

Mexico's Energy Policy and Environmental Care: From the Constitutional Energy Reform to a New Initiative

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Abstract

After more than 70 years of operation of a state-owned petroleum monopoly and 50 years of a state-owned electricity duopoly which evolved into a monopoly, the implementation of the 2013-2014 constitutional energy reform in Mexico involved significant changes: It allowed for private investment all along the value chain of hydrocarbon and power industries and rejected any kind of monopoly power even from the two hydrocarbons and energy power state-owned companies, Pemex and CFE. By the end of 2018, only a tiny fraction of all expected private foreign and domestic investment and the underlying technological capabilities were put in place, originating plenty of regrets from the government which took office on December the 1st, moving the emphasis toward nationalism, energy self-reliance and lesser environmental commitments. To what extent this policy will allow the country to regain its oil production capabilities and what the international consequences of reinforcing the monopoly power of the state-owned energy enterprises will be remains unknown, as it is unknown whether the strategy looks for a reversal to the energy reform commitments.

Keywords: energy policy, energy reform, oil, power, economic growth, public finances

JEL classification: L52, L71, L94, L95

I. Introduction

Due to the high availability of hydrocarbons from the mid-1970s to about 2010, Mexico's energy sector remained unchanged in terms of its enormous dependence on fossil resources. However, in 2013 the political constitution was reformed in order to eliminate state monopolies for hydrocarbons and power and offer new opportunities to private national and international companies all along the value chain, including the investment in alternative energy sources, in particular wind, solar photovoltaic and geothermal power.

As the use of private automobiles has been rising steadily, due to relatively chipper real prices than those before 1994, when the North American Free Trade Agreement (NAFTA) was put in place, combined with better credit facilities and a deliberate industrial stimulus, railroads and urban public transportation have declined. This tendency is difficult to reverse in the short-run due to the paramount influence of the car and auto-parts industries in the economy measured by their participation of 3.7% in the gross domestic product (GDP); 30% in the merchandise exports, and 2.6% in the number of formal jobs generated (INEGI/AMIA, 2018). Much of this is explained by Mexico's vicinity to the United States (U.S.) but also by its rather low wage level, compared to those of its commercial partners from North America, Europe, and Japan (INEGI, 2014; ILO, 2015)

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Such conditions, coupled with declining hydrocarbons production and the lack of investment in the refining industry, pushed up imports of automotive fuels and natural gas during the last 10 years up to 2018, generating a 75% net foreign dependency for such products. Also, the trade balance for hydrocarbons and the national energy balance entered into deficit for four years in a row starting 2015, as had not happened ever since the early 1970s (SENER, 2018).

Energy policy objectives have changed over time. Between 1940 and 1978 the objective was to cover the needs of the domestic market, which demand was growing fast due to Mexico's industrializing efforts. Between 1979 and 2014, the only apparent objective was to export as much oil as possible in order to get foreign exchange, which supposedly would help to develop the economy. A change of view came about in 2015, motivated by three factors: the virtual exhaustion of what used to be the largest oil field of the country, Cantarell, and the second of its kind in the world; the enforcement of the 2013-2014 energy reform; and the 68% reduction of international oil prices between June 2014 and February 2016. All these factors materialized in a reorientation of energy policy towards diversification by promoting private sector investment and reinforcing fossil fuels saving, basically through the price mechanism. At the same time, Mexico's government signed some ambitious compromises to reduce greenhouse emissions with its partners from NAFTA and took important initiatives at the 2015 United Nations Climate Change Conference, Cop 21 (IBD, 2016).

Lastly, a new view came into being in December 2018, when a state-oriented government took office, supported by 53% of the popular vote, and decided to reinforce the two state-owned energy enterprises, Petroleos Mexicanos (PEMEX) and Comision Federal de Electricidad (CFE). This comes about as a response to the private national and international oil companies that through public auctions won in 2015-2018 the rights to explore and exploit a large part of Mexico's deep water, shallows and in-land oil fields, but at the end of 2018 were responsible for less than 1% of national hydrocarbons exploration and production (CNH, 2018), just over 3% of foreign investment and none oil or gas proven reserves (Gutierrez-R., 2018).

To contextualize Mexico's energy sector and then discuss the mentioned problems as well as the underlying energy policy and environmental commitments, this chapter goes as follows. Section II addresses the issues of Mexico's energy resources, net production, foreign trade, expected levels of end-use consumption and the environmental effects. The next three sections deal with the governance structure, in which issues ranging from the laws and regulations governing the energy sector to the role of institutions are addressed. The following sections are devoted to discussing the historical experiences of the energy policy-making process, the factors driving the new policy, the internal and external actors, and the outcomes up to late 2018. Finally, a section for perspectives and conclusions is presented.

II. Domestic energy resources and environmental effects

In 2015, Mexico's primary energy production amounted to 8,261 petajoules, 90.5% of which came from fossil fuels: oil, 61.3%; natural gas, 24.7%; condensed fuels, 1.2%, and coal, 3.5% (one petajoule = 238,845.9 gigacalories). The remaining 9.3% was explained by renewable sources: nuclear power, 1.5%; hydroelectric power, 1.3%; geothermal power, 1.6%; wind, solar and biogas energy together, 0.5%; and biomass, mainly rewood, which is not precisely renewable, 4.4%. Total production in 2015 dropped 10.7% in comparison to 2005, when it amounted to 9,250.7 petajoules. The reason for this was particularly the declination of the mega-field Cantarell, located in the shallows of Mexico's southeast region, which production came down from 2.4 million barrels per day (MBPD) at the end of 2004, representing 63% of the country's national production, to 160 thousand barrels per day (TBPD) in 2018, representing only 8.6% of national production. Through the production of another big field in the same region, Ku-Maloob-Zaap, attenuated the Cantarell's drop effect and corroborated how well-endowed is the Gulf of Mexico in terms of hydrocarbons, overall oil production exhibited an annual rate of declination between 2004 and 2018 of 4.5% (SENER, 2018; SENER, 2016; PEMEX, 2018).

The Cantarell effect on the production of natural gas did not show up immediately, as associated gas production kept growing and that of dry gas increased steadily thanks to the intensification of activities in the northern region of the country, particularly the province of Burgos, in the northeast mainland. The peak of gas production was reached at the end of 2008, 7,359 million cubic feet per day (M3FD), quite enough to satisfy national demand. From that point on it started to fall up to 4,895 M3FD at the end of 2018, an annual average drop of 4% (SENER, 2018).

Due to this fact, and also the transformation of the national industrial activities, particularly that of power generation, which was reoriented to consume natural gas instead of liquid fuels, consumption of natural gas kept growing as well as imports. In 2018 the latter represented about 50% of national consumption. Such a figure is larger for gasoline and diesel imports (Mexico holds six refineries, four of which operate around 45% installed capacity and two had to be shut by late 2018). Besides, the country depends on the imports of multiple petrochemical products. Crude oil is, on the other hand, the only fuel Mexico exports abundantly: 1.1 MBPD up to 2018 (PEMEX, 2018).

In view of the previous considerations, since 2015 Mexico's consumption of energy in terms of petajoules lags behind its production, and if petrochemical products are included, the exports of energy in terms of foreign currency are lower than those of imports. Most trade movements in both directions are carried out with the U.S., and the intra-trade deficit with that country is considerable.

Proven hydrocarbon reserves have been falling at a faster speed than production during the last years: In 2005, they amounted to 17,650,000 million barrels of oil equivalent (MBOE); by 2018 they moved to 7,694,700 MBOE, a -6.2% average annual rate of growth (AARG)(SENER, 2018). As a consequence, the expected life of proven reserves came down from 10.3 years in 2005 to 8.1 years in 2018, and the average replacement rate was nil. The reasons were the high level of consumption; wrong resources estimation, with an important correction in 2016 (proven reserves have fallen faster than consumption); and a rather low rate of investment in productive and development wells (PEMEX, 2018; PEMEX, 2007).

Mexico's deepwater hydrocarbon resources are estimated to be close to 26,500,000 MBOE (Senado de la Republica, 2013), and the U.S. Energy Information Administration estimates the country's shale-oil reserves to be the eighth largest in the world, and those of shale-gas to be the sixth (EIA, 2015). Different analysis show also that Mexican geological formations can be considered extensions of commercially productive U.S. formations; that is the case of the Eagle Ford, in Texas. Otherwise, Mexican formations are surely correlated with commercially productive U.S. formations. The same could be said about the resources in deepwater of the Gulf of Mexico. Despite these facts, exploration and production activities are intense in shale-oil, shale-gas and deepwater on the U.S. side, and insignificant on the Mexican side.

In the power industry, effective generation capacity for commercial uses in 2015 was 54,825.4 megawatts (MW), from the following sources: conventional thermoelectric plants (liquid hydrocarbons and natural gas), 62.6%; hydroelectric plants, 21.9%; coal driven plants, 9.8%; nuclear power plants, 2.8%; and renewable sources (geothermal and wind power plants), 2.7%. Biomass energy is not included, as it has not a commercial character, and solar photovoltaic energy as well as certain kinds of bioenergy are not mentioned as they have a rather low participation on commercial energy. Surprisingly, this structure has not improved compared to that of 1986, when the first measures to substitute traditional energy sources by renewable ones were put in place. In that year, conventional thermal power stations were the source of 62.6%, and hydroelectric plants of 30.7% (Wionczek, Guzman and Gutiérrez-R., 1986).

After three decades, hydro-electric plants lost almost 10 percentage points of participation; coal plants, which are by far the most environmentally aggressive, gained 5.4 percentage points; geothermal power plants remained almost unchanged; and a 2.8% increase was observed due to the incorporation of a nuclear power plant, Laguna Verde. Wind generators established themselves with almost 1%. The bulk of the structural change can be explained for two reasons: the lower participation of hydroelectric plants, and the substitution of natural gas thermoelectric plants by conventional liquid fuels thermoelectric plants. Nowadays, combined-cycle plants and turbo-gas plants, both powered by natural gas, represent together 41.3% of the power effective generation capacity, whereas the participation of plants powered by liquid fuels has fallen to 20.8% (Gutierrez-R., 1990; SENER, 2016 and 2018).

Two points should be underlined. Besides combined-cycle and turbo-gas plants, the wind powered ones have had the highest growth in the industry in the last decade. Their prospects for development have increased due to the strong winds that blow across states like Baja California, Tamaulipas, Nuevo Leon and Oaxaca. This has attracted the interest of several Spanish and U.S. firms already established in Mexico. Additionally, about two thirds out of the existing 54,825.4 MW effective commercial generation capacity belong to the CFE, with a great deal of idle capacity; the rest belongs to private companies.

Nineteen percentage points of this 33% are sold to CFE for distribution in the national electrical system and the remaining 15 percentage points are distributed in the following way: producers' self-consumption, 7%; joint generation, 4.6%; continuous use by the producers, 1%; and exports, 2.2% (SENER, 2016 and 2017).

Oil and wet gas reserves are geographically concentrated on the Gulf of México: either deepwater and shallows or mainland close to the coast, from the northeast state of Tamaulipas to the southeast state of Campeche. Prospection also suggests the presence of hydrocarbons in the further state of Yucatan's deepwater, between the city of Progreso and the island of Cuba. Besides, in the inland strip of the Gulf of Mexico, dry gas resources have been found -some already exploited- in the northern states of Coahuila, Nuevo Leon and Tamaulipas, which share border with the U.S. state of Texas. A part of that geological formation is an extension of the Eagle-Ford basin. Too much of the national territory remains unexplored, but by the time being the inland northwest and central regions plus the two peninsulas, are no considered hydrocarbon basins (PEMEX, 2014).

Refineries and petrochemical plants, polyducts and storage facilities are located nearby oil and gas production centers, i.e. the states of Veracruz, Tamaulipas and Chiapas. Only three out of the six refineries of the country are located in non-productive states: Tula, Hidalgo, close to Mexico City; Cadereyta, Nuevo Leon, close to the industrial city of Monterrey; and Salamanca, Guanajuato, close to the industrial cities of Leon, Irapuato, Guanajuato, Salamanca and Queretaro. Petrochemical complexes concentrate on the state of Veracruz (La Cangrejera, Morelos, Pajaritos and Cosoleacaque), and some petrochemical plants are inside the latter state or close to it: Escolin, Veracruz; Tula, Hidalgo; San Martin, Puebla, and Camargo, Tamaulipas (PEMEX, 2014). At least 16 plants inside the complexes have shut down or interrupted their operations during the last years either because lack of raw materials or incapacity to cover at least their variable costs. As to ducts transportation, the lines concentrate on the hydrocarbon producing areas already described, as well as on the central part of the country and the northeast area. They are incipient in the northwest and the southwest areas, where hydrocarbons transportation is carried out through railroads, pipeline-trucks and petroleum ships.

In the case of power infrastructure, the national grid has developed according to regional demand and nowadays covers virtually the whole territory and 99% of people's demand. Accordingly, the highest facilities concentrate on the central, north-east and central-west regions. Only small communities far away from the cities have to rely on alternative energies, mainly biomass. The Mexican grid and that of the U.S. have become progressively integrated as established by some agreements derived from the NAFTA (USDOE, 2017). There are about 11 points of border connection between both grids, which serve to facilitate energy flows during contingency periods, such as black-outs and excessive demand lapses. Other two border connections are those of Mexico-Guatemala and Mexico-Belize, in Mexico's south-east border. Although this is not the norm, the power commercial balance of Mexico, measured in terms of MW, passed from deficit up to 2012 to superavit from 2013 on (SENER, 2018).

Mexico's participation in the world's greenhouse emission is about 1.65%, similar to its participation in the world's GDP. In 2013 the country produced 666.3 million tons of carbon dioxide (CO₂) equivalent. The main productive agents were: cars and other moving sources, 26.1%; electric power generation, 19%; industry, 17.2%; hydrocarbons industry, 12.1%; and the agro and livestock sector, 12.1%. The remaining 13.5% was explained by deforestation, woods fire, changes in the use of soil, liquid and solid waste, and residential and commercial fossil fuels burning. By source of greenhouse emission, the most important is CO₂, which worries too much because of three reasons: since 1990 it has been advancing at a 2.3% AARG; its atmospheric life spans from 50 up to 200 years, period during which it contributes to global warming; and it concentrates deeply in the atmosphere. The main activities responsibly for its accumulation are: fossil fuels combustion, cement production and changes in the use of tropical soil. The second source of greenhouse emission is methane gas (CH₄), produced by different kinds of agricultural activities, biomass combustion, handling and decomposition of garbage, and also fossil fuels combustion. The third source is nitride oxide (N₂O), produced by agricultural activities, particularly grazing in tropical regions; burning of biomass, and industrial processes associated to the production of adipic and nitric acids (INECC, 2013).

III. The Governance structure

The Mexican United States (official name) is a democracy established after its independence from Spain, in 1821, whose governance structure was more inspired upon the U.S. political model than on those of Europe. So, Mexico is a federation composed by 32 independent states which have their own political powers and their own political constitution and are committed both to the federal government and to the federal constitution. In practice, the system, which is presidential, holds a stronger degree of centralization than that of the U.S.

Their bases were settled on the Federal Constitution of 1824, enriched by that century's liberal ideology and gave place to the 1857 Federal Constitution of the United States of Mexico. Sixty years later the legislature discussed sensitive social and civil rights as well as natural resources control, paving the way to the 1917 Political Constitution of the Mexican United States. This incorporates lay education, political and civil rights, agrarian reform, work force protection, the principle of the Nation as the owner of Mexico's land and water natural resources, and the reinforcement of property rights.

The three branches of Mexico's government (domestically referred as "powers") are the Executive, the Legislative and the Judiciary. The Executive is elected every six years in the context of a multi-party system, dominated by four larger organizations. The first has been historically the Institutional Revolutionary Party (PRI), which was in charge of Mexico's federal government from 1928 to 2018, except for the two sexennial periods going from 2001 to 2012. Ideologically it has moved from the central-left-leaning during the 1930s to the center-leaning up to 1982 and to the center-right since 1983. The second is the National Action Party (PAN), which governed the country during 2001-2012, holding an extreme right-leaning political position. The third is the Party of the Revolutionary Democracy (PRD), which has an important territorial presence, had probably enough votes to win the country's 1988 and 2006 presidential elections and holds a center-left-leaning position. The fourth is the National Regeneration Movement (MORENA), created just in 2014 due to a split between left-wing parties. It has a great deal of followers, won the 2018 presidential election, holds an ample majority in both deputies and senators' chambers and won that year's most state and municipalities elections.

As established in the Organic Law of the Federal Public Administration (DOF, 2017), adjusted after the 2013-2014 energy reform, the Executive branch includes 18 Secretariats, among them those of Energy (SENER) and Natural Resources (SEMARNAT). The internal laws of each Secretariat establish the qualifications the professionals must hold to occupy the post of Secretary. Each Secretary is chosen and appointed by the president of the Republic at the beginning of his/her administration and can be removed the number of times the President considers necessary. Each secretariat is in turn the head of a group of special-purpose dependencies either directly controlled by the Secretary or with administrative and budgetary independence. SENER looks over two State Productive Enterprises (EPE) and their subsidiaries (State Subsidiary Enterprises): Pemex plus seven subsidiaries, and the CFE plus nine subsidiaries. It also looks over five decentralized dependencies: The National Center for the Control of Energy (CENACE), the National Center for the Control of Natural Gas (CENEGAS), the National Institute of Nuclear Investigations (ININ), the Mexican Petroleum Institute (IMP), and the National Institute of Electricity and Clean Energies (INEEL). Finally, it looks over two coordinated organs, crucial to the liberalized energy sector and its regulation: The National Commission of Hydrocarbons (CNH), and the Energy Regulatory Commission (CRE).

The duties of SENER refer to conducting and coordinating the country's energy policy, as well as supervising its compliance with energy security and diversification priorities, including energy saving and the protection of the environment. It also establishes that medium and long-term energy planning carried out by the Secretariat must meet the following criteria: sovereignty and security, improvement of energy productivity, restitution of hydrocarbon reserves, diversification of energy sources, and reduction of the environmental impacts of energy production and consumption. Other duties are the promotion of energy saving, the impulse to renewable energies, the accessibility of energy to all people, the strengthening of the EPE, and the support to national energy research and technological developments. Besides, SENER may, among other actions, exercise the rights of the Nation in the matter of oil and all the carbides of hydrogen solid, liquid and gaseous; of radioactive minerals; and use the goods and natural resources required to generate, transmit, distribute, market and supply power electricity. The Secretariat may also conduct and supervise nuclear power generation; promote the participation of individuals in the activities of the sector; and carry out guidelines to ensure economic and social benefits for the energy sector (DOF, 2017). As it is obvious, SENER's duties supplant some SEMARNAT's. Literally, the Organic Law of the Federal Public Administration establishes that SEMARNAT is to encourage the protection, restoration and conservation of ecosystems and natural resources; promote the use and sustainable development of environmental goods and services; formulate and conduct the national policy on natural resources, provided that are not expressly entrusted to another unit (...); and manage and regulate the use and promote the sustainability of natural resources corresponding to the Federation, with the exception of hydrocarbons and radioactive minerals...(DOF, 2017.)

Also important in the configuration of the energy activities is the Secretariat of Finances and Public Credit (SHCP) which is in charge of most financial aspects of the energy resources: Taxation and royalties charged to PEMEX, CFE and the energy private enterprises; develop and operate the formulas to fix and change the prices of energy products; establish the annual budget of the energy sector, including PEMEX, CFE and the rest of energy entities, and determine the charges to private enterprises participating in the sector's auctioning processes.

The Legislative branch, officially the General Congress of the Mexican United States, is bicameral, with a Senate (124 senators) elected every six years, and a Chamber of Deputies (500 representatives) elected every three years. They discuss laws, approve treaties, create taxes, deal with foreign relations and even declare war, but the main initiatives they discuss come from the Executive branch. Though they cannot serve two terms in a row, they can re-run for election later on. There are also proportional participation Senators, 32 out of 124, and proportional participation Deputies, 200 out of 500, who are determined according to the number of votes that each political party fetches in the election. Besides, the Senate designates other 32 senators, one for each state, according to the principle of first minority, i.e. the political party which accumulates the second largest number of votes in the election. Reelection of legislators in a row will be allowed for the first time in 2021 for Representatives up to three times (12 consecutive years of service), and in 2024 for Senators, up to one time (also 12 consecutive years).

The third branch is the Judiciary, topped by the Supreme Court, which is composed by 11 judges, all in the first instance appointed by the President but then approved by Congress. They serve during 15 years as interpreters of the law and the constitution and can never run for reelection.

The process of bringing a law into being or modifying an existing one is started commonly by the Executive Power and then it is discussed and eventually approved by the Congress. Given the composition of the latter, and the fact that constitutional modifications require 66.66% approval of both Senators and Deputies, and then the ratification of at least two-thirds of local Representations (22 out of 32 states), political party coalitions are a common practice. In that sense, during the last years PRI and MORENA have gained the support of various small parties, which struggle to get at least 3% of national votes to hold their register, as the electoral rule establishes; PAN decided to go on coalition with a smaller party in 2000 and alone in the 2006 and 2012 national elections; and PRD faced troubles after the partition of the left-leaning parties in 2014, but colluded with PAN in the 2015 mid-term elections just to face the PRI bloc, getting together important local government victories. For 2018 general elections the blocs changed considerably, as MORENA pragmatically reinforced with both left-leaning and right-leaning parties. On the other side, PAN colluded with PRD, and PRI reinforced with a right-leaning party, the Green Ecologist of Mexico (PVEM).

On the basis of the difficulties to approve laws in the Congress, a strong PRI-PAN coalition has recurrently been ensemble during the recent years. This was the case for most of 14 structural reforms during the first two years of President Peña Nieto's administration (2013-2018), including the energy reform. After 2018 elections, MORENA has the capacity to approve constitutional reforms in the Senate just by colluding with its two elections allies, the PT and the Social Encounter Party (PES): together they reach 69% of all seats. In the Deputies Chamber it has to add to them the whole support of both PRD and PVEM to get 68.6% of all seats. Once the proposals are approved by the two chambers, they have to receive the support of local chambers of deputies (at least 21 out of 32 states) before being promulgated by the President and then become a law (the figure of veto does not exist in the Mexican system). The Executive's force rests upon his ability to mobilize the leaders of his own political party in both chambers to fetch the minimum number of supporters needed to pass his proposals. Depending on the proposed law, one chamber acts as the chamber of origin, and the other as the reviewing chamber.

IV. Existing laws and regulations governing the energy sector

Seven fundamental laws discussed and approved by the Congress during 2014, once the articles 25, 27 and 28 of the Political Constitution had been modified (DOF, 2013) to allow private investment all along the hydrocarbons and power industries value chain, govern Mexico's energy sector (DOF, 2014): The *Hydrocarbons Law*, and the *Hydrocarbons Revenue Law* legalize and regulate the participation of private sector companies in exploration and exploitation activities. Four types of contracts are specified: utility-sharing, production-sharing, licenses and any possible combination of them. The CNH is given total rights to administer them, and the National Center of Natural Gas Control (CENEGAS) holds the right to operate the transmission network.

The law also gives SENER the authority to grant permits to private companies to carry out activities previously held exclusively by PEMEX: Petroleum treatment and refining, natural gas processing, and crude oil, natural gas and petroleum products imports and exports. The *PEMEX Law* establishes the new responsibilities of PEMEX as a State Productive Enterprise, including the payment of dividends to the Petroleum Fund for Stabilization and Development, administered by the central bank (Bank of Mexico). Dividends follow a decreasing schedule over time: 30% of revenues in 2016, 15% in 2017 and 0% in 2018, when the SHCP shall determine a new dividend. The law states that all royalties and rents from the hydrocarbons industry will be held by the fund and caps at 4.3% of GDP the resources that the government can withdraw from it. Also, the law allows PEMEX to go into partnership with private companies (farmouts) wherever it wants along the production chain, bidding as any other company for areas of exploration and exploitation in tenders organized by the CNH.

As to the governance of PEMEX, the Law mandates a corporate structure in which the Minister of Energy is the president of the board of directors, along with 10 members, half of whom are independent from the government. PEMEX trade union representatives have been excluded from the board ever since the 2008 non-constitutional energy reform. For operations, PEMEX was divided into seven “subsidiary productive enterprises”: Exploration and Production, Industrial Transformation, Ethylene, Cogeneration and Services, Perforation and Services, Logistics, and Fertilizers. Also, a new subsidiary was created, Commercialization of Commodities (Pemex, 2017b). At the international level an enterprise which is said independent from PEMEX but operates on its headquarters has been in place for more than 30 years: PMI International Trade.

The *CFE Law* establishes the responsibilities of CFE as a state-owned enterprise, which include paying dividends to the government and putting in place a corporate governance structure with a board of 10 directors among which four are independent to the industry (academicians, researchers and other kind of outsiders) and one is named by the workers. CFE is being unbundled into nine subsidiary productive enterprises specialized on generation, transmission, and commercial services. These entities will not communicate with each other, and each will try to achieve efficiency in a competitive environment as private firms do. Over time, CFE would transit from power activities to a more complex structure in which natural gas import and distribution businesses will be included.

The *Electricity Law* has the main objective of creating a competitive electricity market in which the existing structure of CFE becomes disaggregated, as established in the previous law. It maintains its monopoly power over public service transmission and distribution, but loses it as operator of the national grid, which will be shared with private companies. The new regulatory regime gives SENER energy policy functions, mainly associated with a vision of the energy sector as a whole regarding the use of more efficient and less polluting power plants and implementing a transition to renewable resources. Also, the law gives CRE regulatory functions such as overseeing the development of a competitive market emphasizing environmental quality. In addition, it gives CENACE market-control functions including security-constrained economic dispatch, resulting in the prioritization of low-cost producers.

The *Energy Transition Law* coupled with the Electricity Law provides the legal framework for the accelerated penetration of renewable sources of electricity. These sources include high-efficiency cogeneration, waste-based generation and thermal power plants with carbon capture and storage along with wind and solar photovoltaics. The *Geothermal Energy Law* provides a legal framework for the private sector participation in geothermal development. Mexico has traditionally been the fifth largest producer of geothermal energy in the world, after the US, The Philippines, Indonesia and New Zealand. This position could improve in the future, particularly since SENER issued concessions to CFE in 2015 for the development of 13 geothermal sites, which potentially increase installed geothermal capacity by 450 MW.

V. Cultural attributes and informal institutions

Rhetorically, Mexico’s energy policy is designed by SENER considering the opinion of the following actors: the state-owned productive enterprises PEMEX and CFE; other government agencies, particularly SHCP, for budgetary and taxing purposes; and the Bank of Mexico, for the sake of the national price index control. Also, the following opinions are considered: social and economic regional groups where energy activities are carried out, local governments, academic and research institutions, international organizations, and private national and international companies.

Nonetheless, after the enacting of the 2013-2014 energy reform, the influence of private interests grew considerably. Not only energy laws and rules were adjusted to protect all kind of energy activities from possible social, political and even environmental restrictions, but the market-oriented principle that legally guides the industry has not been able to send enough signals to stop bad practices.

There is not a manual for oil companies to deal with the Mexican energy structure and bureaucracy, which at federal level involves SENER, CNH, CRE, SHCP, SEMARNAT, the Secretariat of Labor and Social Prevision (STPS), and social security institutions. Also, at local level some non-written state and municipality rules have to be sorted out. Nonetheless, the experience gained during 2015-2018, when the enactment of the energy reform brought to the hydrocarbon industry 107 awarded contracts and over 35 national and international bid-winner companies, going alone or in consortia, shows that integrating a consortium with at least one local partner is the best way to initiate the exploration and exploitation of deep-sea, shallows and inland's business. This rule helps to deal with the administrative and political clues of the Mexican system and have been followed even by larger-sized bid-winner companies such as Exxon Mobil, BP, Royal Dutch Shell, Chevron, ENI, Total and Repsol (CNH, 2018).

In the rest of oil and gas activities, foreign companies have no had problems working on their own. They include the request and gathering of permits to import, transport, storage and sell gasoline, diesel and natural gas to final consumers. Also, private companies have had no problems to establish power generation plants on their own.

VI. The energy policy-making process

Energy planning officials have not developed the will nor the instruments to foresee the international oil price cycle and their effects on the Mexican economy. Neither have they developed the capacity to estimate the consequences of hydrocarbons depletion on the domestic supply of oil, gas and refined products from 2004 on. Consequently, the trade balance for hydrocarbons and the national energy balance became negative ever since 2015. Apparently, the only energy variable which seems important to policy makers is that of crude oil exports, as such resources help to improve the balance of payments and push up BANXICO's foreign currency reserves, which in turn support the rate of exchange of the Mexican peso. This conceptualization of the oil industry comes from 1974, when Mexico became for the second time in history a net oil exporter. Neither present nor previous energy policy has been able to incorporate enough investment to alternative energy sources to substitute fossil fuels.

It seems apparent that policymakers did not care about gasoline and diesel imports, which up to 2016 accounted for 75% of total net consumption, while the refineries' idle capacity reached frequently more than 70%. The latter problem can be explained on the one hand for the low API gravity of sour Maya, not able to be processed as such by Mexico's refining system, having to be mixed with better-quality crude. This results in needed imports of about 90 TBD of light oil. Ironically, the country produces a similar grade oil called Olmecca, out of which 108 TBD were exported in 2016 (PEMEX, 2017), but the underlying fields can be near to exhaustion. Further, national environmental regulations, which promote the use of natural gas as a cleaner primary energy source, have led to the construction of a great deal of combined-cycle power plants since the mid 1990s. The modifications in the Public Service Electricity Law (DOF, 1992) that allowed private investment participation in the field of energy generation, did not take into consideration how national gas production would struggle to keep pace with this demand.

While income-elasticity for the demand of gas, both natural and liquefied, was 6.1 during the period 2001-2016, the same elasticities for gasoline and diesel were 1.2 and 0.6, respectively. For the rest of refined products, it was 2.2. Nonetheless, all the blame about the supply-demand disequilibrium has been put on car owners, who pay for gasoline and diesel taxes on the final price close to 40%. Just for comparative reasons, in U.S. the tax represents 21% of the retail price, and in dollar terms at the current rate of exchange the price of regular gasoline in the U.S. Gulf Coast was in 2018 45% cheaper than in Mexico (INEGI, 2018; PEMEX, 2018; USEIA, 2018).

This shows that the state-administered prices system was still active up to 2018, in spite of the liberalization mechanism put in place at the beginning of 2017. Due to the latter, the annual rate of inflation in Mexico doubled in 2017 that of 2016 and in 2018 it was close the level it reached in 2017. As a consequence, the energy costs of production for the industrial sector are growing several times faster than those of Mexico's main commercial partners (OECD, 2017).

VII. The factors driving the energy policy up to 2018

Three factors drove energy policy change in Mexico up to 2018. The first came about in 2004, due to the unexpected turning point in the production of oil of Cantarell field, which reached 2.4 MBD in October 2004 (the second of its kind worldwide), and then progressively fall to establish itself in 2017 in 165 TBD: the average annual reduction of production was 170 TBD. This implied about 4.3 billion dollars per year less for the economy, considering the 2005-2017 average price of 68.70 d/b. The resources were equivalent 0.5% the average annual GNP (PEMEX, 2017; INEGI, 2017b).

The second was the promulgation of the energy reform in 2013-2014, which modified the whole energy sector to allow private investment all along the value chain. An exception has been so far geothermal power plants, as Mexico is well endowed with that kind of sites but all production comes from CFE because economically a great deal of initial capital is required, and administratively the arrangements with SENER to get access to the sites are slow and tiring. In the rest of activities, private companies already are participating or beginning to do so: exploration and exploitation of hydrocarbons; combined-cycle energy generation; gas storage, transportation and commercialization; exploitation of alternative sources particularly through wind and solar photovoltaic plants; and imports, distribution and retail sales of natural gas and refined products. On the other hand, two areas remain untouched by private capital: oil refining and power transmission. To petrochemical plants, capital arrives rather slowly, though petrochemical products are badly needed for the whole industrial sector's intermediate production. The same is true for the areas of pipe-line transportation and storage of oil and refined products, in part because PEMEX shares with private enterprises its installations and in part because of the fear they feel about smuggling experiences along the polyducts.

The third was the 68% reduction of international oil prices between June 2014 and February 2016, for which Mexico reduced its 2013 oil, gas and related products foreign trade surplus of 20.3 billion dollars to a deficit in 2015. Between 2014 and 2017 the annual average deterioration of that account in relation to 2013 amounted to 18.8 billion dollars, a 1.7% of the GDP. This is a net figure which takes into account the foreign trade balance of PEMEX, composed mostly by exports of crude oil and some derivatives, and imports of gasoline, diesel, gas and some petrochemical products. In average, that meant a reduction of public sector resources via taxes to PEMEX of about 1.2% of GDP. This in turn forced to increase public sector revenues via production and consumption taxes, and to reduce expenditures. The annual federal budget was cut four times between 2015 and 2018, each time in average 1.0% of GDP. The most affected kind of expenditure was that of public sector investment, particularly for the oil sector. All this contributed to accelerate the implementation of facilities for the private sector to invest more. For example, the rights to establish private gasoline stations were advanced one year, from 2017 to 2016, as the permissions to import gasolines, from 2018 to 2017. Additionally, the energy diversification program was supported by a series of facilities for potential investors in wind and geothermal power plants. But by the end 2018, only around 1.5% gasoline imports were made by private companies.

The PRI-PAN alliance in the Congress was crucial to reform articles 25, 27 and 28 of Mexico's political Constitution. Besides, private companies made a rather conspicuous lobbying headed by many former government officials, five of which had been director generals of PEMEX and two had headed SENER. All of them were working as private consultants, had become advisors to international energy companies, or were part of the board of directors of private energy national or international companies. Up to 2018, a former director of PEMEX Exploration and Production, the most important branch of Mexico's state-owned company, was heading a new national private oil company, and many other former officials were working for international energy companies. Multiple international oil, gas and power companies, and government institutions such as the EIA reported periodically since decades ago their regrets about the state-owned character of the Mexican energy sector.

VIII. Regional and global political institutions

For a large number of years before the constitutional reform of 2013 was put in place, a great deal of pressure came to Mexican authorities through international organizations, mainly the International Monetary Fund (IMF), the World Bank, the Organization for Economic Cooperation and Development (OECD), and the two partners of Mexico in NAFTA. They argued that Mexico had done important steps toward its modernization by opening its economy to foreign trade and by accepting foreign capital in most sectors of the economy.

Nonetheless, the energy sector remained a state-monopoly, and the political Constitution had to be reformed to allow foreign investment all along the value chains of hydrocarbons, power energy and alternative sources. Those institutions not only presented specific documents about the benefits of opening up Mexico's energy sector, based on the experiences of other countries, but also promoted government seminars about the ways the hydrocarbon and power industries could be reorganized. To a great extent, the OECD became an advisor on this theme to Mexico's federal government, and a branch of it, the International Energy Agency (IEA) welcomed Mexico as a former member in February 2018.

Climate change and sustainability considerations, on the other hand, have had an increasing influence on Mexico's energy policy. This influence predates the 21st Session of the Conference of the Parties (COP21) held in Paris in November 2016 where Mexican officials pushed hardest for a climate change agreement. Mexico is the second country in the world to adopt a legislated binding climate target, taking institutional steps to promote clean energy (IEA, 2016).

Mexico places on a high value energy integration with the U.S. too. NAFTA has been the keystone for this. In 2001 the North American Working Group was put in place, to become in 2005 part of the Security and Prosperity Partnership (SPP), in which energy became a key ingredient. North America's energy resources started to be seen as assets which should be shared by the three countries before others, particularly during hard times, showing concern about regional energy security.

In 2012 the U.S. and Mexico signed an agreement on the development of oil and gas reservoirs crossing both countries' maritime borders in the Gulf of Mexico. The idea was both to enhance energy security in North America and to exploit transboundary reservoirs in an orderly manner and with the highest degree of safety and environmental standards.

IX. Outcomes

The main changes of Mexico's energy policy are the result of the enactment of the 2013 energy reform as well as the commitment with international compromises. On these grounds, nine hydrocarbons and three electric bidding acts were carried out between July 2015 and June 2018; more than 35 oil private companies entered the oil business; the larger global companies of the world choose to have presence in the Mexican side of the Gulf of Mexico; many electric power companies are about to put in place more combined-cycle, wind and solar photovoltaic generation plants, and others are planning to reinforce the geothermal power generation potential, where only CFE has devoted resources. Besides, between January 2017 and November 2018 gasoline and diesel prices were liberated; private gasoline stations with different national and international brands grew steadily representing by the end of 2018 more than 10% the total number of gasoline stations in the country; and private capital for the imports of natural gas kept dynamic.

On the other hand, the state-owned remaining part of the hydrocarbons industry, in PEMEX hands, seemed to do nothing to change up to November 2018, in spite of facing a decreasing rate of production, high indebtedness, low labor productivity, bravery scandals, fuels smuggling, serious operation accidents, important plants shutting doors, and rather high salaries and retirement benefits. This industry's maladministration was causing social discontent not only because oil is seen as a resource which belongs to people (so the Political Constitution goes), but also because the constant reduction in the production of oil, gas and derivatives since the enactment of the energy reform was associated with price increments, while in the world they went on the opposite direction. Remarkably, crude oil exports were keeping very high, around 1.15 MBD, while imported fuels increased their participation in national consumption and the refineries' idle capacity reached its highest post-war level. All these problems were seen both as a lack of planning commitment and as the reason to accelerate private enterprises market share, automatically displacing PEMEX from the industry.

At a slower pace, the same was happening to the power industry, where final prices for both large consumers (industry and commerce) and home users increased steadily since the end of 2015, in opposition to the price of the main energy input used by the industry, natural gas, which faced a long-term declination. As 50% of consumption of such a product is covered by imports from the U.S., the energy reform was associated by many people to an increasing energy dependency on imports, a badly designed electric power price policy, and a progressive reduction of CFE's market share.

In June 2016, at the North American Leaders Summit in Ottawa, it was signed by the Prime Minister of Canada and the presidents of U.S. and Mexico the North American Climate, Energy, and Environmental Partnership (NACEEP). The agreement sought to identify deliverables to be achieved and activities to be pursued as part of their enduring partnership. The most important goal was the achievement of a 50% share provided by clean power in North American generation by 2025. Clean power includes renewable, nuclear, and carbon capture and storage technologies coupled with demand reduction through energy efficiency. Previously, Mexico had committed itself to reduce methane emissions by 40-45%, align fuel efficiency standards by 2015 and green-house emission standards by 2017 (IEA, 2016). The agreement was to be implemented individually by each country in accordance with their own conditions, legal frameworks and clean energy national goals. Cross-border transmission projects are contemplated, including renewable electricity, with the idea of increasing the reliability and flexibility of North America's electricity grid, involving, for example, the Nogales interconnection—a high voltage DC line connecting Mexican and U.S. power systems.

In January 2017 Mexico and the U.S. signed a list of 11 guidelines that established the bases of cooperation between the two countries on matters with regard to electricity. These guidelines provided for the regular exchange of electricity in the face of contingencies and the reduction of vulnerabilities that arise due to natural disasters, physical threats and against possible cyber-attacks. The underlying document takes into account how the electrical systems of both nations are interconnected, why they cannot be seen independently, and how to strengthen the measures of reliability and security (USDE, 2017). The endorsed principles are to be implemented through the North American Electric Reliability Corporation (NERC).

X. Perspectives and conclusions

For the 15 years period starting 2015, the previous government forecasted levels of demand for the energy sector as follows: A growing tendency in the transport sector demand for oil products from 1,096 TBD in 2015 to 1,534 TBD in 2030, a 2.3% AARG, and an expected reduction in the dependency on oil derivative imports (mostly gasolines and diesel) from 54% out of national consumption to 30%.

- In the power industry, the demand for primary energy was expected to remain almost flat, moving from 941.1 TBOE per day in 2015 to 947.5 TBOE per day in 2030. Due to international compromises, particularly the NERC and COP 21 commitments towards energy security and greenhouse emissions control, by 2030 the demand for coal, heat-oil and diesel was expected to be disappearing and natural gas participation growing from 55% in 2015 to about 60% in 2030.
- In the industrial sector, the demand for energy was expected to have a 2.2% AARG during the period, from 346.4 TBOE per day in 2015 to 481.3 TBCE per day in 2030. The gas participation, both natural and petroleum liquefied (PLG), in the same sector should increase from 71.6% in the first year to 80.2% in the second, advancing at a 3% AARG.
- In the oil industry, the demand for refined products was expected to stay still around 45 TBD along the period, so that by 2030, 51% out of the 3.0 MMBD of expected amount demanded come from the transport sector, 31.5% from the electric generation industry, 16% from the industrial sector and 1.5% from the oil industry.
- In the case of the power industry, the demand coming from the whole economy was expected to match the forecasted GDP rate of growth, about 3.4%, so that the unit elasticity of demand is preserved: in 2005-2015 the AARG of such demand was 2.7%, slightly above the economy's AARG (2.4%).
- By regions, the lowest rate of energy demand would come from the central portion of the country, and the largest from the northern states, which are the most dynamic (SENER, 2016).

Some changes in the energy policy have been announced from the 1st of December 2018 on, supported by the majority the political party MORENA gained in the Congress and mostly by the convictions that the MORENA's president of Mexico has spelled out:

- Pemex, which due to Round Zero of the energy reform holds more than 80% of proven reserves, is expected to retake its preeminence in the production of oil, as the government has decided to focus its attention on already productive or potentially productive sites where technology is well known, mostly in the south-east territory and shallows, assigning PEMEX immediately 75 billion pesos (3.8 billion dollar) to develop those

resources. In this way, it is expected that by 2024 oil production goes up from nowadays 1.85 MBD to 2.6 MBD.

- The six refineries of Pemex (in this case Pemex equates to Mexico), are receiving 25 billion pesos (1.3 billion dollar) to be modernized and or reconfigured, in part to make them able to use more heavy Maya (22 API degrees and 3.3% sulfur content), the only crude with long-term proven reserves (light Olmeca and medium Isthmus are about to be exhausted). Nowadays, Maya has to be mixed with about 90 TBD light oil imported (or interchanged by Maya) from other countries, mainly US in order to produce only a fraction of those gasolines and diesel demanded by Mexico.
- The edification of a new Pemex refinery in the state of Tabasco, in the south-east region of the country, expected to be concluded by 2022 investing 8 billion dollars of public resources with a 350 TBD transformation installed capacity.
- Reinforcing power generation by assigning CFE one billion dollars in the short-run to improve 60 hydroelectric plants, in association with Canadian companies, and also to reinforce thermoelectric plants based on heat-oil and probably coal, contributing so to reduce gas natural imports and to rise Mexico's industrial competitiveness.
- Due to the four previous actions, the government expects that self-sufficiency in gasolines and diesel be feasible by 2022, and that of natural gas shortly after, with three possible benefits ripped by shifting from predominantly combined-cycle plants to traditional thermoelectric plants: a higher supply of power, lower retail prices of electricity services, and a lower demand for natural gas imports.
- The cancelation of oil resources public auctions 3.2 and 3.3 (phases 2 and 3 of Round Three) which were scheduled for early-2019 in order to explore and exploit land plays located in the north-east and the Gulf coast regions, assuming that the best available technology is fracking, to which the new government has been openly opposed, in coincidence with small-sized land owners, ejidos, agrarian communities and ambientalists.
- Revision of the 107 contracts assigned through nine public auctions to some 35 private national and international enterprises in rounds One and Two during 2015-2017, mainly to know whether they are in the position to initiate or accelerate their duties of exploration and exploitation, as established in the contracts.
- Limiting retail and industrial energy price increases (gas, gasoline, diesel, and electricity services) to the inflationary pace.
- Reducing personnel, autonomy and political power to two central institutions of the constitutional reform: CNH and CRE (SENER, 2018a and 2018b).
- Increase the ground transportation of gasoline, diesel and natural gas to avoid polyducts smuggling with the risk this originates to people, through the improvement of lorry-tanks transportation looked over by the army.
- Use more frequently the legal capacity PEMEX has to contract the services of national and international companies to explore the hydrocarbons on the assigned areas where it knows they exist.

Energy policy instruments ought to be both consistent between them and coordinated with those oriented to achieve macroeconomic and environmental objectives. Historically, Mexico's main macroeconomic objectives have been: economic growth, inflation control, public finances equilibrium, export-oriented industrialization, a low rate of unemployment and remunerative wages. The three crucial environmental objectives are: a serious reduction of natural resources depletion, which must be associated to a positive replacement rate; a low environmental damage; and the achievement of international commitments, particularly the reduction of greenhouse gases. Even if the Mexican government had the capacity to coordinate those three areas, and also subordinate energy policy to macroeconomic and environmental objectives, the government in power since December 2018 seeks a formula to properly regulate national and international energy enterprises and counterbalance their power reinforcing that of PEMEX and CFE without modifying, at least by the time being, the legal and the regulatory framework.

The PRI-PAN bloc which made possible the 2013-2014 energy reform has enough reasons to believe that even if MORENA has the support of its small-sized allies, it will not reach the two-thirds Congress votes required reversing the constitutional modifications to the articles 25, 27 and 28. In this regard, some changes to the secondary laws may be enough for the government to regain the national resources control it considers necessary to reinforce the oil and power industries, and properly coordinate energy policy. By addition, and as it is happening in the United States, this government may not be considering seriously the environmental challenge.

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