a decade.

Even with these difficulties, the problem of the commercial barriers concerning the sale of energy to consumers and to the government itself began to improve. As mentioned above, after the Decree on Energy of December 20, 2013, the monopoly on energy distribution started to disappear and an important event regarding the energy market in Mexico was the introduction of the system of auctions for negotiating electricity offers. These auctions were to play a major role in the market for renewable energies. The first auction was opened in November 2015 [28] and an interesting research paper concerning this first auction can be found in Martín (2016). The second auction took place in April 2016[29], and third Long-Term Auction took place on November 2017.[30] A more thorough analysis of the auctions is beyond the scope of this research, and a good summary of the importance of auctions for renewable energies has been made by St. James (2017). The three auctions carried out by the Mexican government so far have obtained prices that were world records for being so low and economical. These prices have shaken the industry, even those who supposedly knew about energy in Mexico, and now all the big industrialists, who have even better financial ratings than the CFE, aspire to obtain those same prices obtained by the CFE.

However, the cancellation of auctions on January 31st, 2019 pushed developers to find a new way to develop their projects. Thus, in the second part of 2019, most developers started again to negotiate bilateral PPAs, trying to find the method or the correct balance to close deals. The objective of the government in cancelling the auctions was to recover the leading position of the CFE in the electrical market, but the future will probably be exactly the opposite. In the auctions, the CFE was getting incredible and historically low prices for the purchase of energy and no company was able to take final consumers from the CFE. Nowadays, the CFE is losing its competitiveness and its final consumers.

[28] For more information regarding the first auction, see Secretaría de Energía – 2015, Prospectiva del Sector Eléctrico 2015-2029.

[29] For more information regarding the second auction, see Secretaría de Energía (SENER). En la tercera Subasta Eléctrica mexicana se obtuvo uno de los precios más bajos internacionalmente: PJC. http://www.gob.mx/sener/prensa/se-lanza-la-convocatoria-para-la-segunda-subasta-electrica-de-largo-plazo.

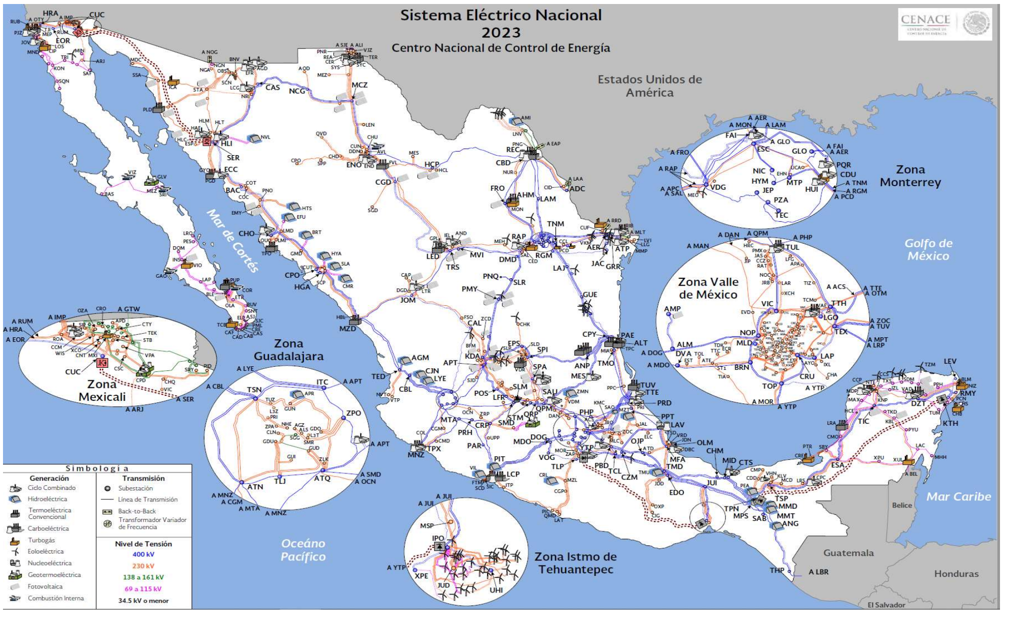
[30] For more information regarding the third auction, see Secretaría de Energía, https://www.gob.mx/sener/prensa/en-la-tercera-subasta-electrica-mexicana-se-obtuvo-uno-de-los-precios-mas-bajos-internacionalmente-pjc

2.4.5 Congestion problems in interconnection infrastructures

Although it seems that the country has an extensive interconnection network both in transmission and distribution with 108,018 km of transmission lines and 838,831 km of distribution lines, enabling 98% of the country to be interconnected, the reality is that CENACE, since the middle of 2019 is requiring permit holders, who are trying to develop renewable energy projects, to carry out reinforcement work on the interconnection lines thereby rendering the projects economically unfeasible.

The reason that CENACE is demanding these expensive infrastructures for new generation projects is the national electricity system itself. It is true that almost the entire country is interconnected, but the Mexican SEN, except for the central area, is very linear, very long and not particularly well meshed, as can be seen in the following figure.

Figure 6. Mexican SEN



Source: CFE[31]

Here it can be seen that, particularly in the north of the country, there are connecting lines that are several hundred, even thousands of kilometers long. This makes Mexico an extraordinarily congested country. The cause

[31]https://www.cenace.gob.mx/Paginas/SIM/ProgramaRNT_RDG.aspx

of this congestion is the instability of the system caused by the phase angles in the electricity transmission lines[32].

Therefore, although logic may indicate that the power line that can be seen next to a project under development has sufficient capacity, the reality is that CENACE cannot allow more electrical current to be transmitted through said line because it would cause the instability in the system because of the lengths of these lines.

Unfortunately, due to confidentiality agreements signed with private third parties, specific data on the requested reinforcements cannot be provided, but they are of such magnitude that on some occasions the cost of the interconnection infrastructure would exceed the cost of construction of the generation facility itself.

The problem in Mexico is that this situation either has no solution or has a solution so expensive that no project or country would be able to solve it in the short term. On the one hand, there is the *Sierra Madre*, a mountain chain of more than a thousand kilometers that starts in the north of the country and encompasses two geographical areas and through which it would be prohibitively expensive to build transmission lines.[33]

On the other hand, there are the large almost deserted and unpopulated areas of the country where there is no population and therefore there is no demand. Until these areas are populated and the electricity demand grows, the construction of transmission lines for the meshing of these regions does not make economic sense. The demand of a city has a lot of inductance due to the motors in factories, air conditioners, washing machines, etc ... but if this demand does not exist to compensate for the impedance created by the line itself, this problem will not be solved.

The scant existing interconnection with the USA is also striking. Greater interconnection would be a possible solution, at least in the northern part of the country, in order to increase the percentage of renewables.

2.4.6 The special barrier of financial services

Financial resources deserve a special mention when analyzing barriers, since without them, no project can be executed. Regarding the literature

[32] In an AC electrical system, the real power that is transmitted through a circuit is equal to V*I*cosΘ. Where Θ measures the phase shift between the sinusoid of V (voltage) and the sinusoid of I (current). This angle varies depending on the motors and capacitors that a given electrical system has. The problem is that power lines work like a capacitor and the longer the line, the larger the capacitor and therefore the greater the angle Θ. This means that although the power line could transmit more electric current, by increasing its length, the current that we pass through it has to be less to prevent the system from becoming unstable.

[33] The same situation exists between Spain and France because of the Pyrenees. This mountain range prevents the construction of transmission lines between Spain and France and means that the surplus renewable energy that exists in Spain cannot be transmitted to the rest of Europe.

analyzing the financial support for clean energy, Cucchiela et al. (2015) present a general financial analysis of investment and policy decisions in the renewable energy sector. With respect to solar photovoltaic (PV) industry, an interesting investigation for China by Honghang et al. (2014) has already been mentioned in this research. Also, international organizations such as the World Bank started financing these kinds of projects years ago, in this sense a study by Miller and Hope (2000) is relevant for the cases of India, Indonesia, and Sri Lanka. In the case of Europe, there is an investigation on Italy by Ameli and Kammen (2014).

Finally, and not for lack of references, but because it is not the objective of this research to go much further on this matter, I would just like to highlight the relatively recent study by Mundo-Hernández et al. (2014), in which the authors offer an overview of solar photovoltaic energy in Mexico in comparison with Germany, also analyzing regulations and financing in both countries.

To briefly analyze the financial difficulties of the photovoltaic sector in Mexico, a distinction should first be made between the two alternatives available when seeking finance for the construction of a project of these characteristics. One is the debt with recourse to shareholders (guarantees) and the other is debt without recourse to shareholders (Project Finance, where the only source of repayment are the project flows). In this sense, one important thing is that, in general, “debt makes up the majority of the investment going into many utility-scale renewable energy projects, either at the project level in the form of non-recourse loans, bonds or leasing; or at the corporate level in the form of borrowing by the utility or specialist company that is developing the project” (United Nations Environment Programme, 2016).

The conditions of debt with recourse depend on the creditworthiness of the debtor, which is why it is limited to the major global players in the sector. In any case, Mexico has much more restricted credit than developed countries, especially since the “tequila crisis” of 1994-1995.[34] Therefore, private debt levels are low, due to high interest rates on debt / default levels. Nevertheless, this type of debt has begun to be used in several projects arising from the auctions in which the sponsors place corporative guarantees to raise debt at the holding level (not at the project level) to obtain better rates. The risk is that this type of debt is consolidated in the company's financial statements, which may weaken its financial position and additional funding capacity.

In addition, analyzing the growth of the sector in the countries where this type of technology has developed strongly, this growth has been led by

[34] For more information concerning the tequila crisis, see, for example: Musacchio, A. 2012. Mexico’s financial crisis of 1994-1995. Harvard Business School, Working Paper 12-101, May.

many medium-sized players which were then merged into large players. The problem in Mexico is that these players, numerous but with limited resources, cannot access this type of financing.

Regarding non-recourse debt, this depends very much on the visibility of the cash flows generated by the project. A project with long-term PPA is more likely to be financed with Project Finance if the off takers credit position is high. This was the case for the large projects that were developed under the previous law under the scheme of self-sufficiency, in which major self-supplying partners such as, for example, Walmart, CEMEX, or Bimbo gave guarantees to financial institutions.

However, now that large corporations already have their energy needs covered or almost covered, it is necessary to move to other entities of different sizes that do not offer the same guarantees of payment as the previous ones, which leads to the financial institutions, being more reluctant to finance those entities through Project Finance.

Apart from the debt, another option is to sell energy to the market, where the source of payment is guaranteed. The problem that Mexico has faced to date, and which has prevented any project or very few projects from being financed under this scheme, is the lack of transparency on the part of the Mexican government when calculating the final price of energy called CTCP. This made it difficult or impossible to predict the incomes that would be received, leading market analysts of international prestige failed in their forecasts, not only in the long term, but even on a monthly basis.

Now, in the new electricity market, in which transparency is supposed to be guaranteed, the sector is faced with a lack of historical data, so its analysis has also become extremely complicated[35]. This, together with regulatory changes during the reform and the general uncertainty of the situation of the sector and the country, make banks unable to provide loans with good rates or high levels of leverage. Some banks consider imposing structures to mitigate risk (e.g., cash sweeps), or simply do not approve such credits.

2.4.7 Spot market functional change

Since the entry of the new government on December 1st, 2018, the market has begun to behave in a way that does not respond to the operating patterns of the last 20 years.

[35] We will see in the next point that the supposed transparency of the market price leaves much to be desired.

Although it is true that the market began to function with the entry into force of the LIE. [36] There was an "electricity market" that small independent producer[37] projects could turn to. This "electricity market" could be monitored by the previously called CTCP[38] in the LSPEE.[39] Throughout this section it will be tried to explain what has happened with this change in the spot market and the detrimental consequences it has had for the development of renewable projects.

2.4.7.1 Historical operation of the market

To analyze the Mexican electricity market, it is necessary to go back to the historical analysis of the CTCP under the LSPEE. The methodology for calculating the CTCP was approved by the CFE resolution No. RES156 / 2002 and was intended to calculate the Total Short-Term Cost that CFE would use for the payment of electric power for a Small Independent Producer permit holder to deliver at a point interconnection. The key definition for the calculation is the Marginal Plant[40]. The calculation of the CTCP of the Marginal Plant should include the:

a) Cost of the energy used, such as coal, fuel oil, natural gas or diesel including its transportation cost.

b) Cost of water, chemicals, lubricants, ash handling where applicable, as well as consumable materials.

The two previous concepts define the variable cost of generation of the Marginal Plant. To this concept must be added the variable cost arising from the transport[41] of electrical energy between the marginal plant and the interconnection point of the permittee in $/kWh. This increase or decrease would be the cost of losses valued at the variable cost of generation of the marginal plant. The described methodology can be expressed mathematically with the following formula[42]:

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[36] For more information about this new law see: DOF, Diario Oficial de la Federación. *Ley de la Industria Eléctrica*, Mexico DF, August 11, 2014.

[37] This was a modality in which the Mexican government allowed individuals to build projects of up to 30 MW of nominal capacity with the aim of selling it to the CFE, to the CTCP every hour at the interconnection node or to isolated communities as long as they became a cooperative for such consumption. For more information on Small Producer projects, consult the Electric Power Public Service Law. http://www.diputados.gob.mx/servicios/datorele/cmprtvs/iniciativas/Inic/427/2.htm

[38] CTCP refers to the total short-term costs of the electrical system and the expected unit costs and costs incurred from freight dispatch, from the public and private power plants that deliver energy to the system for the supply of demand throughout the country. For a detailed information, see http://www.cfe.gob.mx/paginas/Home.aspx.

[39] On February 17th 2017, the government change the calculation method of CTCP to make it equivalent to PML. For more information, please review DOF: 02/03/2017, Resolution Num: RES/143/2017

[40] The generating unit with the highest variable unit cost of generation and whose electrical energy can be substituted by the Permittee's generating plant.

[41] The variable cost of transmission consists of the increase or decrease in the unit transmission costs originated in bringing the electric power between the Marginal Plant and the Interconnection Point. These costs consist of the variation of Transmission Losses in the electrical system.

[42] For more information, consult the DOF of September 24, 2002. Resolution No. RES156 / 2002.

CTCP = HMR*(1+P/100)*CC*10^6+CV

where:

- HMR is the heat consumption to generate a net kWh in the marginal plant in BTU/net kWh;
- P are the transmission losses to transfer the energy generated in the marginal plant to the interconnection point expressed as a % (this percentage can be positive or negative depending on the level of demand in the electrical system);
- CC is the cost of fuel expressed in USD per MMBTU; and
- CV is the cost of water, chemicals, consumables, and fuel transportation in the marginal plant expressed in USD per net kWh.

As can be seen in the following graph, the CTCP behaved month by month in a similar way throughout the twelve months of the year for about 20 years. The price of energy in the market rose in the summer months due to the increase in energy consumption caused by the increase in temperatures and fell in winter due to the decrease in said consumption.

Figure 7. CTCP price Durango (2002-2021)

Source: Own elaboration with CENACE data

In fact, if you look at the graph from January 2016, it can be seen that during the first years of the entry into force of the LIE, the Market of the Day in Advance (MDA) behaved the same, with the same historical patterns with which the CTCP had been behaving.

The LIE modified the CTCP for the MDA, which became more transparent and predictable, since the calculation formulas were known, with well-defined parameters and therefore perfectly projected over time. The operation of the Mexican electricity market is regulated by the Energy Market Manual published in the Official Gazette of the Federation (DOF) on Friday, June 17, 2016. Within this manual it finds the operation of the Short-Term Energy Market, the MDA and the Real Time Market (MTR). Specifically, the price of these markets is set by submitting offers by generators, the characteristics of which are regulated in the manual, as well as their review and control[43].

This security in the calculation of the spot price, its supervision and control by CRE[44] and its relatively easy calculation made foreseeable a good implementation of renewable projects assuming market price risk.

Specifically, EOSOL, as a pioneer in this new adventure, managed to finance the first photovoltaic project in Mexico with exposure entirely to spot. This financing was obtained with the development bank Nacional Financiera[45] After this first great milestone, EOSOL obtained a second financing with 100% exposure to the spot market both with another development bank, Banco Nacional de Comercio Exterior[46], and with the Mexican subsidiary of a Spanish commercial bank Sabadell.

Other projects also obtained market financing with development banks and commercial banks. The development of renewable projects with market exposure looked promising.

[43] In accordance with the fourth paragraph of the Third Transitory Law of the Electricity Industry, the Ministry of Energy must oversee the Wholesale Electricity Market with the technical support of the Energy Regulatory Commission. For this purpose, the Ministry of Energy established the General Directorate for Analysis and Surveillance of the Electricity Market in accordance with the provisions of bases 2.1.7 and 2.1.142 of the Electricity Market Bases published in the DOF on September 8 from 2015.

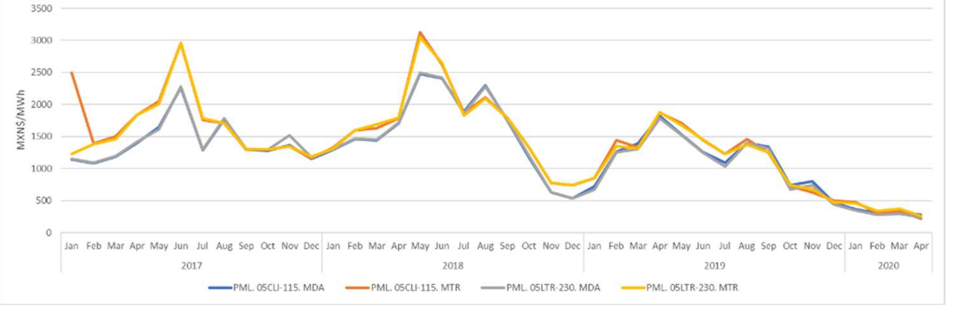
[44] This control was real and highly effective. We can find an example in an Official letter 361.168 / 15 The Market Surveillance Unit sent a letter on August 4, 2016 to the Ministry of Energy, indicating that it had detected manipulation in the prices of energy offers in the Short-Term Market and instructed it to modify the Local Marginal Prices retroactively in said market to correct said errors.

[45] Nacional Financiera was established in Mexico in 1934 as a national development bank. Its main objective is the local market for micro, small and medium-sized companies that operate in Mexico to promote regional development and thus create jobs. It also serves the Mexican government to finance strategic projects, and as a guarantor of the government itself in international markets. For further information visit: https://www.nafin.com/portalnf/content/home/home.html.

[46] The Banco Nacional de Comercio Exterior was founded in 1937 as a national development bank. Its main objective is to finance Mexican companies in their export and foreign companies in their establishment in the country to contribute to the development and generation of employment in Mexico. For further information, please visit: https://www.bancomext.com/

However, without any technical explanation, after April 2019 the spot market no longer worked as usual. During the last 20 years, as we have seen in figure 7, the PML (previous CTCP), followed a stable pattern with high prices in summer. On the other hand, as we see in figure 8, it stops following this pattern, without anyone in the sector, not even international advisers being able to justify it.

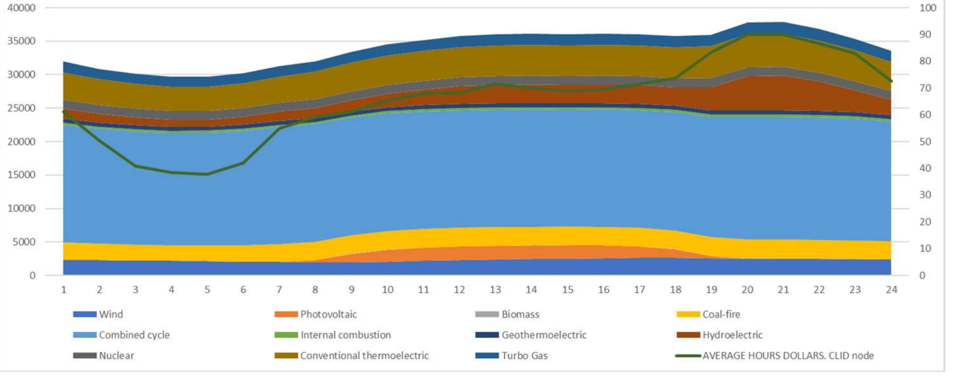
Figure 8. Historical PML prices in Node CLI (115KV) – MDA&MTR (solar time). 2017-2020 (MXN$/MWh)



Source: Own elaboration with CENACE data

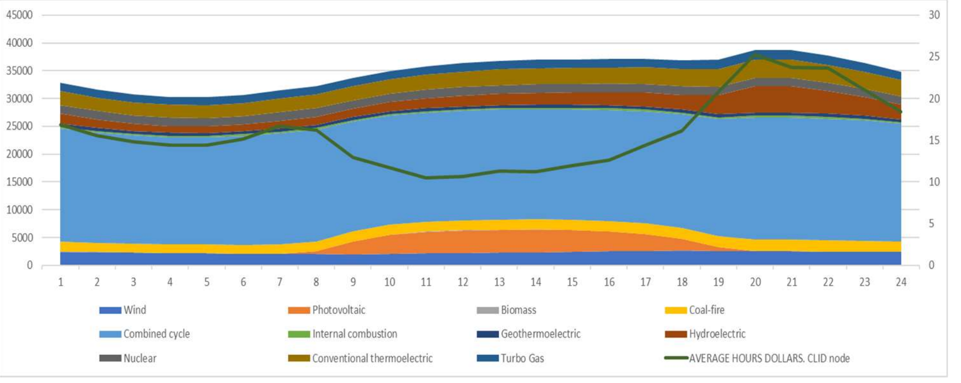
Also, another change that was predicted for the future was the change in the spot price between daytime and nighttime. This change was supposed to happen once the penetration of solar energy in the country was greater. But the price changes between daytime and nighttime came into force too quickly, with the result that the energy marginal cost during the day was cheaper than the same cost during the night. This effect can be seen in the following figures:

Figure 9. Average Hourly Generation (MWh) by Type of Technology. March 2019



Source: Own elaboration with CENACE data

Figure 10. Average Hourly Generation (MWh) by Type of Technology. March 2020



Source: Own elaboration with CENACE data

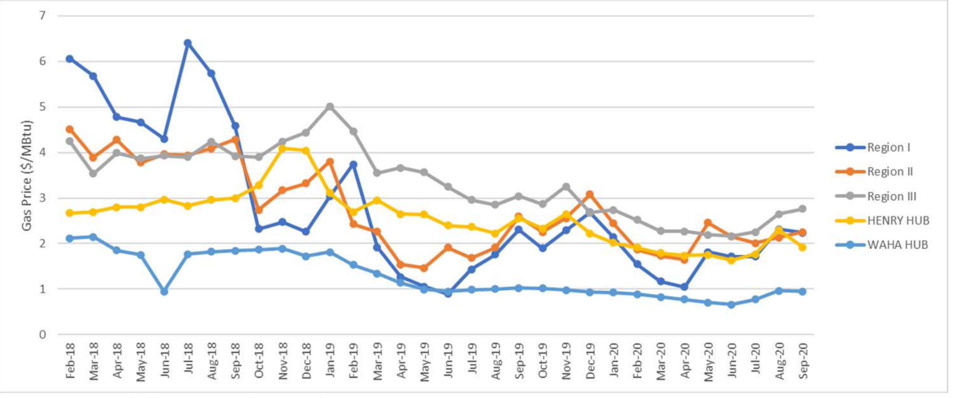
The logical answer to these two situations should be low prices in gas and the introduction of new gas pipes allowing better access to cheaper gas, at the same time as a high penetration of solar energy in the country. In particular:

/a/ The current solar installations and the current gas pipeline infrastructure were all previewed in official documentation so all of them were taken in consideration at the time of making the spot price predictions. Also, most of the new infrastructure was delivered long after the estimated delivery dates. Thus, such a big difference between the situation estimated by experts and the real situation cannot be due to new installations that today are under operation. All new thermic production installations came into operation at the estimated time or later. The same occurs with solar and wind installations. Solar and wind installations still represent a very low percentage in the generation mix in the country. The new gas pipeline infrastructure came into operation very late because of a controversial situation with the government.

/b/ As can be seen in next picture, gas prices in the US were low and the import data levels were in a record situation[47]. Prices decreased by 25% at the end of 2019, but this isolated issue cannot completely explain the change in the spot market and especially the peaks. Moreover, it can see that gas prices recovered their level but this did not result in the spot price recovering its level.

[47] A warm winter was the cause the low demand together with low exports to China due to coronavirus while the gas supply was higher than usual. Low demand at the same time as a high supply usually results in a low price, and this is what it happened with gas prices last year especially last winter.

Figure 11. Mexican Gas Price ($/MBTU)



Source: Own elaboration with CRE data

/c/ Transmission deficiencies are causing high congestion problems as seen in Northeast and Northwest in Mexico.

/d/ CENACE actions could be the main reason of the current situation in spot market prices. This started in May 2019.

/e/ In general, the spot market continues to be a solid payment system, but this new administration market management cannot be considered as favorable to the private sector. The CFE objective is to reduce the spot market now and in the new future as the CFE is the main energy buyer in the market and thus is the principal beneficiary of those extraordinary low prices. It may be however, that the way the spot market prices are calculated is under doubt and there is an important and urgent necessity to limit the exposure to the market.

2.4.7.2 What could be the real reasons for those changes in the market?

Nobody in the sector has been able to answer this question with certainty. The electrical system is still confusing, and this situation was getting worse during 2020:

- CRE, CENACE and CFE could be considered to have aligned interests in this new situation.

- CFE *Suministros Básicos* is the biggest consumer in the spot market, so CFE is motivated to keep spot prices as low as possible to maximize their profits.

- Coal energy generation installation seems to be running at “0” marginal costs and they do not count in the calculation of the spot price.

- The HFO installations seem to be added to the market at an exceptionally low marginal cost. This situation could arise because they are considered as a “must run” installation or because PEMEX is selling the fuel at an incredibly low price. These two possible explanations bring about the same situation, they are not translating the real price to the market.

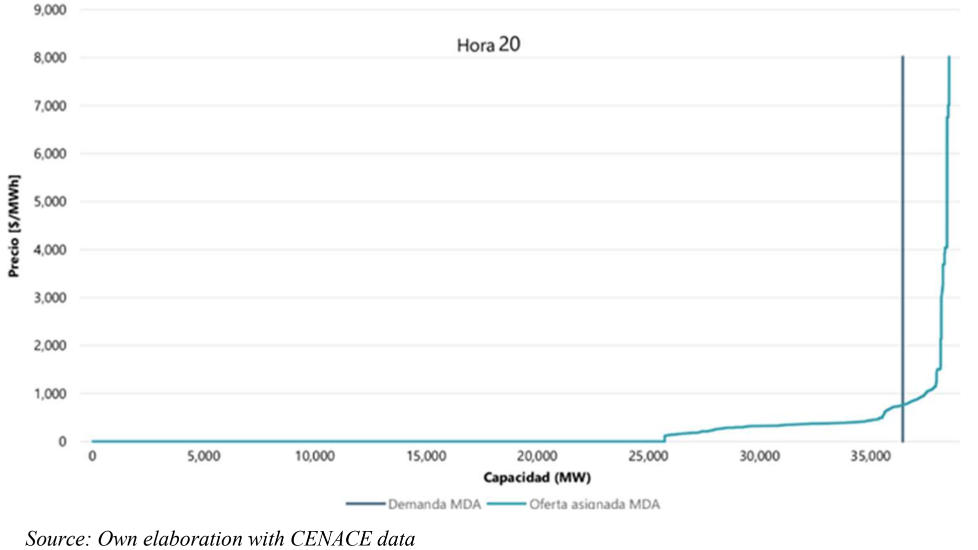
- 4,000 MW installed are in the category of not programing, including the private cogeneration. It seems this could be one of the reasons behind low market prices because the market allows them to operate without considering the merit order.

- In general, it could be said that CENACE is controlling the high spot market price exports and imports to avoid new entries in the area where the price was rising dramatically.

The real situation is that the merit order installation is not available on a daily basis. Nobody from CENACE/CFE can know exactly the criteria they are following to operate the system.

In Figure 12 and Table 4, from January 20^{th}, 2020, it can be seen that coal and HFO installations were under operation at peak time and at the same time the marginal cost was 30 USD/MWh far from the coal leverage cost in the merit order.

Figure 12. MDA Peak Hour Analysis ($/MWh, MW, MWh & %). Assigned supply and demand curve



Source: Own elaboration with CENACE data

Table 4. Durango projects Performance Ratio, November 2019

Type of Technology	Peak Hour	Percentage
Coal-fire	20	25,00%
Combined cycle	20	60,00%
Internal combustion	20	0,00%
Importation	20	5,00%
Conventional thermoelectric	20	10,00%
Turbo gas	20	0,00%

Source: Own elaboration with CENACE data

- CENACE could also be influencing MDA / MTR prices - possibly executing MDA without system constraints, which lowers that price and is reflected in a more expensive reality in MTR.

- The dispatch information is only known by CFE and CENACE. When the ex-post analysis is done, it is seen that the price of a day in the past is not correlated with the plants that were dispatching.

- The merit order curve is no longer published as was previously the practice.

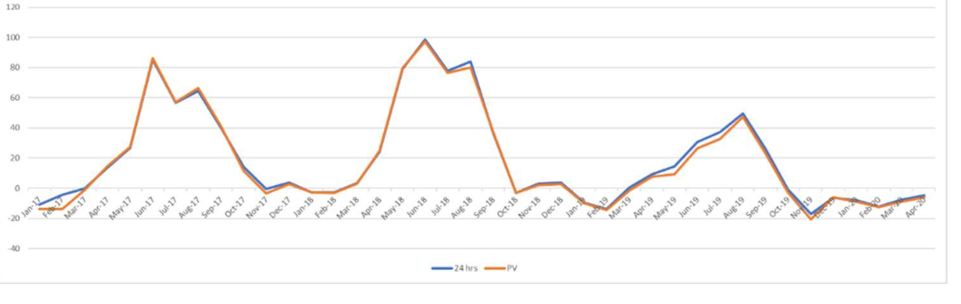
- Previously, the cost of the fuel used by CFE to produce energy was published and now it is no longer.

In addition to these low energy prices in the spot market, there are further problems which have a considerable effect on the prices received by the solar plants which operate in the daily energy market.

2.4.7.3 Transmission and congestion losses

Transmission losses in the north of the country continue to break records as a percentage of the price of the system. This shows that CENACE is managing the system in an extremely poor way; these losses in February 2020 reached $ 15.82 per MWh.

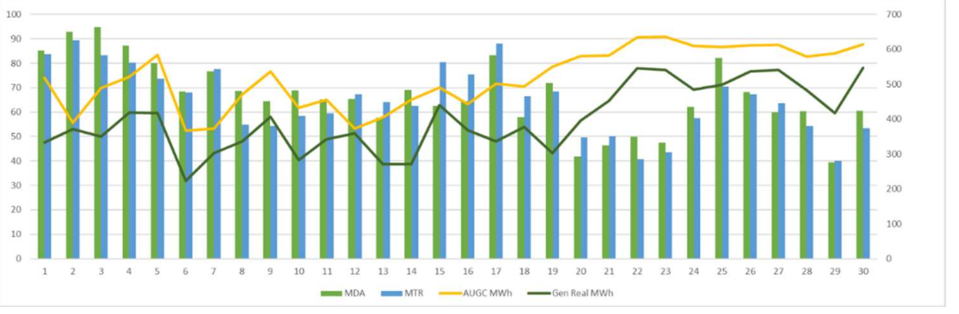
Figure 13. MDA Losses 2017-2020 ($MXN/MWh)



Source: Own elaboration with CENACE data

As we can see in figure 13, the congestion loss is even worse in the afternoon hours on average than during the day. Negative congestion during the day remains poor.

Figure 14. Offer for Sale vs. Real Generation (MWh) MDA vs. MTR Sep 2020 ($MXN/MWh)



Source: Own elaboration with CENACE data

More than likely, the main reason for this significant increase in congestion losses is that the north of the country has changed very quickly from being an energy deficit area to one with surpluses that cannot be transmitted to other areas of the country. These surpluses cannot be transmitted due to the length of the transmission lines and the instability in the system due to the increase in the phase angle as explained in point 2.4.5. The problem is that, in reality, more projects have not been developed than were planned, and the banks asked all the advisers to carry out congestion studies for the projects, instead the reality has not behaved as the technical advisers had predicted.

All this inexplicable or unpredictable operation of the market has caused banks to abandon the idea of financing projects with spot market risk. In fact, all the projects that had been exposed to this have decided to abandon and look for PPAs.

This problem would improve with a much better meshing of the country, as happens in Europe. In fact, if the country were perfectly meshed, the marginal cost would be the same throughout the country and the congestion losses would not exist. However, as indicated in 2.4.5, that is not easy to achieve in Mexico.

2.4.8 Operational barriers

Another recent series of barriers that had not existed until the entry into power of the new government on December 1st, 2018, are the barriers to market operation. Until July 10th, 2019, the market had been operating with rules similar to those used by the Small Independent Producers' projects. These basic operating rules were that the energy producers communicated the day before to CENACE an estimation of how much energy they were going to produce the following day, but then, given that renewable power plants depend on the wind or the sun, at the end of the day, they reported the actual energy they had produced hour by hour to the system without too much consequence. This, however, as we have seen, has also changed.

2.4.8.1 Renewable energy injection restrictions (CENACE Orders)

As of July 10th, 2019, the CENACE operating department maintains the instruction to strictly monitor the "Supplementary Assignment of Power Plant Units for Reliability" (AUGC-S)[48], which is why in the grouped plants in which EOSOL participates the control of the plant by active power is limited to the values shown in the AUGC files.

These CENACE operations are causing losses in the dispatch of around 8% of its production and penalties in the MDA and the MTR in the solar plants. In particular:

/a/ Plants connected to a high voltage are limited to generation by forecast. If the generation is underestimated, they are not allowed to generate more, and that production is lost;

/b/ In 2019, the losses in the three plants in which EOSOL participates and had to follow AUGCs instructions, were affected by this issue by approximately 5.5% of production (close to P75[49] instead of > P50);

---

[48] Process of allocation and dispatch of power plants in the second stage of the MEM. This process is additional to the MDA process, according to the AUGC model, CENACE determines each day based on the sales offers received, on the demand forecasts and on other relevant factors, the anticipation or postponement of the startup or shutdown of the plants with respect to the original MDA sale offer, as well as the modification of the generation program for certain time intervals. In practice, we observe that the amount of energy that we initially send from O&M in our generation forecasts is limited. The objective of the AUGC is to complement the MDA allocation model and process it by issuing additional start and stop instructions, when this occurs it results in production losses due to limitations or total stoppage during some hours of the day (sporadic cases that have been happening since July 10, 2019). This AUGC allocation process is performed every day at least once after the completion of the MDA allocation process (on the day before the day of operation). According to the MEM manuals, this is in order to respond to unexpected changes in plant availability, demand forecasts, transmission restrictions in the electricity grid, physical limitations of the plants and other variables that have not been taken into account during the execution of the allocation process in MDA; it also considers new sales offers generated after the issuance of MDA offers and network reliability status. As long as the day prior to the operation day has not concluded, they can execute the AUGC model or process several times as needed until 8:00 pm. At the end of the day prior to the Operation Day, CENACE publishes the new generation instructions for each hour of the Operation Day by sending an Excel AUGC and the RID (Registry of Dispatch Instructions), which are followed by the operators in the plant through real-time access to the RID platform (PCs that CENACE requires to be installed in the control centers) and they execute according to the instructions in the PPC to limit the active power of the plant according to the final run of the AUGC model for that Trading Day. The AUGCs are mentioned and explained in the following documents: Bases of the Wholesale Electricity Market published in the DOF on September 8, 2015; Network Code (Forecasts) published in the DOF on April 8, 2016; Short-Term Energy Market Manual, published in the DOF on June 17, 2016; Forecast Manual, published in the DOF on November 23, 2017.

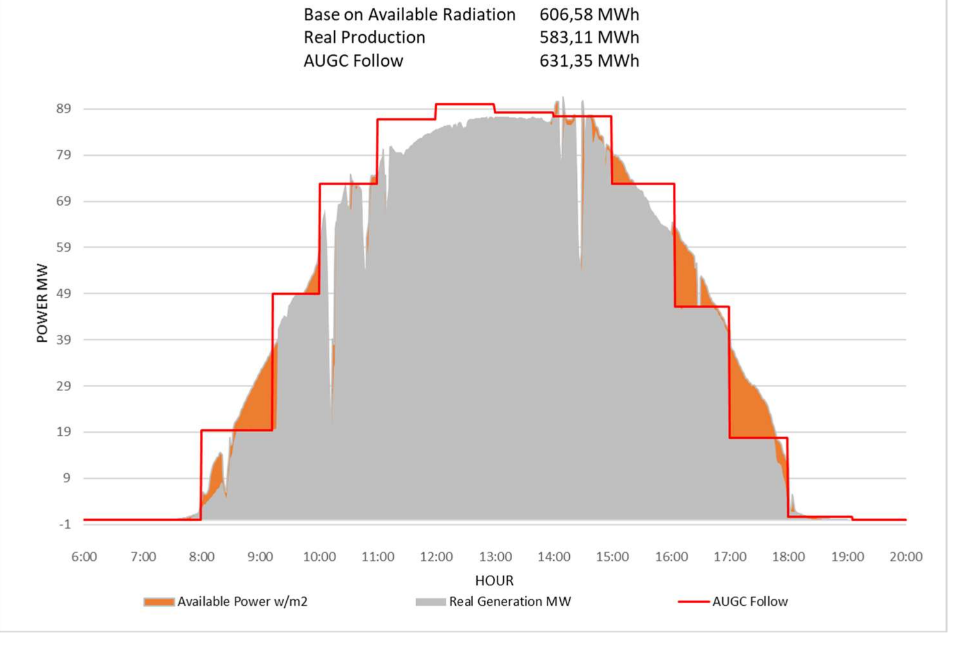
[49] PXX is nothing more than the probability that production will be equal to or above that estimated value throughout the year. For this reason, a probability of 75% (P75) is lower than a probability of 50% (P50)

/c/ The solution is to overestimate; however, if the sun does not radiate and the plants under-generate, then the plants are presumed to have sold at the MDA and purchased at the MTR;

/d/ There is an increased risk of loss if the MDA < MTR. There is no definitive relationship between the MDA and the MTR (as there should be).

As can be seen in Figure 15, according to the instruction to follow the AUGC, the production of the PV generators will always be below what is offered[50], as it is known that this type of generators depend mainly on the irradiation available at all times, the offer that is sent is the integrated production of one hour (MWh). However, in reality the power of the plant increases or decreases drastically depending on the available radiation, especially on days with adverse weather conditions (very cloudy days, rain, cold fronts, etc.), when it is not possible to keep the power to a PV generator fixed for a period of time of one hour without limiting the power.

Figure 15. Available generation vs AUGC



Source: Own elaboration with EOSOL data

because, in uncertainty analyses, the lower the production estimate, the greater the percentage of probability that reality is equal to or greater to the estimated value. For more information about percentage probability and how it is calculated, please review footnote 45 .

[50] The generator has two options. The first is to offer more than it thinks it will produce, but this would always imply having to pay CENACE for energy at the price of the MTR that it has not produced. Or bid less than what you think you will produce. In this scenario, it is obliged to limit the production of the plant and lose all the energy that it produces and cannot inject into the market.

Following AUGC instructions, PV plants will not be allowed to increase power when the weather changes favorably and a low offer has been sent (offers based on weather forecasts available at the time of preparation), despite the enormous advances made by meteorology. In recent decades, experts and companies specialized in this sector have not yet reached the level of precision necessary to fully comply with the requirements of CENACE.

The performance ratio (PR)[51] is an important indicator to verify the performance of the plant, which will be constantly reduced by the manual power limitation required to comply with the monitoring of the AUGC. Based on experience, it is known that the PR value for a group of plants managed by Eosol in Durango should fluctuate between 82% and 89% (depending on the time of year) for the time intervals in which there are no production problems at the plant (unemployed investors, failure in transformers, etc.).

Table 5 shows the PR for November 2019 (days with data available at the time of writing this report). The PR shows that most days some impairment in performance was suffered. It is worth mentioning that there is always an effort to send offers slightly above the expected production to mitigate this impact as much as possible, however as has been mentioned previously for a photovoltaic generator it is impossible to meet the reliability assignments (AUGC) because it is required to maintain the fixed power for every hour, which ends up limiting the production of the plants.

[51] The PR of a photovoltaic installation is defined as the ratio between the production produced by said installation and that which could have been produced under nominal conditions:
$PR = \frac{Real\ Production\ of\ the\ Installation\ in\ MWh}{Nominal\ Production\ of\ the\ Installation\ in\ MWh}$. The real production is the one measured in the meter of the installation, and the nominal production is irradiation for the year on the surface of the generator of the photovoltaic installation x yield of the modules of the photovoltaic installation.

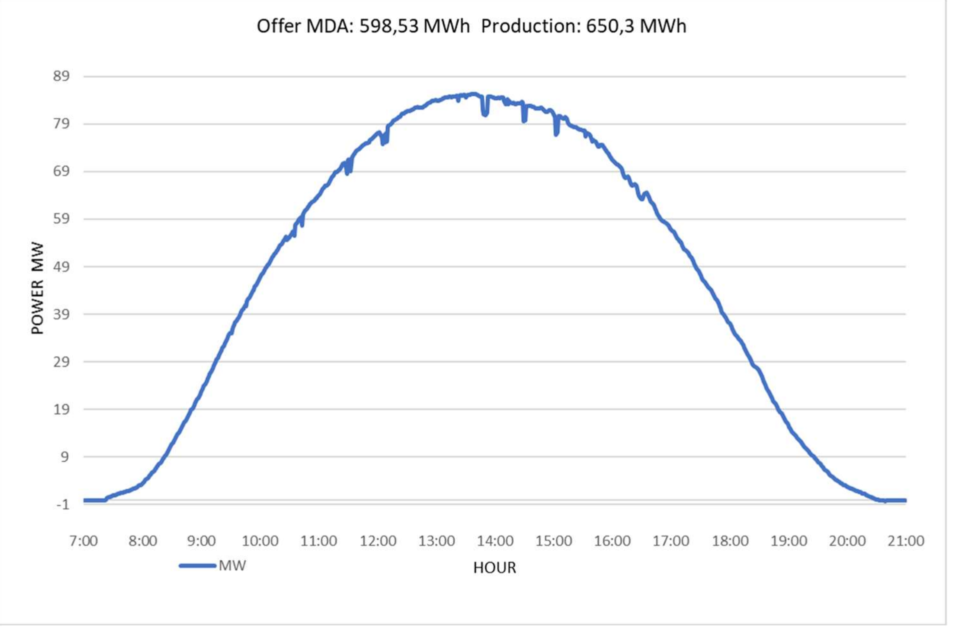
Table 5. Durango projects Performance Ratio, November 2019

Date	Durango Project 3			Durango Project 1			Durango Project 2		
	MWh	(kWh/m2)	PR	MWh	(kWh/m2)	PR	MWh	(kWh/m2)	PR
2019-11-01	166,19	6,07	**75,93%**	166,79	6,15	**75,25%**	165,66	6,07	**75,72%**
2019-11-02	163,47	5,67	**80,03%**	164,10	5,71	**79,75%**	160,61	5,64	**78,97%**
2019-11-03	155,78	5,67	**76,26%**	157,12	5,81	**75,02%**	152,97	5,67	**74,85%**
2019-11-04	171,55	6,64	**71,66%**	174,58	6,67	**72,62%**	173,33	6,74	**71,40%**
2019-11-05	136,43	5,95	**63,66%**	138,56	5,94	**64,76%**	136,75	5,97	**63,58%**
2019-11-06	162,96	5,76	**78,51%**	163,18	5,87	**77,11%**	162,73	5,78	**78,06%**
2019-11-07	161,25	5,97	**74,96%**	165,57	6,09	**75,48%**	164,74	5,98	**76,42%**
2019-11-08	102,58	3,26	**87,42%**	100,60	3,14	**88,87%**	99,35	3,27	**84,21%**
2019-11-09	177,15	6,28	**78,23%**	178,46	6,23	**79,50%**	176,58	6,36	**77,09%**
2019-11-10	170,88	6,35	**74,66%**	171,51	6,34	**75,02%**	171,60	6,42	**74,20%**
2019-11-11	124,49	4,27	**80,90%**	124,53	4,35	**79,52%**	123,75	4,28	**80,15%**
2019-11-12	48,78	1,58	**85,50%**	48,96	1,61	**84,59%**	48,29	1,58	**84,90%**
2019-11-13	37,23	1,56	**66,20%**	37,79	1,49	**70,41%**	36,33	1,55	**65,09%**
2019-11-14	180,26	7,02	**71,30%**	193,36	7,01	**76,56%**	187,95	7,04	**74,05%**
2019-11-15	180,51	6,63	**75,57%**	174,32	6,39	**75,73%**	172,57	6,33	**75,60%**
2019-11-16	148,54	5,55	**74,23%**	152,48	5,62	**75,31%**	154,47	5,66	**75,73%**
2019-11-17	45,26	1,63	**77,27%**	46,16	1,64	**78,11%**	44,94	1,62	**76,83%**
2019-11-18	111,88	4,36	**71,16%**	109,37	4,19	**72,49%**	109,37	4,19	**72,49%**
2019-11-19	172,04	6,43	**74,26%**	174,08	6,46	**74,83%**	172,75	6,48	**73,92%**
2019-11-20	128,69	4,57	**78,21%**	132,75	4,75	**77,56%**	133,15	4,62	**80,03%**
2019-11-21	139,78	4,96	**78,13%**	142,50	5,13	**77,01%**	138,88	5,03	**76,68%**
2019-11-22	180,83	6,85	**73,28%**	182,74	6,81	**74,52%**	181,04	6,87	**73,13%**
2019-11-23	184,96	6,99	**73,44%**	186,90	6,94	**74,71%**	182,32	7,05	**71,72%**
2019-11-24	180,76	6,92	**72,48%**	184,25	6,89	**74,24%**	181,34	7,00	**71,90%**
2019-11-25	147,45	5,07	**80,67%**	148,18	5,07	**81,10%**	147,01	5,10	**79,93%**
2019-11-26	109,30	3,90	**77,68%**	109,32	3,85	**78,85%**	107,98	3,97	**75,51%**
2019-11-27	88,01	4,17	**58,51%**	89,16	4,14	**59,74%**	86,97	4,20	**57,42%**
2019-11-28	20,04	0,69	**80,59%**	19,90	0,70	**79,43%**	19,66	0,69	**78,58%**

Source: Own elaboration with EOSOL data

Figure 16 shows a generation graph for a group of plants managed by Eosol in Durango for a mostly sunny day (May 16th, 2019) where the restriction imposed by CENACE did not yet exist.

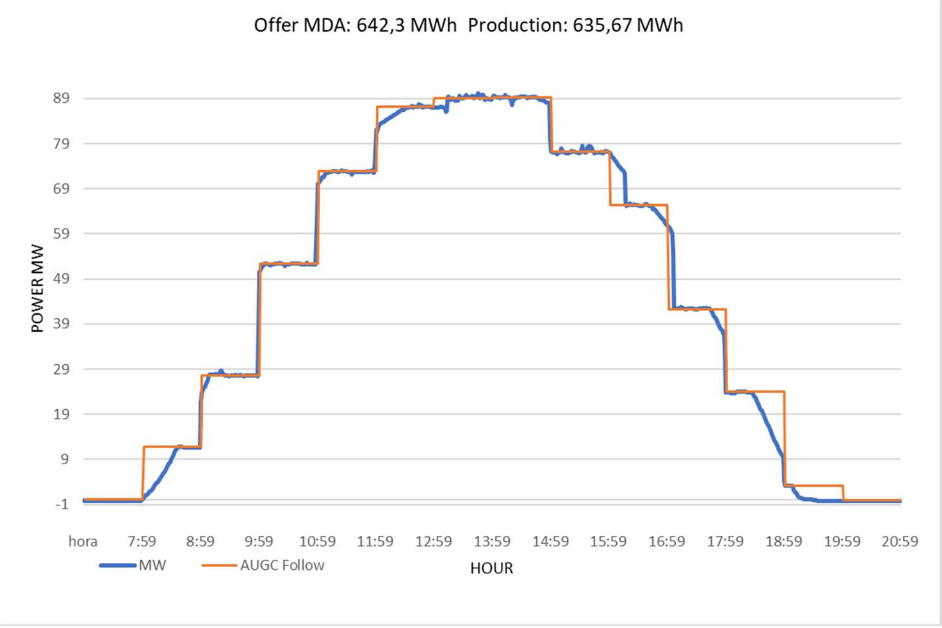
Figure 16. Durango Project Generation, May 16th, 2019



Source: Own elaboration with EOSOL data

Figure 17 shows the generation for the plants on a mostly sunny day (October 9th, 2019), in this case already following the instructions of the AUGC, as can be seen, although the offer sent is higher than the generation, it is clearly seen that power ends up being limited for each of the hours, in addition to the gaps formed between the AUGC monitoring and the power that the plants can deliver, as a consequence there will always be payments to CENACE for the production not generated.

Figure 17. Durango Project Generation, October 9th,2019



Source: Own elaboration with EOSOL data

In order to reduce the effects in all directions (PR, MDA and MTR), the operator always try to send offers slightly higher than the expected production, however, as is already known, supply depends mainly on the weather conditions and the accuracy of the weather forecasts, which until now are at least one day in advance[52] and also cover a very large region (not the few hectares which are of interest to us). For these reasons there is usually a discrepancy between the values published in the available weather forecasts and the reality in the area covered by the PV plants, especially on cloudy days.

Based on the experience obtained over time, it is known that when sunny or clear days are forecast, the accuracy of the weather forecast is usually much greater, however, the in opposite case, when cloudy days are forecast, uncertainty is much higher and the weather could be cloudy or clear at any specific time of day.

Taking into account the above, there will be a greater degree of precision when launching offers for days that are forecast to be completely clear, however, for very cloudy days the situation becomes complicated, because if low supply offers are launched and the sky clears in the middle of the day, production will be cut considerably, on the contrary, if the offer is very high and the day in question is completely cloudy, there will

[52] One way to reduce these losses is to be able to modify the production forecast hourly, since the plant operators can see how the weather is evolving and with the experience they have and the real hourly forecast, errors would be greatly reduced. This has been formally requested by EOSOL to CENACE, but a response has never been received.

be a considerable difference between what is offered and what is generated, leading in both cases to economic losses.

Based on the above, the best strategy is to send high offers (considering full production capacity of the plants) on days when it is completely sunny, conservative offers (slightly less than half the generation capacity of the plants) for cloudy days, in the latter case if the sky clears during the course of the day it will leave room for the power plants to increase power.

For a better understanding of the above, the different scenarios are described below with some of the days of the month of November 2019 as examples. For November 17th, 2019, the weather forecast was as shown in Table 6.

Table 6. Durango weather forecast, November 17th,2019

Date	Hour	% Cloudiness
Nov 17th, 2019	6:00	91%
Nov 17th, 2019	7:00	95%
Nov 17th, 2019	8:00	97%
Nov 17th, 2019	9:00	97%
Nov 17th, 2019	10:00	93%
Nov 17th, 2019	11:00	95%
Nov 17th, 2019	12:00	98%
Nov 17th, 2019	13:00	100%
Nov 17th, 2019	14:00	98%
Nov 17th, 2019	15:00	98%
Nov 17th, 2019	16:00	100%
Nov 17th, 2019	17:00	98%
Nov 17th, 2019	18:00	100%
Nov 17th, 2019	19:00	100%
Nov 17th, 2019	20:00	100%

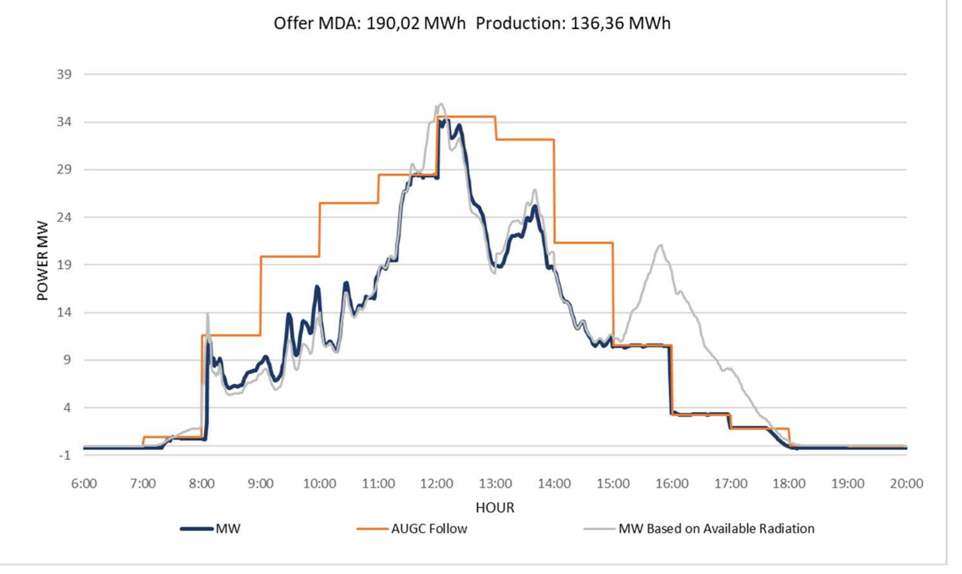
Source: Own elaboration with EOSOL data

As can be seen, the forecast was for an overcast sky throughout the day, based on what was previously commented, the offer sent was for 190.02 MWh (63.36 per plant)and the results were as follows:

- MDA offer 190.02 MWh
- Production 136.36 MWh
- Average global radiation: 4..17 kWh/m^2
- Average PR: 77.40%

Production charts, AUGC tracking and available MW based on radiation are shown in Figure 18.

Figure 18. Durango Project Generation, October 17th,2019



Source: Own elaboration with EOSOL data

Based on the estimated PR for the plants in unrestricted conditions and based on the radiation registered by the meteorological station, the generation would have been expected to reach 153.71 MWh, 17.35 more than the actual figure, however as can be seen in Figure 18, and Table 7, a considerable production limitation was encountered at hours 16, 17 and 18 due to the AUGC follow-up instruction and an increase in available radiation from hour 15 (sky cleared).

Table 7. Durango Real Production vs Expected Production, November 17th,2019

Day	Hour	Global Radiation (KWh/m2)	Expected Production base on Radiation	Real Production	Difference
Nov 17th, 2019	6:00	0,00	0,00	0,00	0,00
Nov 17th, 2019	7:00	0,00	0,00	0,00	0,00
Nov 17th, 2019	8:00	0,03	0,89	0,54	0,35
Nov 17th, 2019	9:00	0,09	7,09	7,21	-0,12
Nov 17th, 2019	10:00	0,11	10,64	10,80	-0,16
Nov 17th, 2019	11:00	0,14	14,16	13,90	0,26
Nov 17th, 2019	12:00	0,27	24,99	24,78	0,21
Nov 17th, 2019	13:00	0,29	30,93	28,61	2,32
Nov 17th, 2019	14:00	0,22	20,99	21,68	-0,69
Nov 17th, 2019	15:00	0,14	12,74	13,16	-0,42
Nov 17th, 2019	16:00	0,17	16,10	10,60	5,50
Nov 17th, 2019	17:00	0,13	12,44	3,44	9,00
Nov 17th, 2019	18:00	0,04	2,73	1,62	1,11
Nov 17th, 2019	19:00	0,00	0,00	0,00	0,00
Nov 17th, 2019	20:00	0,00	0,00	0,00	0,00
Total		**1,63**	**153,70**	**136,34**	**17,36**

Source: Own elaboration with EOSOL data

As of November 27th, 2019, the weather forecast was as shown in Table 8.

Table 8. Durango weather forecast, November 27th,2019

Date	Hour	% Cloudiness
Nov 27th, 2019	6:00	85%
Nov 27th, 2019	7:00	84%
Nov 27th, 2019	8:00	76%
Nov 27th, 2019	9:00	83%
Nov 27th, 2019	10:00	83%
Nov 27th, 2019	11:00	81%
Nov 27th, 2019	12:00	81%
Nov 27th, 2019	13:00	80%
Nov 27th, 2019	14:00	78%
Nov 27th, 2019	15:00	78%
Nov 27th, 2019	16:00	77%
Nov 27th, 2019	17:00	66%
Nov 27th, 2019	18:00	75%
Nov 27th, 2019	19:00	76%
Nov 27th, 2019	20:00	77%

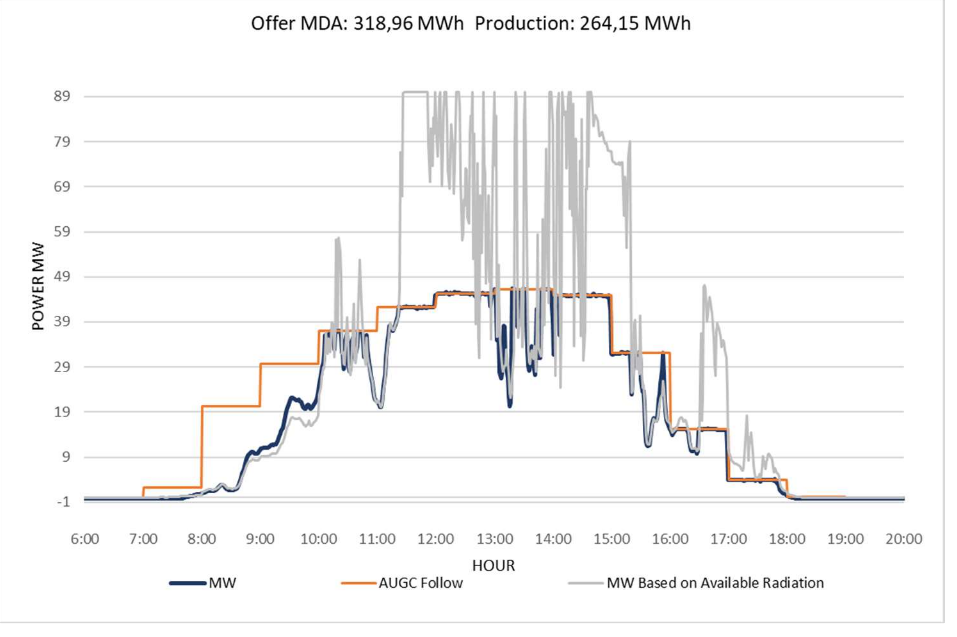
Source: Own elaboration with EOSOL data

As can be seen, the weather forecast was more favorable than on November 17th, 2019, the offer sent was 318.96 MWh (106.32 per plant), the results were as follows:

- MDA offer 318.96 MWh
- Production 264.15 MWh
- Average global radiation: 1.63 kWh/m^2
- Average PR: 58.55%

Production charts, AUGC tracking and available MW based on radiation are shown in Figure 19.

Figure 19. Durango Project Generation, November 27th,2019



Source: Own elaboration with EOSOL data

Based on the estimated PR for the plants in unrestricted conditions and based on the radiation recorded by the meteorological station, the generation would have been expected to reach 387.69 MWh, 123.56 more than the actual amount generated, however as can be seen in Figure 19, and Table 9 there was a considerable limitation in the production between 11 to 18 hours due to the AUGC monitoring instruction and an increase in the radiation available at specific times at certain times of the day (cloudy day with intermittent moments of sun).

Table 9. Durango Real Production vs Expected Production, November 27th,2019

Day	Hour	Global Radiation (KWh/m2)	Expected Production base on Radiation	Real Production	Difference
Nov 27th, 2019	6:00	0,00	0,00	0,00	0,00
Nov 27th, 2019	7:00	0,00	0,00	0,00	0,00
Nov 27th, 2019	8:00	0,01	0,00	0,16	-0,16
Nov 27th, 2019	9:00	0,05	3,88	4,23	-0,35
Nov 27th, 2019	10:00	0,18	16,71	17,32	-0,61
Nov 27th, 2019	11:00	0,36	35,52	32,47	3,05
Nov 27th, 2019	12:00	0,72	67,38	38,26	29,12
Nov 27th, 2019	13:00	0,77	81,21	45,36	35,85
Nov 27th, 2019	14:00	0,46	43,83	38,10	5,73
Nov 27th, 2019	15:00	0,75	70,45	44,49	25,96
Nov 27th, 2019	16:00	0,41	38,27	25,62	12,65
Nov 27th, 2019	17:00	0,26	25,19	14,43	10,76
Nov 27th, 2019	18:00	0,07	5,25	3,65	1,60
Nov 27th, 2019	19:00	0,00	0,00	0,04	-0,04
Nov 27th, 2019	20:00	0,00	0,00	0,00	0,00
Total		**4,04**	**387,69**	**264,13**	**123,56**

Source: Own elaboration with EOSOL data

As of November 28th, 2019, the weather forecast was as shown Table 10.

Table 10. Durango weather forecast, November 28th,2019

Date	Hour	% Cloudiness
Nov 28th, 2019	6:00	61%
Nov 28th, 2019	7:00	65%
Nov 28th, 2019	8:00	66%
Nov 28th, 2019	9:00	69%
Nov 28th, 2019	10:00	70%
Nov 28th, 2019	11:00	71%
Nov 28th, 2019	12:00	70%
Nov 28th, 2019	13:00	70%
Nov 28th, 2019	14:00	69%
Nov 28th, 2019	15:00	76%
Nov 28th, 2019	16:00	77%
Nov 28th, 2019	17:00	84%
Nov 28th, 2019	18:00	83%
Nov 28th, 2019	19:00	77%
Nov 28th, 2019	20:00	76%

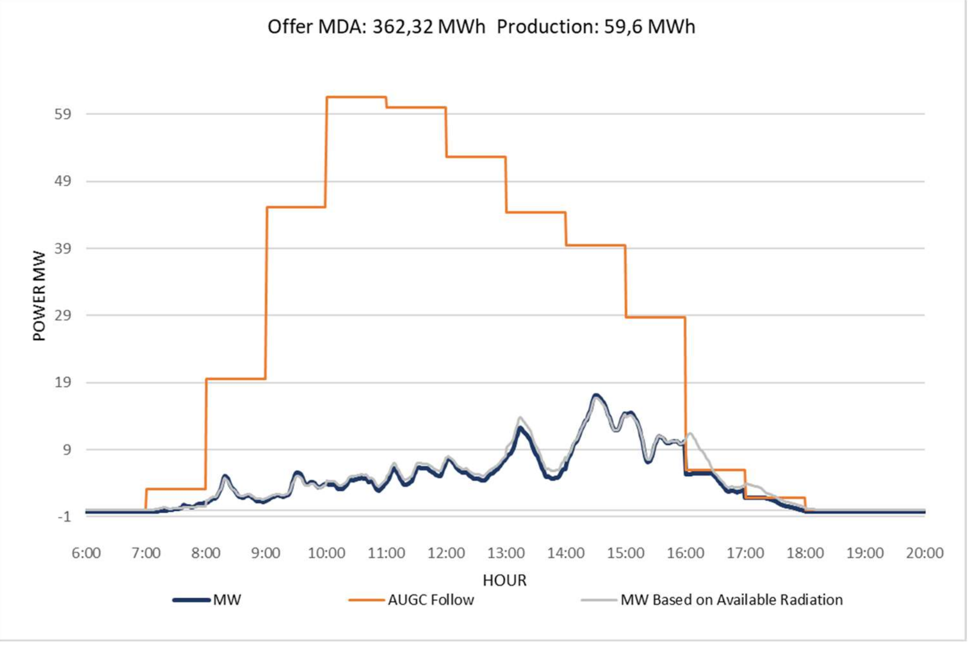
Source: Own elaboration with EOSOL data

As you can see, the weather forecast for November 28th was even more favorable than on November 27th, the offer sent was 362.32 MWh (120,77 per plant), the results were as follows:

- MDA offer 362.32 MWh
- Production 59.6 MWh
- Average global radiation: 0.69 kWh/m^2
- Average PR: 79.53 %

The production, AUGC and MW charts available based on radiation are shown in Figure 20.

Figure 20. Durango Project Generation, November 28th,2019



Source: Own elaboration with EOSOL data

Based on the estimated PR for the plants in unrestricted conditions and based on the radiation recorded by the meteorological station, the generation would have been expected to reach 64.13 MWh, 4.55 more than the actual, however, as can be seen in figure 20, and Table 10 there was a slight limitation for hours 17 and 18 due to an AUGC follow-up instruction.

Table 11. Durango Real Production vs Expected Production, November 28th,2019

Day	Hour	Global Radiation (KWh/m2)	Expected Production base on Radiation	Real Production	Difference
Nov 28th, 2019	6:00	0,00	0,00	0,00	0,00
Nov 28th, 2019	7:00	0,00	0,00	0,00	0,00
Nov 28th, 2019	8:00	0,01	0,00	0,40	-0,40
Nov 28th, 2019	9:00	0,03	2,46	2,46	0,00
Nov 28th, 2019	10:00	0,04	3,90	3,42	0,48
Nov 28th, 2019	11:00	0,05	4,71	4,06	0,65
Nov 28th, 2019	12:00	0,06	5,84	5,44	0,40
Nov 28th, 2019	13:00	0,07	7,13	5,92	1,21
Nov 28th, 2019	14:00	0,09	8,45	8,10	0,35
Nov 28th, 2019	15:00	0,14	12,74	13,06	-0,32
Nov 28th, 2019	16:00	0,11	10,78	10,92	-0,14
Nov 28th, 2019	17:00	0,07	6,58	4,54	2,04
Nov 28th, 2019	18:00	0,02	1,54	1,26	0,28
Nov 28th, 2019	19:00	0,00	0,00	0,00	0,00
Nov 28th, 2019	20:00	0,00	0,00	0,00	0,00
Total		**0,69**	**64,13**	**59,58**	**4,55**

Source: Own elaboration with EOSOL data

Differences between MDA and MTR payments

When the sale offer is greater than the actual generation, CENACE pays the total offer at the MDA price, but the difference of what was no longer generated with respect to the offer is paid to CENACE at the MTR price. Table 12 shows the MWh by which each plant has fallen short of the offer sent in MDA and the corresponding payments to both the participant (payments in MDA prices) and payments to CENACE (payments in MTR prices) for non-generated energy.

Table 12. Durango MDA vs MTR, November 2019

	Durango Project 3				Durango Project 1				Durango Project 2			
Day	MWh	Payment to Participant	Payment to CENACE	Difference	MWh	Payment to Participant	Payment to CENACE	Difference	MWh	Payment to Participant	Payment to CENACE	Difference
2019-11-01	21,38	13.999,91	$11.953,06	**$2.046,85**	20,77	13.673,51	$11.620,87	**$2.052,64**	21,71	14.497,69	$12.077,80	**$2.419,89**
2019-11-02	37,90	15.919,68	$16.024,93	**-$105,25**	37,25	15.610,94	$15.771,54	**-$160,60**	40,56	16.911,60	$17.115,98	**-$204,38**
2019-11-03	27,76	9.987,05	$11.685,23	**-$1.698,18**	26,41	9.628,03	$11.169,31	**-$1.541,28**	30,39	10.848,69	$12.676,55	**-$1.827,86**
2019-11-04	6,24	2.906,60	$3.345,40	**-$438,80**	3,21	2.177,14	$2.094,84	**$82,30**	4,27	2.462,60	$2.559,26	**-$96,66**
2019-11-05	27,15	6.787,18	$8.843,99	**-$2.056,81**	25,03	6.180,93	$8.049,98	**-$1.869,05**	26,69	6.679,42	$8.976,76	**-$2.297,34**
2019-11-06	32,71	8.584,72	$22.014,58	**-$13.429,86**	32,47	8.383,53	$21.959,29	**-$13.575,76**	32,75	8.592,52	$22.175,81	**-$13.583,29**
2019-11-07	25,26	41.866,72	$12.714,03	**$29.152,69**	20,95	34.602,12	$10.587,62	**$24.014,50**	21,61	35.499,39	$11.506,55	**$23.992,84**
2019-11-08	82,49	59.437,07	$80.713,46	**-$21.276,39**	84,44	60.906,08	$82.476,66	**-$21.570,58**	85,59	61.814,53	$83.704,52	**-$21.889,99**
2019-11-09	15,45	12.111,19	$10.491,50	**$1.619,69**	14,13	11.322,00	$9.570,53	**$1.751,47**	15,82	12.454,24	$10.597,52	**$1.856,72**
2019-11-10	13,45	5.856,59	$5.895,73	**-$39,14**	12,81	5.634,43	$5.612,31	**$22,12**	12,55	5.467,45	$5.505,01	**-$37,56**
2019-11-11	60,26	39.354,28	$45.505,19	**-$6.150,91**	60,22	39.356,03	$45.448,11	**-$6.092,08**	60,86	39.633,67	$45.879,32	**-$6.245,65**
2019-11-12	48,21	31.875,84	$36.704,52	**-$4.828,68**	48,08	31.901,92	$36.591,31	**-$4.689,39**	48,65	32.159,74	$37.054,90	**-$4.895,16**
2019-11-13	47,92	30.141,23	$39.789,83	**-$9.648,60**	47,38	29.859,60	$39.328,55	**-$9.468,95**	48,77	30.680,43	$40.479,60	**-$9.799,17**
2019-11-14	13,09	4.442,83	$5.474,26	**-$1.031,43**	0,04	1.276,85	$573,82	**$703,03**	5,22	2.669,80	$2.640,44	**$29,36**
2019-11-15	13,97	8.048,75	$8.391,08	**-$342,33**	20,11	11.186,64	$11.900,38	**-$713,74**	21,69	11.462,04	$12.843,59	**-$1.381,55**
2019-11-16	21,34	10.611,91	$11.925,53	**-$1.313,62**	17,41	8.729,43	$9.713,66	**-$984,23**	15,26	7.692,47	$8.523,20	**-$830,73**
2019-11-17	18,56	7.736,14	$8.154,17	**-$418,03**	17,72	7.559,23	$7.770,98	**-$211,75**	18,76	7.817,93	$8.243,59	**-$425,66**
2019-11-18	45,43	19.632,94	$20.541,82	**-$908,88**	42,90	18.815,28	$19.402,29	**-$587,01**	47,81	20.108,41	$21.618,73	**-$1.510,32**
2019-11-19	6,99	3.440,85	$4.064,68	**-$623,83**	4,95	2.584,59	$2.758,40	**-$173,81**	6,09	3.018,35	$3.475,97	**-$457,62**
2019-11-20	43,22	18.865,22	$20.442,75	**-$1.577,53**	39,17	17.162,76	$18.502,87	**-$1.340,11**	38,63	17.072,53	$18.495,90	**-$1.423,37**
2019-11-21	42,73	24.191,04	$35.855,20	**-$11.664,16**	40,01	22.380,43	$33.395,87	**-$11.015,44**	43,47	24.388,50	$36.857,97	**-$12.469,47**
2019-11-22	3,22	11.140,71	$2.786,88	**$8.353,83**	1,31	8.381,10	$904,19	**$7.476,91**	2,81	10.073,37	$2.244,89	**$7.828,48**
2019-11-23	5,62	3.068,28	$3.858,10	**-$789,82**	3,68	2.244,61	$2.517,52	**-$272,91**	8,05	4.236,99	$5.392,19	**-$1.155,20**
2019-11-24	4,93	1.957,04	$2.202,71	**-$245,67**	1,43	1.043,77	$712,86	**$330,91**	4,14	1.676,12	$1.871,36	**-$195,24**
2019-11-25	33,57	27.760,87	$29.746,05	**-$1.985,18**	32,83	27.240,13	$29.213,16	**-$1.973,03**	33,84	27.904,28	$30.021,05	**-$2.116,77**
2019-11-26	57,41	41.164,90	$44.703,46	**-$3.538,56**	57,38	41.098,81	$44.639,86	**-$3.541,05**	58,59	42.145,15	$45.673,39	**-$3.528,24**
2019-11-27	18,86	20.938,35	$17.652,71	**$3.285,64**	17,71	19.510,93	$16.530,14	**$2.980,79**	19,80	21.861,33	$18.521,88	**$3.339,45**
2019-11-28	91,19	68.680,55	$59.202,56	**$9.477,99**	91,32	68.755,87	$59.259,35	**$9.496,52**	91,54	68.948,29	$59.434,58	**$9.513,71**
2019-11-29	25,53	15.632,86	$16.277,44	**-$644,58**	24,49	15.276,76	$15.592,41	**-$315,65**	26,33	16.093,95	$16.781,95	**-$688,00**
2019-11-30	10,15	5.234,80	$5.359,78	**-$124,98**	8,97	4.641,68	$4.698,33	**-$56,65**	12,71	5.912,38	$7.166,11	**-$1.253,73**
Total	**902,01**	**571.376,11**	**602.320,63**	**-$30.944,52**	**854,59**	**547.125,10**	**578.367,01**	**-$31.241,91**	**904,98**	**570.783,86**	**610.116,37**	**-$39.332,51**

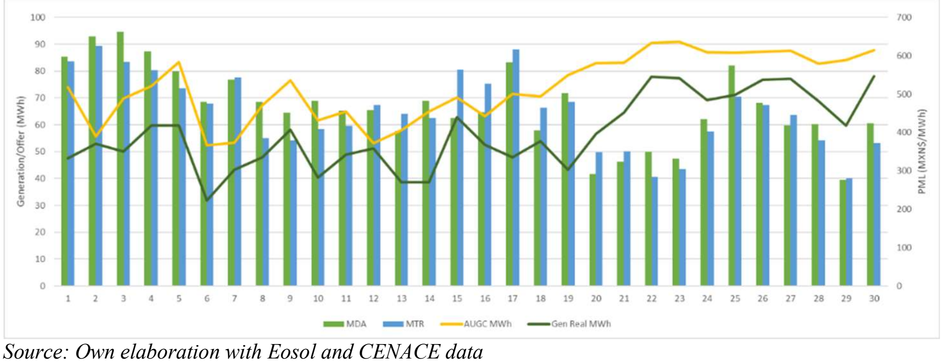
Source: Own elaboration with EOSOL data

<u>Differences between MDA and MTR can generate financial losses.</u>

As it can be seen in next figure 21, in September 2020 at plants managed by EOSOL.

- The sale offer was consistently above actual production in order to limit production losses.
- For 19 days, the MDA was higher than the MTR - EOSOL profits from the over-projection.
- For 11 days, the MTR was higher than the MDA- EOSOL suffers losses from the over-projection.
- There is no consistent pattern from day to day or hour to hour.

Figure 21. Durango projects MTR vs MDA impact in Real Generation vs Offer, September 2020



Source: Own elaboration with Eosol and CENACE data

2.4.8.2 Capacity payment reduction in Renewable Energy Installations

On September 22nd, 2016, through the publication in the DOF, the Ministry of Energy issued the Market for the Balance of Power (MBP)[53]. The MBP is an annual market and ex-post. Thanks to this market, market participants will be able to buy or sell power depending on whether they are over or missing to compensate the amounts agreed with their clients and therefore registered in their Bilateral Power Transactions. The calculation of the power delivered or consumed by generators or consumers is carried out through the 100 critical hours of the system.

The objective of this market is to establish the price that responds to the lack or surplus of generation capacity in the SEN. This price tells us if the demand has been higher or lower than the offer since if the price has been something it is because more capacity was demanded than the offered and vice versa. In this way, the development of new generation capacity for the SEN will be promoted or halted.

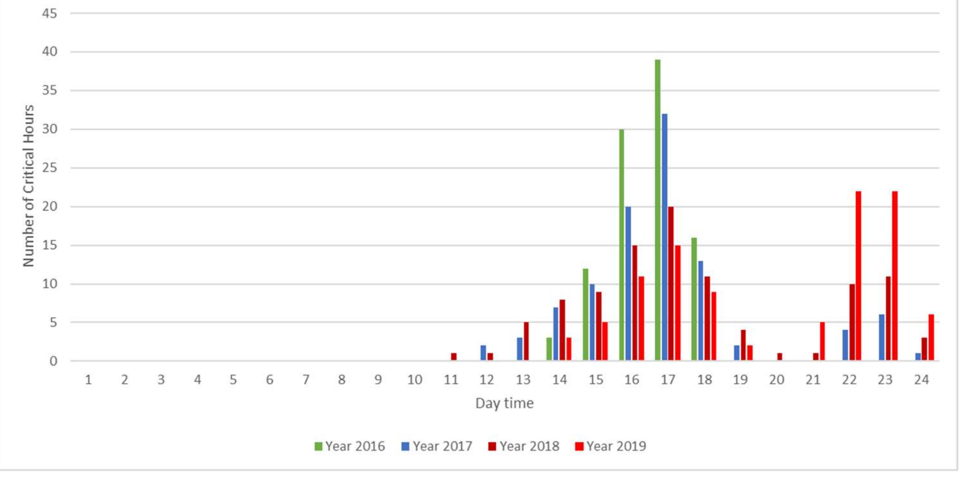
During the first two MBP, MBP 2017 and MBP 2018, the “100 Critical Hours” (CH) corresponded to the 100 hours with the highest demand in the production years 2016 and 2017 respectively. But from the MBP 2019, that is, from the year of production 2018, the government decided to change the method of calculation of these CHs, so that, after their publication and inclusion in the MBP, the CH correspond to the 100 hours that had the lowest level of generation reserves in the identified period. This has had an extremely negative impact for photovoltaic power plants since many of the critical hours have been moved from the hours of

[53] Manual del Mercado para el Balance de Potencia. DOF 22-09-2016 http://diariooficial.gob.mx/nota_to_pdf.php?fecha=22/09/2016&edicion=MAT

greatest radiation to others in which the photovoltaic plants are out of operation[54].

The following table shows how the 100 CH of the system have moved from being 100% in solar time to losing a large percentage due to being moved to the afternoon / night.

Figure 22. 100 Critical Hours of SIN 2016-2019



Source: Own elaboration with data from CENACE[55]

2.5 Governmental involvement

The government of a nation or country is not the main protagonist in the future of an economy, but it is its inhabitants and their companies who must have the initiative and therefore are and must always be the fundamental players for a country to advance or to develop. Nonetheless, it must be not forgotten that it is governments that have the legislative power and therefore can act as a catalyst or as a brake on the economy or on a particular sector of the economy (Mankiw and Taylor, 2017).

During recent years Mexico has experienced two radical changes in the actions of two different governments. Before the approval of the LIE, the Mexican energy sector was based on the monopoly defended and protected by the constitution, of its two state companies CFE and PEMEX. The government promised in its electoral program that it would promote a change in the Constitution of the United States of Mexico in order to

[54] For further information, please visit http://www.cenace.gob.mx/Paginas/Publicas/MercadoOperacion/AcreditacionReqPotencia.aspx

[55] For more detail on both the calculation and the critical hours of the system, consult http://www.cenace.gob.mx/Paginas/Publicas/MercadoOperacion/AcreditacionReqPotencia.aspx

allow private investment in these two sectors that for decades had been monopolistic. The idea was to encourage investment in critical sectors for the growth of a country, and foster the competitiveness which would enable a competitive energy cost and thus make its productive sector more attractive in an increasingly automated world in which the cost of energy was beginning to be a fundamental cost in the value chain of industrial products.[56]

On the other hand, the new government of December 1st, 2018, has tried since it came to power to reverse everything acheived by the previous government, even launching anti-constitutional initiatives to be able to return all power and monopoly to the state companies CFE and PEMEX.[57]

In the next sections I will analyze the measures adopted by one or other government to encourage or impede the development of private investment in the country's energy sectors, especially in the renewable energy sector.

2.5.1 Government initiatives to foment development in the renewable energy sector

Along with around 190 countries Mexico made a commitment to the international community through the Paris Agreement.[58] This agreement was signed by the Plenipotentiary of the United States of México on April 22nd, 2016 and was approved by the Senate of the Honorable Congress of the Union, on September 14th, 2016. The Agreement came into force on November 4th, 2016.[59]

In addition, at the domestic level, the government committed to address the phenomenon of climate change, implementing the LTE with which the country seeks to ensure that renewable energies have a greater impact.[60] The commitments which Mexico has undertaken are that by 2024, 35% of the energy consumed will be from clean sources. These goals were to targeted gradually, with 25% for 2018, 30% for 2021 and the aforementioned 35% for 2024. The government estimates that 70% of greenhouse gas emissions will be eliminated. Furthermore, the clean

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[56] DOF, Diario Oficial de la Federación. *Decreto por el que se reforman y adicionan diversas disposiciones de la Constitución Política de los Estados Unidos Mexicanos, en Materia de Energía*, Mexico DF, December 20, 2013.

[57] See, for example, Financial Times (March 3rd, 2021). https://www.ft.com/content/9284a578-0c4c-49c0-83aa-0ea9cb9dee50

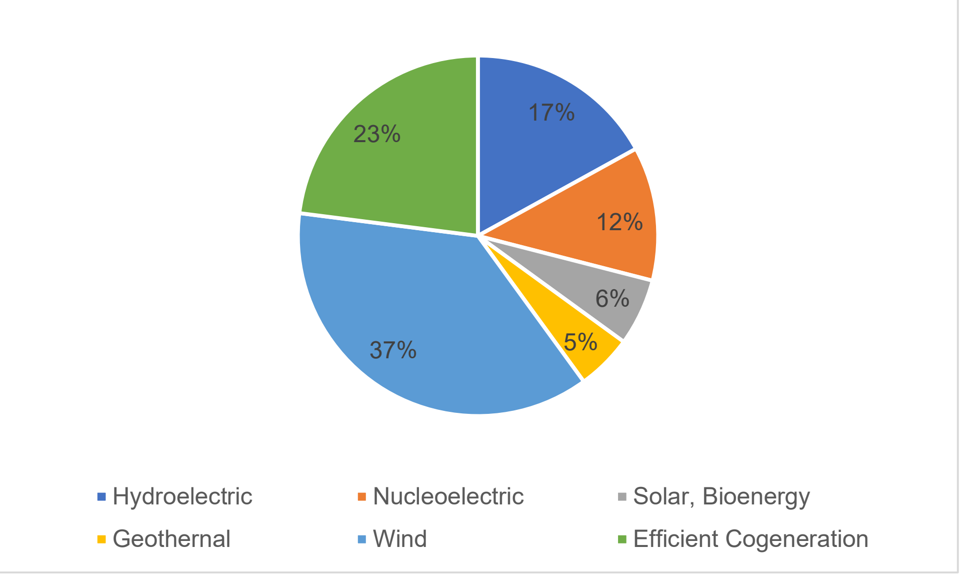
[58] The Paris Agreements were the first binding and universal agreement signed by about 190 countries at the Paris Climate Summit (COP21) to limit the global temperature increase by 2ºC. See, for example, https://ec.europa.eu/clima/policies/international/negotiations/paris_en

[59] More information of this agreement can be found at: http://dof.gob.mx/nota_detalle.php?codigo=5459825&fecha=04/11/2016

[60] On 24 December 2015, the Energy Transition Law (LTE) was published in the DOF. Diario Oficial de la Federación. *Decreto por el que se expide la Ley de Transición Energética,* Mexico DF, December 24, 2015.

technologies the Energy Secretariat has estimated the new clean energy matrix for 2029 (see Figure 23). To meet these ambitious objectives, the Mexican Government, during its previous mandate, had implemented two notably interesting and efficient mechanisms for the promotion of clean energies - the CEL and Auctions.

Figure 23. Clean Energy Matrix 2029



Source: Own elaboration with data from SENER

2.5.1.1 The case of the Clean Energy Certificates

CELs represent an efficient policy to help meet international and national clean energy goals [61]. Qualified users and suppliers will have the obligation to acquire a CEL in proportion to their consumption (5% in 2018; 5.9% in 2019; 7.4% in 2020; 10.9% in 2021; and 13.9% in 2022) (Federal Improvement Regulatory Commission, 2016).

The operation of the mechanism will be carried out through an electronic platform managed by CRE, which will allow market participants to carry out transactions to achieve clean energy goals. The CRE, based on the

[61] Clean Energy Certificates (CEL) are another product that is marketed in the wholesale market among different participants with the aim of promoting the use of energy from renewable sources, since these certificates can only be obtained from generators of renewable power plants. The participants under obligation are the suppliers, the qualified users participating in the market and the end users who receive electricity from the isolated supply. Holders of Legacy Interconnection Contracts which include load centers whose electrical energy does not come entirely from an electric power plant are also required. The regulations that regulate the operation of the CELs were published in the DOF (03/30/2016) which can be consulted on the following link: https://www.dof.gob.mx/nota_detalle.php?codigo=5431464&fecha=30/03/2016. This document was supplemented with a scope agreed by the CRE which was also published in the DOF (01/23/2018) which can also be consulted at https://dof.gob.mx/nota_detalle.php?codigo=5511102&fecha=23/01/2018.

CEL statements made by market participants, will impose, if applicable, fines for non-compliance with the obligations. The criteria for these fines are the following:

a) The fine will be applied for each MWh of default in the acquisition of the CEL.

b) The percentage of non-compliance is defined as the difference between the Clean Energy Obligation (which should consider if there is any deferral) and the number of certificates cleared in the corresponding year divided by the Clean Energy Obligation, expressed as a percentage.

c) Fixing the fine will be considered if a participant opted to defer its obligations.

Table 13, shows the fines for non-compliance, expressed in USD. As a new regulation, in Mexico, the payment of the fine does not exempt you from having to the acquire the CEL, so the need to install clean energy is mandatory. These fines underline the need to install generating plants using clean energy endorsed by CELs.

Table 13. Fines for non-compliance of CEL requirements in Mexico

	Compliance with obligations **was not** deferred				Compliance with obligations **was** deferred			
	> 0% ≤ 25%	**> 25% ≤ 50%**	**> 50% ≤ 75%**	**> 75% ≤ 100%**	**> 0% ≤ 25%**	**> 25% ≤ 50%**	**> 50% ≤ 75%**	**> 75% ≤ 100%**
First time	**6**	**8**	**10**	**12**	**8**	**10**	**12**	**14**
Second time	**12**	**16**	**20**	**24**	**16**	**20**	**24**	**28**
Thirds and following	**18**	**24**	**30**	**36**	**24**	**30**	**36**	**42**

Source: Own elaboration with data obtained from SENER.

2.5.1.2 CENACE Public Auctions

The Mexican Government had implemented an instrument with which they intend to achieve their renewable and clean energy goals[62]. The main characteristics of these auctions are that all technologies compete on a level playing field, products can be offered individually or jointly (energy, CEL and power), there were adjustments by location and generation times, to determine the payment to the generator. To understand the solar sector in Mexico an analysis of what happened in the auctions is necessary.

In the first auction, the states with more radiation were not awarded practically anything. This was because in the auction CENACE offset the cost of transport and congestion, so that there was price compensation for to the states which demanded more energy as it was scarce or expensive. This is the case in Yucatan, where compensation was very favorable. This

[62] For related information about these auctions, see https://www.cenace.gob.mx/Paginas/SIM/SubastasLP12015.aspx

means that an offer of 60 USD/MWh in Mérida were equivalent to an offer of 29.6 USD/MWh in Hermosillo.

For the second auction, unlike the first auction, in which expected differences played a fundamental role, being in the range -22 and +10 USD /MWh in the National Interconnected System, the range in which the expected differences in the SIN were located were -0.6 to +0.6 USD/MWh, with an average value of 0.33 USD /MWh. This reduced the influence of this factor, increasing the importance of other factors such as solar radiation. For this reason, the results were better for the states with better radiation[63].

There have been three auctions, all of which have resulted in historically low prices for photovoltaic technology which for months were record lows throughout the world and consequently produced a contagion effect in other countries. Long- and medium-term electric auctions are instruments contemplated within the Mexican Wholesale Electricity Market, as a way of guaranteeing low-cost electricity to favor the basic service provider, promoting competitiveness in the sector through the inclusion of new participants, as well as being a particularly important source of foreign and national investment in the sector.

Thus, in the three auctions organized by the Ministry of Energy, a significant influx of national and foreign participants could be observed, a gradual decrease in the price offered with the consequent savings in favor of the CFE as basic supplier, and the sum of a total estimated investment of the order of 8,984 million dollars. The auctions were dominated in terms of energy and CEL by renewable energy plants, while in terms of power this was awarded to plants operating under other technologies. The auctions generated an effective tool for Mexico to reach the goal of having a minimum participation of clean energies of 30% in the total generation of electricity by 2021, and 35% in 2024, according to the LTE. The summary results of the auctions were as follows.

a)- First Auction (November 2015).[64] The details are as follows:

- Number of MW, CEL and power placed: 5.4 million MWh from different companies and 5.3 million CEL from other clean anergy companies which were the only ones that could produce them.
- No power was awarded.
- Estimated investment of 2,605 million USD.

[63] See also https://www.cenace.gob.mx/Paginas/SIM/SubastasLP12015.aspx

[64] For further information, see: https://www.gob.mx/sener/prensa/la-sener-y-el-cenace-informan-sobre-el-fallo-de-la-primer-subasta-que-define-a-las-ofertas-ganadoras. The final winners can be found in https://www.gob.mx/cms/uploads/attachment/file/72920/empresas_ganadoras2.pdf

- Average price for energy and CEL: 45.6 USD.

b)- Second Auction (April 2016). [65] The details are as follows:

- Number of MW, CEL and power placed: 8.9 million MWh of energy, 9.3 million CEL and 1,187 MW-year of power.
- The composition of 54% of the energy and 53% of the awarded CELs correspond to photovoltaic energy, 43% of awarded energy and 41% of the CEL correspond to wind energy.
- Hydroelectric and geothermal technology will sell energy with 3% and 2% of the awarded energy (see Table 14).
- Estimated investment of 4,010 million USD.
- Average Price of Energy plus CEL is 33.47 USD per MWh plus CEL.
- Savings of 44.2% for clean energy and 64.1% for power.

Table 14. Second auction. Technology of the selected Offers

Amounts allocated by technology				Participation by Technology		
Technology	**CEL**	**Energy (MWh)**	**Capacity (MW-year)**	**CEL**	**Energy**	**Capacity**
Solar photovoltaic	4.933.382	486.597	184	53%	54%	15%
Wind	3.828.757	3.874.458	128	41%	43%	11%
Geothermic	198.764	198.764	25	2%	2%	2%
Combined cycle			850	0%	0%	72%
Hydroelectric	314.631			3%	0%	0%
TOTAL	**9.275.534**	**4.559.819**	**1.187**	**100%**	**100%**	**100%**

Source: Own elaboration with data from SENER

c)-Third Auction (November 2017).[66] The details are as follows:

- Number of MW, CEL and power placed are 5.49 million MWh of energy, 5.95 million CEL and 593 MW-year of Power.
- The composition of the sale of energy and CEL are photovoltaic 55.35%, of sale of energy and 58% of CEL, wind 44.65% and 41.69% of CEL (see Table 15).
- Estimated investment are 2,369 million USD.

[65] For further information about the results and winners, see https://www.gob.mx/sener/prensa/con-precios-altamente-competitivos-se-anuncian-los-resultados-preliminares-de-la-2-subasta-electrica-de-largo-plazo?idiom=es.

[66] For further information, see https://www.gob.mx/cenace/prensa/anuncian-sener-y-cenace-resultados-preliminares-de-la-tercera-subasta-de-largo-plazo-141668

- Average Price of Energy plus CEL is 20.57 US dollars per MWh plus CEL.
- Total savings for the CFE of 50.77%.

Table 15. Third auction. Technology of the selected Offers

Amounts allocated by technology				Participation by Technology		
Technology	CEL	Energy (MWh)	Capacity (MW-year)	CEL	Energy	Capacity
Solar photovoltaic	3.471.160	3.040.029	10	58,31%	55,35%	1,69%
Wind	2.481.415	2.452.547	83	41,69%	44,65%	13,95%
Turbo gas	-	-	500	0,00%	0,00%	84,36%
TOTAL	**5.952.575**	**5.492.576**	**593**	**100%**	**100%**	**100%**

Source: Own elaboration with data from SENER

The main related question was whether the projects designated by the auctions reached fruition or not. During the early years following the launch of the auctions there were many doubts about the number of winning projects from the auctions that would finally get underway. These doubts were based on two basic criteria:

(i) The award criteria did not review the technical, administrative, or economic feasibility of the projects submitted.

(ii) Much of the considered income by companies were spot market after the CFE period.

Some projects, mainly from the first auction, were undergoing numerous processing problems, mainly those of the peninsula of the Yucatán. Other were experiencing financing problems because, although financial institutions were considering CFE debt as sovereign debt, returns were excessively low and financial models did not square up and the spot market was not clear.

The reason for considering CFE debt as non-sovereign debt was the recent history of PEMEX bailouts, which, like CFE, was a state production company. The reality was that when it needed capital, the state had come to its aid. In fact by early 2017, most projects had not started construction, which made the market think that most projects were not going to get off the ground. However, the reality is that, in 2019, after several extensions granted by the government and even government pressure on development banks to support the auction winners, practically all the projects that had been successful in the auctions were underway[67]. Today, except for rare exceptions, most of the projects in the third auction are in operation[68].

2.5.2 Government initiatives to stop development of renewable energy

Following the entry into power of the new government on December 1st, 2018, the renewable energy sector experienced a major decline to the point where it practically disappeared.

The reasons are varied, but what is clear is a change in the country's energy policy, which is clearly reflected in the first measures taken by new government such as the cancellation of auctions and the threats of retroactive regulatory changes. As we saw previously, the auctions were the major reason behind the elimination of most of the barriers for the development of renewable projects in the country. This was known by the entire sector and thus one of the first measures taken by the new president to try to restore power to the parastatal companies the CFE and PEMEX, was to cancel the auctions. In this subsection, three recent pieces of related news will be provided[69].

- December 11th, 2019. The CFE studied the possibility of installing four nuclear power units. Hector Lopez Villarreal, corporate coordinator of the Laguna Verde Nuclear Power Plant, announced that in 2020 a feasibility study for the installation of four nuclear energy units to increase energy capacity would be presented.

- December 24th, 2019. The CFE sought to persuade the CRE into establishing transmission tariffs for private generators. The CFE Director of Social Communication pointed out that the CFE was subsidizing private electric power generators, in order for them to provide power generation. However, they were using the CFE transmission network, paying lower costs than the actual CFE cost or not incurring costs at all. Therefore, this led to losses for the CFE and signified a subsidy for private companies. A fair price would be sought with the CRE under Mexican laws and the Energy Reform, so that both the CFE and the private sector

[67] From the first auction, the projects that have not been finally built are Chabacal 1 and 2, Ticul 1 and 2, and the Gunaa Sicaru project. For the last one you can find more information in https://www.edf-re.com/es/project/gunaa-sicaru-wind. From the second auction, the only project that has not started construction is that of Alten, although the company claims that it has begun construction. If you want to review the complete list of projects and its status, please visit:
https://www.proyectosmexico.gob.mx/proyectos/

[68] The winners of the third auction also obtained several extensions and most of these projects are currently underway.

[69] See for example: https://globalenergy.mx/ and http://energiahoy.com/category/vivas/electricidad/

could compete under equal conditions. The immediately strategic targets are the following: reliability of the SEN, porting fee, legacy contract from the CFE to CFE basic supply, CFE participation in electricity planning, regulated transmission and distribution rates, integration of power plants regionally, backup fee for renewable energy sources, simulated self-supply companies, independent producer permits, with surplus energy, clean Energy Certificates for CFE plants, rates for the end user, distributed generation, charging for capacity to partners of private plants and recognition of fuel reference costs.

- January 16th, 2020. The 14 CFE target points for 2020 and this governing period. The general director of CFE, Manuel Bartlett Díaz, raised points for the CRE to guarantee its strengthening, which included the following points. Reliability to determine the maximum permissible capacity of intermittent renewable energy to be interconnected in the SEN at regional and national level, to guarantee the operation and optimum reliability of the SEN. Modification of the Legacy Contract to achieve the maximum contribution of CFE generation to Basic Supply. It is intended to increase the contribution of CFE generation, so the CRE designs the necessary regulation so that CENACE dispatches CFE plants, achieving the maximum contribution of CFE renewables. And finally, update of the regulated tariffs for transmission and distribution.

The following point includes the main reasons for the shutdown of the renewable sector in Mexico after the start of the new administration.

2.5.2.1 Cancelation of auctions

As mentioned previously in 2.5.1.2, there were three auctions, which resulted in historically low prices for photovoltaic technology and an expansion of these kinds of projects throughout the whole country.

After announcing their suspension in December 2018, CENACE announced in February 2019 the cancellation of the fourth long-term auction[70], this was preceded by the cancellation of the tender for a transmission line that would transport energy from the Isthmus of Tehuantepec, Oaxaca, to Yautepec Morelos, this being a decisive

[70] On December 3er, 2018, the new government, with barely a few days in power, decided to delay the fourth electricity auction in order to give the new administration time to review the objectives of the CFE, SENER and CENACE. Finally, on January 31st, 2019, the government, through an official letter SENER.100 / 2019/075, informed all relevant actors in the sector in the country of the final decision to cancel said auction. We see some examples of how the main newspapers reflected the cancellations, https://www.energiaestrategica.com/cancelacion-de-las-subastas-de-largo-plazo-ocho-grandes-consecuencias-economicas-politicas-y-ambientales-preocupan-en-mexico; https://www.eleconomista.es/economia-eAm-mexico/noticias/9708075/02/19/Cancelacion-de-subasta-electrica-pone-en-riesgo-generacion-de-energia-consideran-expertos-.html

transmission line to boost wind power generation in one of the most favorable areas for this in Mexico.

With the cancellation of the fourth auction, a process of decreasing prices offered in the first three auctions was interrupted, and where record low prices had been generated internationally, since as could be seen from the previous data, in the third auction prices reached some of the all-time lowest, with an average price of 20,57 USD/MWh for clean energy.

The cancellation of the auctions is but one more step in the measures adopted by the new government in order to limit the participation of private generators in the generation of electrical energy, thereby seeking to favor the already dominant role of state-owned company generation, CFE, under the centralist view of the current government. This centralist vision is reflected in policy for the entire energy sector, since in the hydrocarbon sector the participation of private generators also limited when the oil rounds were canceled.

The cancellation of auctions in the field of electrical energy represents an element of loss of confidence in investors since it clearly marked the objectives of the new government. This very quickly caused institutional investors to withdraw from the country to seek other markets more open to private investment[71].

This negative assessment of the latest RECAI report is confirmed by the sharp drop experienced by foreign investment in the energy sector in Mexico.

This cancellation also had consequences for the CFE since it implied a loss of an effective tool with which the CFE could lower its energy costs, to ensure the growing demand in the country was taken into account, and for Mexico to reach the commitments in the matter of electrical generation from renewable sources, as well as to comply with the international commitments made regarding the reduction of greenhouse gases. Because of this, since the CFE does not cover its demand through renewable energy sources, it will continue to do so as before, with older and less efficient plants, and through polluting resources such as coal or diesel, which goes against the current world trends.

Nevertheless, for a few months the sector remained confident in the development of the renewable energy sector in Mexico, some actors even considered these cancellations as an opportunity for them because the prices being presented in the Auctions had been so low that only large companies could participate, basing the development of the project on

[71] Mexico's attractiveness as a potential investor in renewable energy projects has fallen from 9th place in the world in October 2017 to 33rd in November 2020. For more information on this ranking, please review the 56th edition Renewable Energy Country Attractiveness Index made by Ernest and Young.

having recourse to their own balance sheet and even with strong risks of losses, thus limiting access to auctions for other generators that did not have this capacity.

With the rest of the options available for commercializing energy, some investors interested in continuing to develop power generation projects in Mexico would continue, particularly considering the energy needs of an expanding country, since demand has come growing at constant rates in recent years and this trend will continue. They consider that Long- and Medium-Term Auctions are only one way to carry out the energy commercialization operation, since generators can resort to the same or even more viable schemes from an economic perspective, such as placing energy from their plants through energy purchase contracts for the attention of the qualified supply, or directly placing it in the Wholesale Electricity Market.

For these reasons, the interest in the generation of energy through renewable technologies could persist despite the cancellation of the auctions, so that some of the other negative effects of the cancellation of the auction would be mitigated.

One of the reasons for canceling the fourth auction was to stop the expansion of electricity generation by private generators, however it is worth mentioning that the issue was being addressed only partially by the new government, since on the one hand megaprojects of new transmission lines were canceled, while on the other the budget destined to create new transmission infrastructure was rather limited, in relation to the investment required.

Given the budgetary limitations that prevail in public spending in Mexico, the CFE will hardly have the economic capacity to develop the generation capacity required to meet the growing demand of a country with a population of 127 million inhabitants, and with an industrial activity that must face the challenges of the recently signed T-MEC that replaces the NAFTA. Thus it is only a matter of time before the launch of joint ventures between private initiatives and the CFE for the generation of electrical energy. It remains to be seen however how attractive these schemes will be for the participants.

2.5.2.2 Changes in the composition of the electric regulatory entities in Mexico and in the CFE

The change of administration in Mexico in December 2019 found the CRE with 4 of the 7 positions of its commissioners being vacant. These position had to be filled urgently as there was no quorum in the CRE sessions, creating a bottleneck for the issue of permits and on agreements regarding modifications.

In light of this and in accordance with the corresponding law[72], the President of the Republic has the power to present the shortlist of candidates to the Senate of the Republic, where the different political forces are represented, to decide on their election. This process was met by two consecutive rejections by the Senate of the lists presented by the President, (in fact, the two lists contained basically the same people) who then, empowered by law, proceeded to designate them directly from among the candidates included in the lists.

The double rejection of the Senate of the shortlist of candidates for commissioners, evidenced in general, although not in all cases, the lack of technical and specialized preparation, and even autonomy, of the people proposed for this purpose; qualities which are an essential requirement in the development of energy policy, and more specifically of energy markets.

To the controversial appointment of the CRE commissioners, was later added the resignation of its President Commissioner, after receiving strong pressure from the federal government to this end, but which he formally justified when presenting his resign noting, *"that I have a different vision than the new members of this organization"*.

In addition to the above, it is worth noting that the CRE had suffered a significant budget cut for 2019, since the Federation's Expenditure Budget for that year assigned 248 million pesos against the 360 million it had in 2018, 31% less, which resulted in a particularly important reduction in personnel.

Given a clear influence in the appointment of the new CRE commissioners, there is a risk that the decisions of said organization, rather than obeying technical or economic criteria, based solely on market considerations and its expansion and strengthening, are based on an ideologically influenced environment, that decisions as important as stimulating competition in the energy sector, take a rather statist view by favoring the position of the State Productive Companies, PEMEX and the CFE.

Regarding the CENACE, as the entity responsible for the operation of the SEN and guaranteeing access to transmission systems, there was an immediate change in its General Director with the start of the change in administration.

[72] Article 6 of the *Ley de los Órganos Reguladores Coordinados en Materia Energética.*

The CENACE, a body that was set up as a separate entity from the CFE, is made up of officials and staff who have accumulated vast and specialized experience in the electricity sector.

Since the new general director of CENACE was appointed, he has made clear his disagreement with the then still director of the CRE, who had already revealed a clash of visions within the sector.

What has been observed at the CENACE in recent times, and in accordance with the central state policy in the sector is a strong tightening of the conditions of access to existing transmission lines for generators. Although it is clear that there are restrictive technical conditions, as in all markets, the requirements imposed by the CENACE for generators to access these lines, render these projects financial inviable.

Another aspect that has been changing with the new administration is the criteria with which the dispatch of electrical energy is presented. This is one of the most important function of the CENACE, as is the organization for controlling the SEN. Till this new administration, the dispatch of electrical had been considered a matter of generator costs, and reliability and safety issues. But now the scheme has change and only CENACE can understand the criteria. The reality is that CENACE is trying to help CFE in any decision it takes.

It was in the public domain, in the series of meetings held by the CFE with the Ministry of Energy, the CRE and the CENACE, in which the former requested an in-depth review of the secondary regulations on electricity, to put an end to or limit the series of advantages that the private generators had enjoyed and which had allowed their expansion.

It is striking that, been the current conditions of the transmission network in Mexico the bottleneck to limit the expansion of the generation of electrical energy by the CFE or by private generators, the budget for expanding or modernizing transmission networks is rather low. The participation of private generators in said activity is restricted. This is an issue which could be resolved through public-private associations or other associative schemes but obviously the new administration is not interested in solving it.

2.5.2.3 Change in CEL regulation

On October 28th, 2019, the "Agreement by which the Guidelines that establish the criteria for the granting of Clean Energy Certificates (CEL) and the requirements for their acquisition", was published in the DOF on October 31st,2019.

Furthermore, on the same date, SENER took actions on October 28th, 2019 to release CFE from its obligations to purchase. With this, the rules of the game had changed, since to date the existing plants (Legacies), could only acquire CELs from the extensions and not from what was already in operation. The reason was clear; the CELs were an instrument to promote the increase of clean energy in the country. Instead, the change was now justified by saying that:[73]

- "the promotion of an equal competition market and that the generation of electrical energy from clean energy is recognized for all generators under equitable conditions",
- "the increase in electricity rates with a negative impact on domestic end users",
- "the number of clean generators is not reduced, since on the contrary it is considered that said measure favors competition between generators in both the public and private sectors, increasing productivity".

Thanks to this change the CFE could receive CELs in relation to its Legacy Power Plants. Now, the CFE will be able to receive CELs for each MWh produced by its Legacy Power Plants through clean energy sources (including the energy generated in the Laguna Verde nuclear plant and in all hydroelectric plants).

This had an important impact on the CEL market and in the valuation of these instruments in Mexico, since it increased its offer for all those Cargo Service Entities interested in acquiring CELs. The effect of this action was to stop all material transactions in the CEL market and to lower price expectations. This, therefore, clearly and seriously affected the number of clean generators by eliminating one of the important sources of income for this type of facility.

Moreover, from a legal point of view, the justification given for the change has several inconsistencies. Highlighted below are the most important ones:

i) There is no relationship between the increase in tariffs for domestic end users since private plants could not access that market. Furthermore, it would have been easier to eliminate the obligation of the CEL at these types of rates.

ii) The CEL mechanism was created to encourage the construction of new clean plants and not as additional income for plants that are already operational or even economically amortized.

[73] You can find the complete text in DOF of October 28th,2019.
AGREEMENT by which the Guidelines that meet the criteria for the granting of Clean Energy Certificates and the requirements for their acquisition, published on October 31, 2014:
https://www.cenace.gob.mx/Docs/03_CEL/DocumentosInteres/20191028%20SENER%20Modificaci%C3%B3n%20Lineamientos%20para%20otorgamiento%20de%20CEL.pdf

iii) When the law was approved, it was clearly stated that the CEL could only be for plants built after the law was published and this point was now changed and therefore made retroactive.

The private sector responded against this act. In November 2019, a Federal Court granted the definitive suspension. The result was to maintain the current circumstances for at least one year. However, the government has not stated that it plans to reverse its actions. In particular,

- No one from any sector can clearly indicate where the market is going, if it will continue or not and what projections can be made regarding the price.
- There is currently no market and there is unlikely to be one until this is resolved.
- The financial models for this type of plant had to change the hypotheses for the sale of this type of plant, where previously 15 USD/CEL (in 2020) was assumed to be 5 USD/CEL.
- Financial institutions did not consider the income from CELs in their financial models.

2.5.2.4 Proposes draft regulatory modification applicable to generation permits in the Self-Supply modality

On February 13th, 2020, CRE made a draft agreement available to the public that proposed the modification of the "General administrative provisions that establish the terms to request authorization for the modification or transfer of electric power generation or electricity supply permits", in relation to the possibility of modifying electric power generation permits in the self-supply modality (the "Preliminary Draft"). The proposed modifications consist of the following:

a-. Eliminate the possibility of registering, in the corresponding self-sufficiency permits:

- To the load centers that have not received the electricity supply prior to the entry into force of the Electricity Industry Law (August 12th, 2014).
- To load centers that have entered into a supply contract under the Electricity Industry Law.

b-. Eliminate the possibility of adding, in expansion plans, private generators or legal entities other than those authorized in the corresponding self-sufficiency permit.

Holders of a generation permit in the self-supply modality and owners of load centers interested in being included in this scheme can take measures in the eventual implementation of the Preliminary Project. These measures include: (i) requesting the CRE to modify the expansion plans or the inclusion of new load centers in the self-supply permits; and (ii) obtain legal advice for the filing of the means of defense that are appropriate to this eventual regulatory amendment[74].

It should be noted that the Preliminary Draft is in the process of regulatory improvement before the National Commission for Regulatory Improvement, which allows the public to present comments or observations to the Preliminary Draft. Once this process is completed, the approval of the Preliminary Draft by the CRE's Governing Body will be required. Finally, the agreement approved by CRE must be published in the DOF for it to take effect[75].

2.5.2.5 Further initiatives adopted by the new government of December 1st, 2018 to hinder development during the Covid-19 pandemic

The new government, in charge from December 1st, 2018, taking as justification the global Covid-19 pandemic, launched two new initiatives in its attempt to harm the private sector within Mexico's energy industry.

The first initiative was launched by the CENACE with the argument of guaranteeing the efficiency, quality, reliability, continuity and security of the SEN "*Acuerdo para garantizar la eficiencia, calidad, confiabilidad, continuidad y seguridad del Sistema Eléctrico Nacional con motivo del reconocimiento de epidemia de enfermedad por el virus SARS-CoV2 (COVID-19)*" in April 29th 2020 The Agreement was published on May 1st, 2020 through the System Notification Box in the public area of the Market Information System[76].

This initiative was quickly brought before the federal courts of Mexico, classifying it as unconstitutional, since it was deemed that:

- It prevents the development of a constitutionally relevant activity, considered essential during the health emergency derived from the SARS-CoV-2 virus.
- Provides unequal and discriminatory treatment, without objective or rational justification.

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[74] See the following link in the website of the National Commission of Regulatory Improvement: http://187.191.71.192/expedientes/24002.

[75] For a detailed information on the suspension pre-operational tests for wind and photovoltaic installations, see Annex 6.5.

[76] See, for example, https://www.cenace.gob.mx/MercadoOperacion.aspx

- It makes energy transition, to which the Mexican State is constitutionally bound, more difficult .
- It detracts from the right to a healthy environment and affects the health of people of present and future generations.
- It causes a surprising and unusual regulatory modification, contrary to the legal order, which damages the legitimate confidence generated by the authorities themselves with their actions.
- It is illegal as it is contrary to the applicable legal regime, and comes from an incompetent authority, while lacking objective parameters.

The second initiative was launched by the CENACE and published in the DOF on May 15th, 2020. [77] with the argument of guaranteeing the efficiency, quality, reliability, continuity and security of the SEN "*Acuerdo para garantizar la eficiencia, calidad, confiabilidad, continuidad y seguridad del Sistema Eléctrico Nacional con motivo del reconocimiento de epidemia de enfermedad por el virus SARS-CoV2 (COVID-19)*" on May 15th,2020[78], skipping all the processes and having provoked the resignation of the former director in charge of the COFEMER, who had refused to cooperate in the government's fast tracking.

Like the previous CENACE initiative, this one from SENER was also quickly brought before the federal courts of Mexico, classifying it as unconstitutional under the following considerations:

- The right to health and a healthy environment for development and well-being.
- The fundamental right to sustainable development.
- The fundamental right to equality and non-discrimination.
- The fundamental right to due process, legality, legal security and normative hierarchy.
- The fundamental right and principle of legal security in its expression of legitimate confidence of the governed.
- The fundamental right to free competition and economic competition.
- The principle of non-retroactivity and acquired rights.

[77] For a detailed information on the legal procedure that the initiative should have followed for its approval and ordinary publication, see Annex 6.6.
[78] See, for example, https://www.cenace.gob.mx/MercadoOperacion.aspx

- The principle of proportionality, as well as the principle of regulatory improvement.

In summary, the current public administration has carried out a whole range of practices aimed at favoring the production companies of the State, PEMEX and the CFE, displacing private sector companies as much as possible. All private sector projects have been affected, whether they were in development, construction, or production, with the argument that the energy reform of the previous government has not given fair treatment to these productive state production companies.

This strategy of favoring the state production company, the CFE, and hindering and damaging private companies can be clearly seen in a series of acts carried out by the Federal Public Administration with the aim of preventing or limiting private investment in the electricity sector and thus granting even greater power to the CFE. Among these acts, the following can be summarized.

- Cancellation of Medium and Long-term Auctions organized by the CENACE. This decision hampered what had been shown to be the best tool for the implementation of renewable generation projects by private parties through the sale of energy, capacity and CELs at incredibly competitive prices to the CFE.

- Cancellation of the transmission line tenders “LT / SENER-01-2018 - Baja California” and “303 LT Ixtepec Power –Yautepec Power”, called by SENER and CFE, respectively. These tenders were to allow the private sector to enter the construction, operation, and maintenance of the interconnection infrastructures of the SEN, allowing said system to improve more rapidly by allowing private capital in its development. These tenders were going to allow concretely *La Ventosa* the evacuation of renewable electric energy produced in the region of the Isthmus of Oaxaca, respectively.

- The attempt to terminate the Clearing House scheme for the Long-Term Auction SLP-1/2017, by the CENACE, to the detriment of the private developers who were awarded in said auction with a contract for the sale of electricity, Power or CELs, mainly through generation plants that use clean sources.

- Modification of the "Terms of Strict Legal Separation of the CFE", by SENER, to reorganize the generation companies of said State Productive Company to strengthen their participation in the Wholesale Electricity Market.

- Issuance by the CENACE of the "Agreement to guarantee the efficiency, Quality, Reliability and safety of the SEN, on the occasion of the recognition of the epidemic of the disease caused by the SARS-CoV2

Virus (COVID-19)". This agreement had the purpose, among others, of suspending the pre-operational tests necessary for the commercial start-up of clean power plants, particularly private generators.

- Publication of a preliminary draft of modification to the "General administrative provisions that establish the terms to request authorization for the modification or transfer of power generation or electricity supply permits", to restrict the rights of the permit holders of the regime legacy, by the CRE.

- Publication, on May 15th, 2020, of the "Policy of Reliability, Security, Continuity and Quality in the SEN" by SENER. The reliability policy contains provisions related to: (a) interconnection of power plants; (b) generation permits; and (b) technical and dispatch aspects for plants in operation, which particularly affect private generators.

- Approval by the CRE of two resolutions that increase the charges for electricity transmission services applicable to holders of legacy interconnection contracts with a renewable energy source, efficient cogeneration, and conventional sources.

2.5.2.6 New initiative adopted in February 2021 by the new government of December 1st, to modify the LIE

The last great attempt and probably the worst to date to stop the expansion of private projects in general and renewables in particular, has been the launch of a reform to the LIE launched on January 29th, 2021[79].

This procedure has been launched as a matter of urgency, which means that the House of Representatives has only 30 days to discuss it and to approve it, and then the Senators will have the same 30-day period for the same task.

The entire reform of the law is an attempt to destroy the great work and effort made by the previous law to promote a market of free competition where the sector in general and renewable energies could be developed efficiently.

The proposed modifications are highlighted below:

- Modification of dispatch rules giving priority first to hydroelectric generation, then CFE generation from whatever source, that is, coal and diesel generation will go before renewables, then renewable energies (wind and photovoltaic) and finally the combined cycles of generators other than the CFE.

[79] You can find this initiative in the document No. SG/UE/230/293/21 in next link: http://archivos.diputados.gob.mx/portalHCD/archivo/INICIATIVA_PREFERENTE_01FEB21.pdf

- That all generation permits granted by the CRE be submitted to the approval of SENER.
- That CELs be granted to all clean energy plants regardless of their start-up date.
- Modify the obligation that CFE basic supplies can only buy energy through auctions.
- Force the CRE to cancel all self-supply permits, considering them all fraudulent.
- Cancel all unprofitable contracts that the CFE has signed under the LSPEE with independent generators.

This new attempt to modify the rules of the game in favor of the CFE and against private generation in general and renewables in particular has quickly come under attack from various media, business chambers, law firms, associations of renewables, etc.

Very soon it will be seen if the new government achieves its goals as the consequences of its success or failure become clear.

2.6 Conclusions to be drawn from the barriers in Mexico

Mexico will present a great opportunity for the solar sector in the coming years. With a growing energy sector, with obsolete plants highly dependent on natural gas and therefore highly dependent on the U.S., the Mexican authorities, through the approval of energy reform have liberalized a sector that for decades has been protected and monopolized by the Government to diversify it in the coming years and thus become more competitive.

In addition, Mexico has made a commitment at a national and international level regarding the reduction of pollutants, committing itself through the Energy Transition Law to 2024 that 35% of the energy consumed in Mexico must come from clean sources.

Specifically, the Mexican Government estimates that by 2032, some 20,641 MW of production capacity will be built, but it has been seen that photovoltaic energy always surprises us with installations that are much more productive than the expectations of governments (PRODESEN 2019-2033, SENER).

Nevertheless, to make it possible to meet this objective established by the CENACE and go from 4,847 MW of installed solar power in 2017 to 20,641 MW in 2032, assuming that this target is not finally increased as has been done in recent years by the government in the various published PRODESENs, the entry into service of new solar plants is required at a rate of approximately 1,000 MW per year, before the deadline, which is only 11 years from now.

Is this possible? The answer is no in the current scenario. Even though the renewable resource, technology, capital, and the main actors are available, it will only be possible to meet the indicated energy objective if the difficulties are smoothed out and the barriers mentioned so many times throughout this work are demolished.

For this reason, this chapter cannot be limited to offering a static and pessimistic view of the situation and must go a step further by proposing some measures that would result in a substantial improvement in the development of renewable energies in Mexico in general and solar energy in particular.

Below is a summary of some recommendations whose total or partial implementation will help overcome barriers, allowing Mexico to occupy the role of world leadership in the use of these energies, a role which corresponds to its size, population, availability of resources, energy needs, position in the world and commitments made to social and environmental responsibility.

- Permitting; Creation of a state office with the character of a "single window", in charge of coordinating the relationship with all the competent public bodies (SEMARNAT, CONAGUA, SCT, ...), for the coordination and granting of permits and authorization for both construction and easements and affections to public property and rights. This office must approve a series of (i) clear and transparent regulations with the rates and taxes applicable to this kind of projects and (ii) administrative procedures to provide the necessary legal certainty and ensure certain deadlines for the resolution of the necessary procedures.
- MIA; Establishment at the federal level by SEMARNAT of the catalog of environmental requirements to be met by solar projects, avoiding the creativity and discretion of state and local regulations.
- EVIS; Definition by the competent body of the standard content to be completed in the social impact assessment, also establishing at the federal level the catalog of social requirements to be met.

- Land barriers; Modification of the Agrarian Law of 1915 establishing a specific and singular regulation of the part of the land belonging to ejidos that are to be used for the use of renewable energies. In this regulation, in conjunction with SENER and the CENACE, the areas in which future projects will be implemented must be defined, regulating the conditions in which ejidos must lease their lands.

  This measure would, on the one hand, be able to plan and order the implementation of solar and wind projects that would otherwise be implemented without order and control and, on the other hand, it would benefit a large sector of the poorest population that is usually excluded from this type of project due to the difficulties involved in negotiating with these groups.

- Auctions: Recover the auction mechanism, facilitating the concurrence of private investors, with transparent procedures that objectify the requirements of technical-economic solvency and accredited experience and that do not require disproportionate guarantees.

- Avoid speculative processes; Preventing any transfer of construction permits or licenses obtained before the project has reached the grid connection and commercial start-up or even a minimum period of permanence in the project capital.

- Public-private collaboration; Promoting the creation of stable forums or "sectoral meeting tables" between regulatory public bodies and generators to achieve a fruitful dialogue on the difficulties evidenced and the measures that both parties can adopt to achieve a harmonious development of renewable energies in the country.

- Rationality in the requirements for the interconnection of projects; Not requiring renewable energy projects to make investments disproportionate to their size in new interconnection infrastructure or in reinforcing the existing one that are not fully justified.

  In this regard, it could be of great interest to set up, under the leadership of the competent public entities (CRE CENACE, CFE), "evacuation tables", organized around the nodes, in which all participants pay for the new investments in infrastructure under criteria of technical and cost transparency.

- MEM transparency; Periodically publishing and auditing the energy dispatch criteria and respecting the order of merit of the sources that match the electricity demand, with special priority for those of renewable origin due to their characteristics and multiple benefits.

- Relieve congestion problems; Planning and prioritizing the reinforcement and meshing of the network in the most congested nodes.

  In this section, a public-private investment plan for the development of evacuation infrastructures should be made in such a way that it is transparent for all developers when and where the infrastructures will be built and therefore when and where evacuation capacity will be available.

- Expansion of the MEM; Facilitating access to more energy purchasing agents, favoring fair competition between supply and demand and the transparent and competitive formation of energy prices.

- Elimination of the AUGC; Which is seriously damaging the production of solar and wind plants. If elimination is not an option, implement an incentive for the installation of small battery systems that can give predictability to generator production.

- Elimination of retroactive initiatives; To guarantee to the participants in the sector the security that the rules of the game will not be changed once the game has started.

Chapter 3

Impact of fossil fuel prices on electricity prices in Mexico[80]

3.1 Introduction

The previous chapter analyzed the barriers to the development of photovoltaic projects in Mexico. Faced with these barriers, it was found that one of the most interesting options for the development of this type of project was to sell energy to the spot market, but that unfortunately is no longer possible for the reasons stated above and into which we not expand upon in this chapter. Therefore, the alternative is to seek and sign PPA contracts.

In order to be successful in this negotiation, it is necessary to understand the influence fuels have on the price of energy in Mexico and thus, where appropriate, to be able to link its price to the price of these fuels.

Crude oil prices are one of the most relevant commodity prices when explaining both macroeconomic and financial variables. For example, previous studies have found a significant impact of oil price shocks on real economic activity (Hamilton, 1983; Cunado and Perez de Gracia, 2003, 2005; Cunado, Jo and Perez de Gracia, 2015), exchange rates (Bahmani-Oskooee and Saha, 2015; Pershin, Molero and Perez de Gracia, 2016) or stock returns (Cunado and Perez de Gracia, 2014; Diaz, Molero and Perez de Gracia, 2016). Furthermore, some studies also find that crude oil prices affect other commodity prices such as the price of gold (Sari, Hammoudeh and Soytas, 2010), natural gas (Brown and Yücel, 2008; 2009) or food (Avalos, 2014; Baumeister and Kilian, 2014).

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Following the idea that a significant part of the electricity produced is generated using fossil fuels (i.e., crude oil, natural gas and coal), a recent strand of literature also examines the connection between crude oil prices, natural gas prices, coal prices and electricity prices (see, for example the pioneer work by Serletis and Herbert, 1999 and recent papers such as Mohammadi, 2009; Bosco et al., 2010; Nakajima and Hamori, 2012; 2013 and Frydenberg et al., 2014). In the present chapter, it is explored the impact of alternative energy prices such as crude oil, natural gas and coal prices on electricity prices in Mexico using an unrestricted vector autoregressive (VAR) model. The sample covers the period January 2006 to January 2016 and uses 14 electricity rates. This empirical study is close to that of Mohammadi (2009) who investigates the connection between electricity prices and fossil fuel prices in the U.S. economy.

There are two main contributions of this chapter to the emergent related literature. First, this chapter explores the nexus between crude oil, natural gas, coal and electricity prices in Mexico while previous studies focus on the U.S. (Serletis and Herbert, 1999; Emery and Liu, 2002; Mjelde and Bessler, 2009; Mohammadi, 2009; Nakajima and Hamori, 2012). In addition, others papers analyse the U.K. (Asche et al., 2006), Spain (Muñoz and Dickey, 2009; Furio and Chulia, 2012) and some European economies (Frydenberg et al., 2014; Bosco et al., 2010). Energy consumption in Mexico is highly dependent on fossil fuel and the industrial sector presents a significant dependence on electricity.

In the year 2014, for instance, fossil fuel energy consumption in Mexico (i.e., coal, oil and natural gas products) represented 89.6 percent of the total (World Bank, 2016). In addition, the Mexican industrial sector (which includes manufacturing) consumed 58.6 percent of the electricity (SENER, 2013). In this analisys, instead of using one electricity price as a reference for the national or domestic electricity sectors (see, for example, Mohammadi, 2009; Nakajima, 2012, 2013), it is considered alternative Mexican electricity prices. In particular, it includes alternative electricity prices such as the avoid cost (also known as CTCP) in four different Mexican electric areas -Acapulco, Durango, La Paz and Mazatlan-; public, domestic and commercial prices with low voltage tension; commercial and industrial prices with medium and high voltage tension (see the detailed definition of the relevant variables in Section 4, Table 3).

The structure of the chapter is as follows. Section 3.2 reviews the literature on the nexus between crude oil prices, natural gas prices, coal prices and electricity prices. In Section 3.3 the main institutional and technical characteristics of the Mexican electricity market are documented. Section 3.4 presents the dataset and a first look at the data. Section 3.5 covers the empirical analysis, in which an unrestricted vector autoregressive model is proposed to estimate the impact of fossil fuel prices on different electricity prices. Finally, section 3.6 presents the main results and conclusions.

3.2 Related literature review on fossil fuel prices and electricity prices

The pioneer work by Serletis and Herbert (1999) analyzes the relationship between the price behavior of natural gas, fuel oil, and electricity. Using daily data from October 25, 1996 to November 21, 1997 they find bivariate cointegration between the two natural gas spot markets prices and the fuel oil price. Since then, a number of studies have been published and the majority of them detect some interaction between crude oil, natural gas and electricity prices (see, for example, Emery and Liu, 2002; Asche et al., 2006; Woo et al., 2006; Mjelde and Bessler, 2009; Mohammadi, 2009; Muñoz and Dickey, 2009; Bosco et al., 2010; Furio and Chulia, 2012; Nakajima and Hamori, 2012, 2013 and Frydenberg et al., 2014 among many others).

Some studies investigate the relationship between electricity prices and natural gas prices. Emery and Liu (2002) investigate the relationship between electricity futures prices (i.e., New York Mercantile Exchange's California-Oregon Border and Palo Verde) and natural-gas futures prices. Their findings support that prices of electricity futures contracts are cointegrated with the prices of natural-gas futures contracts. Woo et al. (2006) find bi-directional causality between wholesale electricity and natural-gas prices in California using data from April 20, 1999 to December 30, 2004.

Alternatively, several studies introduce additional price variables in the empirical analysis (i.e., crude oil prices, coal prices and uranium prices). For example, Asche et al. (2006) find an integrated market between gas prices, oil prices and electricity prices in the U.K. over the period January 1995 to June 1998. Using weekly data from the U.S., Mjelde and Bessler (2009) investigate the dynamic price information flows between electricity wholesale spot prices and the prices of the major electricity generation fuel sources, natural gas, uranium, coal, and crude oil, are studied. They report in the short run that contemporaneous time peak electricity prices move natural gas prices. In the long run, they find that fuel source prices influence electricity prices. Mohammadi (2009) examines the long-run relation and short-run dynamics between electricity prices and three fossil fuel prices -coal, natural gas and crude oil-using U.S. annual data. He finds evidence of significant long-run relations only between electricity and coal prices. Oil prices do not play a significant role, and the effect of natural gas prices is statistically weak.

Also, there is some evidence of unidirectional short-run causality from coal and natural gas prices to electricity prices. He also suggests the absence of a unified energy market consisting of electricity, coal, natural gas and crude oil. Muñoz and Dickey (2009) analyze the relationships between Spanish electricity spot prices and the U.S. dollar/euro exchange rate during the period 2005–2007, taking into account the study of the association between the dollar and oil prices. Furio and Chulia's (2012) study investigates the causal linkages between the Spanish electricity, crude oil and natural gas prices over the period 2005–2011. Their findings support that crude oil and natural gas prices play a prominent role in the electricity price formation process. Furthermore, causation, both in price and volatility, runs from Brent crude oil and natural gas forward markets to the Spanish electricity forward market. Bosco et al. (2010), using data from six European economies (namely Germany, France, Austria, the Netherlands, Spain and the Nordic Countries) study long-run relations between electricity prices, gas prices and oil prices. Using cointegration, they find evidence of common long-term dynamics between electricity prices and gas prices. Recently, Frydenberg et al. (2014) study the cointegration relationship between electricity prices and related energy prices such as crude oil, natural gas and coal. Using daily data from 2006 to 2012 for the U.K., the German and the Nord Pool area (Norway, Sweden, Denmark, Finland, Latvia, and Estonia), they obtain cointegration between the U.K. electricity prices and coal and gas, and between Nordic electricity prices and coal.

3.3 Overview of the electricity sector in Mexico

3.3.1 Institutional and regulatory framework

The institutional framework of the Mexican energy sector consists of SENER, CRE and the Secretariat of Finance and Public Credit. SENER takes responsibility for energy policy. Since 1995, the CRE has been established as a regulatory authority. It was a consultative body which became an autonomous body of SENER.

From the point of view of the final destination of the energy, the SEN is made up of the public sector and the energy which is not provided to the public sector -private-. The CFE and all power plants built by PIE are part of the public sector. The power plants provide their entire electricity production to the CFE in order to supply the public service. Another sector integrates cogeneration, self-sufficiency, constant own use, small-scale production, importing and exporting. From theses modalities, self-sufficiency is the one which has the most capacity and it embraces the industrial, service and commercial sectors. From 1960 up to now, the Mexican energy sector has stood out for having a centralized organization.

A constitutional reform was passed on August 12nd, 2013. The initiative was promoted by the former President of the Republic. It was approved by the Senate and the Chamber of Deputies. On December 18th, 2013 the reformation was declared as constitutional by the Federal Legislative Power; it was promulgated on December 20th, 2013 and published the following day in the DOF. In July 2014, the LIE was approved. According to the constitutional reform and the Electrical Industry Law, a market to generate electric power was created.

This reform seeks to manage the SEN through the CFE and private companies under the leadership of the State, in order to reduce costs, increase productivity and the efficiency of the power system, and to finally reduce electricity tariffs. The reform establishes it as essential to reach the vertical disbanding of the generation, transmission, distribution and commercialization processes of electric power. The State should become the organizer of the SEN and energy policies will be developed by the Federal Executive.

Anything relating to system operation will be run by the State. Within a period of twelve months after the entry into force of the Regulatory Law of the electrical industry, the Federal Executive would set up the creation of a public decentralized body named CENACE. This body would be responsible for the operational control of the SEN. It also has to manage the electrical wholesaler market and the open or discriminatory access to the national transmission network and general distribution networks. The CFE should provide the material and human resources that the CENACE requires to meet its fulfilments.

The creation of a body which is responsible for the operational control together with the open access to transmission are essential conditions for completely opening the energy sector to competition in the generation and commercialization activities of electric power. It was expected that there would be many participants who would invest in generation infrastructure, being necessary that the energy produced reaches consumers through the national transmission network and the distribution networks, controlled by the State. The control of the SEN should be carried out by a neutral operator to maintain his impartiality with respect to the participants of the electricity market. This distinction guarantees that the coordination of the power plants is done under minimal cost criteria to the system, eradicating conflicts of interest and avoiding the favoring of a particular company.

Consequently, the CENACE will exercise the operational control of the system. It will determine which power plants will operate at any time, and their production levels, instructing on the necessary works in the transmission and distribution networks to keep the security, reliability, quality and continuity as well as the efficiency in production. CENACE will take responsibility for the electrical wholesaler market, in which public and private electricity generation companies will make offers at competitive prices (variable costs); and, at the same time, electricity traders can also satisfy demand. In order to be able to do this, the decentralized public body will make use of the market rules to choose the power plants which will satisfy demand at the lowest cost possible.

Moreover, the neutral operator will plan the network expansion to optimize the infrastructure in favor of the users and will allow the interconnections to be made with transparency and under no discriminatory conditions.

SENER will implement mechanisms to meet the policy objectives related to the diversification of energy sources, energy security and the promotion of renewable energy sources. In order to reach these objectives, SENER will establish duties to achieve renewable energy certificates or pollution emission certificates. The applicable regulation will make theses certificates negotiable and permit the move of surplus and shortage certificates between different periods to promote price stability.

3.3.2 Supply and demand

Within the organization of the economic dispatch proposed by the new LIE, power plants have to generate according to the increasing order of variable costs in production (economic dispatch). The transmission system (in the public domain and with free access) provides the transmission service to market operators and auto-generators, whose demand and capacity of generation are not in the same node of the network. Table 16 displays the evolution of total electricity generation in Mexico during the period 2010-2015. In the year 2015, the total generation (CFE + PIE) reached 261.07 TWh (including losses in distribution and transmission) (SENER, 2015).

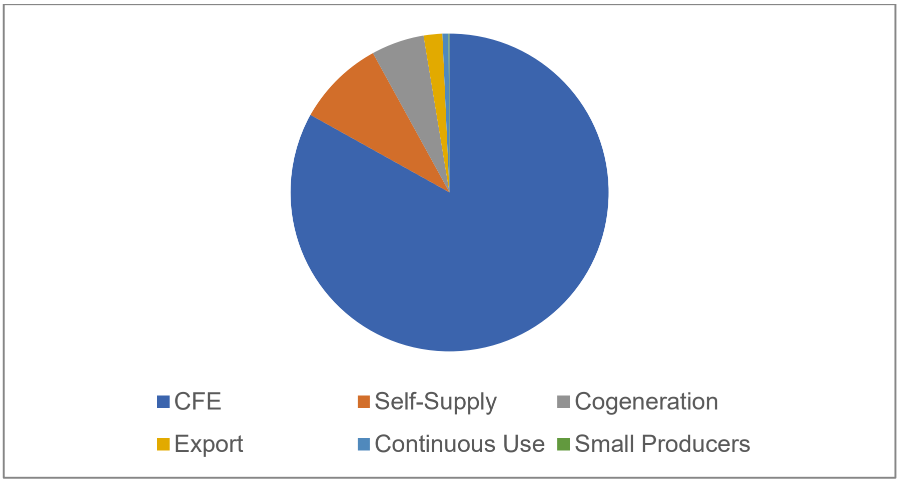
Table 16. Evolution of total electricity generation in Mexico

Year	SIN + Isolated	Baja California	Baja California South	Total
2010	227.976	11.395	2.135	241.506
2011	244.026	11.608	2.249	257.883
2012	246.226	11.994	2.279	260.499
2013	243.400	12.088	2.367	257.855
2014	243.471	12.430	2.355	258.256
2015	246.121	12.565	2.380	261.067

Source: The data are expressed in GWh. The data are obtained from SENER.

Related to last information provided by SENER, Mexico has an effective installed capacity of generation (December 2014) of 65,451.8 MWh (public service, it includes the contracted capacity under the diagram PIE), 995.5 MWh more than December 2013. 83.1% corresponds to CFE (54.366,9 MWh), 8.9 % is self-supply, 5.4% cogeneration, and the last 2.7% to other self-supply. Figure 24 shows the installed capacity by modality in Mexico in the year 2014.

Figure 24. Mexican installed capacity depending on legal modality in the year 2014



Source: Data are obtained from SENER, the Federal Electricity Commission and Energy Regulatory Commission.

Table 17 displays the production of different types of technology in Mexico during 2014 and 2015. This capacity generation is made up mainly from steam turbine power plants, using fuel oil (bunker) and coal, and also combined cycle thermal power plants, using natural gas as fuel (or diesel when there are limitations to using natural gas). The rest of generation corresponds to hydro-electro power plants, nuclear power plants, geothermal power stations and wind farms, gas turbines and engines. In the last 5 years, the Mexican evolution in power generation has been carried out mainly with the inclusion of new combined cycles to natural gas thanks to contracts (Independent Power Producers contracts) with private producers. The generation of thermoelectric power migrated from conventional thermoelectric power plants to combined cycle ones. It was done mainly because of the global efficiency of generation and it also reduces emissions.

Table 17. Production of different types of technology in Mexico during 2014-2015

	Year 2014		Year 2015	
	Production*	Participation	Production*	Participation
Total	258255.8	100%	261.066,8	100%
Thermoelectric power	168731.5	65%	177148.9	68%
Vapour	33480.8	13%	35673.2	14%
Combined cycle	130907.4	51%	134486.6	52%
CFE	47057.4	18%	47513.3	18%
PIE	83850.0	32%	86973.3	33%
Turbogas	2877.6	1%	5281.1	2%
Internal combustion	1465.7	1%	1707.9	1%
Dual (coal/FO)	16167.0	6%	3475.2	1%
Coal thermoelectric	17445.9	7%	30124.0	12%
Geothermal energy	5999.7	2%	6291.2	2%
Nuclear power	9677.2	4%	11577.1	4%
Wind	2077.0	1%	2386.9	1%
CFE	212.6	0%	202.9	0%
PIE	1864.4	1%	2184.0	1%
Hydroelectric power	38144.8	15%	30050.8	12%
Photovoltaics	12.7	0%	12.8	0%

*Source: Data are obtained from SENER, the Federal Electricity Commission and Energy Regulatory Commission. * means that total production data are expressed in TWh. CFE denotes the Federal Electricity Commission, PIE denotes the Independent Power Producers and FO means fuel oil.*

3.4 Dataset and a first look at the data

This analysis uses 14 Mexican electricity prices-rates, the crude oil West Texas Intermediate at Cushing, the Henry Hub natural gas spot price and the NYMEX Central Appalachian coal futures settlement prices. The Mexican electricity prices are expressed in Mexican pesos per kWh and are obtained from CFE (see the web page http://www.cfe.gov.mx/). The natural gas price is expressed in U.S. dollars per million BTU and the crude oil price is expressed in U.S. dollars per BBL. The coal price data is expressed in U.S. dollars per short ton. Crude oil, natural gas and coal futures prices are obtained from the U.S. Department of Energy′s, Energy Information Administration (see the web page http://www.eia.gov/). To define local or domestic fossil fuel prices -crude oil, natural gas, coal-, the Mexico/U.S. foreign exchange rate is employed; Mexican new pesos to one U.S. dollar obtained from the Federal Reserve Bank of St. Louis (see the web page https://research.stlouisfed.org). Monthly data from the period January 2006 to January 2016 is used except for the variable e^{CTCP} which starts in January 2008. Table 18 displays a detailed definition of all the variables.

Table 18. Variables description

Variable	Definition
o	Crude oil prices.
g	Natural gas prices.
c	Coal prices.
e^{DAC}	This rate applies to energy services intended exclusively for domestic use, individually to each residence, apartment, condominium or apartment housing which would be considered as a high consumption.
e^{T2_5}	This rate will apply to first 50 kWh under the tariff e^{T2}. Where e^{T2} is defined as the general service up to 25 kW of demand. This rate will apply to all services intended for low voltage energy to any use, with demand up to 25 kilowatts, except for services which specifically binds his rate.
e^{T2_10}	This rate will apply to second 50 kW under the tariff e^{T2}.
e^{T3}	General service for more than 25 kW demand. This rate will apply to all services intended for low voltage energy to any use, with the demand of more than 25 kilowatts, except for services which specifically binds your rate.
e^{T5}	Service for street lighting. This fee only applies to the supply of electricity for the service traffic lights, ornamental lighting and seasonal lighting, streets, squares, parks and public gardens. In the cities of Mexico City, Monterrey and Guadalajara.
e^{T5A}	Service for street lighting. This fee only applies to the supply of electricity for the service traffic lights, ornamental lighting and seasonal lighting, streets, squares, parks and public gardens across the country excepting the constituencies for which governs the rate in T5.

e^{T6}	Service for pumping drinking water or sewage public service. This rate will apply to the supply of electricity for public service pumping drinking or sewage.
e^{OM}	Ordinary rate for general service medium voltage, with less than 100 kW demand. This rate will apply to services intended for energy for any use, supplied medium voltage with lower demand 100 kW.
e^{HM}	Hourly rate for general service medium voltage with the demand of 100 kW or more. This rate will apply to services intended for energy for any use, supplied medium voltage, with a demand of 100 kilowatts or more.
e^{HS}	Hourly rate for general high voltage sub-transmission level. This rate will apply to services intended for energy to any use, supplied high voltage sub-transmission level, and that the characteristics of use of your claim request register for this service, which will have a validity of one year.
e^{CTCP}	Short-run total cost: unit cost variable generation on the marginal plant unit cost + variable transmission between the marginal plant and the interconnection point of the permittee. In this chapter, it uses e^{CTCP_D}, $e^{CTC\ \_P}$, e^{CTCP_A} and e^{CTCP_M} which corresponds to the avoided cost in Durango, La Paz, Acapulco and Mazatlan I respectively.

Source: Crude oil prices, natural gas prices and coal prices are obtained from the U.S. Department of Energy's, Energy Information Administration. Electricity prices are obtained from the Federal Electricity Commission.

Table 19 includes the summary statistics of the logarithms of each energy price variable. The electricity prices e^{CTCP} present the highest volatility while e^{T2_5} and e^{T2_10} document the lowest volatility. The reason for those different volatilities are because e^{CTCP} represents the real time marginal cost. Marginal cost represents the avoided cost in the area, and the avoided cost is determined by the marginal generation plant. The marginal generation plant is different any time and it changes from one fuel source to another depending on energy demand. The electricity rates e^{T2_5} and e^{T2_10} represent the commercial electricity tariff with the widest margin for CFE.

Table 19. Basic statistics

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jar. Bera
o	2.988	3.143	2.737	0.111	-0.440	2.024	8.709
g	1.747	2.117	1.406	0.135	0.277	2.802	1.745
c	2.858	3.158	2.633	0.102	0.013	3.284	0.408
e^{DAC}	0.507	0.589	0.364	0.064	-0.643	2.154	1.195
e^{T2_5}	0.417	0.487	0.320	0.046	-0.260	1.795	8.680
e^{T2_10}	0.418	0.488	0.321	0.046	-0.261	1.794	8.694
e^{T3}	0.167	0.264	0.061	0.058	-0.104	1.713	8.563
e^{T5}	0.349	0.474	0.224	0.073	8.05E-05	1.800	7.258
e^{T5A}	0.266	0.391	0.140	0.073	0.002	1.799	7.269
e^{T6}	0.143	0.276	0.016	0.073	-0.005	1.815	7.070
e^{HM}	0.030	0.155	-0.108	0.076	-0.105	1.586	1.029
e^{HS}	0.020	0.136	-0.116	0.068	-0.108	1.723	8.450
e^{OM}	0.069	0.183	-0.070	0.074	-0.276	1.708	9.951
e^{CTCP_D}	0.054	0.363	-0.281	0.186	-0.071	1.728	6.134
e^{CTCP_P}	0.446	0.678	0.063	0.134	-0.671	3.070	6.775
e^{CTCP_A}	0.066	0.375	-0.287	0.191	0.081	1.674	6.683
e^{CTCP_M}	0.065	0.385	-0.253	0.189	0.037	1.675	6.600

Source and notes: The sample period runs from January 2006 (January 2008 for e^{CTCP}) to January 2016.

3.5 Empirical analysis

A preliminary step in this empirical analysis is the determination of the order of integration of the relevant time series. Following previous related studies (i.e., Emery and Liu, 2002; Mohammadi, 2009), this study applies the augmented Dickey-Fuller (Dickey and Fuller, 1979, 1981) and the Phillips-Perron (Phillips and Perron, 1988) unit root tests. It runs the augmented Dickey-Fuller and the Phillips-Perron tests for both the level and the first-difference of our variables. In addition, it also runs the augmented Dickey-Fuller and the Phillips-Perron unit root tests considering both constant and constant and linear trends. The lag length of the augmented Dickey-Fuller unit root test is determined by the Schwarz information criterion. For each price variable, the results fail to reject the null hypothesis of unit roots in the level but reject the hypothesis in first-differences (see Table 20). Thus, it can be concluded that crude oil, natural gas, coal and electricity prices are first-difference stationary, and proceed to tests of cointegration. This initial results are in line with previous studies such as Mohammadi (2009) and Frydenberg et al. (2014).

Table 20. Augmented Dickey–Fuller and Phillips-Perron unit root test results

	Augmented Dickey-Fuller		Phillips-Perron	
	Constant	Constant and linear trend	Constant	Constant and linear trend
Original series (in logs)				
o	-2.407	-2.030	-2.043	-1.518
g	-2.266	-3.030	-2.360	-2.853
c	-1.973	-2.009	-2.382	-2.472
e^{DAC}	-2.178	-2.158	-2.014	-1.323
e^{T2_5}	-1.733	-3.487**	-1.804	-2.690
e^{T2_10}	-1.730	-3.489**	-1.804	-2.685
e^{T3}	-2.459	-2.313	-2.027	-1.520
e^{T5}	-0.436	-5.913*	0.332	-3.689**
e^{T5A}	0.444	-4.857*	-0.002	-3.252***
e^{T6}	4.729*	-174.567*	-1.621	-11.092*
e^{OM}	-2.449	-2.247	-1.910	-1.252
e^{HM}	-2.549	-2.285	-1.914	-1.345
e^{HS}	-2.607***	-2.391	-1.958	-1.561
e^{CTCP_D}	-2.493	-2.611	-2.220	-2.185
e^{CTCP_P}	-1.659	-0.622	-3.797*	-3.650**
e^{CTCP_A}	-2.567	-2.578	-2.270	-2.300
e^{CTCP_M}	-2.514	-2.536	-2.120	-2.160
First difference (in logs)				
o	-7.956*	-5.629*	-7.934*	-8.119*
g	-6.919*	-6.886*	-10.194*	-10.143*
c	-10.486*	-10.448*	-10.655*	-10.619*
e^{DAC}	-7.582*	-7.776*	-7.612*	-7.768*
e^{T2_5}	-8.546*	-8.510*	-8.510*	-8.540*
e^{T2_10}	-8.520*	-8.484*	-8.492*	-8.518*
e^{T3}	-4.581*	-4.744*	-8.457*	-8.553*
e^{T5}	-5.677*	-5.682*	-4.317*	-4.128*
e^{T5A}	-4.049*	-4.033**	-4.148*	-4.128*
e^{T6}	-19.15*	-21.975*	-24.171*	-24.052*
e^{OM}	-4.313*	-4.517*	-7.958*	-8.104*
e^{HM}	-8.035*	-8.144*	-8.035*	-8.144*
e^{HS}	-4.549*	-4.690*	-8.662*	-8.739*
e^{CTCP_D}	-5.452*	-5.578*	-9.789*	-9.830*
e^{CTCP_P}	-2.564	-3.212	-10.903*	-10.927*
e^{CTCP_A}	-6.102*	-6.085*	-10.274*	-10.237*
e^{CTCP_M}	-5.893*	-5.196*	-9.553*	-9.538*

*Source and notes: *, ** and *** denotes a statistic is significant at the 1%, 5% and 10% level of significance respectively. The lag length of the augmented Dickey-Fuller unit root tests is determined by the Schwarz information criterion. The spectral estimation method of the Phillips-Perron unit root test is the Bartlett kernel with the Newey-West bandwidth. The sample period runs from January 2006 (January 2008 for e^{CTCP}) to January 2016.*

Once the unit root behavior of the energy price series has been identified, it is tested for cointegration using both the trace and the maximum eigenvalue tests (Johansen and Juselius, 1990). Table 21 reports the trace and the maximum eigenvalue tests for the four-variable model (i.e., crude oil, natural gas, coal and electricity prices). When it considers $r \leq 3$, $r \leq 2$

and r ≤ 1 (where r is the number of cointegrating vectors), both trace and maximum-eigenvalue statistics are below their 5 percent significance levels suggesting a lack of cointegration between the four energy prices. Using U.S. annual data of oil, gas, coal and electricity prices, Mohammadi (2009) also obtains that the null hypothesis of no-cointegration in the four-variable model cannot be rejected.

Table 21. Johansen and Juselius cointegration tests (variables: crude oil prices, natural gas prices, coal prices and electricity prices)

	r = 0		r ≤ 1		r ≤ 2		r ≤ 3	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
e^{DAC}								
Trace statistic	40.363	76.722*	16.593	32.770	5.772	11.701	1.870	3.026
Max-eigen statistic	23.769	43.952*	10.820	21.068	3.902	8.675	1.870	3.026
e^{T2_5}								
Trace statistic	36.810	58.041	11.002	32.123	4.170	9.324	0.738	2.810
Max-eigen statistic	25.807	25.917	6.831	22.798	3.432	6.514	0.738	2.810
e^{T2_10}								
Trace statistic	36.859	58.119	10.989	32.143	4.163	9.316	0.721	2.817
Max-eigen statistic	25.870	25.975	6.826	22.827	3.441	6.498	0.721	2.817
e^{T3}								
Trace statistic	51.697*	71.101*	17.777	32.255	4.697	8.774	1.881	2.606
Max-eigen statistic	33.919*	38.845*	13.081	23.481	2.816	6.168	1.881	2.606
e^{T5}								
Trace statistic	28.151	67.032*	10.242	26.802	4.579	8.962	0.874	3.302
Max-eigen statistic	17.909	40.230*	5.662	17.840	3.705	5.659	0.874	3.302
Trace statistic	33.955	58.748	13.095	29.062	4.380	12.537	0.053	4.285
Max-eigen statistic	20.860	29.686	8.714	16.524	4.326	8.251	0.053	4.285
e^{T6}								
Trace statistic	31.631	59.461	11.241	30.052	4.682	10.180	0.430	3.865
Max-eigen statistic	20.390	29.408	6.558	19.872	4.251	6.314	0.430	3.865
e^{OM}								
Trace statistic	49.526*	77.503*	17.995	32.040	4.427	10.440	1.509	2.653
Max-eigen statistic	31.530*	45.462*	13.568	21.599	2.917	7.787	1.509	2.653
e^{HM}								
Trace statistic	62.372*	79.836*	18.852	32.430	3.621	9.944	1.040	2.550
Max-eigen statistic	43.519*	47.405*	15.231	22.486	2.581	7.393	1.040	2.550
e^{HS}								
Trace statistic	58.206*	72.104*	17.658	30.195	3.530	8.527	1.104	2.424

Max-eigen statistic	40.547*	41.908*	14.128	21.667	2.426	6.103	1.104	2.424
e^{CTCP_D}								
Trace statistic	37.145	55.550	18.795	31.084	5.364	13.750	1.887	2.805
Max-eigen statistic	18.344	24.466	13.430	17.334	3.477	10.944	1.887	2.805
e^{CTCP_P}								
Trace statistic	61.683*	69.889*	20.731	28.560	6.828	8.581	2.001	3.113
Max-eigen statistic	40.951*	41.329*	13.903	19.978	4.827	5.468	2.001	3.113
e^{CTCP_A}								
Trace statistic	35.905	49.970	20.023	23.260	6.583	7.529	2.053	2.820
Max-eigen statistic	15.881	26.710	13.440	15.730	4.530	4.708	2.053	2.820
e^{CTCP_M}								
Trace statistic	35.657	49.896	19.676	23.557	6.846	7.629	2.216	2.849
Max-eigen statistic	15.981	26.339	12.829	15.92784	4.629	4.780	2.216	2.849

*Source and notes: r denotes the number of cointegrating vectors. (i) and (ii) mean exclusion or inclusion of a linear trend in the test equation, respectively. * denotes rejection of the null hypothesis at the 5% level of significance. The sample period runs from January 2006 (January 2008 for e^{CTCP}) to January 2016.*

In the next step, an unrestricted VAR model is estimated for each of the electricity rates. A VAR model of order p that includes k variables can be expressed as:

$$y_t = A_0 + \sum_{i-1}^{p} A_i y_{t-i} + \varepsilon_t, \qquad (1)$$

where p is the number of lags, $y_t = [y_{1t} \dots y_{kt}]'$ is a column vector of all the variables in the model (first difference of crude oil prices, first difference of natural gas prices, first difference of coal prices and first difference of electricity prices); A_0 is a column vector of constant terms; A_i is a $k \times k$ matrix of unknown coefficients; and ε_t is a column vector of errors with the following properties:

$$E(\varepsilon_t) = 0 \qquad \forall t,$$

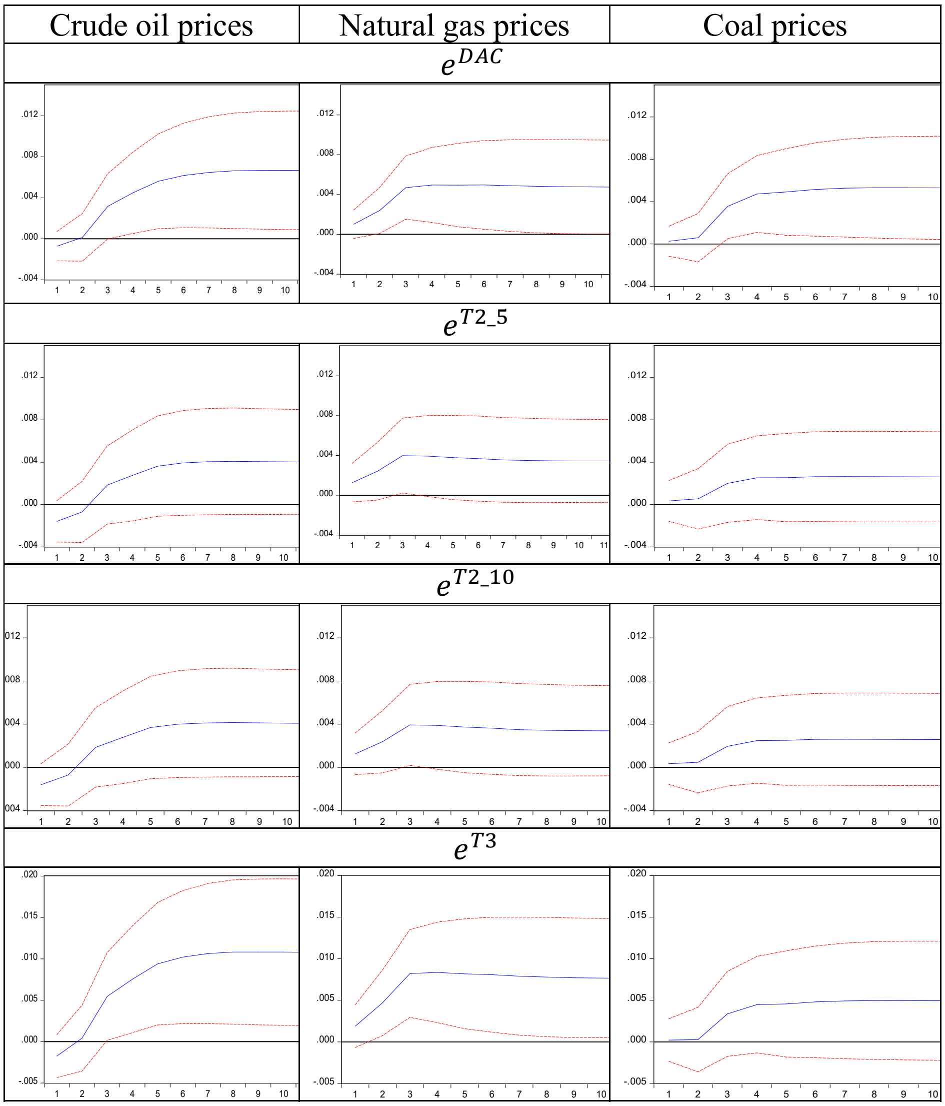
$$E(\varepsilon_s \varepsilon_t') = \Omega \qquad if\ s = t,$$

$$E(\varepsilon_s \varepsilon_t') = 0 \qquad if\ s \neq t,$$

where Ω is the variance-covariance matrix with non-zero off-diagonal elements. The orthogonalized impulse responses of the variables in the model are obtained as a moving average representation of a four-variables VAR with variables placed in the following order: first log difference of crude oil prices, first log difference of natural gas prices, first difference of coal prices and first log difference of electricity prices. The lag length is selected according to the Akaike information criterion. The dashed lines represent the 95% confidence intervals for the response of each electricity rate to crude oil, natural gas and coal prices.

Figure 25 displays the generalized impulse response functions of domestic and commercial electricity rates to the following variables: crude oil, natural gas and coal prices (in the first, second and third column respectively). Initially, the impulse response function of the domestic electricity tariff is displayed, e^{DAC}. In the short-run, a significant positive is found for the impact of crude oil prices, natural gas and coal prices on e^{DAC}. When the commercial electricity rates are included in the VAR model, -e^{2_5}, e^{2_10}, e^{3}-, only a significant positive impact of crude oil prices and natural gas prices on e^{3} is obtained.

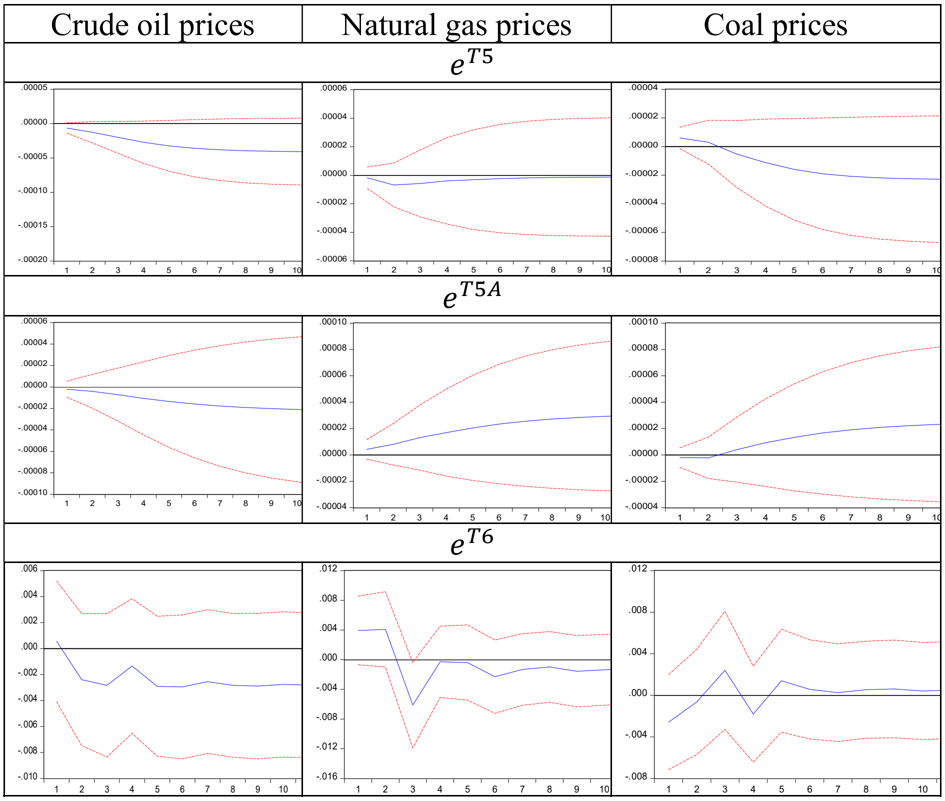
Figure 25. Response of electricity prices (domestic and commercial rates) to fossil fuel prices (crude oil, natural gas and coal)



Source and notes: The dashed lines represent the 95% confidence intervals for the response of electricity prices (domestic and commercial rates) to crude oil, natural gas and coal prices.

Figure 26 presents the response of electricity prices -public rates such as e^{T5}, e^{T5A} and e^{T6}- to crude oil, natural gas and coal prices. In all cases, a significant impact of fossil fuel prices on public electricity rates is not found in the short-run.

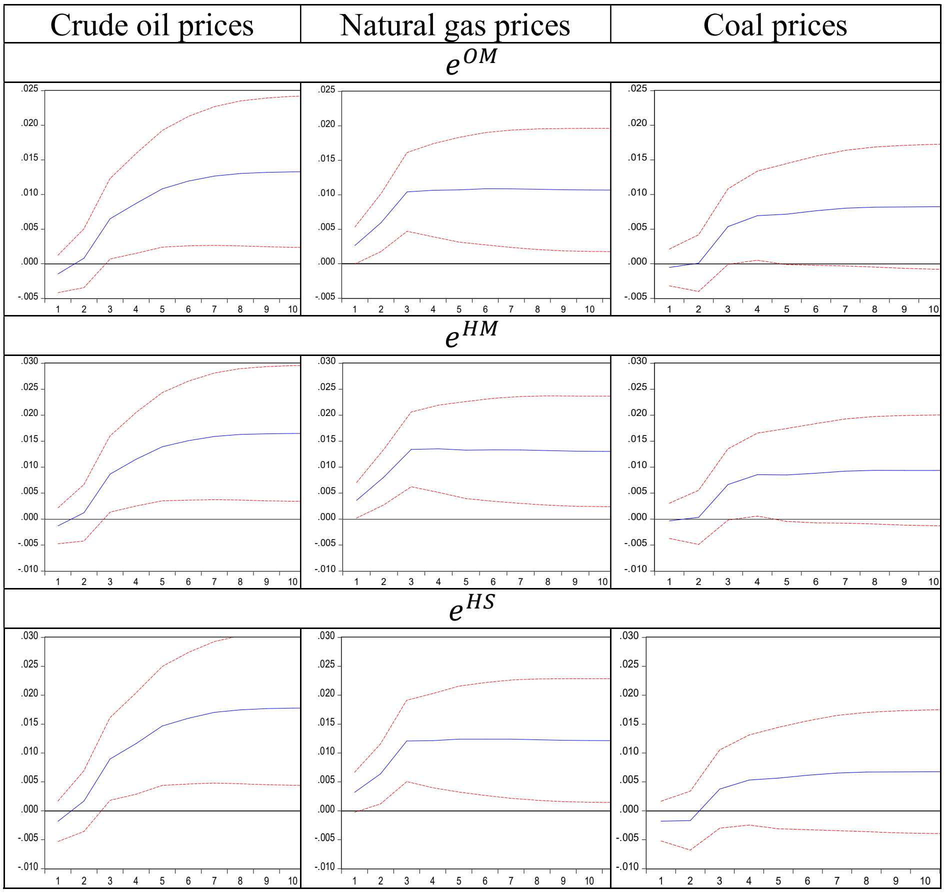
Figure 26. Response of electricity prices (public rates) to fossil fuel prices (crude oil, natural gas and coal)



Source and notes: The dashed lines represent the 95% confidence intervals for the response of electricity prices (public rates) to crude oil, natural gas and coal prices.

In the next step, the industrial electricity rates are included in the unrestricted VAR model. Figure 27 displays the generalized impulse response functions of three industrial electricity rates to fossil fuel prices. In all cases, a positive significant impact of crude oil prices and natural gas prices is found on the industrial electricity rates, namely e^{OM}, e^{HM} and e^{HS}.

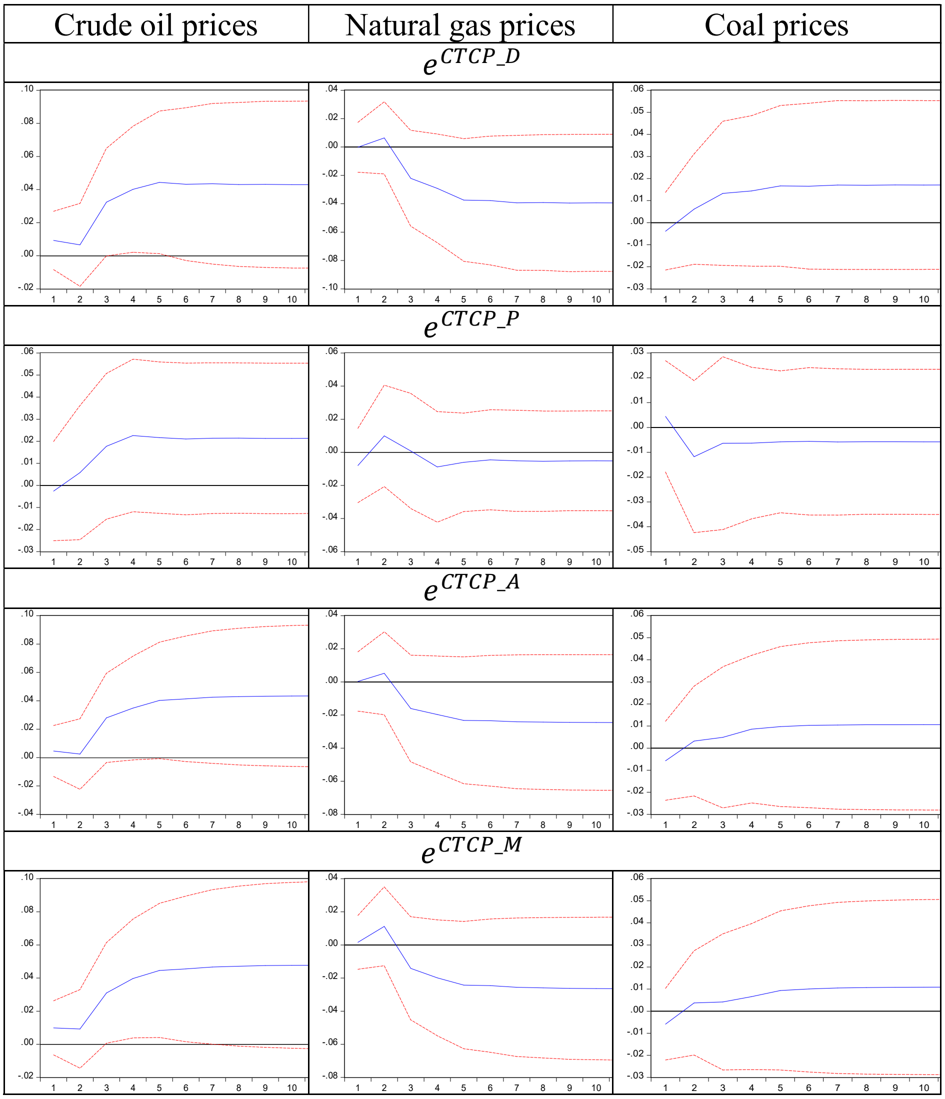
Figure 27. Response of electricity prices (industrial rates) to fossil fuel prices (crude oil, natural gas and coal)



Source and notes: The dashed lines represent the 95% confidence intervals for the response of electricity prices (industrial rates) to crude oil, natural gas and coal prices.

Finally, this study presents the generalized impulse response functions of four electricity rates (short-run total cost) to fossil fuel prices (Figure 28). The different electricity variables e^{CTCP_D}, e^{CTCP_P}, e^{CTCP_A} and e^{CTCP_M} do not react to crude oil, natural gas or coal prices.

Figure 28. Response of electricity prices (avoided costs) to fossil fuel prices (crude oil, natural gas and coal)



Source and notes: The dashed lines represent the 95% confidence intervals for the response of electricity prices (avoided costs) to crude oil, natural gas and coal prices.

The reason for the previous result is that the price adjustment factor for medium and high voltage tariffs are closer to the combustible price adjustment factor than for the low tension tariff. This result is explained with the price adjustment factor (*Comisión Federal de Electricidad*, 2016). The alternative electricity rate variable e^{CTCP} does not react to crude oil prices just because of its definition. This electricity rate - electricity tariff- represents an avoided cost in the area, and the avoided cost is determined by the marginal generation plant. This marginal generation plant is different any time, so sometimes it is determined by a carbon plant, at other times by a gas plant, and at others by a crude oil plant. It was also found that the price adjustment factor explained the disappearing impact on municipal tariff. In summary, the price adjustment factor for those tariffs essentially depends on producer price inflation and cost price national inflation.

3.6 Impact of fossil fuel prices on electricity prices in Mexico conclusions

This chapter investigates the impact of fossil fuel prices on different electricity prices in the Mexican economy using an unrestricted vector autoregressive model. To the best of our knowledge, this is the first document that examines the Mexican economy using alternative electricity rates such as domestic, commercial, industrial, public and avoid costs.

The following empirical results were obtained. First, it can be seen that all fossil fuel prices and electricity prices in levels form are non-stationary, but when first differenced, they become stationary. Second, no evidence is found of cointegration between the four energy prices (crude oil, natural gas, coal and the 14 electricity prices). Third, the unrestricted vector autoregressive model suggests a significant positive impact of crude oil, natural gas and coal prices on domestic electricity rates in the short-run. Finally, a significant positive impact is also found for crude oil prices and natural gas prices on commercial -e^3- and industrial rates -e^{OM}, e^{HM} and e^{HS}-.

Chapter 4

Barriers to the development of the Solar Photovoltaic Sector in Egypt

4.1 Introduction

This chapter of the thesis examines the energy sector in Egypt focusing on the photovoltaic sector and the barriers therein to the development of large plants. Previous studies that also analyze the Egyptian energy sector are Khalil et al. (2010), Breisinger et al. (2019) and Mondal et al. (2019).

The sector is analyzed using the information provided by Eosol, one of the relevant actors in the country during the years 2009 to 2020, and its local business partners[81]. The Eosol team has been present in the area since 2008 and have participated in several combined cycle projects (see, for example, Cairo West II, El Kureimat, El Tebbin and Nubaria) delivering supervision and commissioning services to an experienced contractor, and being in charge of the BOP of the CC. Since starting in 2008, they have been involved in one way or another in the main renewable projects in the country.

The objective of this chapter is to analyze the main barriers to the development of large plants using the last 10 years' experience of one of

[81] North Energy: a Saudi- based renewable energy company. With strong financial support and wide geographic coverage, North Energy operates in the IPP market through subsidiaries and partners in several countries in the Middle East and Africa. Among these, EOSOL became its technological partner.
GIZA Systems: Established in 1974 in Egypt, GIZA Systems is a leading systems integrator in the MEA region, it designs and deploys industry-specific technology solutions for asset-intensive industries such as the telecoms, utilities, oil and gas, hospitality and real estate among other market sectors. We help our clients streamline their operations and businesses through our portfolio of solutions, managed services, and consultancy practice. Our team of 1000 professionals are spread throughout the region with anchor offices in Cairo, Riyadh, Dubai, Doha, Nairobi, Dar-es-Salaam, Abuja, Kampala and New Jersey, allowing us to service an ever-increasing client base in over 40 countries.
Elsewedy Electric: Established in 1938 as a manufacturer of electrical components in Egypt, Elsewedy has evolved into a global provider of energy, digital and infrastructure solutions with a turnover of EGP 46.6 billion in 2019. Listed on the Cairo stock exchange since 2006, it operates in five key business sectors: Wire & Cable, Electrical Products, Engineering & Construction, Smart Infrastructure and Infrastructure Investments.

the leaders and it will be made clear why one of the highest solar resource countries in the world that had a highly active and power sector some years ago, is not currently building even faster or even but in fact the sector today is almost non-existent.

The structure of the chapter is as follows. Section 4.2 presents an overview of the energy sector in Egypt. Section 4.3 describes the photovoltaic sector in Egypt. In Section 4.4 the main barriers to the development of large plants is analyzed. Section 4.5 includes some government initiatives relating to the energy sector. In Section 4.6 I will describe some real cases of projects that have not yet come to fruition (some of them may still have a chance in the future) despite being well planned. Finally, Section 4.7 concludes and presents a final discussion.

4.2 An Overview of the energy sector in Egypt

Egyptian GDP per capita was 3,020 current US$ in 2019, considering the GDP economic scale, which makes it above only Gjibouti, not far from others such as Tunisia (3,317.5), Algeria (3,948.3) or Jordan (4,330.3) and very far from the rich countries in the region such as Qatar (64,781.7), Israel (43,641.4) or the United Arab Emirates (43,103.3) (World Bank, 2021)[82]. It lies sixth from among the surrounding countries that have electricity inter-connections, whether directly or indirectly due to its estimated total population (100,400,000) (United Nation, 2019).

In terms of electric power, even though it was one of the first countries to use electricity as it began to light its streets with electricity before most European cities. Electricity per capita consumption is 1,591 kWh, which, compared again with the neighboring countries, puts it at the level of Tunisia (1,306), Algeria (1,300) or Jordan (1,665), but far again from Qatar (13,149), Israel (6,075) or the United Arab Emirates (11,586) (World Bank, 2021).

If the country's energy history is analyzed it can be seen how in 1864, a French businessman named Charles Lebon gained the usufruct contract to supply natural gas and street lighting to Cairo and Alexandria (Abu-Lughod, 1965). Once he succeeded to cary out the first part of his contract, he began to deliver electricity in Cairo in 1893 followed by Alexandria in

[82] Egypt has a privileged excellent and very distinguished location between the three continents of Africa, Europe and Asia. This adds great value to Egypt’s plans to be an energy hub in the area.

1894 then Port Said and Tanta in 1902. Until 1920 this supply was gradually expanded to most of the country's cities.

At the beginning, electricity was only used for lightening purposes and it was only in 1930 that Egypt began to use electricity for industrial and agricultural purposes.

The electricity sector was led by private companies since the first use of electricity in the country up until 1962, when President Nasser nationalized the whole sector; (i.e. power plants – transmission lines – distribution companies).

In 1996 President Mubarak opened the electricity sector to private initiatives again, allowing them to construct, operate and maintain power plants under law No. 100, which also allowed them to use the public grid to transport and sell their generated electricity.

Thus the main historical milestones in the development of the electricity sector from 1893 till today in Egypt are as follows[83]:

- 1893: First contract to supply electricity in Cairo and Alexandria.
- 1962: President Nasser nationalized all the companies working in the electrical field; i.e. production facilities, transmission lines and distribution points and ordered to set up three authorities for:
    - Electricity Production Authority
    - Electricity Transmission and Distribution Authority
    - Electricity Projects Authority
- 1965: General Egyptian Electricity Authority was created to replace the former three authorities.
- 1976: Some improvements and more powers were granted to the General Egyptian Electricity Authority
- 1978: Seven Distribution Companies were created to take over the distribution and the sale of electricity to all consumers.
- 1983: The General Authority for Electricity Distribution was created to supervise the work of seven minor distribution companies.
- 1996: Law No. 100 that allows private sector, local and foreign investors, to construct, operate and maintain electricity production facilities.

[83] For more references about the electrical history of Egypt, review the book: Energy sources in Egypt and their development prospects, from Dr. Engineer / Mohamed Mounir Megahed.

- 1997: Presidential decree No. 326 to set up EgyptERA (Egyptian Electric Utility and Consumer Protection Regulatory Agency) for customer protection and organize the relationship between all the related governmental entities and the customers.
- 1998: Reformation has been carried out on the structure of the electricity authorities in Egypt as follows: All the distribution companies has been merged into seven new commercial companies and the General Egyptian Electricity Authority has been responsible for Ultra High Voltage (UV) transmission lines and planning for new electricity projects in the country.
- 2000: A separation has been made, under Law No. 164, between production, transmission, and distribution companies leaving them as follows:
    - 4 thermal electricity production companies,
    - 1 hydropower production company,
    - 7 electricity distribution companies, and
    - 1 transmission company.

  All these companies are subsidies of the EEHC (Egyptian Electricity Holding Company) (Egyptian Ministry of Electricity and Renewable Energy , 2021).[84]
- 2012: The electric situation of the country becomes impossible. The electricity cut-off frequency had reached unprecedented levels that left many business sectors seriously threatened. Simultaneously, there was a major crisis in fossil fuel in general and in diesel specifically, since farmers in the newly reclaimed land in Egypt depended basically on diesel for fuel in their typically isolated farms. Diesel was traded on the black market at up to 3 times its official price, this situation has resulted in catastrophic results especially for the small and medium-sized farmers who own small pieces of land as little as 5 feddans[85] and up to 100 feddans. Those farmers were the biggest victims of the crisis because they could not afford to store diesel in large quantities when it was available in order to use during shortages, so they were squeezed between the black market and the official lack of diesel.

[84] For a detailed information, see the web page of the Egyptian Ministry of Electricity and Renewable Energy, http://www.moee.gov.eg/test_new/history2.aspx. The Evolution of electricity in Egypt.
[85] Feddans is a unit of measure equivalent to 4.200 square meters.

The situation described in 2012 provoked an inflexion point in the Egyptian Energy policy leading to a completely different scenario in 2020.

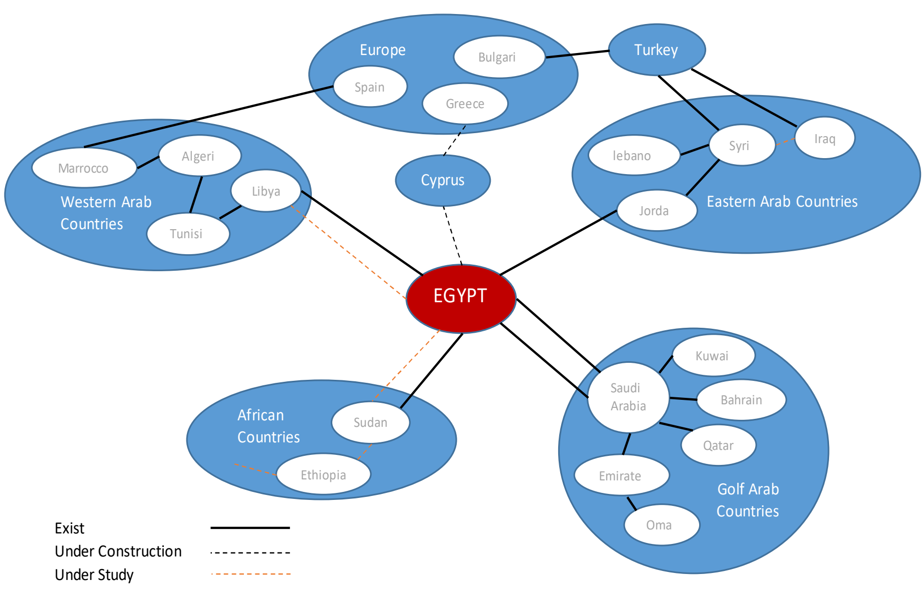
4.2.1 The influence of Egypt in the energy sector in the surrounding areas

Egypt exercises cultural leadership over its surrounding countries, due to its history and its culture. All the countries of Arab influence consider the Egyptians as the natural leaders of their culture and therefore key strategic decisions for the Middle East and East African countries are taken in Cairo.

The electricity sector could not be different, so Egypt has set itself a very ambitious goal, which is to become an energy hub for all the surrounding countries. To this end, it has signed several agreements with Jordan, Libya, Sudan, Saudi Arabia, Cyprus and China, to expand or build new transmission networks allowing them to export energy from Egypt to all the surrounding countries and even to Europe.

The following graph depicts how the network projected by Egypt would look.

Figure 29. Actual and planned Egyptian interconnection with neighboring countries



Source: Own elaboration.

To achieve this goal, Egypt has joined many regional and international organizations such as the Mediterranean Transmission System Operators (MED-TSO), the Union for the Mediterranean (UFM) and the Global Energy Interconnection Development and Cooperation Organization (GEIDCO).

However, the first major step to achieving these ambitious goals for the country was the signature in April 2017 of the Memorandum of Understanding with the 16 countries of the Arab League, to establish a single energy market between the signatory countries.[86]

Recently, last May 2020 a new step was taken in this direction, with the signing of the operating rule of this new single energy market.[87]

But before becoming an energy hub for all the surrounding countries, as well as for Europe, the internal energy market of Egypt requires major improvements in terms of liberalization, organization, modernization, and efficiency to overcome the problem of domestic demand. For this reason, the government of the Republic of Egypt, led by its president, has launched an energy revolution.[88] Starting with its strong commitment to the decarbonization of its economy in general and of electricity generation in particular, ratified both at the Madrid COP25 conference in December 2019, and with the signing of the Paris Agreement dated 2016 (United Nations, 2016).

However, the reality is that the electricity sector in Egypt is a traditional system based on thermal electricity production facilities. Table 22 shows that 82% of the total generation of the country in 2016[89] come from EEHC Thermal.

Table 22. Total Installed Capacity in Egypt in 2016

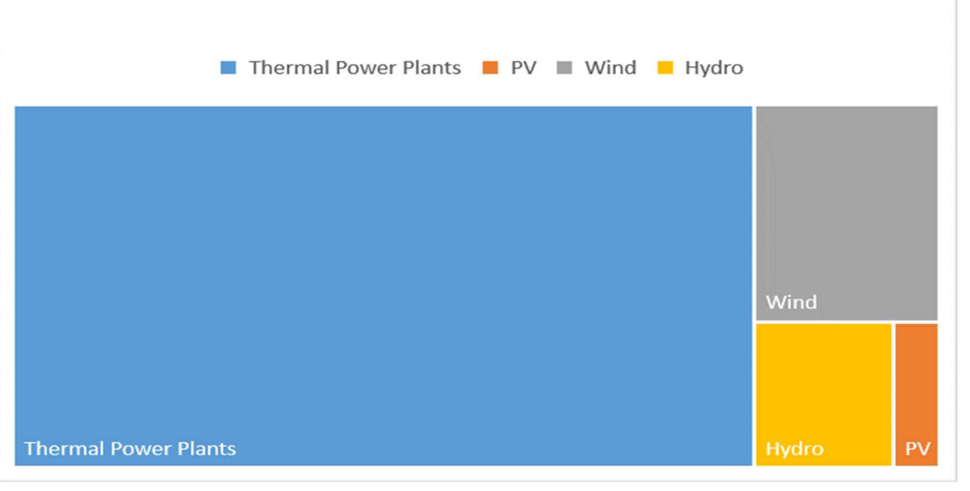
	Installed Capacity (MW)	**Share (%)**
Hydro	2,800	8.75%
EEHC Thermal	26,480	82.71%
Renewable (Wind and Solar)	687	2.15%
Private Sector (Thermal)	2,048	6.40%
TOTAL	32,015	100.00%

Source: NREA (New and Renewable Energy Authority) Eco Con Serv STRATEGIC ENVIRONMENTAL & SOCIAL ASSESSMENT Final Report February 2016.

[86] For further information about this agreement, please visit https://sis.gov.eg/Story/108521?lang=en-us.
[87] For further information, please visit http://www.arabfund.org/default.aspx?pageId=609
[88] For more information on the first steps taken by the governments for this energy revolution, review laws 87/2015 or 230/2016, which describe the steps to be taken to liberalize the country's energy market.
[89] For a detailed information, please visit: http://nrea.gov.eg/test/en/About/Strategy.

The objective proposed by the government is to have 20% of its total generation through renewable energy sources by 2022: wind power (12%), hydraulic power (6%) and photovoltaic (2%). (NREA, 2008)[90].

Figure 30. Egyptian Electricity production 2022

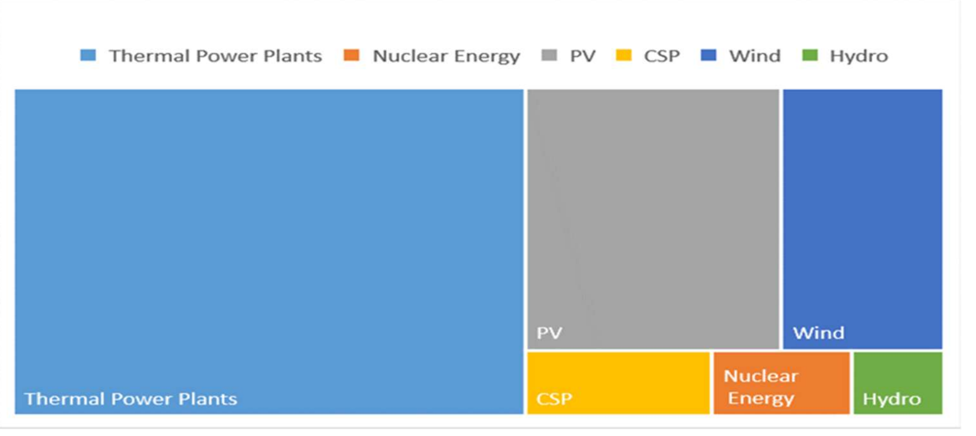


Source: NREA[91]

This percentage of renewable generation should reach 42% of its total generation[92] through renewable energy sources by 2035 (photovoltaic (22%), wind power (14%), concentrated solar plants (4%) and hydraulic (2%))[93].

[90] For further information, please visit http://nrea.gov.eg/test/en/About/Strategy.
[91] For further information, please visit, http://nrea.gov.eg/test/en/About/Strategy.
[92] Expected to reach 62,6GW of total generation capacity by 2035 (NREA 2008).
http://nrea.gov.eg/test/en/About/Strategy.
[93] This plan to diversify electricity generation sources to less polluting sources was ratified by the president through presidential Decree no. 135/2014 (Posted Oct 22, 2014). This objective predated the discovery of the large offshore gas reserves off Zohr. All the decarbonization strategies of the economy and especially of electricity generation are channeled by the government through NREA. As of today, these goals have not been changed despite the discovery of the gas field.

Figure 31. Egyptian Electricity production 2035



Source: NREA[94]

Table 23 includes the percentage targets for electricity generation through renewable sources which would result in the following installed capacity mix in GW. It can be seen how the government considers solar and wind resources as the most valuable and most widely available in the country.

Table 23. Evolution of installed renewable energy power capacity in GW

Type of power station	2009/10	2021/22	2029/30	2034/35
Hydro	2.80	2.80	2.90	2.90
Wind	0.50	13.30	20.60	20.60
PV	0.00	3.00	22.90	31.75
CSP	0.00	0.10	4.10	8.10
Total	**3.30**	**19.20**	**50.50**	**63.35**

Source: IRENA (International Renewable Energy Agency)[95]

4.2.2 Regulatory framework

Like many other countries joining the renewable energy revolution, Egypt has had to adapt its regulatory framework to a new scenario that only a few years ago had not even been imaginable and therefore appropriate regulation was not in place. No country was prepared to authorize large areas of land to be covered with panels or wind turbines or to adapt their national network to the challenges of cleaner but less stable generation

[94] For further information, please visit, http://nrea.gov.eg/test/en/About/Strategy.
[95] For a detailed information, see:
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf

sources, or even to liberalize and atomize the generation and consumption points.

Nevertheless, the Egyptian government was keen to advance in the renewable energy sector from a very early date (IRENA, 2018), and as mentioned previously, set an ambitious goal of reaching 20% of its generation through renewable energy sources by 2022[96].

To reach this new target the government of Egypt set up an entire regulatory frame around the renewable energy sector that can be summarized in next table.

Table 24. Egypt regulatory Laws

Legislation	Type
Law No. 102 of the year 1986 establishing the New and Renewable Energy Development and Usage Authority (as amended in 2015)	. Establishes the NREA. . The NREA has the primary role in promoting and developing renewable energy in Egypt
The Constitution of the Arab Republic of Egypt, 2014 (Article 32)	. To gain optimum benefits from renewable energy, promote its investments, and encourage R&D, in addition to local manufacturing.
Renewable Energy Law (Decree Law 203/2014)	. To support the creation of a favorable economic environment to bring about a significant increase in renewable energy investment in the country.
Cabinet Decree No. 1947 of the year 2014 on Feed-in Tariff	. Establishes the basic for the FIT (Feed In Tariff) for electricity produced from renewable energy projects and encourages investment in renewable energy.
Prime Ministerial Decree No. (37/4/15/14) of the year 2015	. Regulations to make land available for renewable energy projects.
New Electricity Law No. 87 of 2015	. To provide legislative and regulatory frameworks needed to reach the electricity market reform targets.

[96] As we can read in the NREA strategy (http://nrea.gov.eg/test/en/About/Strategy) this target was already fixed in 2008.

Investment Law No. 72 of the year 2017	. Ensures investment guarantees and amendments as of May 2017. . Establishes a new arbitration center for settling disputes. Codifies social responsibility. Instigates foreign investment in Egypt.

Source: IRENA, 2018

As can be seen, the government in 2014 offered a FIT for wind and photovoltaic projects of up to 50 MW of power with the aim of achieving 2,000 MW of wind and 2,000 MW of photovoltaic plus another 300 MW of photovoltaic installation of less than 500 kW, for that target date[97].

Despite these FIT conditions, no new projects were developed in the country. As we will see throughout this chapter, the main reason was that the regulatory framework for the approvals of these projects at the environmental, urban and interconnection level was not clear and therefore the developers were confused about the necessary authorization procedures.

In addition to this difficulty, the appetite of the commercial financial institutions for renewable energy projects in Egypt was not very great given that they were able to finance similar projects, with similar FIT frameworks, in Europe or the United States. Committed to its objectives for 2022, the Government unblocked this situation and established the seriousness of their involvement by launching the BenBan project with even better conditions, pre-authorized public land, with a clear interconnection and duly set up for the PV installations .

Additionally, to resolve the banking problems derived from an undefined regulation, the Egyptian government decided to adapt its own requirements to the standards of the European Bank for Reconstruction and Development (EBRD) and the International Finance Corporation (IFC) in order to gain the support of said entities for developers interested in this project. This was not an easy task and given that the regulations for a project of these characteristics, which in turn would be subdivided into 41 other subprojects, is confusing and sometimes contradictory. However, the Egyptian Government instead of clarifying the regulations and leaving an easy-to-follow regulatory framework with clear criteria, decided to carry out the main environmental studies of the BenBan complex itself, leaving the project, to all intents and purposes, authorized and ready to

[97] This FIT was signed between the interested party in developing the project and the state company EETC (Egyptian Electricity Transmission Company) for 20 years in the case of wind projects and 25 years for photovoltaic projects. This renewable energy target was signed by Prime Ministerial Decree no. 1947/2014 (published on 27 October 2014) and 2532/2016 (published on 29 September 2016). For more information about those Decrees, please visit: http://nrea.gov.eg/Investors/Legislation

build. In this way, the government continued to maintain the discretionary powers to facilitate or hinder future projects depending on whether the country was more or less interested, depending on its own criteria.

As will be seen throughout this chapter, this is the general way of acting of the government in the country. The procedures are either not clear, or are arbitrary or are constantly changing, so that practically no one can carry out a project without having the specific and sometimes arbitrary approval of the government officials.

4.2.2.1 Environmental authorizations

The law that regulates the procedures and environmental and social authorizations in Egypt for new construction projects or for extensions or renovations of existing ones, is Law No. 4 of 1994 (Ministry of State for Environmental Affairs, 2009).

The final decision on these new projects is made by the Ministry of the Domestic Affairs, but the review, supervision, modification or comments on the Environmental Impact Study is the reponsability of the Egyptian Environmental Issues Agency (EEIA).

If this law No. 4 is analyzed, it can be seen that photovoltaic projects would be subject to a shortened environmental procedure because they are classified within category B. On the other hand, this law, like most of the laws in the country, leaves the door open to another classification based on the size or impact of the project, and therefore EEIA could classify the project in category C, which requires a longer procedure that includes, among other things, public consultations with potentially affected communities.

In the case of the BenBan project, since the government wanted to follow the EBRD and IFC requirements, the project was classified as Category C.

4.2.2.2 Urban authorizations

The law that regulates urban planning requirements and procedures is the Egyptian Construction Law, Law 101 of 1996[98]. The approval or rejection of a construction project is the responsibility of the local government of the region or municipality where the project is to be installed. As in the previous case, regulation for this type of project is not properly defined and subjectivity in the requirements, procedures and costs of this authorization is a common situation.

[98] Unfortunately, there is no web access to this law, neither is there an English version. The only way to obtain an Arabic version is by attending EgyptERA in person

4.2.2.3 Operational authorizations

According to the Presidential Decree No. 326/1997, amended by Presidential Decree No. 339 year 2000[99], any electricity generation installation needs the authorization of the Egyptian Utility of Electricity and the Agency for Consumer Protection.

For the electricity authorization a "Non–objection letter" is required from the Egyptian Electricity and Transmission Company (EETC) in order to launch the process of getting the licenses that are given after receiving a Gric Impact Study approval.

A Production License from EgyptERA is also needed.

All these Operational permits can be granted after obtaining the other authorizations described previously.

4.2.3 Electricity production

According with the EEHC (2019), Egypt is a country with a total installed power of 58,353 MW (see Table 25). This power for a peak demand of 31,400 MWh would seem to be well compensated.

Table 25. Egypt Installed Generation Capacities in 2019

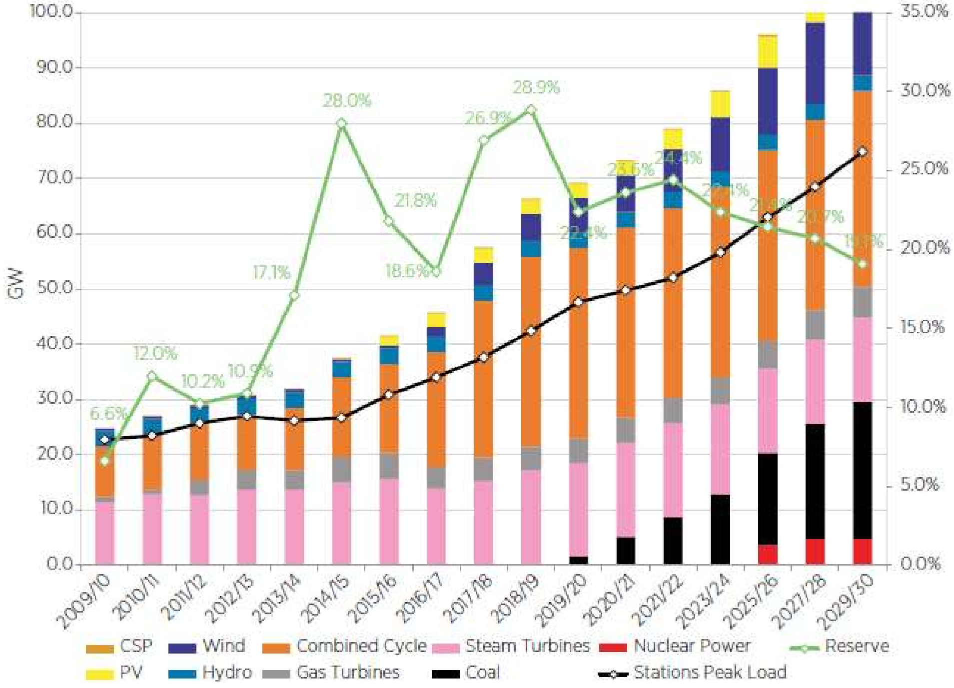
Descripton					2017/2018		2018/2019		Variation %	
Installed Generation Capacity (MW)					55213		58353		5,7%	
Company	**Cairo**	**East Delta**	**Middle Delta**	**West Delta**	**Upper Egypt**	**Hydro**	**EEHC Plants**	**Private Sector**	**Renewables**	**Total**
Gas	1215	2130	336	24	350	0	0	0	0	4055
Steam	3320	4156	420	3651	3154	0	0	2048	0	16749
Combined Cycle	4855	4200	5107	908	3000	0	14400	0	0	32470
Hydro	0	0	0	0	0	2832	0	0	0	2832
Renewables	0	0	0	0	0	0	0	0	2247	2247
Total	**9390**	**10486**	**5863**	**4583**	**6504**	**2832**	**14400**	**2048**	**2247**	**58353**
* In addition to isolated and reserve units with a total installed capacity of 205 MWs.										

Source: EEHC, Annual Report 2018/2019

The problem is that as has been seen in the previous table and can also be seen in the following graph, 36% of the generation comes from inefficient plants, either through steam turbines or gas turbines. Therefore, only 37,549 MW are produced by combined cycle, hydroelectric or renewable energy sources (IRENA, 2018).

[99] Unfortunately, there is no web access to this law, neither is there an English version. The only way to obtain an Arabic version is by attending EgyptERA in person

Figure 32. Egyptian total installed capacity vs peak demand to 2035

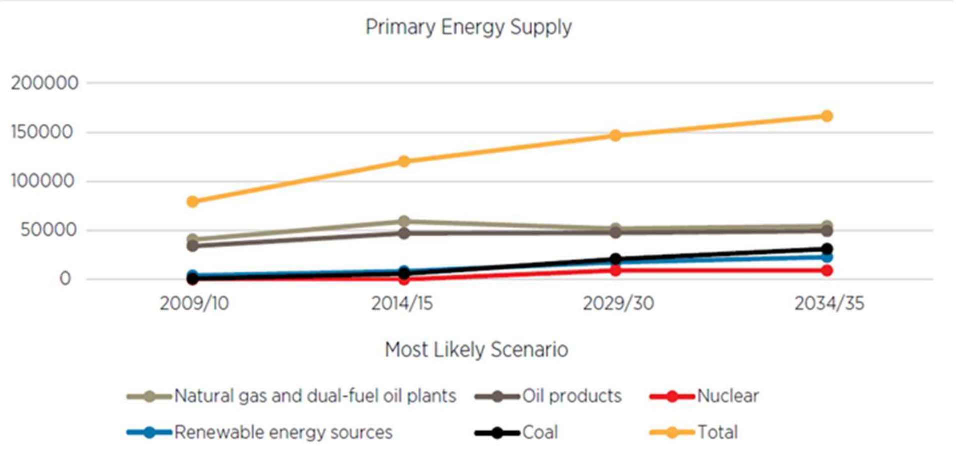


Source: IRENA.

Since 2014, the Egyptian government is trying to change the trend of using plant-based fossil fuel, increasing the installed capacity of renewable sources. This is an official policy reinforced by the signature of the Paris and Madrid Agreements as has been already mentioned (United Nations, 2020). This implementation of renewables would be accompanied by the installation of less polluting thermal power plants such as combined cycles based on natural gas or other stable sources of generation, to guarantee the availability of energy 24 hours a day.

Currently, the country increased its installed capacity from 35,323 MW in 2014 to 58,353 MW in 2019. The most relevant increase appears in combined cycles where the total installed capacity was 11,880 MW in 2014 and 32,470 MW in 2019 (EEHC, 2019).

Table 26. Egyptian Electric Generation Evolution (GWh)



Source: IRENA, 2018.

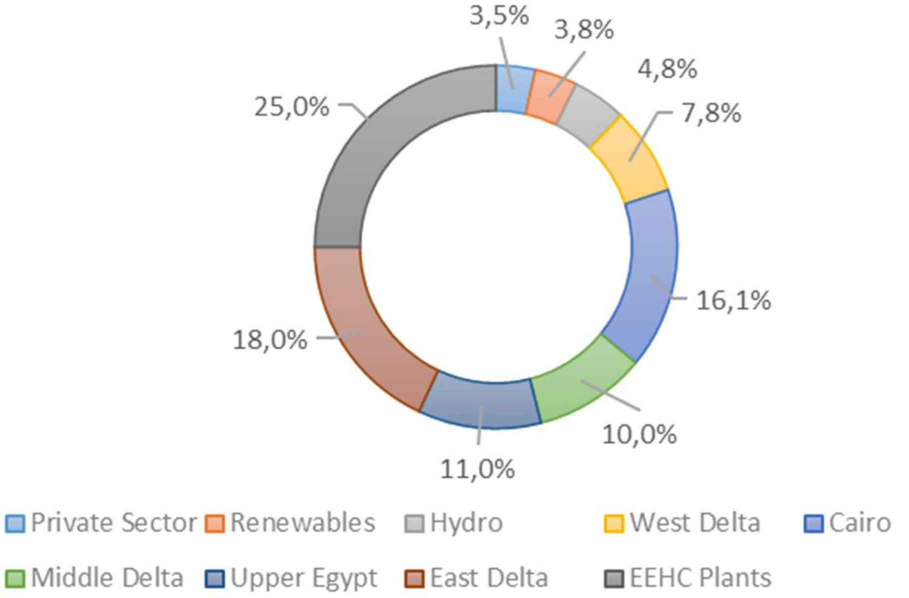
However unexpected problems such as the mega dam built by Ethiopia in the Nile river or the strategic use of the national gas reserves as a commodity to allocate in the international market are playing against the increase of renewable energy sources.

4.2.4 National Electrical System

In Egypt, as in most developing countries, there is a state-owned company that owns and operates most of the generation assets and practically all of the country's electricity transmission and distribution system; this company is EEHC. EETC, also a state-owned company, buys the energy generated both by EEHC and by private generators to sell it to the nine main public distribution companies as well as to other private electricity distribution companies.

In the following graph it can be seen how at the end of 2019, the private generation sector in the country accounted for only 3.5% of the total energy generated.

Figure 33. Egyptian Energy Generation 2019



Source: EEHC, 2020

EETC can also sell energy directly to large consumers that are connected to the transmission network and is responsible for marketing energy with neighboring countries.

However, Egypt wants to leave behind this model of a single state company that generates, distributes and sells energy to a competitive market based on private initiatives, with bilateral agreements between generators and consumers. To this end it published The Electricity Law no. 87/2015, the aim of which was to separate EETC from EEHC so that there would be an independent regulator and a grid manager of the that gave equal access to all private generators who wanted to use it fairly and independently.

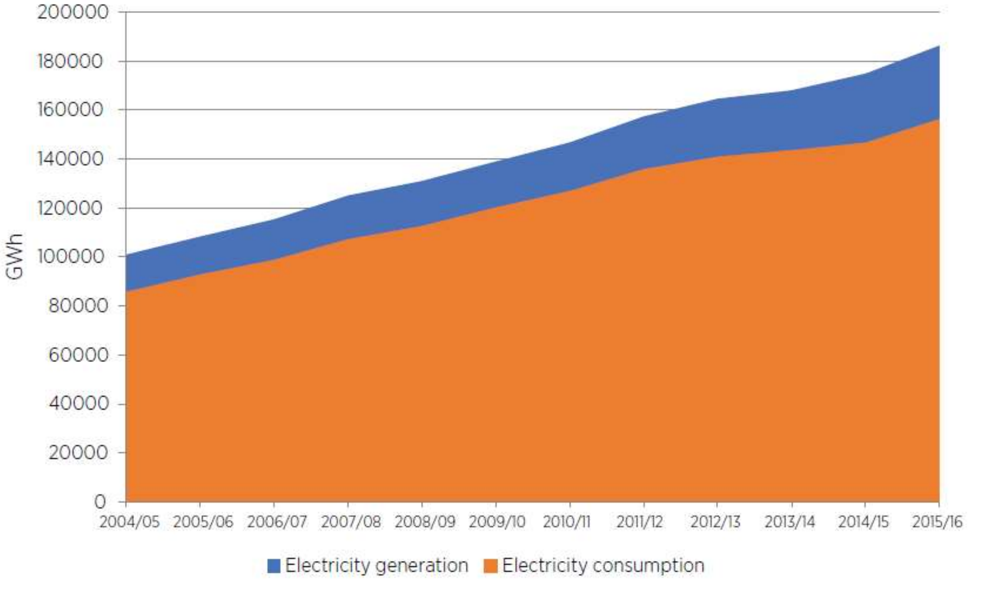
Unfortunately, this is very far from reality. As will be seen in this chapter, the main problem of the electricity sector in Egypt or the main barrier that prevents the effective contribution of the private sector to advance the contribution of the renewable energy to the total electricity production in Egypt is that everything ends up in the hands of the Ministry of Electricity.

4.2.5 National electricity consumption

As was seen in Section 4.2.3, there is excess production of energy in the country as it has more installed capacity than current demand for internal consumption and exportation, however, as a large part of the generation facilities are obsolete or inefficient, Egypt is barely able to cover the internal demand. Moreover, it is still very far from being able to become the energy hub it intended to be for the new energy single market of the Arab league and for Europe.

If we analyze the data on consumption vs. generation, which are shown in the following graph, it can be seen that consumption has been increasing with a linear trend until reaching more than 160,000 GWh per year, at the same time, electricity generation has followed the same trend and has always been above global annual consumption, reaching more than 180,000 GWh in 2016.

Figure 34. Egyptian electricity generation and consumption from 2004 to 2016



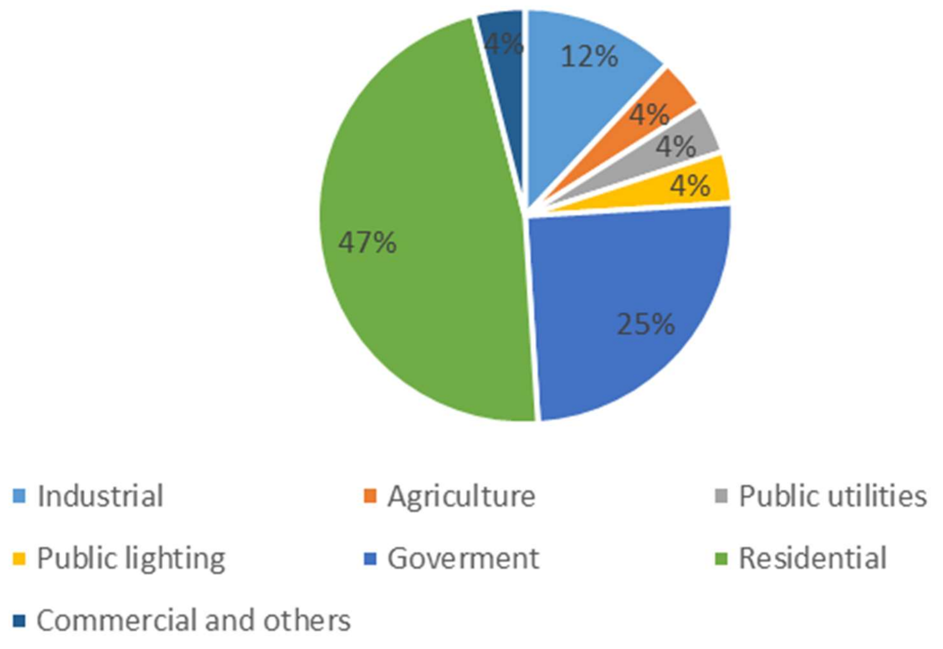
Source: The International Renewable Energy Agency (IRENA)

As seen above, this consumption, despite increasing substantially in recent years, is still far from the per capita consumption of the surrounding rich countries or the more developed countries in Europe or USA.

In terms of sector consumption, residential or domestic consumption represents 47% of total consumption, followed by industrial consumption with 25% and the commercial sector with 12%.

The rest of the sectors referenced in the graph (agriculture, public companies, public lighting, and government) account for 4% each.

Figure 35. Egyptian electricity consumption by sectors. 2015



Source: IRENA.

The literature reviewed does not enter into a geographical analysis of the country's consumption but rather analyzes the country's national electricity distribution and transportation network[100]. In fact consumption is located mainly in the large concentrations of population in the country along the Nile (Cairo and Alexandria,) or in the few areas with activity outside that axis (Suez). It has to be taken into account that in reality 80% of the territory barely accounts for any consumption because it is desert.

This may change in the coming years due to the problems generated by the sharp reduction in the Nile's water flow. The desiccation of the Nile will require the relocation of large masses of population on the shores of the Red Sea.

4.2.6 Decommissioning plan and installed capacity

Energy transition started in 2014/2015 and has been planned until 2035 to achieve the goal of not depending on fossil fuels.

To achieve the set objectives and to increase the installed capacity to meet energy needs, it was planned in 2014 to introduce coal and nuclear plants, to provide greater stability to the generation mix and the transmission

[100] For further information about this, please visit: http://www.geni.org/globalenergy/library/national_energy_grid/egypt/egyptiannationalelectricitygrid.shtml

network. However, it is likely that the coal plants at least, which were due to be connected by 2020 and were projected to account for 10% of the generation mix in 2035, will be replaced by other sources that are more environmentally friendly.

If the country wants to meet the renewable goals committed to in the Paris and Madrid agreements it should abandon the current official plan. There are no official documents to modify the actual plan, instead, there are clear indications that this plan has been or is being abandoned, such as the cancellation of the PPA signed by EETC with the Emirati developer AMEA Power in 2016 for the installation of a 2GW + ultra-super-critical coal fired power plant in Oyoun Moussa, which has been replaced by 2 PPAs for the installation of 500 MW of wind power and another 500 MW of photovoltaic energy[101].

4.2.7 Evolution of grid capacity

One of the problems that the Egyptian government has had to face is the electricity supply to remote neighborhoods in large cities and to this end an important effort has been made for several years to electrify remote areas[102].

Since 1982, the installed capacity of the substations has been increasing in almost all its voltage categories from 8.28 GVA to a total of almost 260 GVA at the end of 2017[103].

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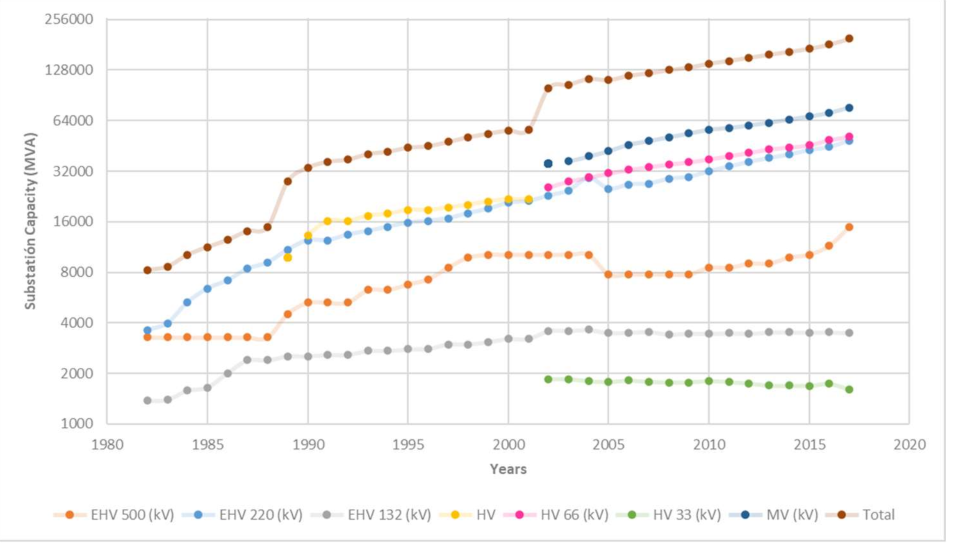
[101] For further information about this, please visit:
https://www.constructionweekonline.com/projects-and-tenders/269620-amea-power-signs-1000mw-solar-pv-and-wind-projects-in-egypt#:~:text=AMEA%20Power%20has%20signed%20a%20solar%20and%20wind,power%20project%20and%20a%20500MW%20solar%20PV%20project
https://www.afrik21.africa/en/egypt-amea-power-will-provide-700-mw-of-electricity-from-renewable-sources/

[102] If we analyze in detail the existing maps of the Egyptian electricity grids on the following Global Energy National Institute (GENI) website:
http://www.geni.org/globalenergy/library/national_energy_grid/egypt/egyptiannationalelectricitygrid.shtml ,
It can be seen that the great concentration of networks and population are found in the delta and on the banks of the Nile River. This population concentration is a serious problem for the country that is today in the debate and analysis of the viability of moving large masses of population on the shores of the Red Sea.

[103] For more information visit http://www.moee.gov.eg/english_new/ST_stations.aspx.

Figure 36. Egyptian evolution in Substation Capacity (MVA)



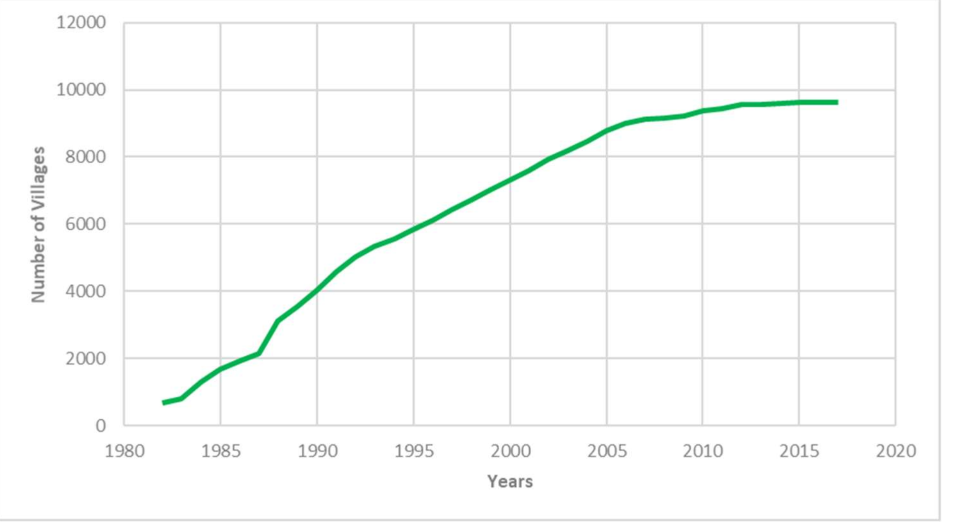
Source: Own generation with data from MOERE[104].

This has been possible thanks to the fact that in 2002 there was a change in the voltage levels of the network, dividing the high voltage (HV) into two categories of 66 and 33 kV and including a new category of medium voltage, this change has installed more than 1,600 MVA of 33 kV substations, more than 51,000 MVA of 66 kV substations and more than 76,000 MVA of medium voltage SE, (MOERE, 2017).

These changes have led to a significant increase of 77% in the installed capacity of substations in the country, which has made it possible to interconnect most of the towns[105].

[104] For further information visit http://www.moee.gov.eg/english_new/ST_stations.aspx.
[105] For further information visit http://www.moee.gov.eg/english_new/ST_supportvi.aspx.

Figure 37. Number of villages with electricity supply in Egypt



Source: MOERE, 2017.

Figure 37 shows the increasing trend over the years, representing an average annual growth of 8.7%.

Today the electricity grid covers a large part of the country, however, due to the gigantic distances between some towns and large cities and generation plants, the solution of electric self-consumption is proposed to cover energy needs, especially for agricultural facilities.

If the specific data is analyzed regarding the interconnection of Egypt, it can be seen that the country had a total of 48,832 km of transmission and distribution lines at the end of 2017, distributed as follows (see, Table 27).

Table 27. Egypt total lengths of circuits in 2017

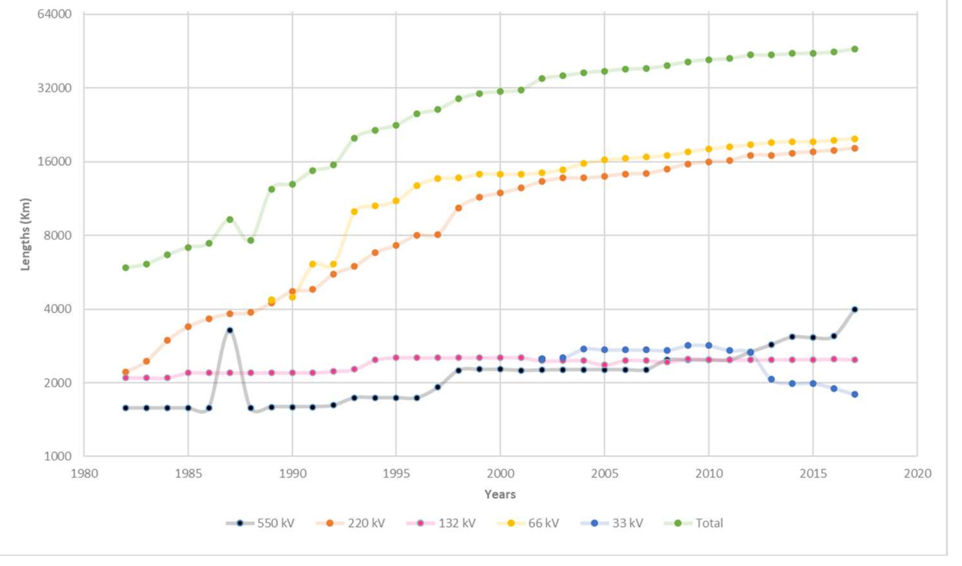
Total Lengths of Circuits		
	Voltage (KV)	Distance (Km)
	22	21
	33	1692
	66	20466
	132	2485
	220	18589
	400-500	5579
Total		**48832**

Source: EEHC, 2017

The following graph represents the km of electricity transmission lines during the last years and where the increase in line lengths is clearly observed with an annual average of 6.64%, especially of the 66 kV voltage levels and 220 kV.

These kilometers of line built have enabled the supply of electricity to multiple consumption points in the region, thus allowing the interconnection of several new generation and consumption points in the country[106].

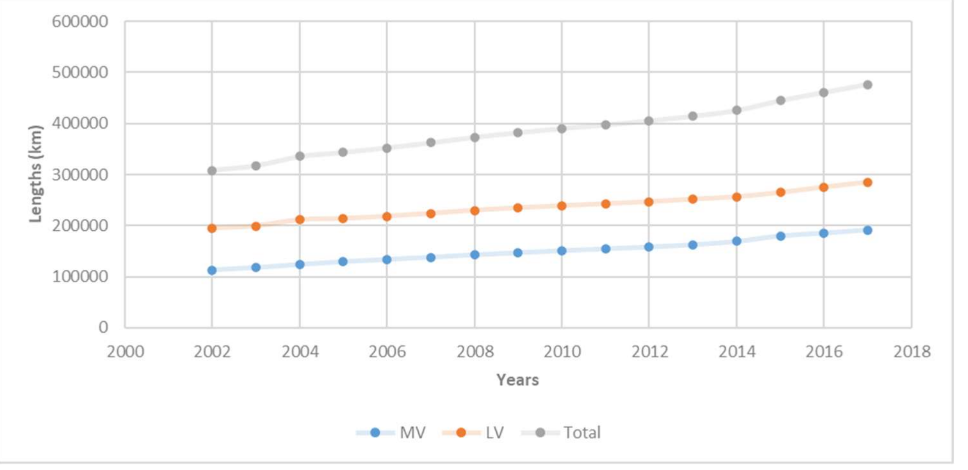
Figure 38. Lengths of the UH and VH tension transmission circuit in Egypt



Source: Own elaboration with MOERE data, 2017.

[106] For further information visit, http://www.moee.gov.eg/english_new/ST_lines1.aspx

Figure 39. Lengths of the medium and low-tension transmission circuit in Egypt



Source: Own elaboration with MOERE data, 2017.

The distribution lines (medium and low voltage) have also increased by around 3% annually, as shown in the previous graph, however, not as much as the transmission networks[107].

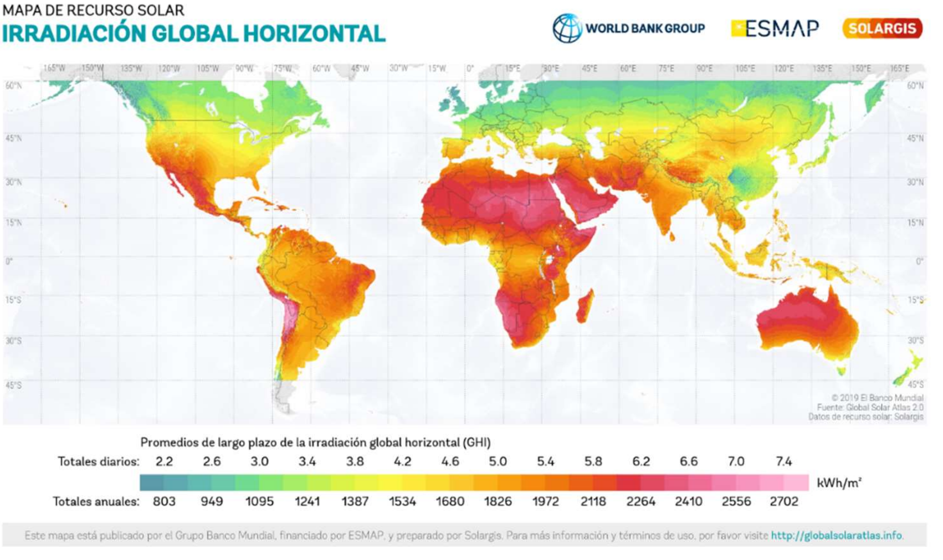
With the goal of supplying electricity to small and remote towns, the new medium and low voltage networks are small compared to the newly built transmission networks.

[107] For further information visit, http://www.moee.gov.eg/english_new/ST_lines2.aspx

4.3 The photovoltaic sector in Egypt

As shown in next picture, with more than 2,200 kWh/m2, Egypt has especially important levels of solar radiation. It is probably one of the world's top 5 countries for radiation.

Figure 40. Horizontal Global Irradiation



Source: SolarGis. https://solargis.com/es/maps-and-gis-data/download/world

Ancient Egyptians were fully aware of the high radiation and were able to make good use of the sunlight, studying the movement of the sun as well as the position of stars at night so they were the first to adapt the year, months and weeks as we know them today, being our current year the year 6,262 in the Egyptian calendar. As a minor result they were able to ensure the phenomena of solar illumination of Ramses II face twice a year, on his birthday and the day he came into power over the country, the 22nd of February and 22nd of October.

Also, ancient Egyptians ware the first to make use of renewable energy, 10 thousand years ago they made use of the sun to bake their bread. Called solar bread is still cooked and eaten the same way today.

They also used hydropower as can be seen in Al Fayoum 100 kms South West of Cairo. There are 200 wooden waterwheels that are driven only by fast-moving water of the Canals and were set up in Al Fayoum around the Ptolemaic era, around 2,000 years ago. Those waterwheels can lift the water up to 3 meters to the higher grounds.

Recently, again, Egypt was the first country in the world to have a solar energy installation. In 1911, Frank Shuman, an American engineer who came to Egypt set up the first worldwide solar energy installation that was able to run 60 to 70 horse power engines to lift 22.7 cubic meters of water per minute from the river Nile to the nearby higher cultivated land.

This solar energy installation was composed of 5 collection units, with a length of 62 meters and a width of 4 meters. They were separated by a space of 7 meters between each line and the next. The installation had proven to be extraordinarily successful and worked very well till it suffered neglect and dropped completely out of service.

The electricity sector faced a lot of difficulties in the 1990's, 2000's and 2010's because of the shortage in production compared to consumption. The main reason for this problem was that, although the Egyptians developed their electricity production capabilities a lot during 1990's, 2000's and 2010's the population increased at much more higher rates and there was always a shortage in electricity supplies[108]. Table 28 shows the evolution of the population and the electricity production over the period 1893 to 2020.

Table 28. Egyptian population and electricity production from 1893 to 2020

YEAR	POPULATION	POPULATION INCREASE RATE %	TOTAL ELECTRICITY PRODUCTION
1893	9,669,000	2.46	67.5 KWh
1952	21,473,798	2.51	423 GWh
1962	28,112,256	2.73	No data available
1990	56,134,475	2.46	41000 GWh
2000	68,831,561	1.95	78100 GWh
2010	82,761,235	2.00	139000 GWh
2011	84,529,252	2.14	146796 GWh
2012	86,442,243	2.24	157406 GWh
2013	88,404,646	2.29	164628 GWh
2014	90,424,656	2.28	168050 GWh
2015	92,442,547	2.23	174875 GWh
2016	94,447,073	2.17	186320 GWh
2017	96,442,591	2.11	189550 GWh
2018	98,423,598	2.05	196760 GWh
2019	100,388,073	2.00	199843 GWh
2020	102,334,404	1.94	No data available

Source: Own elaboration using electricity compilations based on: EETC annual report from 2010 till today, 1893 till 2010 are based on International Energy Statistics and on United Nations – World population Prospects.

Table 28 shows that the growth in electricity generation capacity was not enough to meet the population's growing demand needs. One result was

[108] If you would like to go deeper in this information, please visit, https://www.harunyahya.com/en/Technological-Advances-of-Ancient-Ages/13770/light-bulbs-were-used-for or visit, https://timesmachine.nytimes.com/timesmachine/1916/07/02/104680095.pdf

the blackout that occurred in the summer of 2011.[109] For this reason and for those already explained in Section 4.2, the government proposed a development of the energy sector based on the diversification of generation sources, increasing the role of renewable energies within the national energy mix.

To increase the share of renewables, the Egyptian government launched an FIT program that brought about a strong expansion of the installed capacity of renewable generation plants, especially wind and photovoltaic plants. At the end of 2019, the renewable capacity installed in the country amounted to 11.5 MW biomass, 140 MW CSP, 1,375 MW wind power, 1,491 MW solar PV and 2,832 MW hydropower[110].

Table 29 shows the status of electricity generation projects using photovoltaic technology to date and the expected evolution until 2023 according to the government (IRENA, 2018).

Table 29. Photovoltaics projects in Egypt in 2018

Project	Type	Status	Size	Contract
Kom Ombo	PV	Biding	200 MW	BOO scheme
West Nile	PV	Biding	600 MW	Sky Power and EETC BOO
West Nile	PV	Biding	200 MW	EETC BOO
West Nile	PV	Biding	600 MW	BOO scheme
FIT	PV	Operational	50 MW	EETC PPA
FIT	PV	Under development	1415 MW	EETC PPA
Hurghada	PV	Tendering	20 MW	NREA-JICA EPC scheme
Zaafarana	PV	Under development	50 MW	NREA-AFD EPC scheme
Kom Ombo	PV	Operational	26 MW	NREA-AFD EPC scheme
Kom Ombo	PV	Operational	50 MW	NREA-AFD EPC scheme

Source: IRENA (2018).

As can be seen, most of the projects to date have been constructions solely by NREA. But special attention deserves the BenBan project, described in the table above as FIT. This project can be considered as the beginning of the photovoltaic sector at a private level in the country. In fact, many

[109] In 2011, the electricity crisis reached a record peak when Egyptians experienced a severe shortage in electricity supplies for the first time in modern history, this had never happened before, even in wartime.
[110] For further information visit, https://iclg.com/practice-areas/renewable-energy-laws-and-regulations/egypt#

companies, banks, and international funds have participated in construction, operation, or financing. This project was divided into 41 plots of 50 MW each[111].

After the BenBan Project, the sector has continued to develop thanks to private initiatives. Small, medium, and large entrepreneurs are pushing for the construction and development of the sector that is sometimes not easy to authorize in the country. Nevertheless, given the barriers that will be analyzed in the next section, the penetration of renewable projects in the country is still very far from reaching the goals set by the Egyptian governments and far from the levels of developed countries.

4.4 Barriers to the development of photovoltaic plants

With regard to the analysis of photovoltaic solar energy in Egypt, which the objective of this research, there are no doubts about the existence of barriers to develop this new clean energy, even if nowadays alternative sources of energy are needed to try to reduce pollution. In fact, these barriers exist not only in the case of solar energy but also for all alternative sources of energy.

Abundant literature that has been made available during recent years on this subject, but to delve deeper into the literature would fall beyond the remit of this research. Painuly (2001) offers a general overview on barriers to renewable energy penetration, suggesting measures to overcome them. The existence of barriers stretches worldwide from north to south across the globe. In the case of China, where in fact the solar photovoltaic (PV) industry has developed rapidly (Honghang et al., 2014), an interesting review of solar energy development, including the existence of barriers, is offered by Liu et al. (2010). Negro et al. (2012) present a literature review of studies on the difficult trajectory of different renewable energy technologies, mainly focused on European countries. The paper by Richards et al (2012) analyzes the case of barriers to renewable energy development in a case study for Canada. In the case of Pakistan "the barriers to development of renewable energy can be broadly classified as policy and regulatory barriers, institutional barriers, fiscal and financial

[111] The Egyptian company EcoConServ (www.ecoconserv.com) has conducted an in-depth study for NREA on the BenBan project, with funding from the European Bank for Finance and Development and the support of several countries such as Australia, Finland, France, Germany, Italy, Holland, Norway, Switzerland, China and the United Kingdom. You can find the detailed report in the following link (https://www.eib.org/attachments/registers/65771943.pdf)

barriers, market-related barriers, technological barriers and information and social barriers" (Mirza et al., 2009).

These barriers mentioned above, are also present in Arab countries. In fact, and among others, cultural and institutional barriers are present in the case of Egypt. The novelty of this chapter on solar energy is that, in describing clean energy barriers, I will offer an original analysis of the topic combining the information from the literature and from my personal experience at EOSOL[112].

4.4.1 Barriers in the case of Egypt

In the specific case of Egypt, the barriers to be found are of diverse origin and consideration. It will be seen throughout this chapter how the main barriers come from the Government itself, since, although the government knows that the country needs an opening to the private sector to develop its ambitious plan to become an energy hub for the surrounding countries (especially the ones belonging to the Arab League), Egypt cannot claim to be something that it is not. As a military regime, it is general policy to manage sectors with potential for profit through public institutions such as the Ministry of Military Production, pushing private initiatives aside [113].

Egypt cannot forget its history and culture either, leading to the building of "pharaonic projects", like the one that the country's government has recently been trying to promote. This is an 11 GW CSP project[114], which would, in the coming years, undoubtedly push aside any private initiatives.

On the other hand, Egypt needs the inflow of dollars to stabilize its economy, and consequently it needs to make large profits from selling to third parties who can pay higher prices, overriding the interests of the nation and its people. The same happens with gas; reserves are earmarked for export and not used to ensure a more competitive, efficient and balanced generation in the country.

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[112] For more information about the company, see: EOSOL Company: https://www.grupoeosol.com/

[113] There are several examples of this policy in recent years, such as the cement sector, where they have built the largest cement production plant in the country, or the steel sector where they also have the largest factory in the country. Regarding energy or renewables, we see how practically all the projects developed in the country have been or are promoted and developed by NREA, EETC or BOO. They either make public tenders or promote their own development as in the case of BenBan or KomOmbo, or request the EPCs, or EPC + basic financing.

[114] The first objective of these 11 GW CSP projects is to serve as a new infrastructure projects, such as New Capital, airports or relocations of entire cities from the banks of the Nile to the Red Sea. Once this first major objective has been achieved, Egypt wishes to export to third economies with more advantageous prices and currencies, as it will be seen later in this document.

Finally, there is the problem of legal difficulties or even insecurity (erratic policy, with continuous changes and with fuzzy decision-making that does not conform to the law itself)[115].

The Electricity Law defines the legal framework for the generation, distribution, or sale of electricity more explicitly, and requires any company wishing to carry out these activities to be set up in the form of an Egyptian joint stock company. Such a company must generally seek a preliminary and then a final license from EgyptERA in order to be allowed to carry out its activities.

4.4.2 Permit barriers

A cursory observation of the Egyptian energy regulations gives the impression that all the steps and processes to obtain the authorization of a renewable energy generation project are clear and well defined. This would be what one expected from a country that established NREA as early as 1986, as an arm of the Egyptian Ministry of Electricity and Renewable Energies (MOERE) with the aim of promoting and developing programs for the massive implementation of commercial scale renewable energy projects. Subsequently, in 2000, the national government established EgyptERA with the aim of making it an independent legal entity that would guarantee the permits for the generation, transmission, and distribution of electricity without preferences between the private or public sector. In addition, it had to monitor strict compliance with regulations in the electricity sector.

The regulation also defines a specific type of company to be established for energy generation as well as the wide list of generation licenses and permits to be obtained from EgyptERA and from the Egyptian Environmental Affairs Agency (EEAA) at the environmental level by renewable energy developers.

In Table 30 below a detailed list can be found of all the permits needed to develop a photovoltaics installation in the country as they are described under the current regulation.

[115] Right now, there are plants already built that had received the initial generation license required for the construction but have not yet been connected. We also see this problem and will analyze it later in the constant changes in the law, such as in-front-of-the-meter projects, power banking on the national grid.

Table 30. Permits needed to develop a photovoltaic project in Egypt in 2018

List of Permits						
Permits		Responsability	When	Competent Authority	Duration	Comments
Generation License						
	Interin Generation License	Developer	Before Construction	EgyptERA	1 Year	This covers the Pre-generation/Construction phase
	Permanent Generation License	Developer	After Construction	EgyptERA	5 Years renewable for similar periods (Max 25 total years)	This license is issued after finalizing the construction of the plant and prior to commercial operation.
	Efectiveness Generation License	Developer	After Construction	EgyptERA	1 Year	This license is issued after Permanent Generation License
Project Site Permits		Developer	Before Construction	. The relevant Notary Public office. . The relevant municipal counsel. . The Operations Authority of the Egyptian Armed Forces. . The Civil Aviation Authority. . The General Authority for Antiquities. . The Civil Defense and Fire Fighting Department of the Ministry of Interior. . The National Telecommunications Regulatory Authority (for establishing any wireless communications system in the Project site. . The Egyptian Shore Protection Authority (if the project land will be locates nearby seashore).	Not defined	The permits necessary for the project site vary from one case to another depending on the location of the project site and the relevant govermental entities inovolved.
Enviromental License		Developer	Before Construction	Egyptian Environmental Affairs Agency (EEAA).	Total project life	The procesing time of the license is 30 days from the date of submiting all the required documents to the CAA and CAA forwarding the application to EEAA for its review.
Construction License		Developer	Before Construction	Ministry of Housing, Utilities and Urban Communities.	1 Year	Solar generation projects do not require such license, except if a fence will be built. Insurance of 0,2% of the project amount. Resolution in 30 days.

Source: Own elaboration with Sharkawy & Sarhan Law Firm advice

If the scope of the company is the contracting, EPC and O&M services for renewable energy assets, the licenses and permits requested by the Egyptian Federation for Construction and Building Contractors are also well defined.

Even network studies requested by EETC to connect generation or self-consumption installations are supposed to be well defined[116].

However, in the end, when trying to develop a project, it becomes clear that the regulations are not well defined or more specifically, are not properly observed by the institutions and workers, which will delay the consideration of application procedures which are never 100% fulfilled, making the regulatory framework in Egypt unclear and discretionary. No one knows for sure which administrative authorizations are required to build a renewable project in the country and to be able to get an interconnection to the SEN, since the laws are not perfectly adapted to this type of project, or the approval or rejection criteria are discretionary, or the regulations are continuously changing. This means that it is never certain that the project being developed or promoted will finally become

[116] For a detailed information see http://www.eetc.net.eg/English/about.html.

a reality unless the approval of the main government authorities is obtained.

This situation is common in countries with militarized systems that want to control the development of all areas of the country. This situation may be beneficial or detrimental to the development of projects depending on the objectives that the government has at that time. In the case of Egypt it has been seen how the BenBan project has marked a before and after in the development of projects.

The government not only adapted its regulatory framework, facilitating the FIT for projects, facilitating the Net Metering and public use of the SEN, but it even selected and pre-authorized an area land of 37.2 km^2 and facilitated interconnection, so that developers could develop their renewable projects.

But after this project, the government changed its criteria and decided to stop favoring this type of project. The way to make this change was not as it would have been in most countries in the world, that is, by changing the law of self-consumption and setting new operating rules for the sector. Egypt has its way of doing things, in this case being only unwritten instructions to put as many obstacles as possible to prevent expansion in private sector electricity production.

<u>Why have the criteria changed? Why are more projects no longer wanted?</u>

From the experience of this research, there are some key reasons behind Government obstacles to self-consumption private investments, that would surely be based on PV, since this is the cheapest and technically most simple to be installed at all levels (from big industries to small farms):

1. As long as power exportation plans are not working, the Government cannot allow any reduction to the incomes of the EETC and the Distribution Companies, since those are desperately needed to pay the bills of the committed PPAs in BenBan and other private green energy initiatives. Typically, the self-consumption private initiatives will go for a 1/3 consumption model with net metering, which means a potential 1/3 reduction on the public distributors income, and this would be very risky for the balance of external debt.
2. Additionally, technical problems due to the extreme temperatures registered in summertime in BenBan are killing expected performance of those plants and the reputation of such technology.
3. In general, no private initiative beyond governmental control will work in the country, even for major players like the big international brands.

4.4.2.1 Environmental impact assessment (MIA)

As discussed in Section 4.4.2 above, the Egyptian regulations for project development may seem clear, but then this is so because the bodies and the approvals become discretionary and discriminatory.

At an environmental level it is no different, and an examination of the laws that regulate the MIA, Law No. 4 of 1994 (Ministry of State for Environmental Affairs, 2009), reveals a list of easy to follow steps and deliverables like the ones found in Table 31.

Table 31. List of documents needed to get MIA authorization in Egypt

List of documents		
Document	**Anexes**	**Responsibility**
A letter of intent to undertake certain specific project considered "(B) listed project".		Developer
Environmental Screening Form "B".	General description of the project site with a map of the appropriate scale (indicating the activities of the surrounding areas, roads and detailed plans of the wind rose)	Developer
	General description of the project area (Description of the natural, biological, social and cultural environment in the project area.)	Developer
	Description of project activities and illustrations.	Developer
	Predicted gas emission analysis	Developer
	In the case that it exists, indicating the chemical products used, the method for the elimination of residual water after the treatment and the residual water standards generated by the unit	Developer
	List of environmental laws and regulations.	Developer
	Environmental impact assessment (Attach an analysis of the possible environmental impacts of the project in each of the construction and operation phases, which may include impacts on air quality, soil, surface and ground water, the biological environment , social life, infrastructure and adjacent activities, etc., depending on the nature of the project and its location, while addressing the impacts during emergencies such as spills and leaks. It also includes possible environmental impacts on the project (such as earthquakes and torrents, previous use of the project site, adjacent activities, etc.).)	Developer
	The approval of The Environmental Affairs Agency for The evaluation of The Environmental impact of The previous project (Cemex)	Developer

Source: self-made with Sharkawy & Sarhan Law Firm advise

The reality then shows that the situation is not so simple or so regulated. A clear example, as has already been previously analyzed, was the BenBan project, in which the government itself had to carry out the MIA to facilitate the process for developers.

4.4.2.2 Local municipal management before the competent authorities

The biggest problem that a developer encounters at the local level to develop renewable energy projects in general and photovoltaic in particular is the lack of experience of local authorities and the lack of local regulation for this type of project. This means that no one is clear about the administrative procedure that must be followed to authorize a project and therefore if the municipality is favorable to its implementation the procedure is simple, but if on the contrary the municipality is not favorable they can always find a way to reject it.

Moreover, the municipal fees for the construction license is not clear, so there is always a debate regarding how much to pay.

4.4.3 Land and social barriers

Social barriers and land barriers could be treated as one type of obstacle because the Bedouin[117] consider themselves to be the owners of most of the land in the country. This fact makes the Bedouin and tribe issue a double-edged sword in Egypt.

Anybody who is going to set up any project on any piece of land that corresponds to Bedouin tribes must pay them the price of the land. The negotiation is not usually too complicated if you know the local traditions because they are usually comfortable with much less than the real value of the land. At the beginning of any project at any of those isolated desert areas that belongs to a Bedouin tribe, you negotiate with them to transfer their “rights” to the land. At the beginning of these negotiations, they will ask for far too much money as if they were selling this piece of land to you. However if you are aware of the country’s customs and traditions, you will be able to reach around 10% or even less of what they had originally asked for. Then you should sign a security service contract with them. It is worth bearing in mind that these people are the most effective guards for your site as normal security companies cannot be 100% effective in these isolated desert areas.

This scenario is exactly what happened in BenBan except for the advance payment of the land because the army had taken the responsibility of cleaning the spot before launching the project, yet the Bedouins do have

[117] They are a nomadic tribe living in the great desert areas of the Middle East. They are farmers who move their animals from one area to another depending on the rains. For more information visit: https://www.britannica.com/topic/Bedouin

some rights through small security contracts here and there all around the site.

It is important to be aware that if an investor decides to neglect these tribes, they will surely find ways, legal or otherwise, to cause a nuisance. For example, they will act like thieves, stealing the equipment, preventing water and diesel supplies from reaching the site, apply some “private” tolls to all the trucks that comes in and out of the site. This way the costs will be many times higher than what you should have paid in the first place!

For the moment, you could consider this land and social situation as an advantage more than a barrier because the typical price you have to pay is not high and when considered in the long run it is more beneficial for you as they will provide help throughout the project. However, in the future, if Bedouins and local tribes start asking for higher amounts or more highly paid employees or greater compensation, this could become the worst barrier in the country. It must be remembered that one of the main sources of financing in the country for this kind of project is and will continue to be the multilateral institutions, and they will always ask you to get a peaceful and negotiated solution with local tribes.

At this stage, Bedouins and local tribes will offer you full security services for your equipment and engineers, technicians, and workers, they will offer you cheap workers, water supply and many other important services within their area of influence. However, what will happen in the future remains an unanswered question, this why these barriers are called land and social barriers.

4.4.4 Commercial barriers

In Egypt there is a double trade barrier. First there is the lack of experience of local industrialists and businessmen when negotiating a PPA and second the normal or not so normal resistance that the EETC exerts on customers.

As will be analyzed more deeply in Section 4.4.6., Egyptian businessmen or industrialists are not used to negotiating PPAs since, to date, these have been contracts which they have not had the opportunity to negotiate but which they could only sign with the state company EETC. This company does not negotiate prices or conditions which instead are set by the national government. Therefore, with the exception of large international corporations, negotiators do not have an energy department, nor the qualified personnel that can negotiate this type of contract and cannot even grasp what is required from a private company before it is able to build a generation plant. Thus, clauses such as "take or pay" or purchase guarantees are impossible or very difficult to negotiate.

As is well known by the renewable community, without this type of clause, the banks will not finance the facilities, so if these clauses are not contemplated in the contract, the financing cannot be closed.

Subsequently, and if developer has the ability to manage and overcome the barriers of lack of experience and knowledge of clients when negotiating, there is the pressure that EETC exerts on these potential clients as will be seen in Subsection 4.6.6.

As has been mentioned in Section 4.3, the reality of the state company EETC is that they have taken on very important and long-term energy payment commitments given the FIT contracts that have been signed with various developers within the energy promotion program renewable in the country. This means that the EETC cannot afford to lose a single customer which would help towards paying these long-term commitments, and it cannot afford to generate energy other than what they produce. Therefore, when they find out that negotiations are taking place between a private generator and a private client, they use all their influence to stop them.

All the barriers described in this section will be seen in Section 4.6 in which a practical case that occurred will be described.

4.4.5 Interconnection barriers

To connect a PV installation in Egypt to the public grid is probably the most complicated action in the development of a renewable project in this country. It is necessary to go through a very long process that takes months and involves the preparation of a multitude of documents, including pre-feasibility studies, feasibility studies, environmental impact studies, social impact studies, grid impact studies; in addition to the countless applications and governmental forms to be filled in. This is normal all over the world to protect public grids but what stands out in Egypt is that:

1. There are very limited available connection points all over the public grid that covers most of the national land surface, around 1 million square meters.
2. No one can never be sure about having any kind of approval for his project, even if all the required procedures have been carried out and all the required documents have been correctly applied for.
3. After getting initial approval, companies still risk having the final application of connecting their installations rejected, because the normal procedures here are that developers apply for initial approval to be connected to the grid with all the necessary documents and forms. When they get their initial approval, they begin to set up their installations. When their installation is

finished and ready to inject electricity to the grid, they have to apply to get final approval and have some inspectors from the EETC or from the concerned distribution company to attend the connection hot tests and the actual connection. It has happened that some companies have received initial approval and after setting up their installation they have been told that their request for final connection approval have been declined!

4. One more factor that causes the connection points to be a barrier to the development of the renewable energy sector in Egypt is that, if a developer overcomes all the aforementioned obstacles and is assigned the available connection point which is currently available, most probably it will be far away from the location of the installation and the cabling costs between the connection point and the installation will, in some cases, be higher than the cost of the installation itself.

4.4.6 The specific barrier of financial services

All big and small players working in the renewable energy development in Egypt have suffered a lot because of the extremely complicated process of financing renewable energy projects regardless of the project size. Most of the developers and the EPC providers must finance their projects from their own funds and this naturally slows down the development of the sector because of the limited financial resources of the small and medium local players.

Bank financing is subject to the collaterals that the company have to offer to the bank and not the financial viability of the projects.

Of course, this does not apply to large sized projects as banks are always ready to finance major projects if they can meet the bank's terms and conditions. The experience of Eosol is that it has had to self-finance all the projects it has carried out. It has not received anything from the government or from banks to assist it financially to develop the business or to be able to compete.

With this financial situation, it was down to the profit margin to determine if a business project was worth taking the risk and financing from our own funds or not. After taking into consideration all the business factors, the outcome was often a very tiny margin that was not worth taking any risks for at all. Most of the projects made only a very small net profit.

Also, the different payment methods have to be discussed as most of the micro-project owners are small investors, mainly in the agriculture sector, with very limited financial capabilities, they always expect to pay in instalments over four or five years. This means that, if you want to survive, you have to be able to finance projects for at least two or three years which is an unrealistic option without the backing of a bank or financial institution.

4.4.7 Taxes

Tax issues are big problem all over the world because they always affect profits in a negative way. In Egypt they not only affect your profits in a negative way but they may bring your business to a halt as there is no clear template for each business case. The personal point of view of the tax officer is always the crucial factor. It is true that the government has developed the proficiency of the tax officers yet the situation is still far from ideal because it is still not clearly defined how much taxes any company should pay in any particular business case.

One of the big issues regarding taxes is that, all companies have to present their annual tax report according to their own internal financial records; the tax authorities accepts whatever any company writes in its annual tax report and the corresponding payment is made. Some years later, the company undergoes a tax inspection in which it maybe required to show, for example, all the documents relating to a transaction that took place some ten years ago.

This causes major problems and disputes between the tax authorities and tax payers. Despite the government having taken some steps to reform the tax system and facilitate tax collection procedures the situation is still not satisfactory. More efforts should be made in this direction so that all tax regulations are clear enough to everybody.

In conjunction with this point are the customs duties, which are also subject to the criteria of customs officers which may mean different tariffs for the same item!

Being responsible for handling the logistics of some plots in Benben has meant that Eosol has been through all kinds of problems with customs officers including misidentification of items that took weeks to be amended with the result that substantial extra storage and handling costs were incurred in addition to delayed delivery of shipments which meant that on-site work was delayed and the cost of the projects rose unecessarily.

Given the crucial importance of taxes for the economy and investment the tax authority in Egypt has started the process of developing and automatizing tax procedures and returns through the electronic portal of the tax authority

Tax cuts boost demand by increasing disposable income and by encouraging businesses to hire and invest more. Tax increases do the reverse. These demand effects can be substantial when the economy is weak but smaller when it is operating near capacity. In addition to the tax facilities granted, other measures have been introduced, for example Law No. 173 of 2020 regarding temporary overstaying of the delay fee

The development process has already begun for various tax procedures and kinds of returns and it has become mandatory to upload these returns to the tax authority's website, and this author expects that the electronic invoice will soon be applied as a measure of control and tax evasion prevention, to control and to limit the informal market that harms the national economy as well as negatively affecting the taxpayer who respects and applies the law.

In the considered opinion of the author the time is right to introduce a new tax law. The current legislation is Tax Law No. 91 issued in 2005, that is, fifteen years ago, and the author thinks this law should be replaced, especially as it has been subject to many additions, amendments and deletions, and consequently has become very difficult to interpret and adhere to.

The tax law addresses the entire tax community and not a specific activity, in other words there is no special tax law regulating the solar market in Egypt.

4.4.8 Other barriers

The description of the following barriers are drawn from the experience that Eosol has had in the more than ten years that it has been developing and participating in projects in Egypt.

4.4.8.1 Technical issues

Extreme temperatures in the Egyptian desert are one of the biggest barriers blocking the path of renewable energy development in Egypt. Most of the renewable energy projects in Egypt are in remote places where people are completely isolated from the public grid, most probably in the desert where extreme temperatures are quite common. For example, in the BenBan solar PV complex many inverters that have not been able to survive and some panel surfaces have melted because of the extreme temperatures. In the sun temperatures of 70 degrees are reached!

Lack of trained and skilled technicians is another technical barrier to renewable energy development in Egypt, before the BenBan project there were no solar energy skilled technicians, in 2012, many companies had to bring a technician from Spain for a small installation, all of under 30 kW. With these micro size projects, the cost of bringing an expat inevitably means projects incurring losses.

Operation and maintenance were a disaster at that time, as discussed before there were no local technicians available so most companies had to hire Spanish technicians for each small incident on any installation. It is easy to imagine that if, for one small error in a micro installation, it is necessary to bring in a Spanish technician, profitable outcomes are almost impossible to acheive.

4.4.8.2 Lack of knowledge

The lack of experience and knowledge is another barrier that prevents the renewable energy development in the country.

After the blackout of 2012, many companies started to seek renewable energy solutions, but most of the small and medium local companies which began solar PV projects had no previous knowledge nor experience in the field and the results were disastrous, most had already closed in the first three or four years after starting out. No training courses have been provided, there has been no chance of getting any academic learning in the field. It was expected that the NREA to assist somehow in this area, but nothing happened. Official channels repeated that mantra that the government was extremely keen on promoting the development of renewable energy in Egypt but in reality nothing was done to help the sector.

These first renewable plant installers for the only sector that demanded renewable energy, solar irrigation, had to turn to European companies for knowledge and generation equipment, which resulted in unaffordable technical support and installation costs.

The business for the small and medium size companies was haphazardly solicited, disorganized and depended only on personal effort and chance.

This lack of knowledge was even worse for clients. Clients involved in this sector, small solar irrigation clients, are very humble people with basic education and the developers had to explain the whole process to them. In order to convince them they were taken to visit some existing installations to see how they worked. Some of them asked small installers to wait for a period of ten years to check the long run proficiency of the solar irrigation systems.

4.4.8.3 Culture and business environment barriers

The prevailing business culture is one of the factors that contributed to the slow-down of renewable energy development in Egypt. The basic role of the Egyptian businessmen mentality is to bargain and analyze the basic patterns of the business to its to try to reach close-to-cost prices!

The common practice all over the world in this sector is to make a short list of companies based on each owner's criteria, obtaining financial and technical offers, comparing the offers within the shortlisted companies and then take the business decision. In Egypt, it is not like this, business mentality here relies more on the analysis of the business to determine its minimum components, then soliciting quotations and offers from hundreds of companies all over the world and letting all the competitors fight between themselves to get their best offers, at the end to go and do the business by themselves! This applies to micro instalments with only a few kilowatts up to the government Gigawatt sized projects.

Another similar feature of doing business in Egypt is the strong reliance on personal judgement and the importance of personal relationships. The Egyptians place a great deal of emphasis on this and even the best deal on the negotiating table will not prosper if there is a negative personal issue. In brief the Egyptian market may be described as an "intuitive" on that relies heavily on personal opinions and relationships more than strictly professional criteria.

4.4.8.4 Independence of EgyptERA

EgyptERA is supposed to be a customer protection entity. For example, if you have a problem with the electricity distribution company, the normal procedure is to go to EgyptERA to register any complaint.

However, in reality the situation is different. The head of both entities is the Minister of Electricity who is more interested in paying off the considerable debts of his ministry regardless of the quality of the service offered to the public or of ensuring fair competition.

This is the probably main reason why the renewable energy sector has not grown in the country. The ultimate decisions that control renewable energy developers are taken by their main competitor, the owner of the public production facilities, national grid and the distribution companies: the Ministry of Electricity.

4.5 Governmental involvement

In all countries of the world, whether developed or developing, the renewable energy sector is or has been heavily influenced by government decisions.

Any country wishing to develop the sector has promoted laws or reforms of existing laws making the progress of this non-existent sector possible. However, if a country preferred to stop expansion because it was developing faster than expected or even if the incentives that had been offered were too generous, it also modified the laws and the sector stopped immediately.

Today, in developed countries, the influence of the government is no longer so critical as renewable energies can compete with traditional ones, so general regulations are used to plan and install renewable power plants. However, in developing countries, with weaker interconnection infrastructures and usually with state electricity companies, the influence of the government remains critical for the development of the national renewable sector.

In the specific case of Egypt, this second assumption is the reality. The government, its decisions and its measures have been and are still today, critical for the sector to develop in the country.

Moreover, as in many other countries, the sector has experienced a stage of being promoted and then had to survive an attempt to break it, which is the stage in which we find ourselves right now.

4.5.1 Government initiatives to foment development of the renewable energy sector

From very early on, compared to any country, both developing and developed, Egypt has tried to encourage the growth of the private sector and renewable energy.

It must be remembered, as pointed in 4.4.2, that already in 1986 the Egyptian government had established the NREA, depending on the MOERE and in 1996 they liberalized the energy sector to foster private and international investment and in 1997 they established EgyptERA, that is more than 10 years earlier than Mexico as was seen previously in Section 2.2.

In 1996, Presidential Decree NO 100 was issued to encourage the private sector to invest in the electricity producing sector in Egypt. The problem at this time was that the government was offering subsidy programs to electricity supplies to all consumers in the country so the private sector companies could not compete at these low final prices.

In 2012, the crisis reached its nadir and the government encouraged companies from all over the world to invest in the electricity sector with a broad array of incentives.

In 2013 the Net Metering law was launched. According to this the generators of small photovoltaic installations [118] would inject the electricity they did not consume into the network, discounting them afterwards from their bill regardless of the time they injected and consumed the energy.

In 2014, Renewable Energy Law nº 203/2014 was approved. This set up some mechanisms for the development of renewable energy projects. The most important mechanisms were:

- State-Owned projects with competitive bidding for the EPC contract of the project. As an example of this initiative is the Kom Ombo project carried out by an important Spanish contractor.
- Projects with competitive bidding for BOO contracts.
- Projects with FIT. This was the extremely successful BenBan project. This project has been launched with an exceptionally good PPA price (142 USD per MWh) as part of the FIT program. Only two companies have participated in Phase I because of the local arbitration article in the contract.
- Independent Power Producers selling power in merchant schemes or directly to consumers using the national grid through a wheeling charge or grid access charges payables to the grid operator. The international company Coca Cola made 4 projects under this scheme.

In 2014, at the same time as the government announced the BenBan I project, the three Siemens giant combined cycle stations were contracted.

Also in 2014, a new Prime Ministerial Decree no. 1947/2014 was announced to establish the offtake tariffs applicable to the first and second regulatory periods of the 4 GW Egyptian solar and wind feed-in tariff program.

In 2015 the tax incentive law 17/2015 (The Renewable Energy Law) is launched for the development of renewable energy projects. This law annulled the value added tax on all products and services involved in the

[118] Initially, the maximum power to be able to benefit from this incentive was 5MW and later it was increased to 20 MW.

construction and operation of renewable projects. In addition, these projects were promoted through other tax incentives consisting of a 30% reduction in the tax base during the first seven years of the project, subject to some restrictions. It also set the equipment import rate at two percent, which is very low for the country. Finally, the purchase of the land necessary for construction was tax-free[119].

In 2015, The Electricity Law no. 87/2015. In this new law the government tried to encourage energy efficiency and the generation of electricity from renewable sources, and offer complete independence for the activities of generation, distribution and transmission of electricity to achieve a liberalized and competitive electricity market.

In 2016, a lower PPA price was announced (84 USD per MWh) yet the PPA was still very attractive[120].

In 2017, Investment Law no. 72/2017 and its Executive Regulations were issued by Prime Ministerial Decree no. 2310/2017. This initiative set out the legal framework for the establishment of renewable energy projects and provide incentives for investment in this sector.

4.5.2 Government initiatives to stop the development of renewable energy

After the great success of the BenBan project, the government's position on promoting renewable energy changed radically.

The reasons are varied, but the main ones are as follows:

- First, the Ministry of Electricity has some of the heaviest debts, above all other government sectors in Egypt, almost 25% of Egypt's total external debt - USD 123.5 bn – corresponds to the Ministry of Electricity and Renewable Energy. This means the electricity authority needs to keep each single client paying them and had to avoid paying private companies, so they put more and more restrictions in the way of private pv developers.
- Second, excessive electricity production means that each new PV installation will cause more government produced electricity to be wasted.

For this reason, the government began to promote a series of initiatives, some formal and others informal, to stop the development of new

[119] For a detailed information about tax incentives, see the Renewable Energy Law 17/2015. Unfortunately, there is no English version for this law.
[120] For further information about this modification in the FIT, please visit: http://www.nrea.gov.eg/Investors/FeedInTariff

renewable energy projects. With all these aforementioned initiatives, 2016, saw the beginning of governmental hidden restrictions in the way of developing private sector pv installations, yet private developers could still do some projects and overcame small difficulties that were instigated by the government.

In 2018, more restrictions were put into practice which made the private PV developers' business increasingly difficult.

In 2019, the Prime Ministerial Decree was approved determining the FIT for electricity generated from biomass[121].

In 2020, Circular no. 2/2020 of EgyptERA. The EgyptERA restructures the net-metering system for solar power generation[122].

The situation today is that getting any kind of licenses to be connected to the grid is far too complicated a process, without any clear or written instructions, and no official reply is forthcoming from any governmental officers.

4.6 Case studies

This section will present some real situations experienced by companies or people close to Eosol in order to understand how and where the barriers described during this chapter arise.

These cases will be written in the first person as they reflect the interviews with the main protagonists.

In the first, this being one of the first experiences of attempting to develop photovoltaic projects in the country, the lack of knowledge and experience of both installers and customers will be reflected, which in fact causes economic losses for the installation company.

In the second, it will be seen how the Egyptian negotiating mentality and the lack of experience of the local executives postpone the deadlines to the point of almost making the project fail.

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[121] This measure can be considered as a measure to curb renewable energies, because there is really not enough biomass in the country to make a generation plant. So, this is more of a distracting measure.

[122] The new requisites for getting the net metering scheme are the following: (a) the generation facility must be located within the premises of the electricity consumer; (b) the total capacity of net-metering solar power projects connected to any single distribution company must not exceed 1.5% of the peak load of the distribution companies registered during the financial year preceding the contract; the total capacity generated from solar net-metering projects must not exceed 300 MW (125 MW for capacities up to 500 kW and 100 MW for capacities greater than 500 kW and up to 20 MW); (c) the installed capacity of the met-metering facility must not exceed the maximum load of the consumer during the year preceding the commercial operation date of the facility; and (d) a balancing charge must be payable, among other requirements.

In the third case, this mentality and lack of professionalism in the negotiation finally made the project fail and three years after initial negotiations the project was never built.

In the fourth case, it will be seen how a local construction company lowers prices so much in order to win the contract, that even after receiving an advance, it has to abandon the project and since the client lost money, it was never built.

In the fifth case, it will be seen how the attempted speculation of an international company that did not really have financial support, despite managing to sign the project then fails to build it.

In the sixth case study it will be seen how a well thought out, well negotiated project about to start construction is stopped by EETC for barely justified reasons so as not to lose the client.

In the seventh and last case study it will be seen how another project, generally well thought out and well negotiated, cannot be carried out due to regulatory changes.

In order to maintain the confidentiality, no names will be revealed.

4.6.1 Solar irrigation company case

After 2012, due to the blackouts, the expected reaction of small farmers was to look for a renewable solution but there were a lot of obstacles in this area.

The first one was the knowledge of the clients. People involved in this sector, small solar irrigation clients, tend to be quite humble people with basic education and the developers had to explain the whole process to them. In order to be convinced, they had to visit some existing installations to see how they worked, I, myself, have witnessed one of them asking to wait for around ten years to check the long run proficiency of the solar irrigation systems.

As we have discussed before, I and almost all small and medium developers have no idea about solar installation, we were only equipped with our personal ambitions and enthusiasm. The first big issue for all of us was the technical support, everyone has got their own way of getting suitable technical support, each proved to be successful or not some few years later as indicated below.

Some developers sought to gain technical knowledge from the existing big players in the country at that time, this wasn’t easy because of the lack of big international solar PV players in Egypt at that time and also this approach requires very specific public relations skills that not everyone is in possession of.

Others got Chinese companies to support them as the Chinese companies offered a comprehensive package including some technical support. I received some of those offers but I didn't like the idea of having Chinese equipment for my projects (lack of experience and lack of knowledge from my side)

This approach proved to be the best available option as these companies grew very quickly and they dominated the market till 2014 when the BenBan first phase was launched.

Now those people are big, brilliant names in the solar irrigation systems for small and medium agriculture projects. They dominated the market because of the help their Chinese suppliers offered them.

Some others, I was among this group, very few developers, chose to go to Europe to buy the equipment and seek some technical support. That was a big mistake, as European equipment is very expensive, not competitive in these kinds of small and medium agriculture projects in Egypt. Also, European companies offered very expensive technical support including travel costs and fees for their technicians; unlike Chinese companies who offered free technical support with very competitive payment terms over longer periods of time than the Egyptian banks offered!

Some people have acted like imitators, they waited for the final outcomes of each group and then followed suit, often achieving the best outcomes. Of course, all of them are working with the Chinese companies now.

For me, I have developed some excellent installations, copies of the best small installations I have seen in Spain. This is what I have done for each component of my installations and the obstacles that I have met:

1. The panels which are the most important and the highest cost in any pv installation, were LUXOR panels, famous German produced panels with excellent quality. These are working in many locations perfectly still today without a single complaint. The issues here were that:

    - German panels were extremely expensive, maybe the most expensive panels at that time.
    - I didn't buy directly from the factory in Germany, I bought from retailers in Spain! So the panels have incurred higher costs being transferred first from Germany to Spain then from Spain to Egypt. (I have bought all the components of my systems in Spain)

2. The inverter. I got an American Fujitsu inverter with a control panel assembled in Spain.
3. The structure was made of pure Aluminum, I got the profile sample from Spain, ordered stamps to be made in China and made the profiles in Egypt.
4. All cables and accessories were imported from Spain.

As a result, the confirmed loss had come at the end of each project because of the unbelievably cheap rates that have been offered by the Chinese competitors and the almost free, technical support that the local developers received from their Chinese partner. When it came to evaluating the results and looking for the best way to continue, the BenBan project had been announced and I began to think of giving up the micro installation world to get into utility scale installations and I began to look for some investment partner to come to the country and launch a real solar energy business.

4.6.2 International Cement Company case

We talk in this case with an international developer who installed a solar PV generation facility for an international cement company.

This company, as one of the worldwide leading cement producers, had some plans to go green and to reach this goal senior management had contracted an international engineering firm to do the feasibility studies for their facilities in Egypt.

After the positive report for the solar installation, the company announced a tender to set up the PV installation. The company we are talking to today is the one which, after submitting their bid for the tender, was finally awarded the contract. The communication of the final decision was made only by email and never by an official letter.

After some initial negotiation, the cement company told them they had received a better offer and they had to reconsider the tender adjudication. The cement company kept putting off signing any PPA related to its factory PV installation and finally they signed it two and a half years after concluding the tender. Clearly there are many problems that stopped the project from coming to fruition even today, and on top of those causes are the legal and regulation changes that have taken place in Egypt throughout recent years.

All this discussion has been around the governmental obstacles hindering the project but the main reason of getting into this trap is that cement company has acted with typical Egyptian businessmen mentality. They went deeper into the technical and commercial details as if they were going to set up their own PV Installations Development Co. They went so far in price discussions with so many service providers that they took their eye off the ball, failed to concentrate and wasted so much time that they reached the point when the government began to put all those limitations to developments in the sector. They always looked for some more benefits that in some of those meetings they were discussing having the contract as an EPC not a PPA. This means they had been hesitating to pay for their electricity consumption until the last moment. Moreover they had entered into negotiations with another developer even after granting the awarding letter. This caused not only a long delay but also caused a point to be reached when the whole project was not confirmed.

4.6.3 The case of a big Real Estate Contracting Company (BRECC) case

This project is another example of too long delays and hesitation that caused a successful project to fail to materialize.

This project began, as is usual in Egypt, with a meeting in a café with a friend who told me about a BRECC owner who would like to have his own PV installation. A meeting was held with the owner and below are the final outcomes of the many meetings that followed and the multitude of exchanged emails. The BRECC would have liked the contract on an EPC basis so they would be the owner of the PV installation. The BRECC owner had enough funds in his account for the first 5 MW installation so financing was not a barrier here. Once again, the BRECC followed the typical Egyptian businessman mentality and went to almost all the companies working in this field in the country. The BRECC owner tried to play smart and to get best out of each developer to maximize his profits. The BRECC owner did not have the required licenses and permissions so there could be no big sized project but it was possible to have the small size project, 5 MW, for his internal farm usage. The project is now stuck at the point that the BRECC owner has to take a decision about his self-consumption 5 MW installation to turn this project into a reality otherwise it will never come become a reality.

One of the most complicated issues regarding the behavior of this businessman and moreover, which is a common practice among the business society in Egypt, is that he took the official company offer with all the technical details, deleting just the company name, and distributed it among all the other players in Egypt asking them for quotations meeting the same technical specifications. This naturally resulted in a problem between the BRECC owner and company local managing director who cut the communication and delayed the project for some time.

In brief this project is feasible in its first phase, 5 MW, some decisions have to be taken by the BRECC to sign the EPC contract and go on to fight with the authorities to get the 5 MW installed.

4.6.4 The case of the three farms project

This project consists of three big farms totaling almost 44 thousand Feddans of land area (around 184.8 million square meters) with a current consumption of 24 MWh and expansion plans to reach more or less 60 MW after adding more pumping units and some agricultural industrial units such as fridges, packing, freezing units etc.

The Chief Executive Officer is somehow a family businessman. This man is a most professional agricultural private sector leader, he has followed the typical correct way to secure full success for his project, yet he failed to convert his project into reality, and he is now having serious problems regarding this project. It is extremely interesting to study this case as it will reveal a different kind of obstacle to PV installation in the country.

The main aim of this project is to supply electricity to all the agriculture and industrial facilities of the three farms, so this man announced a limited tender and asked around 5 companies that he knows from his electricity management close friends and consultants. We prepared the best offer we can prepare and applied for this limited tender. On getting the result of the tender I had a long meeting with the owner to see the possibilities of doing business together. He told me that our offer is far above the competition as it is more than 150 thousand USD per MW higher than the closest offer. I tried to explain to him that the equipment offered by us was different and was more suitable for the local environmental circumstances but he wasn't convinced and chose to contract one of the competitors who has a big name in the country, this big name being related to electrical equipment industrialization, specialized cables and not to PV engineering and development.

This project contract was signed to install 44 MW. They paid 20% of the total contract amount, as a down payment.

The contract base was to get a net metering license for all the three farms and once they had signed the contract and paid the down payment, some extra restrictions were placed over the net metering system putting limit on the whole country's net metering capacities of 300 MW in total as well as some extra restrictions that didn't allow any single client to use more than 1.5% of the corresponding total distribution company capacity[123]. The result is that the project is now stopped because 1.5% of the total capacity will never exceed 5 MW for the all three farms and the man has already began to look for another engineering solution to reduce his monthly electricity bill.

The main issue here is not only that the company owner was not aware of the governmental restrictions but also that the competitor who won the contract has announced its desire to subcontract a company to carry out the entire EPC contract on its behalf. The reason behind that is that they do not have the engineering capacity to do it themselves.

I see this behavior from this competitor who won this PV installation contract as one the most important barriers and the most devastating factors affecting business in Egypt in this sector, as most of the companies are not technically prepared to do the business yet they compete and spoil the market. After they win contracts, they look for a cheap Chinese company to subcontract.

4.6.5 Poultry project case

This was one of the most brilliant projects that we have worked on in Egypt. The main purpose of the project was to set up one of the world's biggest farms to breed chickens to secure self-sufficiency for the local market with some excess production to export to a massive logistics area. We were invited to set up a PV installation that was intended to supply electricity to the chicken farm and the logistics area. The first phase of the project was 500 MW installed capacity with extensions and land area available for 5 GW to sell the excessive electricity to the public grid and even, to neighboring Libya, a country that was suffering due to the civil war following the Muammar Gaddafi regime.

The whole project was supposed to be a property of the NSPO which was considered as the economical arm of the Egyptian army. The project was so well planned with only one fatal flaw that resulted in the whole project being cancelled.

The NSPO has all the required funds for this project and they had major support from private sector businessmen and firms as they were the most trustworthy business leaders in the country and they had arranged to develop farm with a company that had been introduced to them as one of the leading companies all over the world in the field. Later, it turned out to be a small firm with no previous record or any experience at all!

[123] Net Metering Law of 2018 published on 08/16/2018. It was suppressed by Periodical Book No. 2 Year 2020. Please visit http://www.nrea.gov.eg/Content/Energy%20legislation/2_2020.pdf

The NSPO leaders had taken all the necessary steps to ensure the success of this project but regulations and precautions have to be followed for any project they are involved with. Among those precautions is the necessary check on all the parties taking part in any NSPO project or any project related to their name, so they checked up on the company that was supposed to lead the project at the World Trade Point at the Egyptian embassy in Geneva only to discover that this company was fake and the whole project was put on ice and at this point is waiting for another proposal to be launched.

So we have here another barrier which is the existence of fake companies and people who spoil the business causing many projects to be cancelled or delayed like this one.

4.6.6 The case of the Libyan owners project

This project is owned by some Libyan businessmen who had a great deal of investments inside and outside Libya. This project is an agriculture project of 33 thousand Feddans (138 million square meters land area) with more or less 20 MW contracted capacity with the related electricity distribution company.

The project reached this installation company via two main business partners more or less at the same time which means the owners had disseminated the project widely. Once we were invited to this project, we have paid a visit to prepare an offer with some technical details. We met with the project Chief Executive Officer, who asked us to prepare an EPC offer. When we submitted our EPC offer, as usual, he told us that this was far higher than the market prices and he could not award this contract to us. Shortly afterwards we were invited by another business partner of this installation company to apply a new PPA offer to the same man under the net metering system.

When we were ready to apply our PPA offer, the new regulation of the net metering system[124] had come into force and we had to wait for the man to solve his problems with the distribution company because we had to apply through the distribution company who is the service provider to this farm.

Here we find another big hidden barrier, once this Chief Executive Officer has declared to the distribution company that he is willing to do some PV installation, they began to take mount strange illegal actions against him and his company.

[124] Unfortunately, there is no web access to this law, nor access to any English version at all. The only way to get an Arabic copy is applying in person at EgyptERA.

For example, they issued a 7.5 million EGP fine for him that had to be settled within three days otherwise they would cut the electricity and leave him in the dark without pumps to irrigate his land and without power to run his other facilities. Their reason for the fine was ridiculous, they told him that he was using the electricity for reasons other than those for which it was contracted, i.e. his contract was to supply electricity for his agricultural land but he had a fridge which was considered industrial usage and he had an administrative building which was administrative usage, each with a different tariff!

Bearing in mind that the Libyan company had acquired this project from the Egyptian government itself with all its components and facilities as they were, also the electricity people had been supplied to these premises for more than 40 years and the bills had been paid monthly and only now had they discovered legal infringement that deserved a fine of 7.54 million Egyptian pounds (more or less $500,000).

I witnessed this behavior from the distribution company because this company is the biggest client of this distribution company so if the employees lose him, they would lose a big portion of their personal incentives and money they get from the total amount that they are able to collect. This is why they are trying to put obstacles in front of Renewable Energy usage, and they act illegally and misbehave in this crude way.

Again, this another barrier to the renewable energy sector in Egypt, employees with far-reaching authority with no strict inspection under the law.

4.6.7 The case of the ceramic factories project

We were invited to this project via a local business partner in Egypt. The project was to supply electricity to more than 11 ceramic factories with a total capacity of around 25 MW installation.

The project never reached fruition because of the net metering regulations. At the time we had been involved in this pre-feasibility study for this project, the Net Metering system was allowed with some conditions, among those conditions were:

- The client or the developer has to install the PV installation within the fence of the customer so there is no wheeling system allowed.
- The customer should be connected to the distribution company and not to the EETC (Egyptian Electricity Transmission Company)

In this ceramic factory project, all the factories were connected to the distribution company yet we were not able to proceed with the project because of the following reasons:

- They did not have enough space within the fences of their factories.
- We were able to install smaller capacities, suitable for the area available inside the factory fences in line with the law, but the ceilings of all the factories were too old and too fragile to the point that I couldn't even walk on them. With such a weak a steel roof it would never have been possible to install thousands of pv modules on them.

The alternative was to reinforce the roofs and do the necessary maintenance on the ceilings, but this was completely unfeasible at that time. Maybe one day those factories will undergo some kind of rehabilitation and have some maintenance done on their roofs after which we will be able to go and do the PV installation.

4.7 Egypt Barriers Conclusions

Egypt is in a dilemma as a country in the development of the energy sector, not only in renewables but in the entire sector in general. They have to decide whether to take the final step to open up the sector to both domestic and international private companies. This decision will depend on whether the country develops its ambitious plan to become an international energy hub that can supply reliable and economical energy both to its own country and to the surrounding countries. Depending on this decision, the renewable energy sector will expand enormously or, on the contrary, will stagnate in the current situation.

If the country decides to open the sector and thereby become an international energy leader, on a renewable level and in order to obtain real development in the renewable energy sector, one quite simple key action should be taken. This would be to separate the Ministry of Electricity from EgyptERA, EETC and the Distribution companies and let the free market and the electricity market mechanism in the country be controlled only by demand and supply as part of a bigger free market.

As it has been seen in this chapter, the biggest obstacle to such a step being taken is probably that the Ministry of Electricity bears one of the heaviest debts of all the government sectors in Egypt, almost 25% of Egypt's total external debt - USD 123.5 bn[125] – belongs to the Ministry of Electricity and Renewable Energy. This means the electricity authority needs to keep each single client paying them and not paying private companies, so they the private PV developers with more and more restrictions. This is why the Egyptian Government neglects to make use of the gas resources to keep a balanced generation mix between solar, wind and gas resources. Its strategic decision is to sell the gas to reduce the debt and to invest in alternative green sources such as CSP, the competitiveness of which is not yet so clear.

Perhaps the question that the country should answer is whether it is preferable to restrict free competition in order to pay the international debt it has acquired in exchange for limiting the growth and competitiveness of a sector or, on the other hand, to liberalize the sector and become an International hub with clean, competitive and available energy. Under the latter situation, the outdated generation and transportation assets would probably be replaced or refurbished more quickly, the stability and correct balance of the generation mix would be secured, and the general economy would become more competitive and therefore grow faster, allowing the Egypt Government to balance its incomes with the export of energy and the fees on the grid use charged to the private sector (not only for domestic but also for export).

Egypt exerts a historical influence on the Arab and African neighboring countries, so let us hope that the decision taken is the correct one as, depending on what Egypt does, the rest of the Arab League countries will be affected.

As in the case of Mexico, this work cannot be limited to offering a static and pessimistic view of the situation and must go a step further by proposing some measures that would result in a substantial improvement in the development of renewable energies in Egypt.

Below are a summary of some recommendations whose total or partial implementation will help overcome barriers, allowing Egypt to occupy the role of regional leadership in the use of these energies, in accordance with its size, population, availability of resources, energy needs, position in the region and commitments made to social and environmental responsibility.

- <u>Development plan</u>: Design of a territorial development plan for the country that clearly defines how urban, industrial, and agricultural development will be allowed. This plan must clearly define future energy needs both for national consumption and for export and the sites where future electricity generation should be implemented.

[125] It would be interesting to know how much comes from the BenBan project.

- Permissions: The Government must define a clear frame for renewable energy, including taxes, and must oblige the various protagonists involved in the process to follow the rules.

  Once a clear definition of the regulatory framework has been established, a state office must be set up with the character of a "single window", in charge of coordinating the relationship with all the competent public bodies (EETC, EgyptERA, NREA, ...), for the coordination and granting of permits and authorization for both construction and easements and affections to public property and rights. This office must approve a series of (i) clear and transparent regulations with the rates and taxes applicable to these kinds of projects and (ii) administrative procedures to provide the necessary legal certainty and ensure certain deadlines for the resolution of the necessary procedures.

- MIA: Statewide establishment by EEAA of the catalogue of environmental requirements to be met by solar projects, avoiding the creativity and discretion of local regulations.

- Land barriers: The government must define the areas in which future projects will be implemented, defining and regulating the conditions under which Bedouins must be compensated.

  These measures would, on the one hand, enable the planning of the implementation of solar and wind projects that would otherwise be implemented haphazardly and on the other hand, make it possible to benefit a large sector of the poorest population that is usually excluded from this type of project due to the difficulties involved in negotiating with these groups.

- Comercial barriers; The government must define the clear criteria to be followed by EETC in the case a costumer decides to leave them and enter into a private PPA.

- Interconnection barriers: Planning and prioritizing the reinforcement and meshing of the network in the most congested nodes and new infrastructure to be built.

  Maximum attention must be paid to this aspect considering the importance that the Egyptian Government attaches to its international interconnections.

  In this section, a public-private investment plan for the development of evacuation infrastructures should be made in such a way that it is transparent for all developers when and where the infrastructures will be built and therefore when and where there will be evacuation capacity available.

- Auctions: Establish an auction mechanism, facilitating the concurrence of investors, with transparent procedures that objectify the requirements of technical-economic solvency and accredited experience and that do not require disproportionate guarantees.

  With this mechanism of auctions, the financial barriers will be solved because all financial institutions are used to these kinds of projects.

- Avoid speculative processes; After the implementation of the auction mechanism, the government must be ready to prevent any transfer of construction permits or licenses obtained before the project has reached the grid connection and commercial start-up or even a minimum period of permanence in the project capital.

- Public-private collaboration; Promoting the creation of stable forums or "sectoral meeting tables" between regulatory public bodies and generators to achieve a fruitful dialogue on the difficulties evidenced and the measures that both parties can adopt to achieve a harmonious development of renewable energies in the country.

- Electricity Market creation: An electricity market with a clear functioning mechanism would help private developers to take decisions regarding renewable installations and signing PPAs, because in the case that the PPAs do not work they would have an alternative.

Chapter 5

Final Conclusions

5.1 Conclusions

It is becoming increasingly more evident that the world needs a transition from an electrical energy generation system based on fossil energies to one in which renewable energies dominate and that this transition is essential and must be accelerated. To this end many improvements have to be made at a technical level, especially in countries or regions with poorly meshed interconnection systems. But in addition to technical improvements, administrative improvements are also essential (International Renewable Energy Agency, 2020).

As mentioned at the beginning of this document, this implementation cannot remain within the level of developed countries, but must be global, since otherwise our attempt to stop climate change and to be able to offer a future to our planet will be in vain. For this, it is essential to fully understand the main barriers faced by developers of renewable energy projects in these developing countries in order to anticipate and thus, to the extent that each country allows, help to eliminate or mitigate these barriers so that the battle for a world free of fossil fuels is the outcome.

It has been found that, both in Egypt and in Mexico, the two countries on which this document is based, the main barriers to the development of renewable projects in general and photovoltaic projects in particular are very similar.

Without entering into detail of the assessment of each of the barriers, which has already been carried out in depth throughout this document, it has been shown that due to the large number of barriers such as those of "permissions", land, commercial technical, financial or regulatory, that government intervention to encourage the development of renewable energy is essential especially in developing countries. For this reason, the international community must impose globally the need for these development policies to be carried out. Once these minimum renewable goals have been imposed, until their implementation is complete, the international community must help developing countries in the preparation and implementation of a favorable legal framework, placing special emphasis on the distribution within the territory so that the benefits of these types of projects reach communities that are usually excluded.

This same community must anticipate the future and not only think about the current problems for the development of renewable projects but must also consider whether the current regulatory framework with regard to pricing may be a barrier that, and although it is not currently the case, within in a very short space of time, energy prices may reach zero or even be negative.

Renewable energy developers are aware that they have to follow a long, difficult and expensive road to carry out a generation project. Along this road, numerous barriers such as those described throughout this document have to be faced and overcome.

Overcoming each of these barriers is a necessary but not sufficient condition to achieve the success of the project. Often the barriers coincide and overlap in time and reinforce each other, resulting in the failure of the project and the monetary loss of everything invested by the promoter in the various phases of development. On other occasions, the barriers have a "delayed" effect, that is, once the project is already in the exploitation phase. In these cases nothing can be done, there is no room for maneuver and the holder faces the loss of their legitimate expectations and even the risk of not being able to meet the financing commitments acquired.

The losses caused to business initiatives that generate development, create jobs and indigenous wealth, due to the existence of the aforementioned barriers, are to be regretted, when in most cases they could be avoided. However, these losses are even more regrettable when considering the issue from a sectoral and national perspective. Missing out on these potential opportunities, which countries such as Mexico or Egypt have of mobilizing their natural resources, means giving up a clear factor which has the potential to contribute to their sustainable economic development, to the reduction of their carbon footprint and, ultimately, to fulfill their international commitments in terms of reducing emissions.

All these conclusions taken from the analysis of two of the main developing countries, or at least the two most influential countries in some of the most important regions for the future of the world, Latin America, the Middle East and Africa, as well as the opinions and the experience of some of the main developers in these countries are key to meeting the challenge of advancing renewable energy projects in developing countries. This is a challenge at the level of all humanity and failure to take advantage of this once in a generation opportunity will have consequences that no one can even imagine.

Annexes

Annexes of the thesis

6.1 Annex: Management to generate electricity within the law transition process

Procedure Required	Competent Authority	General Description	Scope	Deadline Achievement	Cost (MXN)
Electrical generation permit	CRE	Application for a single generation permit that covers the operation of the plant, or permits under any of the modalities in terms of the LSPEE (requested or obtained prior to the entry into force of the LIE).	It allows the generation of electricity and the participation in the new wholesale electricity market of those generating plants that have a permit. O power plants operating under the previous regulatory framework in some of the modalities established by the LSPEE.	60 working days	Per annual permit supervision: $ 98,500 for projects below 10MW and $ 245,500 for projects greater than 10MW and up to 50MW
Interconnection Contract	CENACE	Request of the interconnection contract to be concluded with the carrier for the use of the National Transmission Network and Distribution Networks. Or contracts formalized with the CFE under one of the modalities of the LSPEE (legacy contracts).	It allows the central to be interconnected to the public service network, after completion of the respective technical studies by the CENACE. When an interconnection contract is formalized, priority is given to dump the network at a certain junction point, the energy associated with the installed capacity of the plant, since the capacity of the SEN is limited. And legacy contracts are the instruments through which a commercial relationship is established with the CFE for the purchase and sale of electric energy, under one of the modalities of the LSPEE. A legacy contract in the SAB modality is linked to a transmission agreement, which defines the charges for the porting service to the different loads that will use the energy generated in the plant. Both contracts are for 20 years.	70 working days (No deadline is established for this procedure in the Interconnection Criteria officially published on June 2, 2015)	Non Applicable
Contract of Participant of the Wholesale Electricity Market (MEM)	CENACE	Application of the market participant contract under the modality of generator, figure that will repress the various PV plants by injecting electricity into the utility network within the MEM.	It makes it possible to participate in the different existing electric markets and long-term auctions, as well as the formalization of bilateral transactions through contracts of electric coverage with qualified users. These markets will be created in accordance with the provisions of the LIE, market bases and Market Practice Manuals, for the purchase and sale of electric power, power, related services (firm fossil sources), financial transmission rights and energy certificates Clean (CELs). The only market in operation today is the short-term Energy Market: Day-ahead Market (MDA) and Real-Time Market (MTR). The Participating Market Generator, once formalized the respective contract with the CENACE, will represent n generating plants in the MEM, by means of the express authorization of the permisionary holders of the respective generation permits. Accreditation as a market participant means having full access to the market information system, created in CENACE's web portal for the issuance of offers of sale of the different products mentioned above.	200 calendar days	**$ 1,000,000 (single) for basic market guarantee + $ 8,500 annual quota measurement point + $ 1,000 annual per MW of installed peak capacity + $ 30,000 (single) for obtaining registration + $ 2.5 annual per MWh generated**
Migration of legacy contracts to the new LIE scheme	CENACE/CRE/CFE	Request for modification of the Permit granted by a permit with a unique character of generation. Request of the interconnection contract in terms of the LIE. Request of the modifying agreement to exclude capacity of the plants declared in the legacy contracts, to include them in the new interconnection contracts.	The feasibility to operate in the Electricity Market through the migration of the previous regulatory framework to the new LIE. Either through the exclusion of the total capacity of the plant declared in the legacy contract, or part of that capacity, in which case would operate under both laws. Once the migration was made, it could be returned to continue operating under the Law delgorada, within 5 years after the migration and once.	200 calendar days (evidently involves accreditation as a market participant).	Included in the above procedure
Indicative Study	CENACE	Request for a study of technical feasibility for the interconnection of generating plants	Technical feasibility study to determine the possibility of interconnecting a generating plant to the National Electrical System in a certain node of the network, depending on the capacity available to dump energy. These are preliminary results and do not imply complete security for such interconnection.	10 working days for power plants with capacities up to 100MW and 15 for power plants up to 150MW	**$ 178,400 for projects up to 40MW and $ 267,600 for projects up to 100MW**
Impact Study	CENACE	Application of the technical study of impact to the electricity network, given the interaction that will exist between the generation of the plant and the SEN (demand of loads and possible congestion in nodes of the network).	The Impact Study in the system has the purpose of evaluating in a detailed way the Imoacto that is in the SEN when interconnecting a power plant with a capacity greater than 10 MW. For these effects, both steady-state studies and transient stability studies (Angular and Voltage) will be carried out under normal conditions and contingencies, in order to determine the infrastructure requirements for the interconnection. In order to carry out this study, it is required to request the Indicative Study in advance.	50 to 70 working days	**$ 356,800 for projects up to 30MW and $ 535,200 up to 100MW**
Facilities Study	CENACE	Application for the Facilities Study, which will define the works required for the interconnection of the plant.	The purpose of the Study of Facilities is to document the number, characteristics of the elements and equipment, as well as the estimated costs to carry out the interconnection works, as well as the reinforcements required in the National Transmission Network And General Distribution Networks. In order to carry out this study, it is necessary to have previously carried out the Impact Study.	45 working days	**$ 446,000 for projects up to 30MW and $ 535,200 up to 100MW**

Source: Own elaboration with EOSOL data.

6.2 Annex: Environmental impact assessment (EIA)

Procedure Required	Competent Authority	General Description	Scope	Deadline Achievement	Cost (MXN)
Manifestation of Environmental Impact (MIA)	SEMARNAT	Impact of the project on the environment	Opinion issued by SEMARNAT	30 working days	$130.000
Technical Training Background (ETJ)	SEMARNAT	Study to determine the forest species that will be affected	The feasibility of carrying out the project in terms of affected forest species and the elaboration of the respective MIA	30 working days	$130.000

Source: Own elaboration with EOSOL data.

6.3 Annex: Local municipal management with the competent authorities

Procedure Required	Competent Authority	General Description	Scope	Deadline Achievement	Cost (MXN)
Land Use	Department of Urban Development of the Municipality	Urban compatibility of the project	Issuance of opinion by the competent body that determines the urban compatibility of the project, since the use of the land will be modified	10 working days	$1.500
Building permit	Department of Urban Development of the Municipality	The authorization license to start the works	Express authorization by the competent authority to construct the installation	30 working days	$5,500/MW aprox. installed
Crossings Infrastructures and concessions for the use of federal zones	SCT/CONAGUA	Request for permission to construct the electrical evacuation line when in this route crosses to various infrastructures	Permit to build various crossings and marginal occupations	30 working days	$ 2.5 / m2 for concession and $ 100 / m2 for construction (CONAGUA)
Legal easements of passage	Individuals	Conclusion of contracts with private individuals when the route of the Evacuation Line passes through their premises	Express authorization by various individuals to occupy required surfaces in the layout of the evacuation	Indeterminate	Indeterminate

Source: Own elaboration with EOSOL data.

6.4 Annex: Procedures related to the social impact of the project

Procedure Required	Competent Authority	General Description	Scope	Deadline Achievement	Cost (MXN)
Social Impact Manifestation	SENER	The identification and assessment of the social impacts of the project, which could be derived from its activities, as well as the mitigation measures and social management plan.	Evaluation of the Social Impact of the Project, the contents of which could be summarized as follows: I. The description of the project and its area of influence, II. The identification and characterization of the communities and towns that are located in the area of influence of the project, III. The identification, characterization, prediction and assessment of the positive and negative social impacts that could be derived from the project and IV. The prevention and mitigation measures and the proposed social management plans. The SENER will periodically evaluate the state of progress in the plans and programs implemented and directed towards the installation of capacities in impoverished communities, which will allow the inhabitants of these communities to become the protagonists of their own development.	Undefined	Those associated with the particularities of each project to correct damages to third parties

Source: Own elaboration with EOSOL data.

6.5 Annex: Suspension pre-operational tests for wind and photovoltaic installations

6.5.1 Suspension Pre-operational tests for wind and photovoltaic installations

The main point that was attacked in the courts of this CENACE initiative was the fifth point of the so-called "Actions and operational control strategies to strengthen the reliability of the national electricity system", which establishes:

"*FIFTH. As of May 3, 2020, the pre-operational tests of the intermittent wind and photovoltaic Power Plants in the process of commercial operation are suspended. Likewise, for those that have not started, the pre-operational tests will not be authorized*".

This fifth point is serious and causes immediate consequences to solar and wind installations. It immediately causes irreparable damage to the plants that were under construction or in the commissioning test phase. It was presented by CENACE in a surprise and arbitrary fashion to the responsible authorities, without it having the powers or competence to do so. The pre-operational tests were suspended indefinitely, thus restricting the start-up of the Power Plants that were under construction in the country

CENACE, by launching this initiative, were guilty of several irregularities, among which an initial one stands out, that of not consulting the CRE. Regardless of the reasons for the Sanitary Emergency deriving from the SARS-CoV2 virus (COVID 19), this agreement was presented because of a communication from SENER to CENACE without prior consultation with the regulatory body CRE. This lack of communication is supported by CENACE in Articles 11 and 15 of the LIE, which refer to the direction of the country's energy policy and the operational control of the SEN that SENER can carry out. It is true that the Secretariat of Energy has this power, but it cannot take political measures without consulting the CRE, which is the body with the powers of operational control.

This cannot be a decision of convenience or governed by circumstantial conditions. The powers of the CRE cannot be suspended or ignored by a communication from the SENER, nor can CENACE act beyond the parameters established by CRE itself and invade its powers.

These differences in actions and powers had already been resolved in the LIE, specifically in articles 132 and 136 of said law:

Article 132.- *The Secretariat will establish the policy regarding efficiency, Quality, Reliability, Continuity, safety, and sustainability in the SEN, including the criteria to establish the balance between these objectives.*

The CRE will issue and apply the necessary regulation in matters of efficiency, Quality, Reliability, Continuity, security, and sustainability of the SEN.

The CRE will regulate, supervise, and execute the process of standardization and normalization of the obligations in terms of efficiency, Quality, Reliability, Continuity, safety, and sustainability of the SEN.

CENACE may issue technical specifications on such matters with the authorization of the CRE.

The Secretariat will regulate, supervise, and execute the process of standardization and normalization in the matter of security of the facilities of the End Users.

The members of the electrical industry may not apply technical reference specifications other than the regulation, standardization and normalization issued or authorized by the competent authorities.

The policy and regulation referred to in this article shall be mandatory in the planning and operation of the SEN.

Article 136.- *To protect the public interests in relation to Quality, Reliability, Continuity and Security of the Electric Supply, the CRE may dictate or execute the following measures:*

- *i. Suspension of operations works or services.*
- *ii. Securing and destruction of objects.*
- *iii. Evacuation or eviction of facilities, buildings and premises.*
- *iv. Closure, temporary or permanent, partial or total, of facilities.*
- *v. Make human and material resources available to deal with emergency situations, and*
- *vi. Those that are established in other applicable laws.*

The CRE may request other authorities, within the scope of its competence, the application of additional or necessary security measures to execute the measures provided for in this article.

The security measures will be in force for the time strictly necessary to correct the deficiencies or anomalies.

Based on the Law, this initiative could not be taken by CENACE as the execution of a "communication" from SENER, totally ignoring the CRE. CENACE cannot act by ignoring the specialized regulatory authority, the CRE, precisely to avoid what seems to be clear here, political decisions based on an excuse of Sanitary Emergency, rather than technical and fundamental decisions based on current law.

The CRE is not only a regulatory authority created by the LIE, but it has a particular regulatory entity derived from a specific law, this being the LORCME[126] which, in its Article 4, clearly states:

Article 4.- *The Federal Executive will exercise its powers of technical and economic regulation in the matter of electricity and hydrocarbons, through the Coordinated Regulatory Authorities in Energy Matters, to promote the efficient development of the energy sector.*

CRE's position not only responds to these legal provisions; As the LORCME clearly states in its Article 1, it is a regulatory law of paragraph 8 of Article 28 of the Constitution, which endows a constitutional entity to the CRE as one of the two coordinated regulatory authorities in energy matters. Based on this, The CRE cannot be ignored or displaced even by the Legislator, since its existence is provided for directly in the Constitution.

Therefore, CENACE lacks the competence and powers to be able to issue the Agreement, the fifth point of its Technical Annex, which orders the suspension of pre-operational tests of all wind and photovoltaic power plants.

In addition to all the above, CENACE did so without declaring a state of emergency in the SEN, as the rules set by CRE allow it to do[127].

The reason for not declaring a state of emergency in the SEN is evident, since these rules establish that CENACE must determine the amount by which generation is to be decreased, in accordance with the following: CENACE assesses the operational status of the SEN and, where appropriate, determines the amount by which generation is to be decreased

[126] For more information about the LORCME please visit https://www.cre.gob.mx//documento/lorcme.pdf

This Law states that regulatory authorities have technical, operational and management autonomy and have legal personality and have the income obtained from the rights and benefits obtained from the services they provide in accordance with their powers. For the CRE these powers are clearly established in Articles 41 and 42 of the LORCME and are consistent with those of the LIE and reinforce the argument that the CRE has a position that cannot be ignored or displaced within the regulatory process of the SEN.

[127] "Procedure for reducing generation due to reliability". This procedure establishes the operating guidelines and criteria to reduce generation in a coordinated, orderly, safe and reliable manner, in the event of extraordinary conditions in the SEN, such as the reduction in the demand for electricity.

at the system level or in a specific area of the SEN. The order for generation reduction must be as follows: (i) hydroelectric generation, (ii) thermal generation according to cost, (iii) firm non-dispatchable generation (geothermal, nuclear), (iv) intermittent generation (which includes solar and wind power plants), and (v) legacy generation (self-sufficiency). In any case, what is clear is that CENACE has the powers to make decisions about the dispatch of electric power but not to suspend interconnection procedures in a general and unilateral manner.

6.5.2 Violation of the Must-Run Power plant designation procedure

In addition to the previous point, the initiative published by CENACE gave it the power to designate as must-run power plants, units that are highly polluting since they use coal, fuel oil or diesel.

The direct effect of the designation of power plants as must-run is to program their production as "mandatory" to the detriment of other sources, such as renewables, despite these offering their cheapest electricity production in the wholesale electricity market.

In reality, the option of assigning power plants out of merit order (among which are those considered must-run), to maintain the reliability of the SEN, is already provided for in the Network Code, which establishes the criteria that must be followed for the assignment of these exchanges, as transcribed below[128]:

Criterion OP-127. *For the definition of the Power Plant Units with assignment and dispatch out of merit to maintain Reliability, it is necessary to consider, among others, the following provisions:*

i. *The Power Plant Units with assignment and dispatch out of merit to maintain Reliability, must be justified by electrical studies carried out by CENACE.*
ii. *Second. Technically, the generation operating minimums of the Power Plant Units must be justified to maintain Reliability, considering the economic implications.*
iii. *If there are different types of generation in the same electrical area or region, the reliability of the technology used and the lower cost for selection must be considered.*

The fourth point of the Technical Annex of the Agreement is, at the very least, ambiguous in terms of the scope of its strategy regarding the

[128] For more information about note 3 and 4 see https://www.dof.gob.mx/nota_detalle.php?codigo=5432509&fecha=08/04/2016

designation of must-run power plants. If it is the case that they are being designating through the Agreement, it is clear that none of the necessary requirements are being met, with the omission of the case-by-case technical justification. Or, if we are dealing with new criterion which is being determined to designate must-run power plants, that criterion violates the Network Code with which CENACE is obliged to comply. The reality is that CENACE is not empowered to issue general agreements that modify the criteria for designating must-run power plants, as this would go against the Network Code, issued by the CRE. It should be noted that the Network Code is not part of the Market Operating Provisions or the Market Bases, as defined in the LIE, and in no way can they be modified, in this case de facto, unilaterally by CENACE.

6.5.3 Deviation from the Country's Environmental Objective

This agreement is an obstacle to the achievement of nationally determined targets in compliance with the Paris Agreement, regarding the reduction of greenhouse gas emissions. It also violates the General Law on Climate Change and the Energy Transition Law, by failing to comply with the mitigation actions that establish the obligation on the part of SENER, in coordination with the Federal Electricity Commission and the CRE, to promote electricity generation from clean energy sources so that it reaches at least 30% in 2021 and 35% in 2024, as well as reducing atmospheric emissions by 30% in 2020 and 50% in 2050 with respect to the baseline. SENER is particularly responsible for determining the annual goals for the minimum participation of clean energy. In actual fact, this agreement recognizes that for 2018 clean energy only represented 22.2% of the total energy generated in Mexico; the country is far from meeting its goals and the CENACE Agreement distances them even further.

In the same sense, the Agreement contravenes the stipulations of Articles 4, 6, 16, 64, 65 and the transitory article third of the Energy Transition Law 129 by failing to take into consideration the minimum participation goals of clean energy set by SENER, as well as the obligations to which the members of the electricity industry are subject to regarding the diversification of the energy matrix and the contribution to the fulfillment of the aforementioned goals. Likewise, it contravenes one of the fundamental pillars of the national climate change policy included in the National Climate Change Strategy, consisting of accelerating energy transition to clean energy sources.

[129] For further and more detailed information about the ETL, please visit http://www.diputados.gob.mx/LeyesBiblio/pdf/LTE.pdf

6.5.4 Provisional and Definitive Suspensions of this Initiative

Through the agreement of May 18 of 2020, the Judge considered it appropriate to grant in favor of the EOSOL companies, the Provisional Suspension required, as indicated in the following paragraph of the respective resolution:

"Consequently, and taking into account that the Agreement contains a general rule, based on Article 148 of the Amparo Law, the provisional suspension requested by the complainants is granted, for the purpose of preventing the effects and consequences of the norm in the legal sphere of the complaining party, which implies that the authority must not prevent the necessary pre-operational tests in accordance with *the applicable* regulations, from being carried out under normal conditions, and where appropriate, commercial operations that directly derive from these, as well as not being interrupted or limited, in accordance with the applicable regulations, but with the precision that all extraordinary measures must be complied *with to attend the health emergency due to force majeure generated by the aforementioned Covid virus19 , among which are, but not limited to, those provided by the Secretary of Health in Article One, section n III, of the AGREEMENT by which extraordinary actions are established to attend the health emergency generated by the SARS-CoV2 virus".*

Through the agreement of May 22nd 2020, the Judge considered it appropriate to grant in favor of EOSOL companies the Definitive Suspension required, and in its conducting section refers to:

"The precautionary measure must have the effect of preventing the consequences of the rule in the legal sphere of the complaining party, which implies that the authority should not apply the claimed agreement to the complainants, and therefore, should not prevent the evidence from -Necessary operations in accordance with the applicable regulations, are carried out, and where appropriate, the commercial operations that directly derive from them, in accordance with the applicable regulations, which implies that the authority must carry out all the actions that are necessary within the scope of its competence, to mitigate the possible risks that the practice of said tests and operations implies, as long as it does not imply the total stoppage of the practice of said tests and operations indefinitely".

In any case, CFE continued to apply the final objective of this initiative, but this time based on a lack of personnel and that other situations had greater priority. In fact, the EOSOL plants, which should have been put into operation, under normal conditions, in March 2020, were not able to start up until December of that same year, with the resulting economic damage that this caused to the company.

6.6 Annex: Legal procedure that the COVID initiatives

6.6.1 The Legal procedure that the initiative should have followed for its approval and ordinary publication

The Administrative Agreement was issued by a Secretary of State, and was not a Law issued by the Congress of the Union. In accordance with the General Law of Regulatory Improvement 130, the approval of the Agreement should have begun with the complete Regulatory Impact Analysis process, and not be subject to an exemption as was the case.

With its approval, various provisions contained in the Electricity Industry Law and other Laws (and probably even constitutional principles on the operation and operation of the Electricity Industry) were modified and repealed. As an Administrative Agreement issued by SENER cannot modify the Laws issued by the Congress of the Union, this renders illegal all those aspects in which the established Laws are effectively modified or repealed.

The government decided to launch the initiative in this way because a modification to the respective laws to implement the content of the Agreement, in addition to implying a considerable delay, may not have been successful in Congress, since, although the ruling party had a majority in the Chamber of Deputies, it did not have a majority in the Senate, which implied the possibility that such amendments to the laws would not have been passed.

To the extent that ongoing projects such as those under construction were affected, both due to the decrease in income and the increase in operating costs, and that many of these effects were due to the application of a specific provision of the Agreement that can be classified as illegal, this can be questioned in its partial or total application, and this is precisely the decision that the entire industry in the sector, except Iberdrola[131], took.

[130] For further and more detailed information about the General Law of Regulatory Improvement, please visit: http://www.diputados.gob.mx/LeyesBiblio/pdf/LGMR_180518.pdf

[131] In any case Iberdrola was affected in same way as any other company in the sector. Please review the following press release:
https://expansion.mx/empresas/2020/10/21/iberdrola-descarta-mas-inversiones-en-mexico-ante-cambios-en-politica-energetica
https://elpais.com/mexico/economia/2020-10-21/iberdrola-descarta-nuevas-inversiones-en-mexico-ante-los-obstaculos-a-la-generacion-electrica-privada.html
https://www.elfinanciero.com.mx/empresas/si-el-gobierno-no-da-la-bienvenida-a-la-inversion-no-vamos-a-invertir-asegura-iberdrola

The latter decided to start a separate negotiation process given its company size that others were unable to do.

6.6.2 Impact on projects

This new initiative could be considered as a continuation of the previous CENACE one, since it considered all the points of the proposal by CENACE plus another set of rules and obligations that, if approved, would basically definitively bring the renewables sector in Mexico to an end.

Therefore, in addition to those effects already discussed in the CENACE initiative above in this document, the effects of this SENER initiative are many and varied depending on the phase the project was in.

<u>*Operational projects:*</u>

- Need for storage to meet sufficiency criteria. This will suppose a particularly important extra-cost since the following is requested:

  Numeral 6.1 Sufficiency:

  6.1 (page. 37): "The generation of active power of the Power Plant units connected to the electrical grid will be controlled so that at all times there is the ability to regulate the balance of energy production and consumption, and consequently the frequency of the System during operation in time real."

  6.1.3: "CENACE, through the preparation of Reliability studies, must ensure that the Operating Reserve is distributed throughout the entire SEN and can be used at the time it is required so that there is Sufficiency in all regions, respecting the transmission limits of the gates, as well as maintaining the load and generation balance."

- Loss of generation due to power limitation (<u>lower economic income from energy sales</u>):

Numeral 7. Dispatch Security

7.1.2.9 (page 47) "CENACE may request reductions and adjustments in the Photovoltaic Power Plants during the hours prior to the start of the decline in generation at sunset, to reduce the ramp of decrease in solar generation. Operational actions may be by Power Plant, region, zone and System."

As can be seen in this Numeral 7.1, dispatch security takes precedence over economic efficiency (generation limitations) the implications of this new actions are:

- Higher construction costs due to equipment needs
- Reduction of generation by zones according to CENACE studies (Numeral 7.1.2.4 to 7.1.3)
- Scheduled generation reductions in clean energy plants (Numeral 7.1.2.7) due to the declaration of a State of Emergency. CENACE discretion.
- CENACE may reduce photovoltaic generation at sunrise and sunset to smooth the ramps of increase and decrease in generation respectively (Numeral 7.1.2.8 and 7.1.2.9)
- Central disconnections (Numeral 7.1.2.10)
- Dispatch Limitations in AUGC and / or MTR processes (Numeral 7.1.2.11). Eosol is suffering this already in P10 and P15

Numeral 8. Related services ("Servicios Conexos")

- An increase in construction costs for equipment (battery banks, capacitors) (Numeral 8.2)
- Costs derived from participation in Related Services (Numeral 8.7).
- An extra cost to operating generators (Numeral 8.10). In the same way, it would affect the financial models of new projects if CENACE decides that these plants cause an increase in the requirements of Related Services

Numeral 9. NetWorks

9.16 (page 51) "The replacement of existing equipment or elements must be due to: the end of their useful life, the impossibility of integrating new technologies, non-compliance with minimum safety requirements in their operation, escalation of installation specifications not in accordance with their environment, and the incorporation of Electrical Networks Smart"

Numeral 10. Incorporation of Intermittent Clean Energies

10.5 (page 53) "To guarantee the Reliability by voltage control, the Power Plants with Intermittent Clean Energies, wind and photovoltaic interconnected to the SEN, must guarantee the voltage control permanently."

Projects under construction:

Numeral 5.6: extensions to COD requested from CRE.

Numeral 5.8: recorded permits.

Projects under development:

It can be concluded that many of the aspects that affect projects under operation will also affect new developments due to the inclusion of costs in financial models.

Numeral 5.7: Cenace's opinion is necessary to request permits from CRE.

Numeral 5.12: technical feasibility for interconnection

Numeral 5.13: rejection of applications by CENACE

Numeral 5.15: RNT and RGD expansion and modernization programs

Numeral 5.16: Distributed generation

Numeral 5.18 and 5.19: limits of zones and regions for non-dispatchable plants

Numeral 5.22 and 5.23: priority for CFE centrals). Discriminatory issue

Numeral 7.1: Higher construction costs due to equipment needs

- Higher construction costs due to equipment needs
- Reduction of generation by zones according to CENACE studies (Numeral 7.1.2.4 to 7.1.3)
- Scheduled generation reductions in clean energy plants (Numeral 7.1.2.7) due to the declaration of a State of Emergency. CENACE discretion.
- CENACE may reduce photovoltaic generation at sunrise and sunset to smooth the ramps of increase and decrease in generation respectively (Numeral 7.1.2.8 and 7.1.2.9)
- Central disconnections (Numeral 7.1.2.10)
- Dispatch Limitations in AUGC and / or MTR processes (Numeral 7.1.2.11). Eosol is suffering this already in P10 and P15.

Numeral 8. Related services (“Servicios Conexos”)

- An increase in construction costs for equipment (battery banks, capacitors) (Numeral 8.2)
- Costs derived from participation in Related Services (Numeral 8.7).
- An extra cost to operating generators (Numeral 8.10). Similarly, it would affect the financial models of new projects, if CENACE decides that these plants cause an increase in the requirements of Related Services

Numeral 10.1: Integration of Installed Capacity in the SEN will be maintained for all plants that have reached the Interconnection Contract one day before the publication of this policy. It affects new developments because it has already been published.

Numeral 10.2: Interconnection Studies may be rejected.

Numeral 10.4 to 10.4.11 will imply increases in construction costs (STATCOM's, CEV's, Flyers and LT's).

Numeral 10.5: Permanent Voltage Control. Banks of batteries or capacitors.

Numeral 10.8: it is not really clear what is requested in this numeral. It might seem that they are going to penalize us for not delivering firm power or that it is the Load Centers that are to be penalized.

6.6.3 Provisional and definitive suspensions of this initiative

By agreement of June 5th 2020, which was made known to us on June 8, the Judge considered it appropriate to grant in favor of the aforementioned companies, the Provisional Suspension required, as indicated in the following paragraph of the respective resolution:

"Consequently, and considering that the claimed Agreement contains a general rule, based on article 148 of the Amparo Law, the PROVISIONAL SUSPENSION requested by the complainant is GRANTED, for the following purposes:

1. *The SENER agreement is not applied to everything that involves the coercive reduction of electricity generation to the detriment of the complainants for the simple fact of being producers of electricity from renewable sources.*

2. *The start of their commercial operations, or where appropriate, the operation of self-supply, is not prevented from the power plants of the complainants, in accordance with the limits of their maximum generation capacity allowed, in the terms of the permits that they were issued, with the validity, mechanics and rules that operated immediately before the entry into force of the claimed Agreement.*
3. *The authorities responsible for imposing additional related services in charge of the complainants abstain in terms of the policy that constitutes the claimed act, and instead the regulations that in this regard governed them immediately before the claim shall continue to apply to the complainants validity of the claimed Agreement".*

By agreement of June 24th 2020, the Judge considered it appropriate to grant in favor of the complaining companies, the Definitive Suspension required in the petition for protection presented, as referred to below:

"The effects of the precautionary measure must be as follows and subject to the modalities and conditions established below, in terms of the provisions of Article 147 of the Amparo Law:

The SENER agreement is not applied in everything that involves the coercive reduction of electricity generation to the detriment of the complainants for the simple fact of being electricity producers from renewable sources.

1. *The complainants' power plants are not prevented from starting their commercial operations, or, where appropriate, the self-supply operation, in accordance with the limits of their maximum generation capacity allowed, in the terms of the permits that were issued, with the validity, mechanics and rules that operated immediately before the entry into force of the claimed Agreement.*
2. *The authorities responsible for imposing additional related services in charge of the complainants abstain in terms of the policy that constitutes the claimed act, and instead continue to apply to the complainants the regulations that in this regard governed them immediately before the validity of the claimed Agreement".*

In this case, neither the CFE nor the government have been able to continue implementing these initiatives, but the legal battle is still underway and of course the government has largely, if not fully, achieved its goal: **The destruction of the sector.**

As additional initiatives, the new government has not given up and has not withdrawn from its struggle to return all power to the CFE and PEMEX and to reverse the laws that sought to liberalize the energy sector in Mexico. This can be seen in various press releases and statements from the government itself.[132]

An example of this is that, on September 22nd 2020, the Energy Regulatory Commission agreed to modify some of the regulations applicable to renewable energy companies.

These modifications include the:

i. suspension of the granting of new permits or concessions to private generators.

ii. prioritization of the dispatch of energy produced in plants of the CFE over private ones.

iii. elimination of all subsidies in the energy sector. The notes also reveal that, one day after that agreement was adopted, the CFE's Corporate Deputy Director of Strategy and Regulation assumed the General Directorate of the CENACE.

These modifications, and the change in the General Directorate of CENACE, will have a negative impact on various foreign investments.

The current government is trying too to modify the constitution to give more power to CFE and eliminate the energetic reform granted by the previous government under the presidency of Peña Nieto.[133]

However, the measure that is probably harming the industry most is a measure that has not been channelled through changes in the law or regulations, but rather through the inaction of the government agencies SENER, CENACE and CRE.

None of these organizations, but especially the CRE, is complying with the deadlines established by law to resolve the different cases being studied, extending the deadlines in a deliberate strategy to hinder and limit the generation of electricity by private parties, mostly renewable generation, in order to favor the Federal Electricity Commission.

The CRE is obliged to publish a list of generation permit modification requests that are in process.

As of July 10, 2020, there were in this list a total of 140 permits being processed both under the LIE regime and legacy permits. 79 of these pending permits were legacy permits that were intended to change the

[132] For more information, please visit: https://aristeguinoticias.com/0605/mexico/acuerdo-de-cenace-da-trato-justo-a-cfe-y-revierte-privilegios-a-particulares-amlo-enterate/; https://www.milenio.com/politica/amlo-cfe-tendra-trato-justo-con-acuerdo-del-cenace

[133] For more information, please visit https://www.energiaadebate.com/regulacion/presentan-iniciativa-para-revertir-reforma-energetica/

beneficiaries of the energy. The rest concerned modifications of work programs, description of the facilities and other factors.

Of all these permits being processed, only 19 were within the deadlines set by the law of 3-month resolutions, 31 applications took a period of between 1 and 3 months and 96 of the 140 applications took longer than 6 months to be processed.