ENERGY POLICIES BEYOND IEA COUNTRIES

Mexico

2017

International Energy Agency

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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Executive summary

This first review of Mexico's energy policies by the International Energy Agency (IEA) comes at a momentous time for the country's energy sector. The broad-based reform of the energy sector, beginning with the constitutional changes of December 2013, has continued at a steady and impressive pace. Its reach and scope represent the most ambitious energy system transformation worldwide in recent years. The IEA welcomes these efforts and applauds the government of Mexico for the progress made to date.

Starting from a largely closed and monopoly-driven energy market, the reform has led to concrete steps to harness market forces to attract investments, increase transparency and rule of law, improve energy security and strengthen the environmental sustainability of the energy sector.

Mexico's reforms are bringing its energy policies increasingly in line with the IEA Shared Goals (see Annex D of this report). Some policy areas, such as promoting competition and redesigning emergency preparedness, are not finalised yet and will have to remain a priority for the reform.

Overview of the energy reform

The energy reform is part of the government's broad structural and institutional reform package, introduced by President Enrique Peña Nieto, which aims to modernise the Mexican economy and society and bolster long-term growth through increased efficiency and productivity. In the oil, gas and power sectors, the country was lacking in investment and productivity growth. Oil production had been for decades a major source of government budget revenue, but was declining sharply, while inefficiency in electricity supply was driving costs higher, harming the competitiveness of industry and increasing the volume of subsidies to supply power to the growing population at low cost. Energy supply also relied heavily on fossil fuels which exacerbated local air pollution and put the country's greenhouse gas emissions on a long-term pathway which was incompatible with the country's climate policy ambitions.

The reform required several changes to the Mexican Constitution, adopted in December 2013. By August 2014, the reform had been codified in 10 new laws and 12 modified ones. The reform is covered in more detail in the individual chapters of this report. The reform is being implemented in phases and the government aims to finalise its implementation before the expiry of its current term in November 2018.

The reform opens the long-closed oil, gas and electricity sectors to competition. It turns the state-owned monopolies *Petróleos Mexicanos* (PEMEX) and the Federal Electricity Commission (CFE) into state productive enterprises, which are expected to follow a business-driven strategy and to strengthen incentives for investments from old and new

players. In addition, CFE is legally unbundled. PEMEX and CFE, with a combined workforce of more than 200 000 people, will need to adjust to an era of competition and transparency, while strengthening the internal governance of their newly separated business lines.

IEA scenarios to 2040 indicate that the reform will boost oil production, increase the share of renewable energy sources in the power sector, increase energy efficiency and slow the growth in carbon dioxide emissions. In the absence of these energy reforms, oil production would fall further, electricity costs would be higher, and household spending would be hit. Indeed, failure to reform would reduce Mexico's gross domestic product by 4% in 2040, resulting in a total cumulative loss of one trillion US dollars in economic output (IEA, 2016).

Reform in energy governance

The reform transforms the governance of Mexico's energy sector. A number of responsibilities that were the domain of PEMEX and CFE have been transferred to independent regulatory bodies. The scope and pace of the reform has placed pressure on the capacity of government agencies and regulators whose roles have expanded significantly, and which need to have the resources and expertise required for effective implementation. An obvious area of new activity is monitoring and enforcing competition. It is also critical to ensure a smooth transition of responsibilities for energy security and energy data from PEMEX and CFE.

The IEA sees energy security as one of the key issues to be addressed. The government has historically relied exclusively on PEMEX and CFE to supply the country with hydrocarbons and electricity. However, as new market entrants and new regulators play an increasing role, a revised division of responsibilities between the government and industry players needs to be defined in order to maintain the ability to plan for and react to emergencies. New regulations will have to be put in place; SENER will have to build short-term situational awareness for supply security issues and install a new data collection system for emergencies. Such issues are at the heart of Mexico's ongoing accession process to IEA membership and will be the subject of a separate review in 2017.

Similarly, the government will need to address the risk of disruption in current energy data flows, as energy data collection becomes more complex in a competitive energy sector, and statistics and forecasting functions shift from PEMEX and CFE to the Ministry of Energy (SENER) and other agencies. The IEA encourages the government to continue its work to establish and consolidate an energy information system for collecting, processing and translating data along the entire energy value chain.

Authorising energy infrastructure projects and permitting them involve several steps at different administrative levels, and it is critical to streamline these processes to encourage investment. The energy reform includes removing barriers to enter the market. A welcome example is the reduction in the required administrative steps to connect a generation plant to the grid from 47 to only nine.

Reform in the oil and natural gas sectors

Mexico's long-standing position as one of the world's major oil producers and exporters has weakened in recent years, as oil production has declined by one-third from the peak of 3.8 million barrels per day in 2004 to 2.5 mb/d in 2016. Natural gas output has also been in decline, as most of the production is associated with oil, and imports now meet almost 50% of gas demand. This decline in output is linked to a shortfall in the funds available to PEMEX for capital expenditure to slow declines in mature fields or to develop new ones. It is also widely known that PEMEX did not have the technical capacity to bring new production online from deep-water and shale resources, and could not provide the refining capacity necessary to meet the country's oil product needs.

The energy reform ended the state monopoly on oil and gas production, although it maintains the inalienable national ownership of hydrocarbon resources, as in many IEA countries. A series of bidding rounds that began in 2015 is opening the oil and gas sectors to private investment and technology, leaving PEMEX to focus its resources and expertise on a narrower range of projects, either alone or in joint ventures. The IEA believes this new investment will help to slow the decline in output in shallow water areas, the traditional mainstay of Mexico's production. It will also help to bring forward new projects in deep waters and develop new onshore resources, including tight oil. New entrants will bring dynamism to the upstream sector, and production of both oil and gas is expected to grow again in the coming years. The IEA projects oil production to rise to 3.4 mb/d in 2040, which will help restore Mexico's position as one of the world's top oil producers and exporters (IEA, 2016).

Investment is needed to modernise and expand oil and gas pipelines and storage, and also oil refineries. The authorities should also ensure third-party access to essential oil and gas infrastructure, and clarify the cost assignment of infrastructure expansion to existing and new customers.

In the retail oil market, a combination of limited refining capacities and rising demand means that Mexico is currently a net importer of oil products. The oil products market is being liberalised ahead of the initial schedule. Since April 2016, importing oil products has been open to non-PEMEX entities. From January 2017, the retail oil market will be opened, one year earlier than initially announced. Furthermore, subsidies on oil products were phased out from 2008 to 2014. The IEA applauds the government for these reforms.

Natural gas is the second-largest primary energy source in Mexico (35% of total primary energy supply in 2015, versus 48% for oil) and in SENER's projections to 2029, gas demand is set to grow fast. This underlines the need to focus on upstream supply, storage and transportation in policy discussions. The expansion of the gas pipeline network has lagged behind the boom in gas demand. Further expanding the system is urgent, as the system has already reached saturation on several occasions. This also highlights the need for more storage in the system. Creating an integrated national gas grid also requires close co-operation between CENAGAS (the independent system operator) and private pipeline owners. In the retail natural gas market, it is critical that the gas release programme, under which PEMEX must reduce its market share to 30% by 2020, be implemented successfully.

Reform in the electricity sector

Mexico's energy reform is fundamentally changing the electricity sector which was built on the monopoly of the state-owned CFE. The reform unbundles CFE into separate subsidiaries for transmission, distribution and power generation. It introduces wholesale and retail market competition, which should reduce electricity generation costs and thus enable phasing out end-user subsidies without dramatic price increases. At the same time, the reform introduces mechanisms to help ensure that investment keeps pace with fast-growing demand and that a rising share of electricity is generated from clean sources.

New investment for an estimated USD 9.6 billion annually in electricity is essential to meet the rapid growth expected in electricity demand (IEA, 2016), allowing Mexico to reach its target of producing 35% of electricity from clean sources by 2024, compared to 21% today.

The clean energy target is to be met through a quota system which includes a clean energy certificate (CEC) obligation on retail suppliers (currently only CFE) and large consumers that do not use retail suppliers. The CECs are granted to facilities taken into use after August 2014; they can be bought directly under bilateral contracts with generators, in the CEC market to be launched in 2018, and in long-term auctions. In consequence, generators of clean electricity will obtain additional revenue by supplementing their sales of electricity with the sales of CECs.

A centrepiece of the reform effort is the system of auctions for energy, capacity and CECs that allows investments from new players into the market on a competitive basis. The auctions offer long-term contracts (15 years for energy and capacity, and 20 years for CECs) that provide a degree of stability over future cash flows for generation companies

The Mexican clean energy auction system is one of the most sophisticated procurement mechanisms for renewable energy. Distinctively, it seeks to capture the relative value for the system of different generation technologies by location and production profile. Projects located in higher-price areas of the country, or capable of delivering power at times of day when it is particularly needed, would receive higher revenues through the auctions and therefore attract more attention from potential investors.

Clean energy technologies are defined to include renewable energy, nuclear energy, efficient cogeneration and fossil-fired generation with carbon capture and storage. On the basis of the two first tenders, held in 2016, the auction system is providing a substantial boost to solar and wind energy, tapping Mexico's large wind and solar resources at internationally very competitive prices. It is difficult to see how new nuclear could compete under the current rules, which require the projects to be ready within three years of the auction.

Regarding costs, electricity prices for households and farmers are subsidised by between 60% and 70% of the total cost. Artificially low electricity prices are likely to hamper government efforts to pursue efficiency; they should be replaced by targeted social policy measures for those in need. The relevant regulators and SENER have expressed their intent to work with CFE on correcting these distortions. Bringing down technical and non-technical losses, which are currently significantly higher than

elsewhere in the OECD world, would reduce the need for investment in additional generating capacity, while improvements in operational efficiency in the newly unbundled CFE could significantly reduce the retailing component of the cost structure. A strengthened transmission and distribution system would further help reduce losses and is also necessary to support the projected growth in demand and in supply from variable sources – solar and wind. Efforts to attract investment to this end should be intensified.

The reform is implemented in stages and some of its important elements are yet to be introduced. These include the real-time market, the capacity market and the clean certificates market, all to be introduced in 2017-18. Most of the remaining challenges now lie in the decisiveness and speed in implementing the reform, including the necessary adjustments and improvements that are likely to be required after the first years of experience.

Overall, Mexico's electricity market reform is one of the most ambitious, comprehensive and well-developed reforms undertaken in the world since the 1990s. It has been designed from the onset with targets for clean energy and has been implemented at full speed in only three years, benefiting from lessons learned in other markets. Industry and other stakeholders have been widely consulted during the reform process. The IEA commends the Mexican government for its careful reform approach, based on a very thorough review of available policy and regulatory solutions worldwide.

Long-term approach for tackling climate change and rising energy demand

In recent decades, Mexico's GHG emissions have increased rapidly and, until 2011, grew in tandem with economic growth. From 1990, energy-related CO_2 emissions grew by two-thirds to 431 million tonnes (Mt) in 2014. Fossil fuels account for 90% of Mexico's primary energy supply, a high share by international comparison. Emissions increased the most in transport (now the largest emitter) and electricity generation.

Mexico's prospects for economic and population growth appear stronger than those of IEA member countries. Its population is expected to grow to more than 150 million towards 2050 from around 120 million today. This, together with improvements in productivity, will drive economic growth. As a result, energy demand is set to increase significantly, also because energy use in Mexico is still relatively low: electricity use per capita is only 30% and TPES 40% of the IEA average. The Ministry of Energy (SENER) projects power generation to rise from around 300 terawatt-hours (TWh) today to around 470 TWh in 2029. The IEA foresees it to grow past 500 TWh by 2040.

The government is aware of the challenges ahead and is strongly committed to transforming the country's energy system into a more sustainable one. Mexico has been among the world leaders in integrating climate change objectives into policy making, as evidenced by the Climate Change Law. The law stipulates that the country should prioritise cost-effective actions that create co-benefits for the population, and sets a target to reduce GHG emissions by 30% from the business-as-usual level in 2020. It also includes a long-term target to reduce GHG emissions by 50% from 2000 to 2050. To help prioritise among the various policies and measures, the government should develop estimates of cost-effectiveness, on a cost-per-tonne of CO_2 basis and both in terms of short-term reductions and in delivering on the 2050 target.

Mexico's climate pledge (INDC), submitted in advance of the 21st Conference of the Parties (COP21) in December 2015, further strengthens the country's commitment to reducing its GHG emissions and following a low-carbon and resilient path. Under the mitigation scenario, emissions would peak in 2026 and be 25% below the business-as-usual level in 2030. Carbon intensity could be reduced by 40% between 2013 and 2030.

The intended nationally determined contribution (INDC) also includes goals to reduce the emissions of short-lived climate pollutants (SLCPs). Integrating climate policy and air pollution policy brings synergies, as reducing SLCPs has a direct impact on air quality and the health of the population. In this context, the IEA applauds this decision and also urges the government to strengthen national air quality policy to provide a more solid basis for limiting air pollution.

However, even without official scenarios, the INDC ambition to peak overall emissions will be a significant challenge. For example, the electricity sector is supposed to make the largest contribution to the INDC emissions reduction. However, even in a clean energy scenario, Mexico's emissions may actually increase from today's levels, because of projected large absolute increases in power generation. The projected significant rise in transport may have similar implications for emissions. This calls for further strengthening of sectoral policies, especially in transport, and for developing a comprehensive policy approach for all sectors.

As Mexico's population is growing and urbanising, the country needs to build more urban infrastructure over the coming decades. Energy and climate aspects should be an integral part of long-term transport and urban development policies to avoid a lock-in into private car-dominated inefficient and energy-intensive urban structures. For example, if private car ownership in Mexico increased to today's average EU levels by 2050, the country's car fleet would triple to 75 million.

Given Mexico's role as a major energy producer, its energy policy has historically focused more on the supply side than on the demand side. This also appears to apply to climate-related policies, where increasing clean energy supply has attracted significant attention. In general, energy efficiency and clean transport are important and cost-effective policy levers that could play a stronger role also in a comprehensive clean energy and climate change plan.

In the coming years and decades, more and better buildings will need to be constructed, more appliances and equipment sold, more vehicles bought. Strong policies on energy efficiency will become all the more relevant and a long-term approach is needed to guide the country on an environmentally sustainable path.

Experience in IEA member countries shows that minimum energy performance standards are among the most effective and cost-efficient energy efficiency policy instruments. They have already delivered considerable energy savings in Mexico. The government should continue to introduce stringent standards across all sectors: buildings, vehicles, appliances and equipment. It should also continue to regularly update them and, where applicable, accompany them with energy labelling.

Specifically, the government should also enhance the adoption of building energy codes and standards for building components through better co-ordination, support and enforcement between federal and local governments, as well as through awareness

campaigns. Finally, as price is a significant driver for behavioural change, the government should phase out the remaining subsidies on electricity use and consider using gradually higher taxes on transport fuels, at least for non-commercial use, to limit the growth in oil use and thus help improve energy security, avoid CO_2 emissions and raise budget revenue.

The government has set welcome targets and supporting mechanisms for electricity from clean sources. For renewable energy, Mexico has potential beyond electricity, however, and the IEA encourages the government to consider a more ambitious approach regarding heat and transport fuels from these sources.

Mexico is already engaged in research, development and demonstration on clean energy and energy efficiency. Globally, much more is needed to cut emissions dramatically beyond 2030. The IEA urges the government to consider a stronger focus on these sectors in its research, development and demonstration (RD&D) policy and spending, and ensure a stable and predictable funding for energy RD&D.

Key recommendations

The government of Mexico should:

- ☐ Finalise the implementation of the energy reform, while
  - > continuing to follow closely the principles of transparency and regulatory certainty, while incorporating lessons learned and international best practices
  - > fostering competition across the entire sector, by actively countering the incentives of incumbents to use their market power;
  - > ensuring sufficient resources for the regulators.
- ☐ Define, in the transition to open energy markets, clear roles and responsibilities for the public and private entities involved in order to maintain and improve the ability to collect energy data and to plan for and react to possible energy supply emergencies.
- ☐ Work ambitiously to limit energy-related greenhouse gas emissions and, as the country's population, cities and economy are projected to grow strongly, incorporate energy and climate considerations into long-term urban development and transport plans to limit growth in energy demand.

References

IEA (International Energy Agency) (2016), *World Energy Outlook Special Report on Mexico*, OECD/IEA, Paris.

2. General energy policy

Key data

(2015 estimated)

Energy production: 196.1 Mtoe (oil 68.7%, natural gas 17.8%, biofuels and waste 4.4%, coal 4.1%, geothermal 1.6%, nuclear 1.5%, hydro 1.4%, wind 0.3%, solar 0.1%), -24.3% since 2005

TPES: 187.3 Mtoe (oil 48.1%, natural gas 35.1%, coal 7.3%, biofuels and waste 4.6%, geothermal 1.7%, nuclear 1.6%, hydro 1.4%, wind 0.4%, solar 0.2%, net electricity imports* -0.3%), +4.9% since 2005

TPES per capita: 1.6 toe (IEA average: 4.5 toe)

TPES per GDP: 0.10 toe/USD 1 000 PPP (IEA average: 0.11 toe/USD 1 000 PPP)

Electricity generation: 307.4 TWh (natural gas 59.8%, coal 11%, oil 10.2%, hydro 10%, nuclear 3.8%, wind 2.6%, geothermal 2%, biofuels and waste 0.5%, solar 0.1%), +22.6% since 2005

Power generation per capita:** 2.5 MWh (IEA average: 9.2 MWh)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

*Net electricity imports = electricity imports *minus* electricity exports.

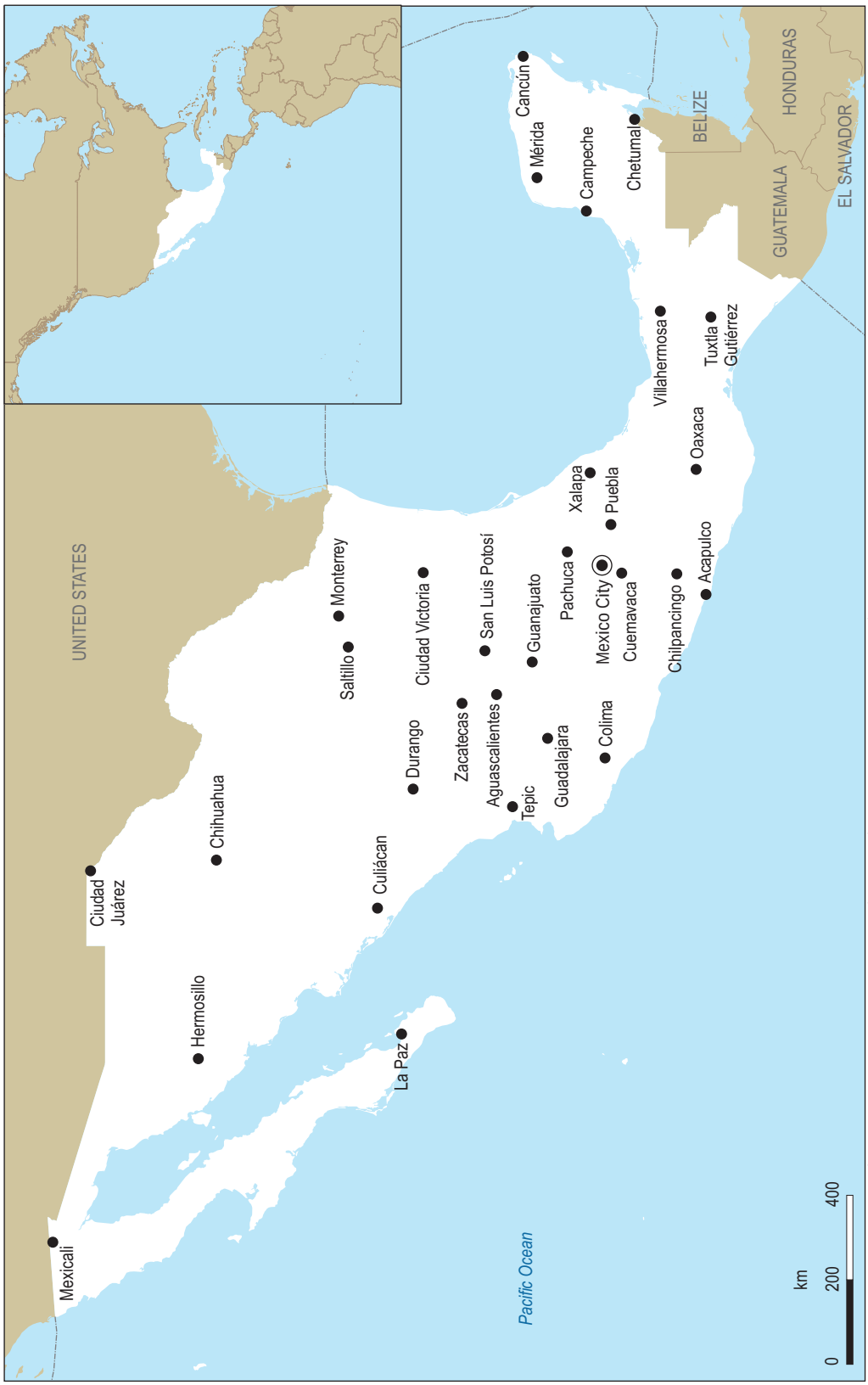
** There is no heat generation in Mexico.

Country overview

Mexico is a federal republic with thirty-two states. The country is bordered to the north by the Unites States, to the south and west by the Pacific Ocean, to the southeast by Guatemala, Belize and the Caribbean Sea, and to the east by the Gulf of Mexico. With 1 944 million square kilometres, it is the fifth-largest country in the Americas and the thirteenth largest in the world. With more than 119 million persons, Mexico is the third-most populous Organisation for Economic Co-operation and Development (OECD) country. It is also the third-largest oil producer in the OECD.

Mexico is endowed with abundant energy resources, both fossil and renewable, and is still a net exporter of crude oil, although its self-sufficiency and trade balance of other fuels have deteriorated rapidly. Mexico has been a net importer of most oil-based products for several years, and since the energy policies of the late 1990s began to shift away from the predominant use of fuel oil and other oil-based products in the electricity sector, natural gas imports have increased remarkably.

Figure 2.1 Map of Mexico



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Economy

Mexico is the second-largest economy in Latin America, the fifteenth-largest nominal gross domestic product (GDP) and the eleventh-largest by purchasing power parity (PPP), globally. Classified as an upper-middle income country, Mexico was the first Latin American OECD member and is also a member of the G20.

The country recorded an average growth rate of 2.5% between 2005 and 2015, which was accompanied by an increase in gross national income per capita by 44%. In PPP terms, Mexico's GDP is USD 1 630 billion PPP with a GDP per capita of USD 13 608 (IEA average is USD 32 621) as of 2014. GDP growth is expected to continue at 2.5% in 2017, reflecting the structural reforms implemented by the government. However, low oil prices and heightened risk aversion by private investors and financial market volatility pose challenges to this outlook (OECD, 2016; World Bank, 2016).

In general, economic growth remains modest. Domestic demand continues as the main driver of overall growth on the back of a strong expansion of credit as well as gains in real wages, services employment and foreign remittances. Inflation has remained below the Central Bank's target, pushed down by reductions in agriculture, electricity, gasoline and telecoms prices. Public-sector spending cuts are being implemented following the sharp reduction in oil-related government revenues. The government is also taking measures to ensure the financial viability of the state oil company PEMEX. Financial market volatility poses challenges to the economic policy and growth outlook, also influenced by the structural reforms being implemented (OECD, 2016).

Supply and demand

Supply

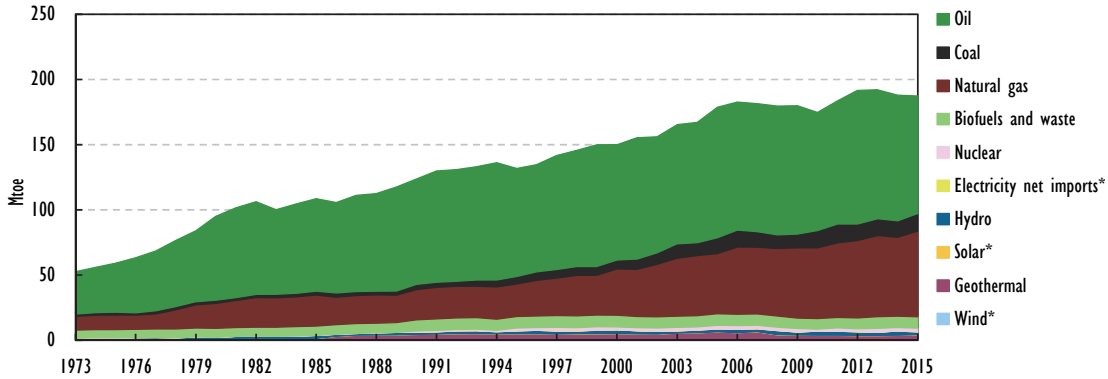
Mexico's total primary energy supply (TPES)[1] has seen decades of relatively consistent growth with the exception of a moderate downturn during 2006-10 (Figure 2.2), and stood at 187.3 million tonnes of oil-equivalent (Mtoe) in 2015. Overall, TPES was 4.9% higher in 2015 than in 2005.

Fossil fuels accounted for 90.4% of TPES in 2015, mostly consisting of oil (48.1%), natural gas (35.1%) and coal (7.3%). Compared to 2005, the share of fossil fuels in total supply grew marginally from 88.6%, albeit with a partial shift from oil use towards more gas use. Oil supply declined by 10% during 2005-15, with its share in TPES falling from 56%. Conversely, natural gas supply was 42.7% higher over the same period, up from 25.8% of TPES in 2005. Coal supply grew by 11.8%, with a slight increase in its share in TPES, from 6.8%.

In 2015, renewable energy accounted for 8.3% of TPES and nuclear power for 1.6%. Renewables were made up of biofuels and waste (4.6%), geothermal 1.7%, hydro 1.4%, wind 0.4% and solar 0.2%. While nuclear power generation has kept its share of TPES steady over the past decade, the share of renewables has grown from 6.5% in 2005.

[1]. TPES is made up of production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes. This equals the total supply of energy that is consumed domestically, either in transformation (for example refining) or in final use.

Figure 2.2 TPES, 1973-2015



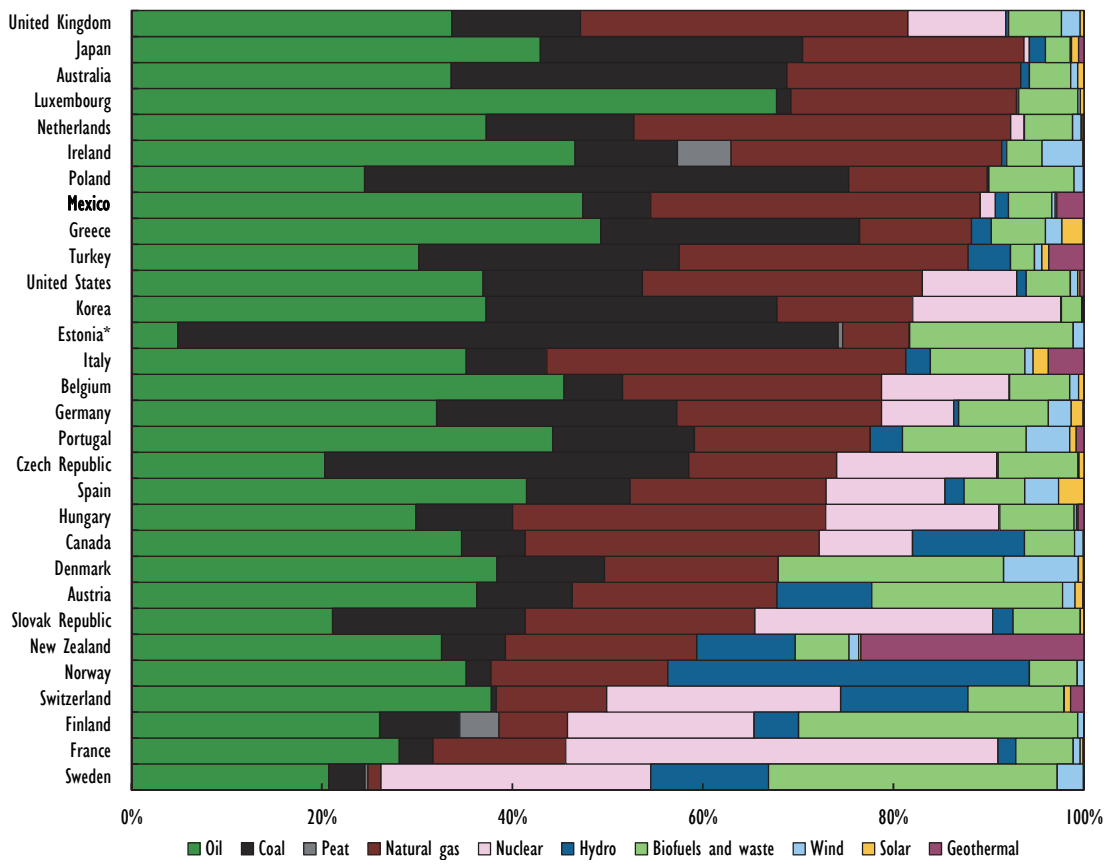
Note: Data for 2015 are estimated.

* Negligible.

Source: IEA (2016a e), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Mexico's fossil fuels share in TPES was eighth-highest among International Energy Agency (IEA) member countries in 2015, similar to Greece and Poland (Figure 2.3). The share of oil and gas in TPES is the third-highest compared with IEA member countries. Mexico is a global leader on geothermal energy and has the fourth-highest share of this technology in the TPES, behind New Zealand, Turkey and Italy.

Figure 2.3 Breakdown of TPES in Mexico and in IEA member countries, 2015



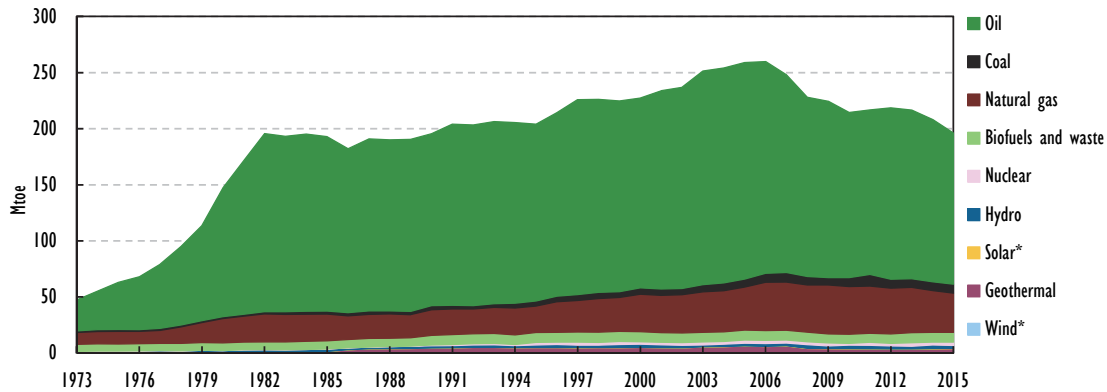
Note: Data are estimated.

* Estonia's coal represents oil shale.

Source: IEA (2016a e), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Mexico's energy production totalled 196.1 Mtoe in 2015, with around 105% self-sufficiency (production as a share of total demand), down from a peak at 145% in 2006 (Figure 2.4). Oil is the main locally produced energy source and represented 68.7% of total production in 2015. Oil production peaked in 2005 at 74.5% of total production (193 Mtoe) but has declined by 30.2% since, to 134.7 Mtoe. Natural gas represented 17.8% of total production in 2015 or 35 Mtoe, falling by 19.8% from a peak of 43.6 Mtoe in 2009. Coal production peaked at 10.4 Mtoe in 2011, down by 23.2% to 8 Mtoe, or 4.1% of total production, four years later.

Figure 2.4 Energy production by source, 1973-2015



Note: Data are estimated for 2015.

* Negligible.

Source: IEA (2016a e), Energy Balances of OECD Countries 2016, www.iea.org/statistics/.

Mexico is an exporter of crude oil and a net importer of oil products. Crude oil exports totalled 65.6 Mtoe in 2015, with only 0.4 Mtoe of crude oil imports. Exports of crude have declined by 36.4% over the past decade owing to declining production and increased domestic consumption. Mexico imported 34.2 Mtoe of oil products in 2015 and exported 9.9 Mtoe. Both imports and exports of oil products have nearly doubled since 2005, with imports increasing by 82% and exports up by 92%. Mexico is reliant on imported natural gas and coal. Natural gas imports were 30 Mtoe in 2015 or 46% of local demand. Coal imports amounted to 5.3 Mtoe or 39% of demand. Gas imports have tripled over the ten years since 2005 while coal imports have increased by 8.1% in total.

Demand

Mexico's total final consumption (TFC)[2] was 118.3 Mtoe in 2014[3]. TFC represents around 62.3% of TPES, with the remainder used in power generation and other energy transformations. TFC has increased by 15.8% from 2004 to 2014, experiencing strong growth in the ten years to 2008 and a 5.1% downturn in 2009 (Figure 2.5). Since 2009, demand has recovered by 6.6%, with a peak of 120.3 Mtoe in 2011 and a plateau in 2014.

[2]. TFC is the final consumption by end users, i.e. in the form of electricity, heat, gas, oil products, etc. TFC excludes fuels used in electricity and heat generation and other energy industries (transformations) such as refining.

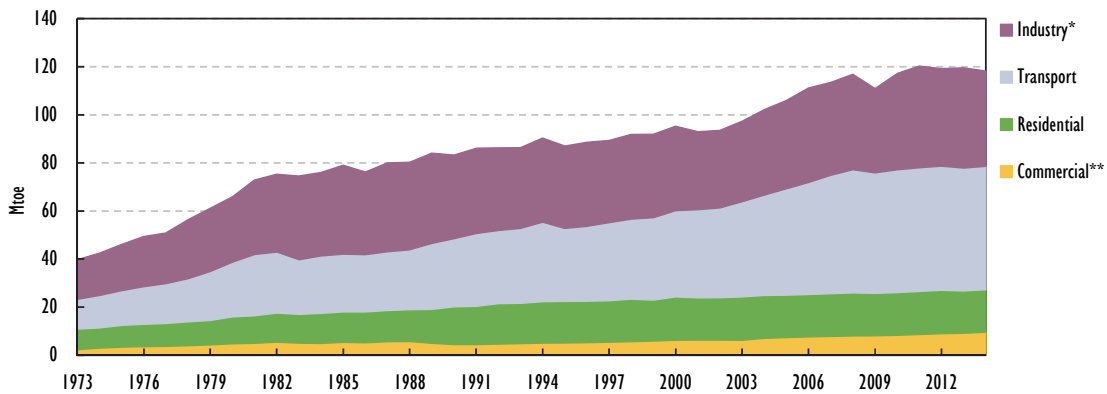
[3]. 2014 is the latest year for which sector-specific data are available.

Transport is the largest consuming sector with a share of 43.4% of TFC in 2014 (51.3 Mtoe). Transport demand increased by 22.7% from 2005 to 2015, growing at a faster rate than overall TFC, with its share increasing from 41.7% of the total it was in 2005. This high share of the transport sector is the legacy of historically low fuel costs and the relatively easy access to car ownership, partly thanks to the cross-border flow of used vehicles from the United States.

Industry is the second-largest consuming sector with 33.6% of demand or 39.7 Mtoe. Demand in this sector increased by 11.6% over the ten years to 2015, with its share in total falling from 34.7%. Industry demand plummeted by 12% in 2009 albeit with a 14.4% recovery during 2010.

The residential sector accounts for 15% of energy demand or 17.7 Mtoe. Demand by this sector has remained relatively unchanged over the past decade, averaging 17.8 Mtoe, and as such its share in TFC has fallen from 16.7% in 2005. The commercial and public services sector, including agriculture, fishing and forestry, is the smallest consuming sector with 8.1% of TFC. However, demand in this sector is the fastest growing, up by 35.5% during 2005-15, increasing its share in TFC from 6.9%.

Figure 2.5 TFC by sector, 1973-2014



* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Mexico's historic energy reform

Mexico's energy policy is undergoing a historic transformation, which arguably is one of the most ambitious energy sector reforms in decades worldwide. In April 2012, Enrique Peña Nieto, then candidate for the Presidency of Mexico, made the commitment to realise a comprehensive energy reform and reaffirmed this in his first message to the nation as President in December 2012. Shortly after his inauguration, the Peña Nieto administration announced the *Pacto por Mexico* agreement with major political parties across the political spectrum, which included the elaboration of an energy reform. In August 2013, Peña Nieto sent the government's reform initiative to the Congress.

Principles of reform

In December 2013, both houses of Congress approved the project following intense debates. In keeping with the Mexican Constitution, the proposal was sent to state legislatures for approval and on 20 December 2013 the energy reform decree was issued. The key amendments to the Mexican Constitution were related to Articles 25, 27 and 28, which had so far reserved large parts of the energy sector activities to the state. The reform decree also included 21 transitory articles, which outlined the main aspects for secondary legislation.

The key principles of the reform were defined as follows:

- reaffirming the constitutional principle of the state ownership over subsoil resources
- free competition among economic actors in the sector
- strengthening of regulatory agencies
- focus on transparency and accountability in the new contracts
- environmental protection and fostering clean energy.

Based on these principles, starting from a *status quo* of a largely closed and monopolised energy market, the energy reform is moving Mexico into line with the IEA Shared Goals (see Annex D). The transition from sectors that have operated under state monopoly structures for decades represents a significant challenge, which will require decisive action on the part of the Mexican government over the coming years.

Key legislation

Following the constitutional reform of December 2013, by December 2015 the Mexican Senate approved 10 new laws and 12 modified ones. Key new components of the package are:

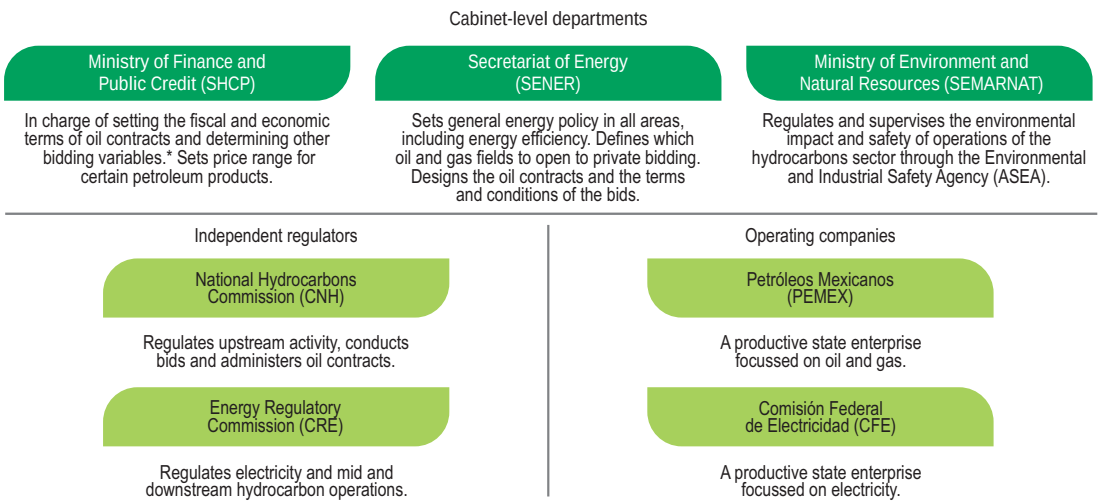
- The law replacing the former **PEMEX and the new Federal Electricity Commission (CFE) Law**, which redefine both companies as 'state productive enterprises' that are subject to normal corporate tax and will pay a dividend to the state.
- The **Coordinated Energy Regulatory Agencies Law**, which establishes the organisation and remit of the energy regulator CRE and the hydrocarbons regulator CNH.
- The **Hydrocarbons Law**, which authorises and regulates the participation of private actors in the sector via service and profit-sharing contracts as well as "licences" and permits. It also creates an independent system operator for the gas pipeline network, CENAGAS.
- A new **Law on Environmental and Industrial Safety** for the hydrocarbons sector, including a newly created specialised regulatory agency (ASEA).
- The **Electric Industry Law**, which redefines the roles of the energy regulatory agency CRE in the power sector and separates the transmission grid operator (CENACE) from the state utility CFE.
- A new **fiscal framework** for the hydrocarbons sector, including a dedicated **Hydrocarbons Revenue Law** defining the various instruments of state revenue.

- A separate law deals with the newly created oil fund for stabilisation and development **(the Mexican Petroleum Fund)**, which will receive all non-tax income from the hydrocarbons sector. It is administered by the Central Bank under the direction of a board comprising the Finance (chair) and Energy Ministers, the Central Bank Governor, as well as four independent members nominated by the President and ratified by two-thirds of the senators in session.
- The **Energy Transition Law**, which reiterates a target of 35% clean energy in the electric generation mix by 2024 (including nuclear energy) through a series of benchmarks, a 25% target by 2018 and a 30% target by 2021. The law includes a flexibility mechanism that allows for the targets to be lowered during the first four years in case of either significant scarcity or price inflation. The Ministry of Energy (SENER) is responsible for the monitoring of the target fulfilment.

New institutional set-up

Key features of the new institutional set-up established by the 2013 energy reform are a clearer separation of regulatory and operational roles and greater independence for state companies and regulators. (Figure 2.6)

Figure 2.6 New Mexican energy institutional set-up



Note: CONUEE and CNSNS are not considered in this organisational chart.

Source: IEA (2016c), *Mexico Energy Outlook: World Energy Outlook Special Report*.

Regulators and Grid Operators

The energy reform strengthened the autonomy of the **Energy Regulatory Commission (CRE)** and the **National Hydrocarbons Commission (CNH)** by granting them budgetary autonomy and by having its Board of Directors elected by the Senate, with nominees proposed by the President. In the new set-up, distribution and transportation operations are monitored and controlled by the national grid operators: CENAGAS and CENACE. In addition, SENER has two dependent administrative bodies: the **National Energy Efficiency Agency (CONUEE)** and **National Commission for Nuclear Safety and Safeguards (CNSNS).** Finally, the

National Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector (ASEA) was newly established.

The **CRE** is responsible for:

- the regulation of storage, transport, distribution retail and commercialization of hydrocarbons
- the regulation of power generation and interconnection contracts
- tariff regulation for transmission, distribution, and operation of basic electricity services
- issuance of electricity wholesale market rules and supervision of operation
- verification of the requirements for clean energy certificates
- regulation of the national electricity grid in terms of efficiency and quality.

The **National Hydrocarbons Commission (CNH)** is responsible for regulating and supervising exploration and extraction of hydrocarbons, including collection from production points to their integration into the transport and storage systems; execution of bidding rounds and the signing of contracts for exploration and extraction of hydrocarbons. Like the CRE, its Board of Directors is elected by the Senate.

The **National Electricity Control Center (CENACE)** has been separated from CFE, and now functions as the independent systems operator and, at the same time, as market-clearing wholesale institution. Its mandate is to guarantee open and non-discriminatory access to the national transmission grid and general distribution grids. In addition, it also has a role in proposing the expansion and modernisation of the national transmission network, with its elements of public distribution systems.

The National Gas Control Center (CENAGAS) is responsible for the management, administration and operation of the **National Gas Transportation System and Integrated Natural Gas Storage (SISTRANGAS)** with the aim of ensuring the continuity and security in the provision of natural gas services. The centre elaborates the Five-Year Plan for the SISTRANGAS Expansion, which is submitted for approval to SENER, along with CRE's technical opinion.

The **National Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector (ASEA)** is an administrative body with technical and managerial autonomy which reports to the **Ministry of Environment and Natural Resources (SEMARNAT)**. Its task is to regulate and supervise industrial, operational safety and environmental protection in the hydrocarbons sector. It also oversees the dismantlement and abandonment of facilities, as well as GHG emissions control.

The **National Energy Efficiency Commission (CONUEE)** is an administrative body with technical and operational autonomy, embedded within SENER's structure. CONUEE aims to promote the sustainable use of energy and energy efficiency measures throughout the energy supply chain from production to consumption.

The National Commission for Nuclear Safety and Safeguards (CNSNS) has the mandate to ensure that all activities involving nuclear and radioactive materials, and radiation sources are carried out exclusively for peaceful purposes and in a safe

manner. This includes monitoring the implementation of nuclear, radiologic, physical security standards and safeguards for the operation of nuclear and radioactive facilities.

State Productive Entreprises: PEMEX and CFE

Before the energy reform, the national oil company PEMEX and power utility CFE were "decentralised public entities" of the Mexican government, with explicit and implicit social and energy security mandates. That is, they were subject to many of the same regulations as other Mexican public agencies. The energy reform has turned both companies into "state productive enterprises", still wholly owned by the federal government, but now endowed with more technical management and budgetary autonomy.

PEMEX, until the reform, was the only oil and gas producer in the country4 and still is by far the dominant player in the oil and gas sector. Its restructuring, including the reduction in the number of subsidiaries from seven to five, seeks to provide a more agile, efficient and transparent management model. PEMEX's tax regime will be adapted to fit the performance of each oilfield and the company will have better access to modern technologies and capital to improve its productivity, including through joint ventures with other companies.

For the past seven decades, the federal electricity company CFE was the monopolist in charge of generation,5 transmission and distribution of electricity in the entire country, including power dispatch. The 2013 reform includes a legal unbundling of CFE into six generating companies, one transmission company, one distribution company and one basic energy-service supplier, plus four affiliated companies. The changes for the first time allow private investment into generation and direct sales to the newly created wholesale market.

In corporate governance terms, the state productive enterprises have formed boards including independent members to define guidelines and strategies. The incorporation of independent members on the boards of PEMEX and CFE promotes greater inclusiveness and impartiality. Both PEMEX and CFE Boards consist of 15 members: Minister of Energy (chair), Minister of Finance, three more representatives from the federal government and the remainder are independent members: five in PEMEX's board, and four in CFE's board with one additional member from the labour association. A condition to serve as independent member is not having ever worked as a government employee during the 2 years before the appointment.

Related Ministries and institutions

The **Ministry of Finance (SHCP)** is responsible for setting the economic conditions of exploration and extraction contracts in accordance with the Hydrocarbons Income Law. SHCP also maintains the right to set certain electricity tariffs, in particular for the

[4]. A cautious reform in 2008 had introduced changes to the regulatory landscape and increased PEMEX's autonomy by introducing a new procurement framework.

[5]. Since 1993 a partial opening has allowed six modalities of private involvement in electricity supply (power self-supply, cogeneration, small power production, independent power production, power export and power import).

residential sector and for agriculture. SENER in turn decides on the model of contract for each contractual area to maximise revenues for the nation, after receiving the opinion of SHCP and CNH.

The **Ministry of Economy (SE)** establishes the methodology for measuring local content in contracts for exploration and extraction of hydrocarbons and verifies compliance with the local content percentage specified by those instruments. SE also formulates and develops general policies in industry and foreign trade, which have implications for the energy sector.

The **Ministry of Agricultural, Territorial and Urban Development (SEDATU)** is involved in the definition of terms and conditions for using, possessing or impairing land, assets or rights needed for hydrocarbons exploration and extraction. Furthermore, it has a crucial role in fostering the implementation of energy efficiency codes for buildings, sustainable transport schemes and, more generally, a transition to sustainable cities (IEA, 2016b).

The **Ministry of Environment and Natural Resources (SEMARNAT**) is in charge of managing, regulating and promoting the sustainable use of the nation's natural resources, except hydrocarbons and radioactive minerals. It is responsible for regulatory and planning instruments related to the energy sector, in particular in the area of climate change policy.

The **Ministry of Communications and Transport (SCT**), in co-ordination with SENER is in charge of promoting and regulating technology adoption as well as fuel efficiency standards.

CONAVI (National Housing Commission), on behalf of SEDATU, co-ordinates sustainable housing programmes, including initiatives of densification in national housing infrastructure and developments. CONAVI implemented the first Nationally Appropriate Mitigation Action (NAMA) in Mexico, consisting of sustainable buildings ("*EcoCasa*").

Cross-cutting institutions

The Coordinated Energy Regulatory Agencies Law mandates the establishment of an **Energy Sector Coordination Council** consisting of SENER (Chair), CNH, CRE, CENAGAS and CENACE. Other ministries and institutions can be invited as observers on an *ad hoc* basis. This council co-ordinates the participating institutions' work programmes, makes recommendations, approves co-ordinating mechanisms to establish shared information systems and institutional co-operation actions, and analyses specific cases that may affect public policies.

In order to cope with the challenges of climate change, President Peña Nieto has set up an **Interministerial Commission on Climate Change**, with comprehensive membership across all important government departments. The Commission is comprised of 14 federal ministries (including SENER) and is responsible for co-ordinating all climate-related policy development and implementation in Mexico.

Data collection

Energy data collection, and specifically energy statistics, in Mexico currently relies almost exclusively on information supplied by PEMEX and CFE, supplemented by limited amounts of data supplied by the National Statistics Institute INEGI. The powers to

request information were previously scattered across several laws and regulations, but the new Hydrocarbons Law gives SENER the right to establish guidelines with regard to energy data collection, which are then implemented through permits issued by the regulatory agencies.

In accordance with these powers, a Specialised Technical Committee is already in place, but its guidelines have not been updated with the most recent legal changes, nor have the details of data submission requirements for permit holders been defined. SENER is in the process of reviewing the need for adaptation of the institutional set-up for data collection towards a new sector approach, which will be characterised by a multiplication of actors that have to supply data.

Although powers to request data or information exist at the broadest level, no particular regulation specifies either the type of information or the basis of such compliance has yet been drafted. Currently, information is required on an *ad hoc* basis to permit holders.

In terms of data publication, Mexico has an online database for part of its energy sector data, the Energy Information System (SIE), where information on energy production and consumption is available to the general public. Sectoral information is published in separate databases such as the National Inventory of Renewable Energy (INERE, http://inere.energia.gob.mx/version4.5).

In addition, Mexico is part of the North American Cooperation on Energy Information (NACEI) initiative between the Energy Ministries of Canada, Mexico and the United States. In December 2014, the three countries signed a trilateral memorandum of understanding on energy information co-operation and, in February 2016, climate change collaboration was included. The initiative has the purpose of creating an institutional framework for improving information and energy outlooks for the North American region (NACEI, www.nrcan.gc.ca/energy/international/nacei/18051).

Legal competence for land use

Land tenure in Mexico is subject to different regimes that range from private property to communal ownership, but in all cases they are restricted by land-use regulations issued by municipalities and state governments. Both the Hydrocarbons Law and the Electric Industry Law grant preferential rights on their regulated activities over any other type of land use in the country, and also set an obligation on all authorities to establish co-ordinated mechanisms to simplify permit granting.

Nevertheless, because outlining land use is a local competence, municipalities can have restrictions on many areas before the Ministry of Energy, the hydrocarbons regulator or the energy regulator grant a company permission to begin activities regulated either by the Electric Industry Law or the Hydrocarbons Law; this may lead not only to red-tape problems, competence overlapping or legal uncertainty both for permit holders and officials working in local administrations, but can also result in permits being granted in peri-urban areas in fast-growing cities or even in natural reserves without a proper environmental or administrative assessment.

Objectives and strategies of Mexican energy policy

Mexico's energy policy is articulated in a series of policy documents, building on the overall guidance from the **National Development Plan (NDP),** which informs the **Energy Sectoral Programme (PROSENER)**, which remained in force after the energy reform was published. Until the reform, SENER also had to produce a yearly update of its National Energy Strategy, which had a 15-year time horizon. The last version of this document was prepared in 2014 (SENER, 2014) and, in the near future, new policy lines, programmes and strategies will be established in the new **Transition Strategy to Promote the Use of Cleaner Technologies and Fuels,** as mandated by the Energy Transition Law (SENER, 2016).

The **National Development Plan (NDP)** is the Mexican government's overarching public policy document in which all national aspirations are expressed. The NDP determines national objectives, strategies and priorities in support of the sustainable development of the country; and it contains provisions on the resources that will be allocated for this purpose. This document determines instruments and responsibilities for implementing the policy guidelines on a global, sectoral and regional basis and considers all economic, social and cultural activities.

Under the fourth goal of the NDP ("Prosperous Mexico"), the Mexican government has set the objective to become a more productive country, placing energy as a national pillar of competitiveness and growth, specifically in its Objective 4.6, namely *"National energy supply with competitive prices, quality and efficiency throughout the productive chain".*

Based on the NDP, the **Energy Sectoral Programme 2013-2018 (PROSENER)** sets national objectives, strategies and indicators to guide energy policy actions. The six high-level objectives of this central energy policy strategy (SENER, 2013) are to:

1. optimise oil production and hydrocarbons processing, ensuring efficient and competitive processes
2. optimise the operation and expansion of the national electricity infrastructure
3. develop the transport infrastructure to ensure supply security and contribute to economic growth
4. increase the access of users to fuels and electricity
5. broaden the utilisation of clean and renewable energy and promote energy efficiency as well as social and environmental sustainability
6. strengthen the operative safety, knowledge, training and capacity building and financing for the national energy industries.

The attainment of these objectives to a certain degree depends on the central strategic element of the reform: opening the energy market to competition and private investments.

Market opening

The opening of the Mexican market was initiated by Articles 25, 27 and 28 reforming the Mexican Constitution. The market reform has been implemented through both legislative and regulatory amendments, including those on the design and operation of the wholesale electricity market, setting the framework for the hydrocarbon bid rounds and making changes to the remits and status of the regulatory agencies.

Initial implementation steps have underlined the commitment of the government to the essentially open and market-oriented spirit of the energy reform. Over the course of 2015, three first bid openings for oil and gas exploration and production were held, during which the government adjusted the bidding terms in response to the outcomes of the previous openings, reflecting its declared objective of holding truly competitive and transparent auctions.

The first reform milestone was the establishment of a Round Zero to support PEMEX´s investments. Within this round, PEMEX was favoured to keep those productive oil and gas fields and exploration areas in which they had already undertaken activities and investments. In August 2014, PEMEX received 83% of proven and probable national oil reserves (20 589 million barrels of oil-equivalent) and 21% of all conventional and unconventional prospective resources of Mexico (23 477 mboe). In the following Round One tenders for upstream hydrocarbon development and liberalisation of imports of transport fuels, the government constituted the initial steps of opening the sector to private-sector investment.

In the power sector, the reform establishes legal separation of generation, distribution, transmission and retail activities. To date generation and supply to large customers have been opened to competition. The state preserves control of transmission and distribution, but for the first time allows associations of the Federal Electricity Commission, CFE, with private parties.

Competitiveness

A core task in implementing the new sector set-up is the promotion and guarantee of free competition in the markets. In this regard, the Federal Economic Competition Commission (COFECE), an autonomous anti-monopoly organism which accompanies the work of the regulatory agencies, CRE and CNH, with technical advice based on its mandate to encourage free competition in the energy market. The new Hydrocarbons- and Electricity Sectors Laws contain provisions that allow the introduction of competition into both markets. For example, the Hydrocarbons Law makes it compulsory for all permit holders in transportation, distribution or storage services to provide open access to their facilities, subject to available capacity and pursuant to rules issued by the regulator CRE. Further to the basic competition provisions contained in the secondary legislation, CRE, with opinion of COFECE, is responsible for establishing regulations to promote a competitive energy sector, including legal and effective separation of administrative, operational and accounting activities of the permit holders.

Sustainability

The reform principle of sustainability and the transition to clean energy has been enshrined in the Energy Transition Law and the two strategies derived from it. In practice, the sustainability outcomes of the reform will largely depend on the successful implementation of the new clean energy certificate (CEC) and long-term auction system for the power sector. Initial results from the first auction have indicated large investor interest and very competitive prices for solar and wind energy.

The **Transition Strategy to Promote the Use of Cleaner Technologies and Fuels (**the **Transition Strategy)**, derived from the Energy Transition Law, is the guiding instrument for the medium- and long-term efforts to foster the country`s energy transition. The first version of this document was published in December 2014. An updated version is

currently being produced and will for the first time contain clean energy and energy efficiency goals, as well as a roadmap to develop an efficient and competitive energy market.

The clean energy goals will be addressed by objectives and strategies contained in the **Special Program for the Energy Transition (**the **Program)**, and the energy efficiency goals in the **National Program for Sustainable Use of Energy 2014-2018 (PRONASE),** which promotes the sustainable use of energy across the whole value chain, from exploitation to consumption. The Transition Strategy, the Program and PRONASE are the national planning instruments in clean energy and energy efficiency.

The objective of clean and efficient energy supply and demand in Mexico has a close correlation with Mexico's climate change policy. The General Law on Climate Change (LGCC) passed in 2012 establishes an obligation to give priority to the least costly mitigation actions. In turn, the **National Climate Change Strategy (ENCC)** along with the **Special Programme for Climate Change 2014-2018 (PECC)** establish strategies and action lines to achieve a 30% reduction of GHG emissions from electricity generation in relation to a projected scenario in 2020, and 35% of electricity generation based on clean energies in 2024. At the international level, policy frameworks adopted by Mexico to combat climate change are the *Nationally Appropriate Mitigation Actions (NAMA)*, and the *Nationally Determined Contributions (NDC),* through which the country committed to reduce its greenhouse gas (GHG) emissions by 22% and its black carbon emissions by 51% by 2030, relative to business-as-usual levels (SEMARNAT, 2015).[6]

Transparency

There are a number of specific corruption risks in the energy sector, which are amplified at times of reform. The Mexican energy reform addresses this by introducing new transparency, accountability and anticorruption mechanisms. All the contracts and tender documents for exploring or producing energy sources will contain transparency clauses, which will be available online for consultation. The award of contracts is made in public and streamed for viewing online. **PEMEX and CFE** disclose their financial statements and information on projects, subsidiaries and other aspects as mandated by stock market regulations. External audits oversee the recovery of costs incurred and other accounting related to contracts operation.

The Ministry of Energy **(SENER),** the Ministry of Finance **(SHCP)** and the hydrocarbons regulator **(CNH)** have the responsibility to publish oil revenues and payments made to contractors on a monthly basis, according to the Hydrocarbons Law. Meetings and agreements between the regulators CRE and CNH will be public and subject to a code of ethics, which includes rules to prevent possible conflicts of interest. Furthermore, regulations grant unrestricted access to both regulatory agencies and SENER to the information, data and measurement systems of permit holders; this measure ensures that the government will have the required knowledge to improve decision-making processes.

[6]. In addition to this conditional pledge, there is also a conditional one (see Chapter 3 on climate change).

An important measure of transparency and corruption prevention is the establishment of the **Mexican Fund of Petroleum for Stabilisation and Development,** a sovereign wealth fund and the central instrument to collect all hydrocarbon income and then to transfer revenue to the federal budget (up to 4.7% of GDP per year), long-term savings (until reaching 10% of GDP) as well as other purposes. The Fund is managed by Mexico´s Central Bank and overseen by a technical committee composed of the finance minister (Chair), the Energy Minister, the Central Bank Governor as well as four independent board members (see Chapter 5 on oil for details).

Finally, another step to reinforce transparency in oil and gas activities is the government's intention to join the **Extractive Industries Transparency Initiative (EITI)**, to promote citizen participation, combat corruption and promote transparency; through EITI, energy project proponents are required to undertake social and environmental impact assessments, and to identify what measures they will use to mitigate potentially adverse effects.

In the interest of clarity of processes, the government strives to make information on governmental procedures available on the website (www.gob.mx/tramites), where information on classification, information about requests to produce, store, transport or sell energy, as well as other notices, modifications and extensions are available.

Assessment

The broad-based energy reform, beginning with the constitutional changes of December 2013, has continued at a steady and impressive pace. Its reach and scope represent the most ambitious energy transformation within the OECD in recent years. Starting from a largely closed and monopoly-driven energy market, the reform has led to concrete steps to improve energy security, increase transparency and rule of law, harness market forces to attract needed investment, and strengthen the environmental sustainability of the energy sector. Overall, Mexico's reforms are bringing its energy policies increasingly in line with the IEA Shared Goals (see Annex D). However, some areas, such as competition policy and emergency preparedness will have to remain at the top of the agenda for reform implementation in the years to come.

From monopoly to multiple actors

The government has taken bold steps to liberalise energy markets, addressing long-standing inefficiencies resulting from the monopolies in both the hydrocarbons and electricity sectors, which had become increasingly unsustainable in recent years. In the oil and gas sector, PEMEX struggled with attracting the necessary investment to cope with the falling oil production. CFE had difficulties in adequately and efficiently supplying the national power demand due to budgetary constraints, opaque rules governing the interconnection to the national grid, and the existence of significant congestions, that limited transmission services.

According to IEA long-term scenario analysis, in the absence of reform Mexican oil production would be more than 1 mb/d lower by 2040, than with the enactment of the

current reform. This would lead to a cumulative GDP loss of more than a trillion US dollars in the same timeframe.[7]

With the reform, the government has established an asymmetric regime to regulate these enterprises, recognising that a period of transition is required to counterbalance their dominance in the market. PEMEX and CFE will need to adjust to an era of new competition and transparency, while strengthening the internal governance of their newly separated business lines. At the same time, the government will need to take on tasks which were the former domain of PEMEX and CFE.

For example, for energy security the government has historically relied on PEMEX and CFE. However, as new market entrants and new regulators play an increasing role, a revised division of responsibilities between the government and industry players needs to be defined, in order to maintain the ability to plan for and react to emergencies. New regulations will have to be put in place, and SENER will have to build short-term situational awareness for supply security issues and install a new data-collection system for emergencies.

Similarly, as energy data collection becomes more complex in a competitive energy sector, and as statistics and forecasting functions shift from PEMEX and CFE to SENER and other agencies (mainly regulators CNH, CRE, CENAGAS, CENACE and ASEA), there is a risk of disruption in current energy data flows. The government is working on the establishment and consolidation of an energy information system, in charge of collecting, processing and interpreting data along the entire energy value chain, with emphasis on regulatory entities and others ministries. As part of such efforts, it will be defined how energy reform affects information collection by the National Statistics Institute (INEGI) under the Program for National Economic Surveys.

Competition policy

In many areas, the reform legislation and regulation have deliberately built in more competition; for instance, the creation and reinforcement of an independent transmission grid operator (CENACE) that will be charged with providing open and non-discriminatory access to the transmission and distribution grids. Another example is a "gas release" programme, under which PEMEX will have to offer its customers the option of changing to another supplier. In both cases, however, it remains to be seen how exactly the release will be implemented in practice and, therefore, it will be crucial to ensure that the actual implementation ends up effectively fostering competition.

Overall, a key challenge will be the tension between conflicting objectives such as maintaining PEMEX and CFE as "state productive enterprises" and leaders of energy sector development, while at the same time ensuring the competitiveness of the markets. In particular, the incomplete unbundling of CFE's value chain raises concerns about counter-competitive behaviour, and the effectiveness of "Chinese walls" between the new CFE subsidiaries.

The constant monitoring of competition aspects will be crucial for the implementation of the reform, given the tendency by incumbents to use their dominance on the market to

[7]. See *Mexico Energy Outlook: World Energy Outlook Special Report* for details on a "no reform case" (IEA, 2016c).

avoid competition from developing. The data and information requirements for such monitoring will entail the resolution of confidentiality issues for PEMEX and CFE as well as new entrants to the market.

In addressing such challenges, the Federal Economic Competition Commission (COFECE) issues non-binding recommendations on how to improve regulations, both at its own initiative and at the request of sector institutions, including SENER. However, in many aspects, the new set-up has already shown the effect of competition and market forces at work: the energy regulator CRE held the first long-term clean energy auction in February 2016, which, to the surprise of established stakeholders, resulted in 74% of the generation on offer being awarded to solar photovoltaic projects. This showed that the new sector framework is effectively using market forces to optimise the use of Mexico's excellent renewable resource potential.

Policy implementation and monitoring

In implementing the energy reform, the Mexican government has been open to input from industry and other stakeholders. However, despite the government's laudable efforts of promoting public consultation and transparency, it has not been easy for stakeholders to keep up with the rapid pace of implementation of the reform. In this regard, the legislation derived from the energy reform, in general, contains deadline provisions for the publication of the respective guidelines and regulations, mostly set at three months from the validity of each law, creating several rule-making processes in parallel. It will be crucial to maintain the dialogue with stakeholders, as they strive to catch up with regulations, and potential entrants need legal certainty and clarity as regards the energy sector legal framework. For this purpose, the Mexican government is taking further actions to promote the participation of stakeholders in the rule-making process; for example, SENER is planning to assign a section on its website where current and potential new entrants will be able to consult the legal and regulatory framework already issued, under development or in process of public consultation.

In terms of monitoring implementation, quantitative objectives have been established within the energy sector (e.g. 35% clean electricity by 2024) and the achievement of these objectives is systematically monitored by SENER (see SENER, 2015) and – in the case of the National Development Plan – by the Ministry of Finance (SHCP). However, it is advised that additional efforts be carried out to define a comprehensive set of overarching macro-indicators to track and communicate the success of the reforms in optimising social and economic development, and in comparing international results, as well as extensive traceability and visibility of the results.

The energy reform has provided impetus for Mexico's efforts to mitigate climate change, in particular through the clean energy certificates, public investments in clean energy research, development and demonstration (RD&D), and the partial fossil fuel tax. Given its role as a major energy producer, Mexico has historically placed more focus on the supply side, where measures were initiated earlier and are more broadly based than those on the demand side. This also appears to apply to climate-related policies, where increasing clean energy supply has attracted significant attention. In general, energy efficiency and sustainable transport are important and cost-effective policy levers that could play a stronger role in a comprehensive clean energy and climate change plan, particularly given trends in Mexico's demographics, transport patterns, and urban sprawl.

A key challenge for the energy reform is to ensure sufficient and capable human capital for firms, regulatory agencies and certification laboratories; a shortage of human capital could constitute a bottleneck for reform implementation. The Mexican government has thus begun to endorse agreements, internationally, with regulatory agencies, universities, educational institutions, industry and labour organisations, to foster human capital formation (see Chapter 11 on energy technology research, development and demonstration).

As a low-cost manufacturer, Mexico already has a competitive advantage for clean energy production and other industrial activities. As this sub-sector grows, it could also drive further investments in related segments of the value chain, such as private-sector R&D.

Regulation and permits

Licensing and permitting of energy infrastructure projects involve several steps at different administrative levels, which can lead to lengthy processes that discourage investment. The energy reform includes a deliberate effort at removing barriers to entry to the market, for example by reducing the number of administrative steps necessary to connect a generation plant to the grid from 47 to only 9.

The scope and pace of the reform has placed pressure on the capacity of government agencies and regulators, whose roles have expanded significantly, and that need to have the resources and expertise required for effective implementation. A particular challenge exists for newly created or reformed agencies, such as the environmental and industrial safety regulator ASEA, whose tasks and processes are being defined over time, in parallel with the implementation of the reform across the hydrocarbon value chain.

Licensing and permitting procedures should be streamlined as far as possible, without compromising other social, economic and cultural objectives. To assist in this, the new online portal for renewable energy permits could provide a useful model for other energy sub-sectors, particularly if expanded to acknowledge local and state permitting processes. Nevertheless, for new entrants, navigating across the 10 new energy laws, 12 modified laws, and subsequent regulatory decisions and permitting processes can prove challenging, particularly as important parts of the regulation are still under development. The government should work to reduce legal uncertainty related to land use and improve co-ordination between local, state and federal authorities, all this while respecting local land-use planning.

For oil and gas and renewable energy projects, SENER is required to engage affected indigenous communities in meaningful consultation. This assessment and engagement requires particular attention and resourcing at SENER, if local communities are to feel engaged in the energy development process.

Low-carbon transition

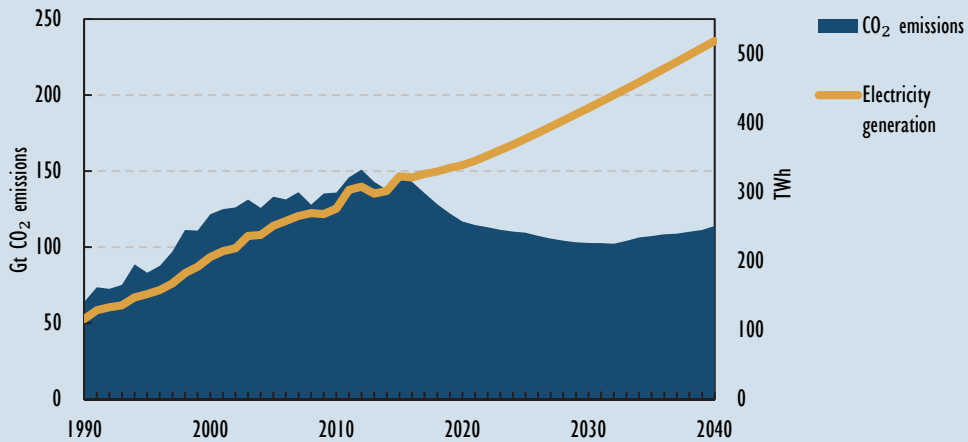
As a major oil-exporting country, Mexico's energy sector is central to its transition to a sustainable development model. Until recently, the country's energy mix still included large amounts of fuel oil for power generation and, as indicated, the country has one of the highest shares of fossil fuels in its TPES. Overall, Mexico today stands at 21% clean energy power generation, with hydropower (13%) and nuclear (3%) contributing the greatest amounts. Despite their huge potential, non-hydro renewable energies still accounted for only 4% of electricity generation in 2013, mostly geothermal and wind (SENER, 2015). In order to reach the ambitious target of reducing carbon dioxide (CO_2) emissions by 50% below 2000 levels by 2050, key options will be stronger deployment of renewables and fuel-switching in power generation (see Box 2.1).

Box 2.1 Climate policy and Mexico's low-carbon energy transition

Climate change objectives are deeply entrenched in Mexico's current policy making, not least in the energy reform. To meet these goals, Mexico is pursuing a number of concurrent strategies: it has set ambitious clean energy goals and is in the process of designing a National Energy Efficiency Policy Strategy which, among many benefits, is likely to help bring down Mexico's carbon intensity. In the *WEO* New Policies Scenario, (IEA, 2016c) such measures help to cut the carbon intensity of the economy by more than half.

The strong proliferation of renewables in the power sector, where around one in two gigawatts of new capacity installed to 2040 is projected to be either wind or solar, coupled with a shift to natural gas from more polluting oil, makes a major contribution to the decrease in CO_2 emissions from the power sector (see figure below). This is despite electricity generation increasing by 70%. CO_2 emissions related to power generation fall by almost 20% by 2040, implying a 52% drop in carbon intensity. In the transport sector, the largest emitter of CO_2 in Mexico, emissions continue to increase, but at a much more moderate pace than previous trends: between 1990 and 2014, emissions increased by over 80%, to reach 151 $MtCO_2$; by 2040, they are expected to reach 170 $MtCO_2$, a 13% increase (while car ownership increases by more than one-fifth).

Electricity generation and energy-related CO_2 emissions, 1990-2040



Source: IEA (2016c), *World Energy Outlook, Special Report on Mexico.*

Although Mexico reaches (and even surpasses) its clean energy targets in the New Policies Scenario, reaching the overall GHG mitigation goal will be a challenging endeavour. The lower bound of the pledged target requires GHG emissions in total to be reduced to around 760 Mt in 2030. In the New Policies Scenario, energy-related GHG emissions fall modestly to around 460 Mt in 2030, meaning that emissions from other sectors (such as agriculture or waste) would need to roughly stabilise at the present level if the lower end of the GHG target is to be achieved. The higher end of the pledge would require GHG emissions to drop to around 620 Mt in 2030, an emissions budget that, without additional measures, would already be largely absorbed by the energy sector.

Source: IEA (2016c), *World Energy Outlook, Special Report on Mexico*.

In order to support the low-carbon transition, energy data collection should be more closely integrated with scenario development, policy-making and priority-setting activities. In particular, a lack of demand-side information currently limits the consideration of price sensitivity, energy intensity and technology assumptions in forecasts and scenarios.

Energy pricing

Mexico has a strong, expensive and distorting tradition of electricity subsidies and very low taxes on energy use; however, the country has achieved exemplary progress in gradually phasing out gasoline subsidies in recent years. Mexico can be commended for its efforts to phase out gasoline subsidies since 2007, and for its plans to eliminate price controls on liquefied propane gas (LPG) in 2017, as well as for the plan to fully liberalise gasoline and diesel prices starting in 2017.

Recently, Mexican Congress approved the Federal Income Law, which accelerates gasoline and diesel price liberalisation in those regions where the energy regulator CRE finds that the necessary conditions for competition are given. CRE must publish the criteria and schedule for those purposes. In those regions where CRE finds there are no competence conditions, prices will remain regulated and the Ministry of Finance will define them, according to the methodology that will be published before 31 December 2016. This methodology will take into consideration the international reference, logistic cost and quality differences. Communication will be key to explain the overall approach and the functioning of the pricing mechanism to the general public (IEA, 2016d).

As regards electricity, significant price subsidies persist in the residential and agricultural sectors; in 2014 they diverted over USD 6 billion in state resources. The energy reform will contribute to lowering the subsidy bill by making the utilities more efficient and by reducing their losses. This is urgently needed: according to the IEA scenario analysis, the previous set-up without reform would have generated a cumulative subsidy bill of USD 90 billion by 2040, creating significant fiscal pressures (IEA, 2016c).

Although there is no policy to reduce subsidies, the reform, by requiring an annual budget allocation for electricity subsidies, has made these electricity subsidies more transparent, which should facilitate their gradual reduction over time. As price controls and subsidies are removed, a transition plan to smooth any eventual impacts on consumers should be considered.[8]

Data collection

The current system of data collection relies to a large extent on the incumbents PEMEX and CFE, especially for the upstream oil and electricity sectors. In future, this will change with the arrival of new entrants. A particular gap in the collection system is that information on demand is not uniformly and completely collected. Rather, this information is estimated, which affects the reliability of energy efficiency information.

Significant changes in data collection activities and data systems will follow the implementation of the new regulations. The changes will result from the increased number of market players and of institutions involved in these activities. Guidelines on

[8]. See IEA (2016d) for detailed reform recommendations in this regard.

data collection should take into account the ongoing stocktaking exercise by SENER and sector stakeholders, and put in place clear obligations for permit holders in line with IEA standards (IEA, 2007). A close co-ordination of the activities and appropriate allocation of resources will be critical to successfully implementing those changes.

Recommendations

The government of Mexico should:

- Continue to implement its reform, including competitive markets, in a measured fashion that considers lessons learnt and international best practices. The ability of regulators, industry and local communities to adapt to the new system should also be taken into account.
- Better define its institutional approach to energy security, clearly delineating the differing roles for the government, regulators and industry.
- Continue to improve energy data and statistics, by:
  - putting in place data collection guidelines and criteria for the new Energy Sector Shared Information System to ensure that all data are available to plan and understand the impact of policies and to meet international reporting requirements
  - ensuring there is full co-operation and data sharing across ministries, agencies and regulators
  - clarifying the role of SENER and other ministries, agencies and regulators, so that appropriate resources can be allocated to energy statistics.
- Make systematic efforts at attaining its intended nationally determined contributions and pursue a credible path to fulfil its long-term climate policy ambitions.
- Establish stronger linkages between data collection and scenario development, policy, and priority-setting exercises.
- Recalibrate the overall policy and programme balance between supply-side and demand-side considerations (e.g. demographic growth, transportation trends and urban sprawl).
- Make it easier for industry, citizens and stakeholders to navigate through the array of new legal, regulatory and permitting processes.
- Ensure that SENER, other federal agencies' and regulators' resources and capacity increase in line with their expanding mandates (e.g. for indigenous and community engagement).
- Work with other federal agencies, universities and educational institutions, industry and labour organisations to implement a comprehensive human capital strategy for the energy sector.
- Use the energy reform to nurture Mexico's competitive advantages across the entire energy value chain (e.g. clean energy manufacturing).

- Develop a series of macro-indicators to communicate the success of the energy reform in optimising social and economic development.

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3. Climate change

Key data

(2014)

GHG emissions without LULUCF (2013): 633 $MtCO_2$, +38% from 1990 to 2012[1]

GHG emissions with LULUCF (2013): 665 $MtCO_2$, +33% from 1990 to 2012

CO_2 emissions from fuel combustion: 431 $MtCO_2$, +67.8% since 1990

CO_2 emissions by fuel: oil 56.9%, natural gas 31.9%, coal 11.1%, other 0.0%

CO_2 emissions by sector: transport 35.1%, power generation 32%, manufacturing and construction 13.4%, other energy industries 12.1%, residential 4.2%, commercial and other services, including agriculture, 3.2%.

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Greenhouse gas emissions

Mexico is a non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC). According to the country's 2015 First Biennial Update Report to the UNFCCC, its GHG emissions were 665 million tonnes of carbon dioxide-equivalent ($MtCO_2$-eq), including land use, land use change and forestry, in 2013. CO_2 accounted for 75.1% of the total, followed by methane (CH_4, 19.0%), nitrous oxide (N_2O, 4.5%) and hydrofluorocarbons (HFCs, 1.4%). Perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) collectively accounted for 0.03% of the total.

From 1990 to 2012, emissions of CO_2 increased by 33%, while those of CH_4 grew by 32%, N_2O by 5% and fluorinated gas emissions by 92%.

In 2013, CO_2 emissions were mainly (around 85%) from fossil fuels use in the energy sector. The largest source of CH_4 emissions was agriculture and livestock (43%), while other major sources were oil and gas production (24%) and the waste sector (22%). Five-sixths of N_2O emissions came from agriculture and livestock.

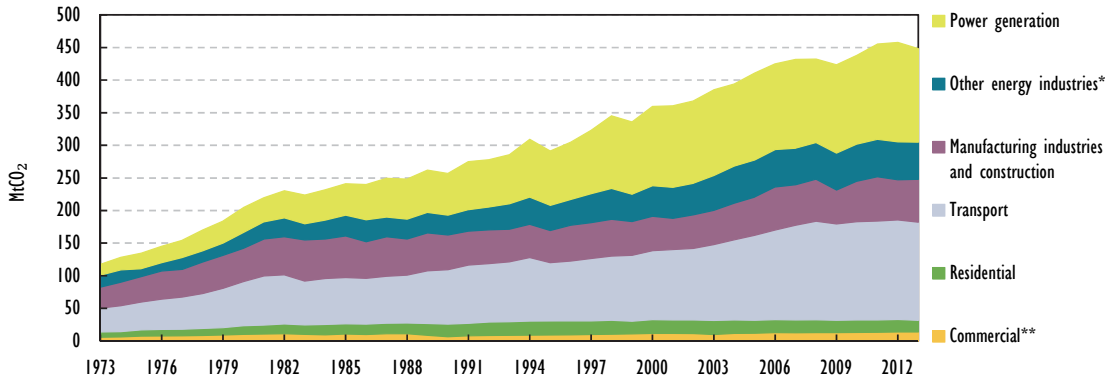
[1]. Mexico has revised the methodology for calculating GHG emissions from 2013 on. Revised historical data from 1990 will be provided in the next Biennial Update Report to the UNFCCC. Comparisons between 2013 and earlier years will only be possible once the revised time series are available.

Energy-related CO_2 emissions

Sources of CO_2 emissions

Mexico's energy-related CO_2 emissions from fuel combustion are estimated at 431 million tonnes (Mt) in 2014, 67.8% higher than 1990 levels (257 Mt) and 9.4% higher than 2004 levels (394 Mt). Emissions have been increasing for decades to a peak of 458 Mt in 2012 and have declined by 5% since (Figure 3.1).

Figure 3.1 CO_2 emissions by sector, 1973-2014

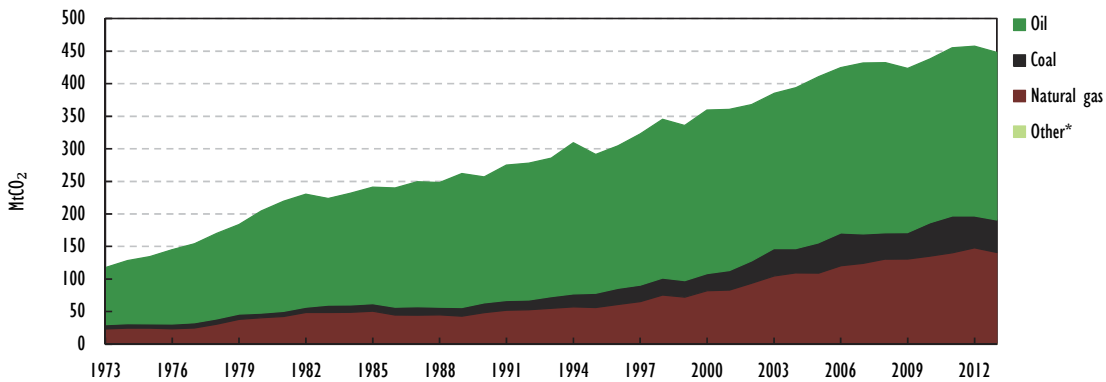


* *Other energy industries* includes other transformations and energy own-use.

** *Commercial* includes commercial and public services, agriculture/forestry and fishing.

Source: IEA (2016a), *CO_2 Emissions from Fuel Combustion 2016*, www.iea.org/statistics/.

Figure 3.2 CO_2 emissions by fuel, 1973-2014



* *Other* includes industrial waste and non-renewable municipal waste (negligible).

Source: IEA (2016a), *CO_2 Emissions from Fuel Combustion 2016*, www.iea.org/statistics/.

The largest CO_2 emitting sector in Mexico is transport, representing 35.1% of the total in 2014. Power generation accounts for 32.0% and industry (manufacturing and construction) for 13.4%, while other energy industries (including refining) emit 12.1% of the total. The least emitting sectors in Mexico are households (4.2% of the total) and services and agriculture (3.2%).

Until recently, emissions increased with economic growth (see Figure 3.4), mainly as a result of growing power generation and transport sector energy consumption. Emissions in power generation grew by 116% from 1990 to 2014, and those in the transport sector by 81%. CO_2 emissions increased in all other sectors, for example by 110% in the

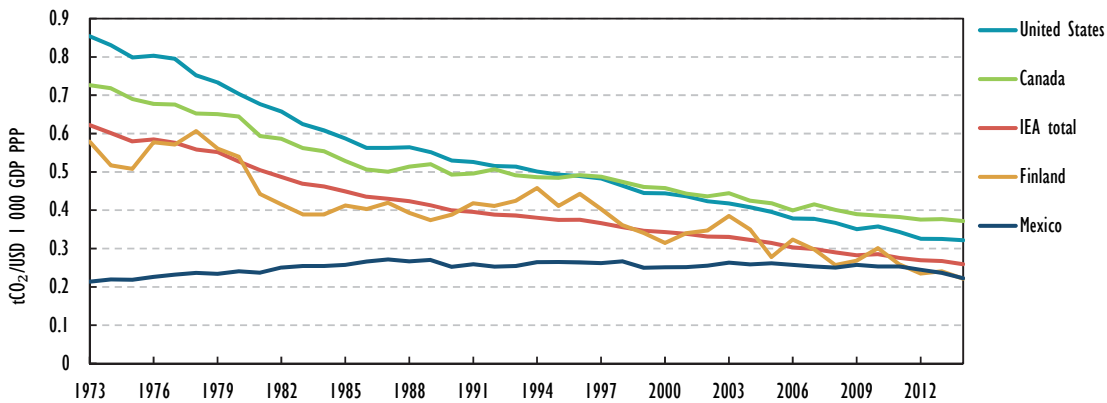
services sector and by 72% in energy use other than power generation. Over the past ten years, however, emissions have declined in the residential sector (by 12.9%) and from energy use other than power generation (by 8.2%).

In 2014, 57.4% of CO_2 emissions from fuel-combustion were from oil, while natural gas accounted for 31.4%, coal for 11.1% and waste for 0.1% (Figure 3.2). From 1990 to 2014, emissions from coal increased by 217.4%, those from natural gas by 184% and those from oil by 26.9%.

Carbon intensity

Mexico's carbon intensity, measured as CO_2 emissions by real gross domestic product adjusted for purchasing power parity (GDP PPP), amounted to 0.22 tonnes of CO_2 per USD 1 000 PPP (tCO_2/USD 1 000 PPP) in 2014. This is similar to the level of Finland, the ninth-highest among IEA member countries. Mexico's carbon intensity level is lower than the IEA average of 0.26 tCO_2/USD 1 000 PPP and lower than the IEA North American average of 0.33 tCO_2/USD 1 000 PPP. Mexico's carbon intensity has been relatively flat over the years, falling slowly from a peak of 0.27 tCO_2/USD 1 000 PPP in 1987. Intensity was 14% lower in 2014 compared to 0.26 tCO_2/USD 1 000 PPP in 2004 and similar to the level in 1976. In comparison, the average IEA intensity declined by 19.8% from 2004 to 2014, and has fallen considerably over the decades, but, at the same time, it remains higher than that of Mexico (Figure 3.3).

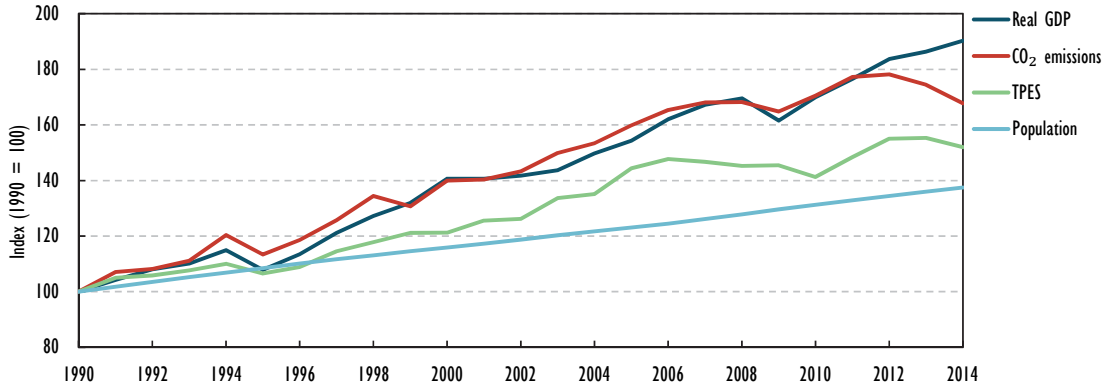
Figure 3.3 Energy-related CO_2 emissions per unit of GDP in Mexico and in other selected IEA member countries, 1973-2014



Source: IEA (2016a), *CO_2 Emissions from Fuel Combustion 2016*, www.iea.org/statistics/.

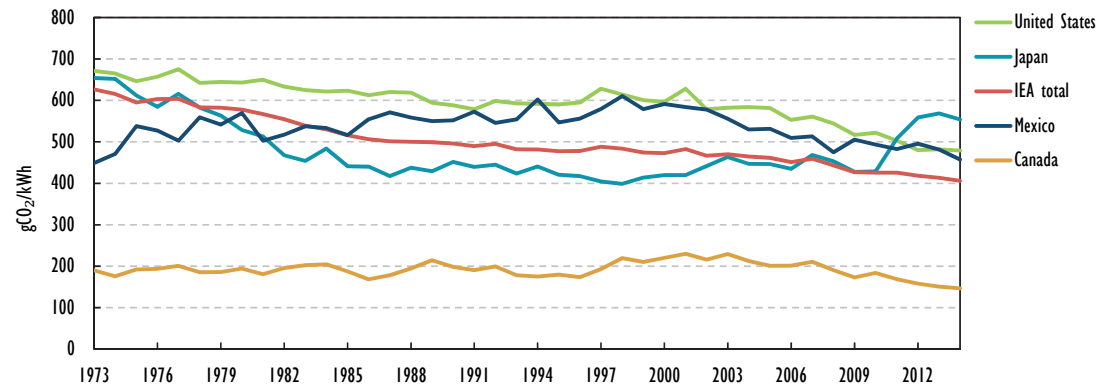
Regarding electricity generation, the fastest growing source of emissions since 1990, carbon emissions per kilowatt-hour (kWh) generated have declined since the late 1990s, as natural gas has replaced oil as a fuel (see Figure 3.5). In 2014, carbon intensity of Mexico's electricity generation stood at 457 grams of CO_2/kWh, roughly equal with that of the United States and 13% higher than the IEA average. The country's plans to increase the use of clean energy sources for power generation are expected to help decarbonise the sector further (see Chapter 8 on electricity).

Figure 3.4 CO_2 emissions and main drivers in Mexico, 1990-2014



Sources: IEA (2016a), *CO_2 Emissions from Fuel Combustion 2016*, www.iea.org/statistics/.

Figure 3.5 CO_2 intensity of electricity generation in Mexico and in selected IEA member countries, 1973-2014



Sources: IEA (2016a), *CO_2 Emissions from Fuel Combustion 2016*, www.iea.org/statistics/.

Institutions

Under the 2012 General Law on Climate Change (LGCC), Mexico created an institutional framework to establish the National Climate Change Policy. The instruments and institutions created include:

- The **National Climate Change System** (**SINACC**) to co-ordinate between the three levels of government and facilitate co-operation between public, private and social sectors; includes governments of the federal entities, representatives of national associations of local authorities, and representatives of the Congress of the Union.
- The **Inter-Secretariat Commission on Climate Change** (**CICC**) that includes 14 ministries, among them the Ministry of Environment and Natural Resources (SEMARNAT) and the Ministry of Energy (SENER).
- The **Council on Climate Change** as a permanent consultative body to support the climate change policy.

- The **National Institute of Ecology and Climate Change** (**INECC**) that produces technical and scientific knowledge to support policies related to climate change mitigation and adaptation, and to other environmental issues.

Policies and measures

UNFCCC

Mexico is a non-Annex I Party to the UNFCCC and ratified the Kyoto Protocol in 2000. It is one of the most active non-Annex I parties in conducting and communicating national inventories on greenhouse gas (GHG) emissions, having submitted five national communications under the UNFCCC. Mexico hosted a successful Sixteenth Conference of the Parties (COP16) in Cancún (2010) which lay the groundwork for a successful outcome at COP21 in Paris in December 2015. Mexico's 2020 goal (set at COP15 in Copenhagen) of "reducing its GHG emissions up to 30% with respect to the business-as-usual (BAU) scenario by 2020" was incorporated into the UN process at Cancún. The target is conditional on the "provision of adequate financial and technological support from developed countries" (Mexico's notification to the UNFCCC, January 2010).

Intended Nationally Determined Contribution

In the lead-up to COP21, Mexico became the first emerging economy to submit its intended nationally determined contribution (INDC) (i.e. post-2020 targets), which included a GHG and short-lived climate pollutant (SLCP) reduction target of 25% (unconditional) to 40% (conditional) below BAU by 2030. The unconditional target implies reductions in GHG emissions by 22% and in SLCPs by 51% by 2030. It also implies a peak in net emissions in 2026 and a reduction in emissions intensity (CO_2/GDP) by 40% below 2013 levels by 2030.

Mexico would aim for the conditional target if a global agreement were reached on topics including international carbon price, carbon border adjustments, technical co-operation, access to low-cost financial resources and technology transfer, all at a scale commensurate to the challenge of global climate change. The conditional INDC implies reductions in GHG emissions by 36% and in SLCPs by 70% by 2030.

Mexico's INDC also covers adaptation actions, such as measures to enhance the resilience of its strategic infrastructure, including the energy sector. This component of the INDC takes into account gender equality and human rights approaches and prioritises synergies between mitigation and adaptation.

The INDC includes concrete actions to be undertaken from 2020 to 2030 in the following three areas: *i)* adaptation to climate change for the social sector; *ii)* ecosystem-based adaptation; and *iii)* adaptation of strategic infrastructure and productive systems.

In line with its emissions profile, Mexico's INDC (unconditional) expects the largest emissions reductions from the electricity sector (31% of BAU emissions of 202 $MtCO_2$ eq) and the transport sector (18% of 266 $MtCO_2$-eq). Smaller reductions are expected in the oil and gas sector (14% of 137 $MtCO_2$-eq), manufacturing (5% of 165 $MtCO_2$-eq) and agriculture (8% of 93 $MtCO_2$-eq). Mexico's GHG emissions per capita are much lower than the IEA average. If Mexico implements its INDC pledge effectively, per-capita overall GHG emissions will peak around 2025 and would still be one of the lowest

among the G20: higher than India, but two-thirds of China's emissions, half those of the European Union and only 30% of the per-capita GHG emissions of the United States (PBL, 2015).

General law on climate change

Mexico's comprehensive *General Law on Climate Change* (2012) provides the foundation for the country's mitigation and adaptation policies and programmes. This law was supported by all political parties, especially because of the vulnerability of Mexico to the impacts of climate change. The law enables policy makers to establish institutions, create connections within the administration and facilitate further actions. The law also increased Mexico's capability to implement climate policy following a long-term approach, binding future governments.

The law sets a conditional 2020 target of 30% GHG emissions reduction below a BAU scenario, subject to the availability of financial resources and technology, as well as an ambitious absolute 50% GHG emissions reduction by 2050 compared to 2000. It also includes a target for clean energy sources to provide 35% of electricity supply by 2024. The INDC was developed in consistency with the Law's objective of -50% by 2050.

The clean electricity target became a more concrete legal obligation under the 2015 Energy Transition Law. Its purpose is to promote sustainable and efficient use of energy, and to gradually increase targets for the share of clean energy in electricity generation by 2024. It also introduces an obligation to SENER to prepare a national strategy and programme on energy transition to promote cleaner energy sources and technologies (see Chapter 9 on renewable energy).

The General Law on Climate Change has been further spelt-out through the 2013 National Climate Change Strategy (ENCC) and concrete policy measures have been taken in the Special Programme on Climate Change 2014-2018 (PECC), described below.

National Climate Change Strategy

The 2013 National Climate Change Strategy (ENCC) set 10, 20 and 40-year milestones to guide climate change policy within the three levels of government (federal, state and municipal). It also integrates short-lived climate pollutants (SLCP) emissions abatement into national policy for the first time (SEMARNAT, 2015). From a diagnosis of the country's emissions, the ENCC defines five strategic pillars for low-carbon development:

1. Accelerate energy transition towards clean energy sources.
2. Reduce energy intensity through efficiency and responsible consumption schemes.
3. Move to sustainable city models with systems of mobility, comprehensive waste management, and low-carbon footprint constructions.
4. Promote better agro-livestock and forestry practices to increase and preserve natural carbon sinks.
5. Reduce SLCP emissions and encourage co-benefits to health and well-being.

An important aspect of Mexico's climate policy is the inclusion of SLCPs. In practice, this refers to black carbon ($PM_{2.5}$) which is a major component of particulate matter. Black carbon is formed in the incomplete combustion of fossil fuels and biomass. In Mexico, the main sources of black carbon are transport, more concretely diesel vehicles (38% of

total emissions in 2013) and industry (28%). As part of the 2030 INDC, Mexico aims to reduce black carbon emissions by 51% from BAU. Inclusion of black carbon in the climate targets is important also because Mexico is still lacking national legislation on air quality, although Congress is working on a proposal for an air quality law. Local air pollution is a major health risk in several of Mexico's largest cities, and reducing black carbon emissions will thus also bring health benefits.

The ENCC also includes the following three pillars on adaptation:

1. Reduce the vulnerability and increase the resilience of the social sector to the effects of climate change.
2. Reduce the vulnerability and increase the resilience of strategic infrastructure and production systems to the effects of climate change.
3. Conserve and use ecosystems sustainably and maintain the ecosystem services they provide.

Special Programme on Climate Change 2014-2018 (PECC)

The Special Programme on Climate Change (PECC) is the programme that effectively leads actual climate policy and is valid only for the current government term. It includes budgetary commitments, monitoring and an independent review of progress every two years. Some 62% of the mitigation commitments of PECC are in the energy sector (not only CO_2, but also methane and black carbon). PECC summarises 23 quantified mitigation-relevant policy measures that could lead to a reduction of some 8% of the forecast emissions by 2018.

PECC introduced new policy instruments, one of which is a carbon tax on production and import of fuels. The carbon tax has been imposed since 2014, but only on fuels with a higher CO_2 content than natural gas. The government had proposed a broader tax, but the proposal failed to be approved by the Congress. However, the policy instrument exists now and a further increase of the tax remains an option for the future. In this way, negative external effects would be further internalised.

The tax rates have been set to MXN 5.91 cents per thousand cubic meters for propane, MXN 10.38 cents/L for gasoline, MXN 12.59 cents/L for diesel and MXN 27.54 per tonne for coal (anthracite). Companies covered by the tax can alternatively meet their obligation by purchasing an equivalent number of credits from projects in Mexico funded by the clean development mechanism under the Kyoto Protocol (OECD, 2015).

According to the General Law on Climate Change (LGCC), climate change policy must be evaluated every two years. The evaluation began in 2016 and includes PECC. The National Institute of Ecology and Climate Change (INECC) is in charge of the evaluation and the results are expected by the beginning of 2017.

Sectoral policies

Measures with potential for reducing energy-related CO_2 emissions in Mexico are listed in the 2015 First Biennial Update Report to the United Nations Framework Convention on Climate Change (UNFCCC). The measures are in different stages of development or implementation and include the following:

Oil and gas

- Prioritise projects for increased operational and energy efficiency in PEMEX, even if they are not as profitable as the extraction of oil and gas.
- Reduce fugitive emissions by adopting international best practices that are feasible with the new governance structure of the sector. It is necessary to identify appropriate methodologies to exploit gas from geographically isolated fields, particularly in unconventional and deep-water gas reservoirs.
- Ensure operating practices typical of the industry through increased competition and transparency owing to the entry of new international producers.
- Increase the supply of natural gas intended to displace fuels with higher carbon intensity (coke, fuel oil and diesel) in sectors such as industry and electricity generation.
- Increase production of light hydrocarbons, thanks to the restructuring of refineries to increase the use of the heavier and more carbon-intensive fractions.
- Implement a platform for research, innovation, development and adaptation of climate technologies in the sector. For example, the development of systems for sequestering and storing carbon.

Power generation

- Develop tax policies and economic and financial instruments which spark investment in renewable energy projects to achieve the goals of the Law on Climate Change and the Law on the Use of Renewable Energy and Financing of Energy Transition.
- Generate a suitable system of supports and incentives to internalise the environmental benefits of clean energy in electricity production, including distributed generation.
- Implement electricity dispatch smart grids to improve the management of supply and demand in an array with a higher content of intermittent sources of energy (including renewable ones) and to identify non-technical losses in distribution.
- Attract investment in research and development of technologies to lower their cost and increase the use of renewable energy by maximising the benefit of these investments for the Mexican economy, including job creation.
- Develop a strategy for biofuel production that considers the conservation of ecosystems, sustainable water use, the maximisation of environmental performance, and preservation of soil quality.

Industry

- Increase efficiency and support the adoption of better practices, above all in small industries.
- Develop standard regulations and an incentive system for regulating future energy consumption, including energy services markets.

- Adopt the best practices and behaviours both along the production chains and for the end-consumers.
- Certify products generated from efficient technologies.

Transport

- Expand and improve infrastructure for public transportation systems to support massive modal transportation changes.
- Increase energy efficiency of the national vehicle fleet and regulate emission levels.
- Optimise mobility management for example by introducing electronic road tolls, restricting movement in congested areas, encouraging non-motorised transportation.
- Improve the efficiency of freight transportation through participation of railways in land cargo transport and with the co-ordinated operation of vehicles, the construction of specialised terminals and freight corridors, and the implementation of reliable information systems.
- Promote the development of a climate culture and plan urban centres to reduce demand for transportation and increase its efficiency.
- Plan urban centres to reduce demand for transportation and increase its efficiency.
- Use biofuels in the production of gasoline distributed nationwide.

Residential, commercial and services

- Remove the electricity subsidy that discourages the investment required for the adoption of more efficient technologies.
- Promote distributed generation, for example with photovoltaic cells on roofs in urban areas.
- Increase adoption of efficient wood stoves.
- Meet progressive regulations for energy-efficient consumer appliances and in new constructions.
- Strengthen incentives to purchase efficient electric appliances through the electricity bill.

Adaptation and resilience

Mexico is highly vulnerable to the negative impacts of climate change, particularly to the impacts of rising sea levels, increases in average temperatures, increased frequency and intensity of extreme weather events such as cyclones, hurricanes and droughts, and changes to precipitation patterns that exacerbate water stress and flooding.

The limited resilience of lower-income segments of the population, combined with increased exposure to climate risks, means that 319 municipalities (13% of the country) are considered “highly vulnerable” to climate change.

The negative impacts of climate change pose various risks to the energy sector and energy security such as the following:

- Energy infrastructure (including oil and gas infrastructure, power plants and transmission lines) face risks of physical damage from increasing frequency and magnitude of extreme weather events, causing disruptions in the supply of electricity, oil and gas. Coastal and offshore infrastructures face compounded risks from sea level rise and more frequent floods. The National Climate Change Strategy recognises that 46% of PEMEX's infrastructure and over 30% of CFE's transmission lines are vulnerable to the impacts of climate change.
- Increasing water stresses caused by changing hydrological patterns have direct repercussions for hydropower generation. Thermal power generation (particularly from coal) is also highly dependent on the availability of water for steam cooling. Rising water constraints can increase cooling costs for power plants and may require adoption of alternative cooling technologies or improved water management practices.
- Rising temperatures reduce the efficiency of electricity transmission and distribution lines, as well as that of thermal processes in power plants. Projected hotter temperatures (and more frequent and intense heat waves) will increase cooling and energy demand during the summer months.
- Looking ahead, a growing and changing energy system characterised by increased electrification, more variable renewable energy, and other low-carbon energy technologies (e.g. carbon capture and storage) may alter the nature of the climate-resiliency challenge, including changes to water demand, the ability to localise and buffer supply disruptions, and risks from extreme weather events.

Given its high vulnerability to climate impacts, adaptation is a priority for Mexico, and is reflected in their COP21 INDC and in domestic climate and energy policies. Enhancing resilience of the energy sector is of critical importance to ensure energy security and is receiving further attention in Mexico and across the North American region. In fact, "identifying trilateral activities to further climate change adaptation and resilience" is one of six key areas identified in the North American Energy Ministers' Memorandum of Understanding on Climate Change and Energy Collaboration, signed in February 2016. One of the short-term deliverables of this Memorandum was the IEA's 6th Nexus Forum on energy sector resilience in June 2016, where SENER and CFE participated, along with other key government and energy sector representatives from Canada and the United States.

Carbon capture and storage

Carbon capture, use and storage (CCUS) technologies have the potential to play an important role in reducing emissions from the use of fossil fuels. Mexico's energy reforms recognise that fossil fuels will continue to contribute to social and economic development, but must do so in a way that is compatible with the country's ambitious climate goals.

The electricity sector presents a particular challenge with anticipated strong growth in demand. While coal use is expected to decline from 5 500 megawatts (MW) in 2014 to 4 000 MW in 2029, natural gas will continue to dominate the electricity mix and will

account for almost half of all generating capacity in 2029, notwithstanding significant growth in renewables capacity. A natural gas combined-cycle plant produces around half the emissions of a subcritical coal-fired power plant, but these emissions would still need to be managed in the context of long-term global and domestic climate targets. CCUS technologies offer an opportunity to address these emissions, including through retrofitting existing plants.

Mexico has also identified a role for CO_2 use in enhanced oil recovery (EOR) as an important driver for CCUS investment. This is consistent with experience across North America, where CO_2-EOR has provided an important revenue stream for 13 of the 15 large-scale CCUS projects currently operating or under construction in the United States and Canada. Globally, almost three-quarters of CCUS plants operating or under construction include CO_2-EOR, with growing interest in CO_2-EOR opportunities in China, South East Asia and the Middle East.

CCUS Technology Roadmap

Mexico has developed a comprehensive and practical approach to CCUS development reflected in the *CCUS Technology Roadmap* published in 2014. The Roadmap articulates a 10-year strategy for CCUS in Mexico, including a multi-staged approach to development and deployment. It provides a framework for a range of activities, including: co-ordinating research activity, building capacity, establishing regulations; encouraging private-sector investment; developing a pilot project for CO_2 capture (on coal or gas-fired power generation); a pilot project for CO_2-EOR; and ultimately the commissioning of a large-scale CCUS demonstration project around 2020. The importance of building public acceptance and engagement with key stakeholders is acknowledged throughout the Roadmap, recognising that confidence in the technology will be essential for widespread deployment. The Roadmap also emphasises a role for international networking and linkages to promote capacity building and technology transfer. The Roadmap was developed in conjunction with the World Bank and all parties should be commended on a well-considered strategy that could serve as a model for other countries looking to develop CCUS technologies.

Carbon Capture and Storage (CCS) projects

A USD 37 to 40 million CO_2 capture pilot project is under development at the Poza Rica natural gas combined-cycle (NGCC) plant using post-combustion capture technology. The plant will have flexibility to test up to three technologies and is 50% funded by the World Bank through its CCS Trust Fund. Although the *CCUS Technology Roadmap* envisaged a CO_2 capture pilot on either a coal- or gas-fired power plant, the decision to apply the technology to a natural gas-fired power plant is consistent with Mexico's current and future reliance on gas-fired power generation. Gas-fired power generation with CCUS would also be eligible to receive clean energy certificates (CECs) under Mexico's Law on Electric Industry. A combined-cycle gas turbine (CCGT) with 90% CO_2 capture can produce carbon emissions around 40 kilogram per megawatt-hour (kg/MWh) or less, which is well below the 100 kg/MWh threshold to be considered "clean energy" under the law. In contrast, subcritical coal-fired generation units with 90% CO_2 capture would still likely fall above this threshold, at around 120 to 140 kg/MWh.

There are currently no large-scale projects demonstrating CCS on gas-fired power generation anywhere in the world, and also none in advanced planning. Mexico could

therefore make a valuable contribution to global technology deployment efforts if plans for a commercial demonstration proceed according to the Roadmap.

Mexico has also commenced planning for a CO_2-EOR pilot project, the intention being that this could support the development of a commercial-scale CO_2-EOR operation. The CCUS Technology Roadmap acknowledges the importance of CO_2 monitoring, reporting and verification (MRV) in order to provide confidence to the public and ensure minimal risk of leakage. Appropriate MRV will also be important to confirm permanent storage of CO_2 for verifiable emissions reductions. The IEA has identified four key actions to move from traditional CO_2-EOR practices to operations, which would be consistent with an objective of permanent CO_2 storage, including: additional site characterisation and risk assessment; additional measurement of venting and fugitive emissions; monitoring and enhanced field surveillance; and changes to abandonment practices (IEA, 2016b). The Mexican government should consider measures to encourage these activities alongside the introduction of CO_2-EOR practices in the country.

Research and development

Mexico has established seven Energy Innovation Centres (CEMIEs) which provide a platform to launch and grow a portfolio of low-carbon activities, including CCS. The CEMIE on CCUS has been allocated USD 28.6 million over four years, making it the second-largest of the seven CEMIEs, behind CEMIE Bioenergy. This investment in CCUS research and development will be important in underpinning the implementation of the Roadmap and expanding existing technology capability in Mexico.

Mexico's membership in Mission Innovation also provides an opportunity to build international linkages on CCUS research and development, to promote practical collaboration and to maximise knowledge sharing. Mexico is encouraged to be an active participant in CCUS-related programmes under this initiative.

Assessment

Over the last decades, Mexico's GHG emissions have increased rapidly. Energy-related emissions grew from 1990 to 2013 from about 260 to 450 $MtCO_2$. The largest increase has taken place in transport (now the largest emitter) and electricity generation.

Mexico is highly vulnerable to climate impacts and, despite having large oil and gas resources, it has been among the world leaders in integrating climate change objectives into policy making, as evidenced by the 2012 General Law on Climate Change. The law stipulates that the country should prioritise cost-effective actions that create co-benefits for the population, and seeks a 30% reduction of GHG by 2020 below business-as-usual (50% below 2000 levels by 2050).

Mexico's climate pledge (INDC), submitted in advance of COP21 in 2015, further strengthens its commitment to reducing its GHG emissions and following a low-carbon and resilient path. Under the baseline scenario, GHG emissions would increase but, under the mitigation scenario, emissions would peak in 2026 and start decreasing. Carbon intensity could be reduced by 40% between 2013 and 2030.

The INDC also includes goals to reduce the emissions of short-lived climate pollutants (SLCPs). Integrating climate policy and air pollution policy brings synergies; reducing SLCPs has a direct impact on air quality and the health of the population. In this context, the IEA also urges the government to strengthen national air quality policy to provide a more solid basis for limiting air pollution.

The expected emissions reductions largely depend on activities in the energy sector, including through commitments to increase the share of clean energy in power to 35% in 2024 and 43% by 2030, and by controlling methane leaks in the upstream sector. A carbon tax was placed on fuels in 2014, but there is also broad recognition of the opportunities that energy efficiency measures could offer in reaching Mexico's targets, including through improving the sustainability of buildings, harmonising the standards for vehicles and machinery traded through the North American Free Trade Agreement (NAFTA), and promoting sustainable transport. In general, the government should intensify efforts to internalise the negative externalities of energy use into energy prices.

Projections of current policies show that Mexico will reduce emissions, but not enough to meet its conditional pledge of 30% emissions reduction by 2020, relative to the national business-as-usual levels (about 670 $MtCO_2$-eq). The announced INDC target of 22% (unconditional) to 36% (conditional) reduction in GHG emissions by 2030 compared to national business-as-usual levels (973 $MtCO_2$-eq) is also not likely to be met under current policies (IEA, 2016c). Additional policies are thus needed.

Policy instruments seem to have been developed in a relatively bottom-up way based on the government's expectations to draw up the Special Programme on Climate Change 2014-2018 (PECC) and the INDC. However, there is little information on the progress that has been made and whether additional activities are needed to attain these targets. Additional measures need to be developed, but time for implementing them will be short.

It appears that there are no official estimates or studies available about cost-effectiveness of the various mitigation instruments. To help prioritise among the various policies and measures, the government should develop such estimates, on a cost-per-tonne of CO_2 basis and both in terms of short-term reductions and in delivering the 2050 target.

The government is aware of this policy deficit. PECC will be evaluated by the National Institute of Ecology and Climate Change (INECC) by the end of 2016. No evaluation is foreseen on whether the 2020 target as prescribed by the 2012 General Law on Climate Change is within reach, however.

INECC will also publish an official forecast to provide the information needed to take cost-effective policy decisions on the implementation of the INDC proposals. Furthermore, the long-term scenarios that are being developed in the framework of the Energy Transition Strategy could be helpful in outlining future options for emissions reductions. In general, the government should ensure that reliable data are available for preparing scenarios and projections and that medium- and long-term forecasts and scenarios are developed in a co-ordinated way, enabling the government and the broader public to track progress towards climate objectives.

However, even without official scenarios, the INDC ambition to peak overall emissions will be a significant challenge. For example, the electricity sector is supposed to make the largest contribution to the INDC emissions reduction and, even in a clean energy scenario with 71% clean electricity by 2046, emissions may actually increase from today's levels because of projected large absolute increases in power generation. The projected significant rise in transport may have similar implications for emissions. This calls for further strengthening of sectoral policies, especially in transport, and developing a comprehensive policy approach for all sectors.

A relatively recent aspect of Mexico's climate policy is the aspiration for a "green economy". The recent auctions for clean energy (see Chapter 8 on electricity) revealed the potential not only for wind energy but also for solar PV. There is business interest to build upon the successful development of vehicles and electronics sectors in Mexico that are part of a global chain of manufacturing. Mexico could position itself in such value chains, for example in wind energy and solar PV. The visibility of a new green economy could generate support for the energy reform as well as climate and clean energy policies more generally.

The government considers research, development and demonstration projects in CCUS as an integral part of its climate policy. The IEA welcomes this approach. In 2014, a 10-year *CCUS Technology Roadmap* was published. This roadmap focuses on the development of a regulatory framework, on the analysis for designing a CO_2 capture pilot project in an NGCC plant, and on the methodology to introduce an enhanced oil recovery project using CO_2. Legally, electricity generation using CCUS has been accepted as a "clean energy" as long as the remaining CO_2 emissions are less than 100 kg/MWh. This implies that CCUS could qualify for clean energy certificates, which would be an important incentive in the electricity market for the next steps after the expected pilot. The government of Mexico co-operates with the World Bank in developing two CCS pilot projects. The gas power CCS pilot plant is close to a final decision. The EOR pilot started later, but is well under way. The important issue of public engagement is not yet developed, but is on the agenda. The long-term future is uncertain, especially as regards technology costs. It is plausible, however, that the expected large share of gas in the power sector would have either to decrease in the long run, or to be fitted with CCS to attain a halving of GHG emissions by 2050.

Recommendations

The government of Mexico should:

Climate change

- ☐ Strengthen federal air quality policy, together with states, and make efforts to reflect interactions with climate policy.
- ☐ Strengthen efforts to internalise the negative externalities of energy use, such as climate change, into energy prices.

- Evaluate the short- and long-term cost-effectiveness of different mitigation instruments on a cost-per-tCO_2 basis. Translate aspirational intended nationally determined targets into definite ones in a timely way after careful analysis of feasibility, costs and benefits.
- Further strengthen sectoral policies, especially in transport, and develop a comprehensive policy approach for all sectors.
- Strengthen the gathering of reliable data and develop medium- and long-term forecasts and scenarios in a co-ordinated way, enabling the government and the broader public to track progress towards objectives.

CCS

- Continue to pursue its focused and practical approach to carbon capture, use and storage.
- Encourage measurement, reporting and verification practices for CO_2-EOR activities to ensure these are consistent with climate policy objectives.
- Continue to build international linkages and promote practical collaboration in carbon capture and storage technology development, including through Mission Innovation.

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4. Energy efficiency

Key data

(2015 estimated)

Energy supply per capita: 1.5 toe (IEA average: 4.5 toe), -7.2% since 2005

Energy intensity: 0.09 toe/USD 1 000 PPP (IEA average: 0.11 toe/USD 1 000 PPP), -16.1% since 2005

Total final consumption (2014): 118.3 Mtoe (oil 61.8%, electricity 18.3%, natural gas 11.6%, biofuels and waste 5.9%, coal 2.2%, solar thermal 0.2%), +15.8% since 2004

Consumption by sector (2014): transport (43.4%), industry (33.6%)[1], residential (15%), commercial and other services, including agriculture (8.1%)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Overview

The Mexican government is committed and has made significant efforts to invest in energy efficiency, even though, Mexico is still among the few Organisation for Economic Co-operation and Development (OECD) countries that have not yet decoupled total primary energy supply (TPES) from economic growth over the past decade.[2] In the context of increasing energy consumption per capita, energy efficiency has a potentially important role to play. There are still various opportunities to improve energy efficiency at little or no net cost in the transport, industrial and buildings sectors. Recognising that the energy efficiency market potential in Mexico is considerable, investment in energy efficiency has been growing progressively, stimulated mainly by government policies such as energy efficiency standards. In addition, the government has developed a series of large energy efficiency programmes focusing on buildings, lighting and appliances (e.g. street lighting and residential replacement programmes) particularly targeting low-income households (IEA, 2015).

Final energy use

Mexico's total final consumption (TFC) was 118.3 million tonnes of oil-equivalent (Mtoe) in 2014. It was 1.7% lower in 2014 than the record high of 120.3 Mtoe in 2011. Energy demand has been growing steadily for decades and was 15.8% higher in 2014 than ten

[1]. The industry sector includes non-energy use.

[2]. Nevertheless, in some sectors, energy use has been decoupled from economic growth, particularly in the residential sector in temperate zones (55% of residential customers) where, on average, energy use is the same as 25 years ago.

years earlier, with a very slow downturn in 2009 and demand contracting by 5.1% but then increasing by 5.7% in the following year.

Final consumption by sector

Transport is the largest energy consuming sector in Mexico, with final consumption of 51.3 million tonnes of oil-equivalent (Mtoe) in 2014 or 43.4% of TFC. Transport demand was 22.9% higher in 2014 than ten years earlier, in 2004, with its share in TFC increasing from 40.8%.

Demand by the transport sector experienced the strongest growth from 2001 to 2008, increasing by 4.6% per annum, with a significant slow-down since. In 2009, demand contracted by 2.2%, increasing by only 0.5% on average in the five following years.

Industry is the second-largest energy-consuming sector, with final consumption of 39.7 Mtoe in 2014 or 33.6% of TFC, including non-energy use. Industry demand has increased by 11.6% over the ten years to 2014. In 2009, consumption by this sector was down by 11.8% albeit with a 14.4% recovery in the following year.

Households represented 15% of TFC in 2014 or 17.7 Mtoe. Residential energy demand has remained relatively unchanged over the past decade, finishing marginally 0.5% lower in 2014 than in 2004, with its TFC share down from 17.5%. Residential demand exhibits a marginal level of year-on-year volatility, related to climate conditions.

The strongest ten-year energy demand growth, 35.5% in total, has been in the *services sector* (including public services and agriculture). This sector accounted for 8.1% of TFC in 2014, with its share increasing from 6.9% in 2004. Commercial demand has increased each consecutive year since 2003, despite an economic downturn in 2009.

Final consumption by source

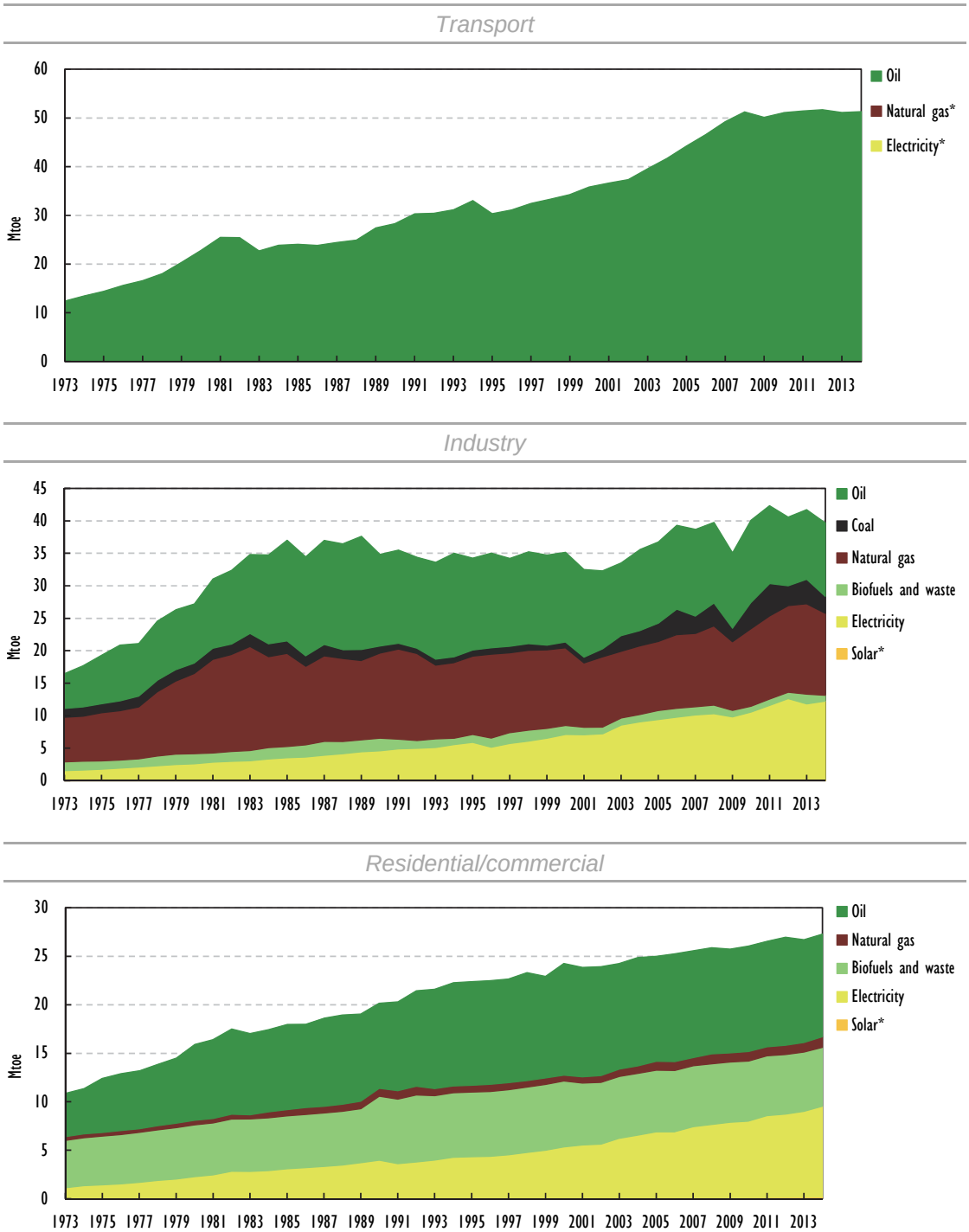
The transport sector is fuelled by oil, 99.8% of total fuel demand, with a 0.2% share of electricity use. Motor gasoline accounts for around 63% of transport oil use, while the remainder is mainly gas and diesel oil. Natural gas is also consumed albeit at negligible levels. The transport sector fuel mix in Mexico has remained unchanged over the past decade.

Fuel consumption in the Industrial sectors split between natural gas (31.8% of the total), electricity (30.8%) and oil (28.5%). Coal and biofuels and waste make up a smaller share of the fuel mix, 6.6% and 2.3% respectively, while negligible amounts of solar (thermal) energy are also consumed. Since 2004, industry consumption of electricity and natural gas has increased by 35.3% and 19.2%, respectively, while oil use has fallen by 9.3%. Consequently, oil has lost its 35% share in industry TFC since 2004, while electricity and natural gas shares have increased from 25.4% and 29.8%, respectively. Coal use was 11.2% higher in 2014 than in 2004 while the use of biofuels and waste declined by 19.6%.

The residential and commercial sectors together consume mostly oil (38.8%), electricity (34.3%) and biofuels and waste (22.2%). Natural gas and solar (thermal) energy account for 4% and 0.7% of sectoral final consumption. In the ten years since 2004, demand for oil and biofuels and waste in these sectors has contracted significantly, leading to a lower share of sectoral final consumption – down from 44.9% for oil and 26.3% for biofuels and waste. This contraction has been offset by an increase in electricity

consumption by 44.3% and in natural gas consumption by 42.2%, over the ten years, with their shares in sectoral final consumption up from 25.4% and 3.1%. Solar consumption has doubled over the ten years, even so remaining at negligible levels.

Figure 4.1 TFC by sector and by source, 1973-2014



* Negligible.

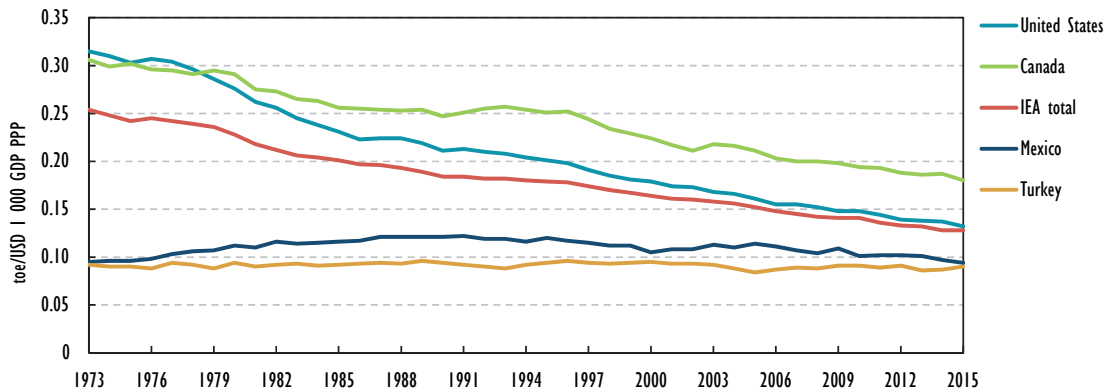
Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Energy intensity

Energy intensity, measured as the ratio of TPES per unit of real gross domestic product at 2010 prices and adjusted for purchasing power parity (GDP PPP), was 0.09 tonnes of oil-equivalent per USD 1 000 PPP (toe/USD 1 000 PPP) in 2015. The ratio is lower than the International Energy Agency (IEA) average of 0.11 toe/USD 1 000 PPP and the IEA North America average of 0.14 toe/USD 1 000 PPP. Mexico's energy intensity declined by 17.5% from 2005 to 2015, falling at a slightly faster rate than the IEA average intensity that declined by 16.3% over the same period (Figure 4.2).

A further common indicator for international comparisons is energy consumption per capita (see Figure 4.3). Mexico's rate of 1.5 toe per capita per year is lowest in comparison to the IEA member countries average, roughly similar to Turkey's rate.

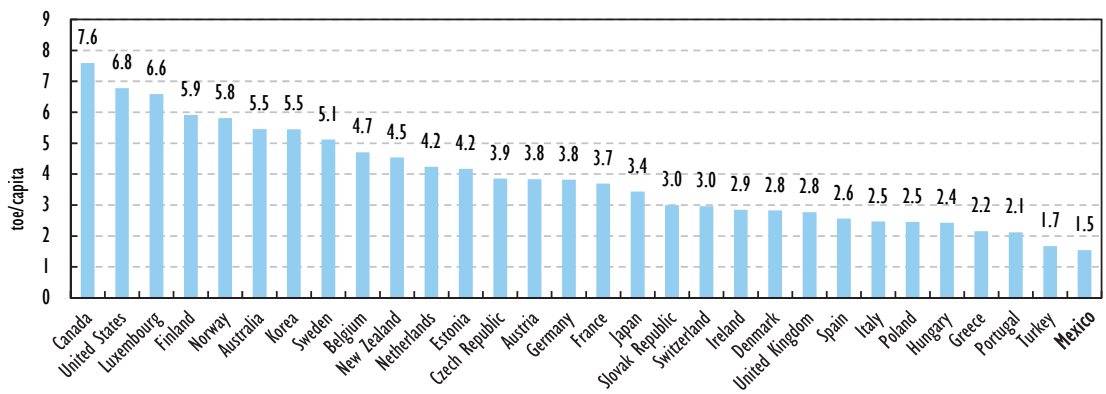
Figure 4.2 Energy intensity in Mexico and in selected IEA member countries, 1973-2015



Note: Data for 2015 are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 4.3 TPES per capita in IEA member countries and in Mexico, 2015



Note: Data are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Institutions

The **Ministry of Energy (SENER)** is responsible for Mexico's energy strategy and policy, including energy efficiency in all productive sectors. It is currently working on a long-term

national energy efficiency strategy as well as developing an energy efficiency roadmap and targets as required under the new Energy Transition Law approved in December 2015.

The **National Energy Efficiency Commission (CONUEE)** is a decentralised body of SENER, responsible for promoting energy efficiency, enacting and supervising the enforcement of energy efficiency standards and providing technical expertise regarding sustainable energy use throughout all the energy value chain from supply to consumption.

Other ministries also have duties and responsibilities in establishing and implementing energy efficiency actions:

The **Ministry of Finance (SHCP)** allocates the federal budget and provisions to the public sector to carry out the priorities set in the Energy Transition Strategy and other planning instruments. SHCP is part of the Advisory Council for Energy Transition.[3]

The **Ministry of Environment and Natural Resources (SEMARNAT)** collaborates in actions to promote the environmental sustainability in the energy sector such as the adoption of clean and low-carbon technologies, as well as the implementation and promotion of environmental regulations and measures. Moreover, SEMARNAT tracks all GHG reductions from the energy sector. This ministry is also part of the **Advisory Council for Energy Transition**.

The **Ministry of Agricultural, Territorial and Urban Development (SEDATU)** sets national urban development policies, and through the **National Housing Commission (CONAVI)** is responsible for promoting a model of sustainable urban development and supporting the implementation of eco-technologies in new households. SEDATU also is part of the Advisory Council for Energy Transition.

The **Ministry of Communications and Transport (SCT),** in co-ordination with SENER, promotes and supports energy efficiency in the transport sector. A representative of SCT also participates in the Advisory Council for Energy Transition.

The **Ministry of Education (SEP),** through the **National Council for Science and Technology (CONACYT)** and the **Energy Sustainability Fund,** fosters the implementation of projects based on improvements of energy efficiency, implementation of clean energy technologies and renewable energy.

The **Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)**, the **Ministry of Economy (SE)** and the **Ministry of Health (SALUD),** are also represented in the Advisory Council for Energy Transition.

Furthermore, other institutions promote directly energy efficiency in different sectors. They are:

[3]. This is a permanent body aimed at review that advises SENER on the necessary actions to comply with the national goals of energy efficiency and clean energy, as well as on the contents of other planning instruments. The Council will meet in ordinary form twice a year at least, or whenever SENER requires its opinion.

The **Federal Electricity Commission (CFE)** promotes energy efficiency through its **Programme of Energy Savings in the Electricity Sector (PAESE)** which aims to produce and distribute electricity efficiently in all sectors through energy efficiency projects, technical assistance, training in energy conservation, evaluation and dissemination activities. PAESE evaluates devices, techniques and technologies which promote savings on electricity.

The **Trust Fund for Electricity Savings (FIDE),** a private, not-for-profit institution, is made up of a mix of private and government members. It promotes and funds projects for efficient end-use, particularly technology development and innovation in industry, commerce and services sectors, as well as in the agricultural sector. It also operates residential programmes for SENER, particularly for lighting, refrigerators and air conditioning (AC) systems. FIDE is responsible for programmes such as a voluntary appliance endorsement label known as *Sello* FIDE (IEA, 2015).

The **Trust for Thermal Insulation (FIPATERM)** was created to finance energy efficiency measures in the residential sector in hot climates, particularly thermal insulation in Mexicali City on Baja California State. It includes replacement equipment actions for AC systems, compact fluorescent lamps (CFLs), thermal insulation and refrigerators; some actions have been co-ordinated with FIDE. The federal government has promoted co-operation between public and private institutions to promote the design, implementation and funding of policies, programmes and projects in energy efficiency. Institutions working on data collection to analyse energy consumption patterns are:

The **National Institute of Statistics and Geography (INEGI)** is the body in charge of national statistics. The Energy Transition Law establishes the National System of Energy Information which has to follow INEGI's regulations and principles. The National System will integrate information regarding all energy efficiency actions implemented in the ministries and by high energy consumers.

The **National Council of Population (CONAPO)** is a provider of data on demographic growth and national population trends which helps to analyse energy consumption patterns.

Another institution working on buildings sustainability and focusing on energy efficiency is the **Institute for National Fund of Workers' Housing (INFONAVIT)** which established and operates a green mortgage initiative that provides an additional credit to implement eco-technologies in new or existing houses.

In addition, there is a series of non-governmental organisations dealing with different aspects of energy efficiency: the **National Standardisation and Certification Body for Buildings and Construction (ONNCCE)**, a non-profit organisation dedicated to the development of activities such as standardisation, certification and verification of products, processes, systems and services, which are intended to contribute to the improvement of the quality of building construction in Mexico. The **National Association for Standardisation and Certification of the Electricity Sector (ANCE)** promotes energy management standards implementation in all kinds of enterprises. The **Quality and Sustainability in Buildings (CASEDI)** is a civil association related to construction in Mexico and interested in promoting quality buildings to enable sustainable cities. The **Alliance for Energy Efficiency (ALENER)** is a public-private association the objective of which is to promote energy efficiency in buildings, and to provide technical and

commercial information. The **Mexican Chamber of Construction Industry (CMIC)** is a public institution representing all issues concerning the Mexican construction industry.

Policies and measures

Energy efficiency policy of Mexico is aligned with the **National Development Plan (NDP)**, based on its national goal "*México Próspero*", objective 4.6, which seeks to promote energy efficiency throughout the productive chain. In addition, energy efficiency actions are set according to the **Energy Sectoral Program (PROSENER)** with the objective of expanding clean and renewable energy use, promoting energy efficiency and social-environmental responsibility.

In addition, as a result of the Energy Reform, the **Energy Transition Law** represents a major keystone in Mexico's new legislation on clean energy, energy efficiency and sustainable use of energy. The Law establishes the obligation to create long-term clean energy and energy efficiency goals regarding the total generation and consumption of clean energy electricity in Mexico, as well as measures on sustainable use of energy. The implementation is guided by three instruments that will be published or updated during 2016:

- Transition Strategy to Promote the Use of Cleaner Technologies and Fuels
- Special Programme for the Energy Transition
- National Programme for Sustainable Use of Energy.

The **Transition Strategy to Promote the Use of Cleaner Technologies and Fuels** will become the main strategy of the national energy policy. This strategy is aimed at boosting the national's energy transition and delivering an efficient and low-carbon economy and society. The strategy will include medium (15-year) and long-term (30-year) action lines. These actions comprise a shared responsibility of the three levels of government, private and academic sectors and society in general. A first version of this Strategy was published in December 2014 and the Energy Transition Law mandated the production of an updated version is currently being produced and will for the first time contain clean energy and energy efficiency goals, as well as a roadmap to develop an efficient and competitive energy market.

The **Special Programme for the Energy Transition** will spell out the specifics of implementing clean energy goals and others action lines identified in the abovementioned Energy Transition Strategy to boost the development of clean distributed generation facilities, regulatory incentives to ensure compliance with the clean energy goals and analysis of economic viability, as well as details on how to proceed with their implementation.

The **National Programme for the Sustainable Use of Energy (PRONASE)** establishes strategies, objectives, actions and targets to achieve optimal use of energy in all processes and activities for exploration, production, processing, distribution and consumption. This programme should contain the energy efficiency goal and on this sense should be updated by the end of 2016. At the time of writing of this report, SENER and CONUEE were reviewing and updating current PRONASE.

The Roadmap of Energy Efficiency is the guide for implementing actions to meet energy efficiency targets established in PRONASE, in accordance with the Energy Transition Law, Article 12. The roadmap contains strategies to achieve a final energy intensity reduction rate of 1.9% from 2016 to 2030, and 3.7% from 2031 to 2050.

In terms of funding mechanisms, the Mexican government has established three main funds for energy efficiency (SENER, 2015):

1. The **Fund for Energy Transition and Sustainable Energy Use (FOTEASE)** financed 33 projects from 2009 to mid-2015, with more than MXN 8 700 million (USD 417 million) of which approximately 75% was for funding energy efficiency projects.
2. The **Sustainable Energy Fund (FSE)** was created in 2008 but only a small percentage has been used for energy efficiency. For example, in 2013 only 2% of the FSE budget was used for energy efficiency projects worth MXN 52.8 million (USD 2.47 million).
3. The **Programme of Energy Savings in the Electricity Sector (PAESE)** is managed by the Federal Electricity Commission (CFE) and covers a number of areas such as clean energy and energy-efficient technologies. The available budget was approximately MXN 45.0 million per year (USD 2.3 million).

In addition to these instruments, CONUEE has developed an *Annual Work Plan* which classifies action lines and strategies according to sectoral, transversal and support programmes. Table 4.1 shows the main topics covered in each of the sections.

Table 4.1 Energy efficiency programmes co-ordinated by CONUEE

Sectoral programmes	Transversal programmes	Support programmes and actions
Federal Public Administration States and municipalities Energy service companies (ESCOs) High energy consumers (UPACs) Small and medium-sized enterprises Residential sector	Standardisation Transport Buildings Solar water heating	PRONASE National subsystem for energy use Statistics, modelling and energy efficiency indicators International co-operation Promotion and support Information technology and communications General administration and technical area

Source: CONUEE (2015), "Final activities report of CONUEE 2015", www.conuee.gob.mx/pdfs/que/06InformeConueeener_dic_2014Final.pdf.

In general, cross-sectoral energy efficiency actions are based on *i)* equipment and systems regulated through energy efficiency standards, Mexican Official Standards (NOMs), building energy codes; *ii)* programmes promoting technological change and application of energy efficiency actions; *iii)* capacity building and best practice dissemination to foster behavioural changes on energy use.

Transport

The transport sector represents 43.4 % of TFC, far above the IEA average. This implies that energy efficiency improvements in the sector can potentially have a large impact on overall Mexican final energy consumption. Current policies and measures to improve

efficiency in the transport sector are primarily directed at road transportation and at encouraging urban mobility schemes combined with efficient transport modes.

Transport efficiency is mainly stimulated by improvements to light-duty vehicle standards[4], including a local standard issued by the Ministry of Environment and Natural Resources (SEMARNAT), the Ministry of Economy and the National Energy Efficiency Commission to regulate the fuel efficiency and restrict pollutants emission levels of light vehicles (NOM-163-SEMARNAT-ENER-SCFI-2013). These standards are technically related to those in the United States, but they are less stringent, although a large part of Mexico's car production is destined for the US market.

Mexico is currently considering adopting energy efficiency standards for heavy-duty vehicles. These standards are difficult to implement in general, and in Mexico in particular, because the category includes a large diversity of vehicle types, as the feasibility of the suggested standard is related to the availability of low-sulphur diesel. In this respect, opening the market for new players to import finished oil products from April 2016 offers new possibilities. In large Mexican cities, in particular the capital, air pollution is an important issue. At certain times, local air quality is so poor that it is necessary to ration the number of cars allowed in Mexico City (IEA, 2016b). Rationing in general is a sub-optimal instrument from an economic perspective. At the same time, policy instruments with proven benefits in IEA countries are not implemented in Mexico, such as vehicle levies with different levels according to their CO_2 emissions.

In the same regard, partly because of the traffic congestion, SENER, CFE and the Mexican Association of the Automotive Industry (AMIA) have launched electric taxi programmes in Mexico City and Aguascalientes with the aim of incorporating more and cleaner vehicle technologies and continue promoting the market development of electro-mobility. A first roll-out of BMW's "charge now" programme has been launched, in co-operation with General Electric and Schneider Electric, to develop charging stations for electric vehicles (EVs) in several large cities, with the explicit goal of creating an ecosystem of suppliers to start the deployment of EVs in Mexico. Furthermore, SENER, in co-ordination with the Mexican Association of Railroads (AMF), has plans to establish a pilot project named "Energy Efficient Locomotives", which aims to promote a railway sector with lower GHG emissions.

In an effort to internalise a culture of energy efficiency into public entities, the Mexican government has provided technical support to the development of public vehicle fleets, including through energy management systems, training and dissemination of best practices. In 2015, actions accounted for assistance to 268 entities, obtaining fuel savings of 17.4 million litres of fuel, mainly gasoline and diesel.

Buildings and appliances

Buildings accounted for 25% of Mexico's TFC in 2014. Urbanisation, growth in the service sector, and increased wealth are likely to drive energy consumption further, providing imminent challenges for Mexico to keep improving efficiency in buildings and appliances. For example, air conditioning can represent up to 50% of energy

[4]. See list of energy efficiency standards in Annex C.

consumption in buildings, depending on the regional climatic conditions; the penetration of air conditioners is likely to increase significantly in the near future.

Mexico has wide-ranging programmes for energy efficiency, such as replacement programmes for refrigerators, air conditioning and fluorescent lights, standards for building components and appliances, and a voluntary energy labelling programme (the FIDE stamp).

Building standards

The main energy efficiency measures in residential and commercial sectors concern efforts and investments for the creation and accomplishment of buildings standards.[5] The government is focusing on enforcing the engagement of all stakeholders to devise applicable standards for new buildings and retrofits; on implementing strategic measures such as the design of an Energy Management System Programme in public buildings; and on developing an Energy Conservation Code for Buildings[6] with minimal requirements for buildings' envelope, thermal insulation, heating, cooling, lighting, water heating, electric energy for equipment, building systems and construction characteristics. Buildings energy standards have been set at the federal level, but compliance can only be possible through their adoption by local/municipal governments in their local codes and compliance processes as the Mexican Constitution assigns authority to municipalities on permits to build. Given the lack of interest and limitations by state and municipal governments, the Energy Efficiency Commission has opted to promote the standards with selected state and local authorities and has mandated that new federal public buildings comply with the commercial buildings standards. Large buildings awaiting green certification are requesting evaluation under the standards.

In the commercial sector, actions are related to promoting highly-efficient equipment and energy efficiency measures. The Eco Business Credit Program, established by SENER in coordination with the Ministry of Economy, NAFIN (a National Development Bank), CFE and FIDE, has helped replace inefficient lighting technologies, cooling and pumping technologies. From mid-2014 to mid-2015, more than 3 600 companies participated, saving 20.6 GWh with MXN 158 million (USD 7.6 million) financing from the programme. In addition to these efforts, the government has implemented a National Energy Efficiency Municipal Public Lighting Project to enable street lighting retrofits in municipalities. Since its implementation in 2012, up to June 2016, financing from the Fund for Energy Transition allowed 24 municipalities in 10 states to replace approximately 173 000 street lights, generating electricity savings of 73.9 GWh in 2015.

In the residential sector, actions are focused on enhancing homes by efficient appliances and energy-efficient building materials and components, such as SENER's Efficient Lighting and Appliances Project to promote the adoption of energy-efficient technologies, replacing incandescent bulbs with compact fluorescent lamps and old refrigerators and air conditioners with highly-efficient ones. This programme from 2010 to 2015 has registered energy savings of 9.6 TWh and has benefited

[5]. See Annex C.

[6]. The Ministry of Energy, the Energy Efficiency Commission, the Agency on Quality and Sustainability in Buildings, and the Standardization and Certification Body for Buildings have created a working group for the development of a certification model for green buildings in the country.

11.3 million households. Another example is the EcoCasa programme (Table 4.2), the objective of which is to promote energy-efficient social housing, including technological changes as insulation of ceilings and walls, reflective paint, efficient gas heaters and others (IEA, 2015).

Other programmes to foster energy efficiency based on technological improvements in the residential sector are described in Table 4.2.

Appliances

Appliances and equipment represent around 20% of energy consumption in buildings. This value is expected to increase rapidly with the assumed increase in population and income. In 2015, 48% of TFC was regulated by mandatory efficiency standards. And the National Program for the Sustainable Use of Energy (PRONASE) plans to have 51% energy consumption regulated under energy efficiency standards by 2018 (SENER, 2016).

Table 4.2 Selection of energy efficiency programmes in the buildings and appliances sectors

Programme	Status	Description	Achievements
Efficient Lighting and Appliances Project	Concluded	Replacement of incandescent bulbs for CFLs, refrigerators and air conditioners	Around 46 million CFLs, and 1.9 million refrigerators and air conditioners were replaced across the country.
"Ahórrate una luz" programme	In force	Replacement of incandescent bulbs for CFLs	As of October 2016, according to SENER, 28 million lamps have been delivered nationwide. The goal is to deliver 40 million lamps by 2018.
FIPATERM	In force	Thermal insulation of housing and replacement of AC systems, refrigerators and CFLs.	Since 1990 more than 100 000 installations have been implemented, basically in Mexicali, BC.
FIDE Programme	In force	Replacement of incandescent lights for CFLs	Between 1996 and 2006 more than 10 million incandescent bulbs were replaced within the operation zone of CFE.
Green Mortgage *(Hipoteca Verde)*	In force	Financing schemes for energy-saving measures in new housing.	By 2015 the programme had saved 9.7 GWh of electricity and 27 Mt of gas.
EcoCasa/SISEVIVE	In force	Promote energy-efficient social housing which consumes at least 20% less energy than typical existing buildings	By April 2016, the EcoCasa programme had invested around USD 222 million in more than 20 000 Ecohomes. With SISEVIVE, during 2015 the number of households evaluated was 8 704 units across the country.
Energy Efficiency in the Federal Public Administration	In force	Monitoring and promotion of energy efficiency measures in public buildings	Covers more than 2 900 public buildings and sets a specific target for reducing energy consumption. An estimated 20.6 GWh savings achieved in 2014.

AC = alternating current; CFKs = compact fluorescent lamps.

Sources: Adapted from de Buen et al. (2016); IEA (2015), with updates from SEDATU (2015), SHF (2015), SHCP and SHF (2016).

Currently, there are 30 NOMs of which 15 are related to appliances. The NOMs for appliances all include specifications and mandatory minimum energy performance levels for each appliance type. In addition, a voluntary labelling programme (the **FIDE stamp**) has been introduced for 29 products, including appliances and building components to certify their high efficiency and quality. However, in practice the adoption of the stamp by producers is limited to between 10% and 15% of all products. Unlike official measures, for the general public it remains unclear whether or not the efficiency thresholds used in the programme are structured in a way that the certified products represent the "top tier" group in efficiency, suggesting that some FIDE-labelled products may not necessarily represent competitive efficiency or provide sufficient efficiency benefits to consumers. That said, for some products such as LCD (liquid crystal display) televisions, efficiency standards are comparable to those of the Energy Star programme in the United States and Canada. However, it should be noted that Mexico currently does not have a NOM for televisions in general although they are included in the standard that limits stand-by power and includes mandatory labelling.

The Mexican government also implemented an Efficient Lighting and Appliances Project to promote the adoption of energy-efficient technologies such as CFLs. Approximately 45.8 million incandescent bulbs were replaced with CFLs in 11.3 million households, resulting in estimated savings of 6 993 gigawatt-hours (GWh). The project also replaced a total of 1.9 million refrigerators and air conditioners resulting in estimated savings of 2 586 GWh (IEA, 2015). At present, the Mexican government is implementing the programme "*Ahórrate una luz*", which has delivered 28 million CFLs up to October 2016, according to the Ministry of Energy.

Industrial sector

Industry accounted for one-third of Mexico's TFC in 2014. Since 2000, energy demand in the sector has increased considerably. Energy-intensive industries, such as steel and chemicals, have improved efficiency significantly, resulting in energy intensity declines of between 20% and 50% since 2000. As these industries are expected to grow, energy efficiency will remain an important issue.

Energy efficiency measures have been relatively limited, focusing on energy audits and providing recommendations in private and public industrial facilities. There is also limited interaction between industry and the energy services companies (ESCO) market.

There is a requirement for high energy consumers (UPAC) to report their annual energy information as well as energy efficiency measures implemented. However, the programme has had limited impact and was revised in 2014. The government is also fostering the application of energy management systems through the National Programme for Energy Management Systems. This programme is accompanied by learning networks to facilitate the implementation of the Energy Management Systems. Currently, the first learning network considers a formal agreement with eight large companies from different sectors.

Energy consumption by small and medium-sized enterprises (SMEs) constitutes a quarter of total industry consumption. As in other countries, SMEs often lack awareness, quality data and resources to manage energy consumption. With the Eco Business Credit programme, the Trust Fund for Electricity Savings (FIDE) provides preferential loans to SMEs to replace inefficient equipment, such as refrigerators and air

conditioners. In addition, the Energy Efficiency Commission (CONUEE) provides technical guidelines to help identify potential energy-saving measures.

Further efficiency gains could be achieved by improving efficiency in motor-driven systems, which in general represent 69% of electricity consumption in the industrial sector. The government has already taken a first step to address the issue by introducing an efficiency standard for motors. Up to date, the third generation of motor energy efficiency standards is in the process of being published. This standard will be harmonised with those in the United States in terms of minimum efficiency performance standards (MEPS) and test procedures.

Assessment

The Mexican government has taken important and encouraging steps in energy efficiency and some have been particularly effective in the residential sector such as the energy efficiency standards, large appliance replacement programmes and introduction of innovative programmes such as the EcoCasa and Green Mortgage. However, meeting new and ambitious national climate change targets and uncovering the remaining energy efficiency potential will require additional efforts, particularly in the transport and industrial sectors.

There is still a lack of awareness of energy efficiency in Mexican society, whose image of energy is informed by the notion of abundant availability of cheap fossil resources. The government should continue to make efforts to increase consumers' knowledge and influence decision making. In line with the low level of awareness, Mexico has limited ESCOs and financial markets for energy efficiency, with little capacity for technical support. The introduction of market-based mechanisms could help trigger greater private-sector investment in energy efficiency.

The official energy efficiency goals of 2012 reflected a rather low ambition, namely keeping energy intensity level at 2012 levels. To date, energy efficiency activities highly depend on government support, which exposes them to a risk of decline at times of federal budget cuts. The Energy Transition Strategy in its version for public consultation establishes the following goals on energy efficiency: 1.9% average annual rate reduction of final energy consumption intensity (2016-30) rising to 3.7% for the period of 2031-50. The definition of these goals will help raise the profile of energy efficiency within the government and beyond.

The proximity to the US market proves to be a double-edged sword for Mexico: on the one hand, any new regulatory framework in the United States will strongly affect Mexican markets as well, even with a time lag, and there is an agreement at the highest level among NAFTA partners to harmonise energy efficiency standards. However, second-hand, low-efficiency used equipment can also be easily brought across the border, extending its life-span and raising electricity consumption, especially for air conditioning and refrigeration. This is compounded by the persistence of electricity subsidies for households, which make energy efficiency improvements in households unattractive.

High-quality and disaggregated data on energy end-use and activity are essential for designing efficiency policy. Currently, the government requires selected large industries to report on their energy use and energy efficiency actions. In the building sector,

availability of quality data is limited by a lack of data collection beyond that of federal buildings. Continuous efforts to further expand the data collection coverage and improve data quality would help the government improve the effectiveness of its efficiency policies. As an example, the electricity commission CFE reports to SENER all medium voltage consumers as “medium industry” although many of them correspond to commercial and public buildings of all types.

Energy efficiency standards have delivered considerable energy savings to Mexico and these standards should continue to be regularly updated and expanded. Based on experience in IEA countries, MEPS are among the most effective and cost-efficient energy efficiency policy instruments. However, in terms of buildings energy codes and standards, a greater effort is needed to ensure their adoption and enforcement at local level.

Transport

In the transport sector, Mexican car manufacturers have two different energy efficiency standards, whereas the standard bringing most benefit to society is used for export only. Harmonisation of these standards would benefit the Mexican society both environmentally and economically. Furthermore, the existing standard for light-duty vehicles should be complemented with other fuel economy actions such as a mandatory heavy-duty vehicle standard, fuel quality regulations, as well as a regulation to reduce and control second-hand vehicles coming from the United States.

At present, Mexico does not have an energy efficiency label for vehicles. The Energy Efficiency Commission has a considerable amount of fuel use data of different car types at its disposal, and publishes these on its website. It would be relatively easy to develop a labelling system – provided that car manufacturers were to co-operate with such an initiative – which could be overseen by three ministries: Economy, Environment and Natural Resources, Energy. This would enable consumers to make their choices more easily and better informed.

Buildings

Given the limited resources available to the government, maximising the impact of the existing regulatory frameworks, such as standards for buildings components, will be of great importance. While the government is in charge of setting standards, states and municipalities are in charge of adopting and enforcing buildings energy codes. Mandatory standards exist for buildings components, including envelopes, but they have not been sufficiently enforced, owing to lack of awareness of efficiency, institutional resources and capabilities in states/municipalities, and their communication with the federal government. Buildings energy codes, which are enforced at the local level, could also be used much more ambitiously to improve energy efficiency. Current efforts by the federal government to develop a model of buildings energy codes that incorporates current standards should be an important step to this end.

In addition to such efforts, the infrastructure for standards enforcement needs to be strengthened. For example, buildings components that are part of walls, roofs and windows have standards but there are currently no testing laboratories, with the first laboratory to be set up by the end of 2016.

In addition to standards, other important aspects to consider are negotiation and funding mechanisms among authorities and developers to facilitate energy efficiency technological improvements in housing. Because of the usually high price of housing in Mexico, where a low-income housing costs approximately USD 200 000, the technology to improve energy efficiency would entail a relatively small additional cost of USD 2 000.

Industry

In the industry sector, the government's efforts to introduce voluntary energy management systems are commendable and should be further accelerated by increased technical support and energy audits, together with adequate incentives and regulations. With regard to FIDE's Eco Business Credit programme, it is unclear whether or not the threshold used in the programme is set in a way that ensures that replaced equipment represents optimal saving potential for SMEs. Additional evaluation tools could be developed to optimise the use of resources, but further data collection capabilities would be needed.

As regards the current focus on motors in the industrial sector, one should note that using the best available motors will typically save only about 4% to 5% of all electric motor consumption, leaving more room for efficiency gain by expanding coverage of the standard to the whole motor system.

The influence of electricity subsidies

Subsidies on electricity cover up to between 60% and 70% of the total cost in certain residential tariff categories. Artificially low electricity prices are likely to hamper government efforts to pursue efficiency; they should be replaced by targeted social policy measures for those in need. Abolishing electricity subsidies would bring multiple benefits. A gradual phase-out of electricity subsidies would help suppress the wasteful use of electricity, in particular in the residential and agricultural sectors. It would serve to increase consumers' awareness of efficiency and provide better price signals to justify efficiency investments. It would also encourage consumers to buy more efficient products. Phasing out subsidies would also have positive environmental and budgetary impacts. According to an analysis by the Energy Efficiency Commission, the full adoption and implementation of NOM-020 (thermal gains) in households in warm climate zones could save the government around MXN 179 million per year in avoided electricity subsidies. It would also help prepare ground on which ESCOs can grow.

The Electric Industry Law establishes new rules for determining tariffs, where the CRE now has the competence to issue and apply methodologies for determining the calculation and setting regulated tariffs for the following activities: transmission and distribution services, operation of the suppliers of basic services, as well as final rates of basic supply. For a transition period, however, the Ministry of Finance maintains the right to override the Energy Regulatory Commission's tariffs, which has been the case for most tariffs (especially for residential and agricultural customers).

Recommendations

The government of Mexico should:

General

- ☐ Enhance demand-side data collection in order to inform policy and programme decisions.
- ☐ Formulate a quantitative efficiency target and strategy, consistent with climate targets, to mobilise government resources and capabilities and monitor its progress on an annual basis.
- ☐ Phase out electricity subsidies to provide the right price signal for energy efficiency.
- ☐ Consider establishing a dedicated energy efficiency fund and other market-based mechanisms to trigger greater private-sector financing and support the development of an energy services market in Mexico.

Transport

- ☐ Harmonise energy efficiency standards for light-duty vehicles with the more stringent US federal standards.
- ☐ Set a timeframe for introducing heavy-duty vehicle efficiency standards.
- ☐ Consider introducing an air quality or CO_2 emissions-related energy levy connected to the purchase of cars.
- ☐ Introduce, in co-operation with car manufacturers, an energy efficiency or CO_2-related labelling system for passenger cars.

Buildings and appliances

- ☐ Enhance the adoption of buildings energy codes and standards for building components (e.g. building envelope, including insulation and windows), through better co-ordination, support and enforcement between federal and local governments, as well as through awareness campaigns.
- ☐ Consider for the current FIDE stamp programme to introduce a rating geared towards identifying “top-tier” appliances.

Industry

- ☐ Enhance technical support and consider financial incentives, including tax credits and market-based mechanisms, for heavy industrial consumers of energy to implement energy management systems and conduct energy audits.
- ☐ Strengthen the financial incentives for SMEs to optimise the cost-benefit relation of the Eco Business Credit programme by:
  - > introducing targeting criteria
  - > enhancing targeted efforts to disseminate best practices to increase awareness.
- ☐ Consider updating and expanding the coverage of current efficiency standards for motor-driven systems.

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5. Oil

Key data

(2015 estimated)

Crude oil and NGL production: 126.5 Mt, - 33.9% since a peak in 2004.

Crude oil exports: 61.2 Mt, -41.8% since 2004

Oil products net imports: 23 Mt (imports 33 Mt, exports 10 Mt), +118% since 2004

Share of oil: 48.1% of TPES and 10.2% of electricity generation

Supply by sector (2014): 96.4 Mtoe (transport 54.9%, energy other than power generation 12.2%, industry 12.1%, power generation 9.3%, residential 6.5%, commercial and public services and agriculture 4.8%)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Overview

Oil has been historically important in Mexico. The Constitution of 1917 announced that the Mexican subsoil and its contents belong to the state. Early involvement of foreign investment in exploration and production resulted in Mexico becoming the world's second-largest oil producer in the 1920s.

In 1938, President Lázaro Cárdenas announced the nationalisation of the oil sector and the creation of Petróleos Mexicanos (PEMEX), the national oil company with a monopoly over the industry. Subsequently, PEMEX became a symbol of national pride and oil came to be perceived as a national treasure.

Since then, until the enactment of the 2013 energy reform, PEMEX remained the sole operator in the Mexican oil sector. The energy reform changed the status of PEMEX into that of a "state productive enterprise" and maintains the Mexican state's exclusive hydrocarbons ownership but now allows the oil industry to be strengthened with the participation of private and foreign companies.

Around half of total primary energy supply (TPES) in Mexico comes from oil, making it by far the most important fuel in the energy mix, which for the foreseeable future will remain important for national energy supply as well as government revenue. Over the last decade, a distinct downward trend of crude oil production and total reserves was one of the main triggers of the 2013 energy reform. In view of the unsustainable trends, the ongoing thorough transformation was needed in order to ensure the optimal and continuous development of Mexico's oil resources.

Reserves, supply and demand

Reserves

Mexico has a significant remaining resource potential amounting to 37 405 million barrels of oil-equivalent (mboe) of proven, probable and possible (3P) reserves, and proven reserves (1P) of 13 017 mboe. The reserve-production ratio of crude oil equivalent[1] in 2015 for 3P reserves is 29 years and 10 years for 1P (PEMEX, 2015).

Table 5.1 Oil reserves and cumulative production, 2015 (mboe)

	1P	2P	3P	Cumulative production
Northeastern marine	6 012	8 374	11 532	21 091.5
Southwestern marine	2 227	3 736	6 001	8 666.3
North	1 520	6 893	14 911	9 667.2
South	3 258	3 980	4 961	18 080.7
Total	**13 017**	**22 983**	**37 405**	**57 505.7**

Note: mboe = million barrels of oil-equivalent.

Source: CNH (2015), "Reserves report 2015", http://cnh.gob.mx/informacion/docs/2.%20Reporte_reservas_agregada_activo_2015.pdf.

Supply

Oil is the largest energy source in Mexico, representing 48.1% of total primary energy supply (TPES). Oil supply totalled 90.1 million tonnes of oil-equivalent (Mtoe) in 2015, which is 6.6% lower than a year before. Supply peaked at 102.6 Mtoe in 2012 and has fallen each consecutive year since. Oil supply was 10% lower in 2015 than ten years before (2005).

Crude oil and NGL

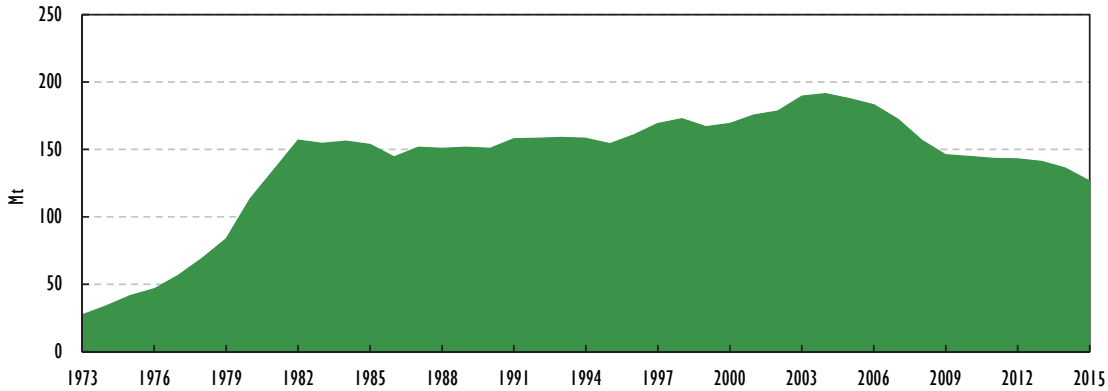
Mexico's crude oil production is estimated at 117 Mt in 2015, declining for 11 years since the peak of 178.3 Mt in 2004, because of depleting resources and lack of investment in exploration and production activities. Production declined sharply from the peak to 2009, falling by 24.2%, after which it plateaued to 2012, followed by another three years of sharp decline (Figure 5.1). Overall, crude oil production was 33.2% lower in 2015 compared to the peak.

Mexico also produces natural gas liquids (NGL) and additives/oxygenates with production of 9.5 Mt during 2015. NGL and additives/oxygenates production has declined by 26.9% since 2004.

[1]. Relation between the remaining reserves at 1 January 2015 and the production of 2014.

Total production of crude oil, NGL and additives/oxygenates came to 126.5 Mt in 2015, representing around 63% of the total energy production of the country. The crude mix was 52.1% heavy oil; 35.6% light oil and 12.3% extra-light oil. Crude oil is mainly produced in offshore fields (75%), such as the Ku-Maloob-Zaap and Cantarell fields (heavy oil) and the Tabasco field (light oil). Yet, Mexico remains the fourth-largest producer in the Americas after the United States, Canada and Brazil.

Figure 5.1 Crude oil production, 1973-2015



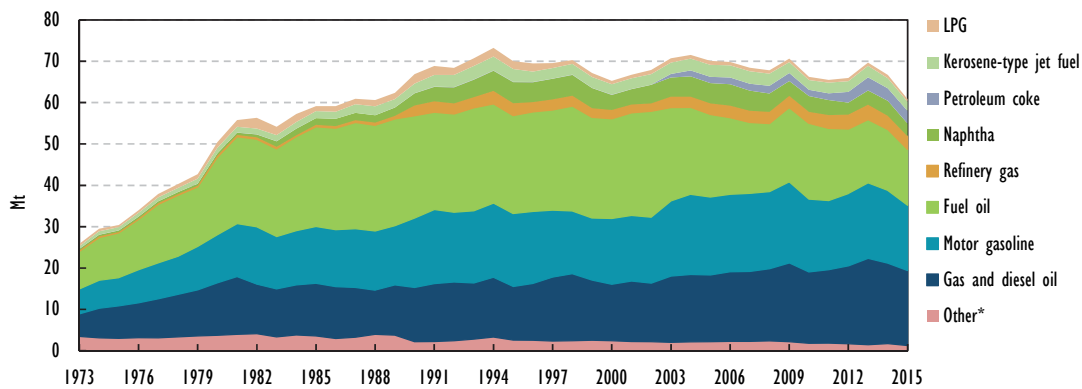
Note: Data for 2015 are estimated.

Source: IEA (2016a), *Oil Information 2016*, www.iea.org/statistics/.

Oil products

In 2016, the domestic refinery output was 60.9 Mt, made up of gasoil and diesel oil (29.8%), motor gasoline (25.9%), fuel oil (22.2%) and various other products. Mexico's refinery output peaked at 73.2 Mt in 1994 and has experienced a number of production cycles since (Figure 5.2). During 2004, output was at a local high of 71.5 Mt, followed by a downturn to 67.8 Mt in 2008 and an upswing to 70.6 Mt in 2009. In the two years since 2013, output has fallen by 12.7%, to the lowest level since 1988. PEMEX refineries typically operate at 66% of capacity.

Figure 5.2 Refinery output by oil product type, 1973-2015



* *Other* includes ethane, aviation gasoline, gasoline-type jet fuel, other kerosene, white spirit, lubricants, bitumen, paraffin waxes and other non-specified oil products.

Source: IEA (2016a), *Oil Information 2016*, www.iea.org/statistics/.

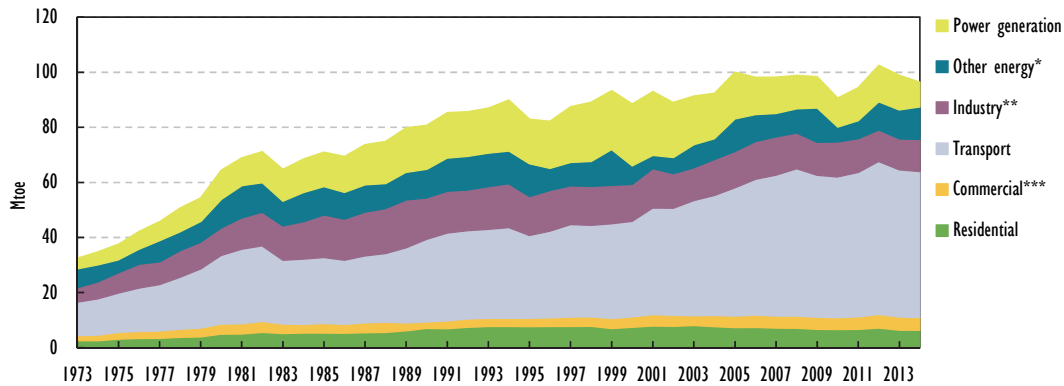
Demand

The transport sector consumes the majority of oil in Mexico. The sector accounted for 54.9% of total oil demand in 2014[2], while oil use in refineries (and other transformations including energy own-use) and in the industry sector represented 12.2% and 12.1% of demand, respectively (Figure 5.3). The remaining 20.7% was made up of the power generation sector (9.3%), the residential sector (6.5%), and commercial and public service and agriculture (4.8%).

Oil demand in transport has been growing for decades and was 21.6% higher in 2014 than in 2004. Demand from the commercial and public services sector has also risen steadily, finishing 14% higher over the same period. Conversely, demand from the residential sector, industry and power generation shrank during 2004-14. The power generation sector reduced oil use by 45.7% over the ten years, switching to natural gas; households cut back by 17.4% while industry use was 10.3% lower. Demand in refineries averaged 9.6% of total oil consumption during this period.

Because of transport and commercial sectors' strong demand growth, and a reduction in oil use in other sectors, the sectoral share in total oil consumption has changed notably since 2004. In 2004: transport accounted for 45.8%, the power generation sector for a 19.4% share, industry for 13%, refiners and other transformations for 9.2%, households for 8.8% and the commercial sector for 3.8%.

Figure 5.3 Oil supply by sector, 1973-2014



Notes: TPES by consuming sector.

* *Other energy* includes refineries and energy own-use.

** *Industry* includes non-energy use.

*** *Commercial* includes commercial and public services, agriculture/fishing and forestry.

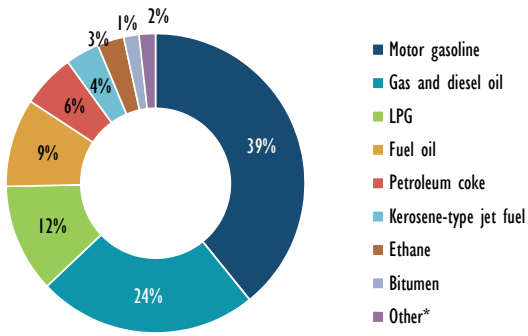
Source: IEA (2016b), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Motor gasoline, diesel and gas oil are the most widely used oil products in Mexico, accounting for 39% and 24% of total oil products consumption, respectively (Figure 5.4). LPG and fuel oil represent 12% and 9% respectively, while petroleum coke, kerosene-type jet fuel, ethane and bitumen account for another 14%. The small remainder is made up of naphtha, lubricants, other kerosene, paraffin waxes, aviation gasoline, gasoline-type jet fuel, white spirit and other non-specified oil products. Since 2004, the product

[2]. The latest year for which consumption data are available is 2014.

mix consumed in Mexico has also changed, led by the decline in the use of fuel oil owing to the ongoing shift to gas in power generation. Demand for motor gasoline and gas and diesel oil increased by 22% and 28.9%, respectively, over the same period.

Figure 5.4 Oil consumption by product, 2014



* *Other* includes naphtha, lubricants, other kerosene, paraffin waxes, aviation gasoline, gasoline-type jet fuel, white spirit and other non-specified oil products.

Source: IEA (2016a), *Oil Information 2016*, www.iea.org/statistics/.

Trade

Mexico is a significant crude oil exporter, with exports of 61.2 Mt in 2015, down from a peak of 105.2 Mt in 2004. This decline, in combination with the low oil price, has led to a steep reduction of Mexico's oil trade surplus, which in 2015 reached a low of USD 336 million, down from USD 26 billion in 2008. Mexico mainly exports crude oil to the United States (60% of total exports in 2015), with the remainder destined for Spain (14.1%), India (9.4%), Korea (4.1%), Japan (4%) and other countries (8.5%). No exports to Canada are expected for 2015, for the first year in decades; they averaged around 15% to 18% of total exports during 2004-14.

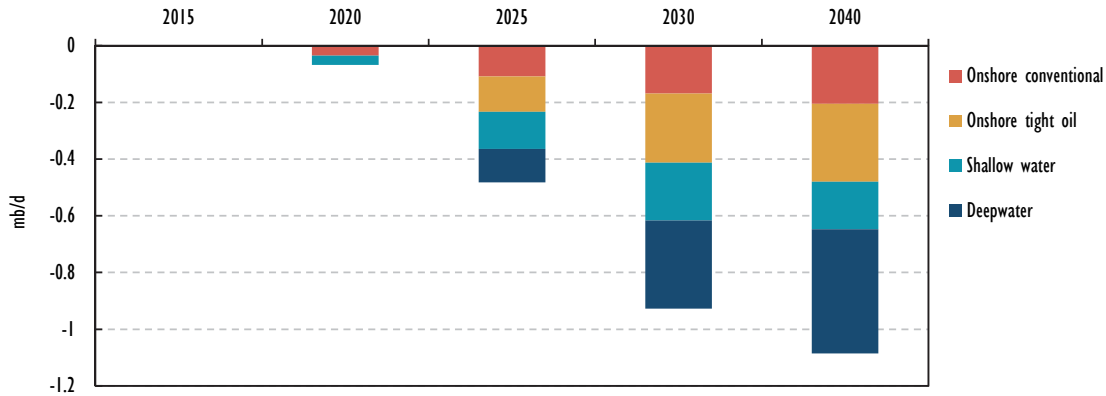
Despite its significant crude oil exports, the country is a net importer of refined oil products, with imports growing at 3% per year since 2010, reaching 23 Mt of refined products in 2015. Mexico imported 0.4 Mt of additives/oxygenates in the same period, 78.9% more than in 2004. The main refined products imported are gasoline (64%) and diesel (22%), essentially from the United States. Oil products trade is increasing over time, with both imports and exports growing; imports increased by 129% during 2005-15 while exports, primarily of naphtha and fuel oil, grew by 161% to 10 Mt. The majority of the oil products imports are from the United States (89.8% in 2015), with 8% sourced from the Netherlands and the remaining 2.1% from other regions.

Outlook to 2040

In order to quantify the impact of the reform on the Mexican energy sector, the *World Energy Outlook Special Report on Mexico* (IEA, 2016) includes a scenario of oil production in Mexico under a hypothetic "No Reform Case", for which the reform is wound back and pre-reform trends are resumed. In such a scenario, the crucial difficulty for PEMEX is that, particularly in the early years of the projection, it is caught in a spiral of lower prices and falling production that severely limits the capital available to fund expansion and enhanced recovery projects in legacy fields, and delays the start of technically challenging deep-water and tight oil development projects. By 2025, production in a No Reform Case is around 500 thousand barrels per day (kb/d) less than

under full implementation of the reform: the largest difference is in shallow-water areas, where heavy oil projects are delayed and investment in enhanced recovery programmes is crimped (Figure 5.5).

Figure 5.5 Oil production in the "No Reform Case" relative to full implementation of the reform



Source: IEA (2016c), *World Energy Outlook, Special Report on Mexico.*

The lower oil output would have strong repercussions for the national oil balance. Oil demand is similar in the No Reform Case, but oil production is hit hard and crude export revenue falls by almost half, meaning that the oil trade balance deteriorates sharply. Funds for refinery investment are limited, meaning that the capacity modernisation envisaged with the reform implementation fails to materialise to the same extent and refinery runs remain at around the current level. In essence, thanks to the energy reform, Mexican oil production promises to be 1 million barrels higher in 2040 than without implementation of the reform. The cumulative value of the additional oil output over the projection period amounts to around USD 650 billion, while cumulative additional upstream investment amounts to some USD 260 billion.

Institutions

The **Ministry of Energy (SENER)** is in charge of developing the national energy policy, including downstream, midstream and upstream. As regards upstream, SENER determines areas for public bidding and arranges their allocation and schedule, proposes the model of contract that applies to each, and determines the non-fiscal terms of the contract. Regarding mid- and downstream, SENER issues permits for refinery and gas processing as well as for import and export of refined products and natural gas. SENER is in the process of preparing a stockpile public policy which aims to reinforce energy security in the country.

The **National Hydrocarbons Commission (CNH)** is in charge of establishing upstream regulation, conducting and managing contracts of exploration and production activities, overseeing the industry, and interfacing with PEMEX, the state oil company, and private companies granting allocations and contracts. CNH collects, protects, uses, manages and upgrades the information on exploration and production activities.

The **Energy Regulatory Commission (CRE)** regulates all activities with regard to pipeline transportation and storage, mainly in setting their tariffs. CRE also determines the prices of first-hand sales of hydrocarbons and petroleum.

The **Ministry of Finance (SHCP)** is responsible for establishing the fiscal terms to apply to each contract for developing the upstream oil industry.

The **Federal Economic Competition Commission (COFECE)** monitors the effective development of competition across all processes of the oil industry, issuing recommendations on improvements, which other institutions are obliged to take into consideration and to report on the extent of their implementation.

Petróleos Mexicanos (PEMEX) since the implementation of the energy reform has changed from a national oil company to a *state productive enterprise* with fully integrated operations in exploration and production, refining, distribution, retail, and petrochemicals. It remains the largest oil company in Mexico.

Currently, PEMEX operates through the following subsidiaries and companies: PEMEX Exploration and Production, PEMEX Industrial Transformation, PEMEX Ethylene, Fertilizers, Logistics, Drilling and Services, Cogeneration and Services, PMI Comercio Internacional S.A de CV (a subsidiary company) and other subsidiaries related to PMI.

PEMEX's subsidiaries can be categorised in two types: *i) subsidiary productive entities* of PEMEX that are decentralised agencies established by the federal government, and *ii) subsidiary* companies that have been created under the new regulatory framework, they are considered as private companies with a participation by PEMEX of more of their 50% of their social capital.

The **Mexican Petroleum Institute (IMP)** is an applied research centre aimed at developing technologies for the petroleum industry and providing knowledge and training for specialised human capital. The Institute also provides support to PEMEX in finding hydrocarbons and new oilfields, producing fuels under environmental specifications, and training its human capital.

The **National Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector (ASEA)** is in charge of regulating and monitoring industrial safety and operational security concerns related to the hydrocarbon sector, and controls waste and emissions resulting from the decommissioning and abandonment of facilities. ASEA is supervised by the Ministry of Environment and Natural Resources (SEMARNAT).

Government policies

The ongoing energy reform is starting to open what until 2013 was one of the most restrictive legal frameworks for oil investments in the world. While maintaining the deeply engrained concept of state ownership of hydrocarbons, the new legal framework empowers the state, for the first time in decades, to establish and grant contracts to attract foreign investment in exploration and production (E&P) with different forms of contracts corresponding to different risks. All contracts will be awarded through bidding processes of identified areas, defined in a five-year plan established by the Ministry of Energy. The fuel market will be opened to competition as prices will be gradually

liberalised during 2017. Areas which had so far been reserved for PEMEX, namely imports and distribution, have already been opened to private companies.

Upstream: Legal framework

The **Hydrocarbons Law (LH)** considers E&P activities of social interest as having precedence over any other activity involving the use of soil or subsoil of the land affected by these activities. This law regulates all upstream activity related to the recognition, exploration and production of hydrocarbons. Within this legislation, SENER can put on offer four different contract types:

- production-sharing agreements
- licensing
- service contracts
- profit-sharing agreements.

Although ownership of hydrocarbons continues to be reserved for the state, contracts do allow private companies to book reserves for accounting purposes, an important precondition for their involvement, facilitating project financing. Joint ventures (that are established in partnership with PEMEX), farm-outs and migration of existing service contracts are additional vehicles, but the launch of these has been relatively slow as all institutions involved have had to learn the new process by doing, and low oil prices have increased the challenges involved.

The Hydrocarbons Law establishes that E&P contracts will be awarded through a bidding process conducted by CNH and based on the five-year bid plan for exploration and extraction of hydrocarbons 2015-2019 (see below under National Plans and Strategies).

Furthermore, the **Law of Coordinated Energy Regulatory Agencies (LORCME)** co-ordinates and regulates the organisation and operation of CNH and CRE as the regulatory agencies of the energy sector. With regard to the oil sector, the law grants CNH responsibilities in upstream activities, such as:

- Regulating and supervising the recognition and surface exploration, as well as exploration and extraction of hydrocarbons, including collection from points of production and their integration into the system of transport and storage; launching bid rounds for E&P in hydrocarbons fields and sign contracts to perform E&P activities.
- Managing the technical assignments and contracts for E&P of hydrocarbons.
- Providing technical advice to SENER.

SENER can grant and modify assignments to recognise and carry out surface exploration, and E&P activities, either by PEMEX or any other assignee that should be a subsidiary productive enterprise. With SENER's authorisation and CNH's opinion, assignees can transfer or give up assigned areas, and sign contracts only with private companies.

CNH is empowered to sign contracts for E&P activities in order to formalise them between PEMEX and other companies, individual or in consortium. The assignee may request from SENER the transfer of allocations related to contracts for performing E&P activities.

The **Hydrocarbons Revenues Law** establishes the fiscal terms for E&P activities through assignments and contracts whereby the state receives a percentage of the revenue derived from the hydrocarbons production, as defined in each contract[3], the payment of which will be through the **Mexican Petroleum Fund (FMP)** that receives all incomes from E&P activities in the country, and is regulated according to the **Law of the Mexican Petroleum Fund for Stabilization and Development.**

The **PEMEX Law** regulates all functions undertaken by the state productive enterprise PEMEX along the hydrocarbons production value chain. For upstream activities, the law stipulates that PEMEX may perform E&P activities in the following cases: *i)* if the activities are conducted under an assignment, PEMEX will act through one or more subsidiary productive entities; *ii)* if the activities are performed under a contract for E&P activities, then:

- When PEMEX performs E&P activities exclusively, without any association or alliance with third parties, these activities must be performed through one or more *subsidiary productive companies*.
- When the activities are planned in association or alliance with third parties, PEMEX can do this through the creation or participation in *subsidiaries*, other corporative societies or any other allowed association, accordingly to all applicable regulations mentioned in the law.

Mid- and downstream: Legal framework

According to the **Hydrocarbons Law**, SENER will be in charge of authorizing permits for oil treatment and refining, as well as for trading hydrocarbons and petroleum products. In addition, CRE will authorise licences for transportation, storage, trading, distribution and retail sales, and at the same time promote competition in the sector.

Furthermore, the Hydrocarbons Law assigns SENER with responsibility for devising policies concerning minimum oil, gas and products storage levels in order to safeguard national security of supply. Aspects to be addressed include regulatory best practices, minimum inventory requirements for wholesale traders, estimated strategic inventory costs, and the potential for national strategic reserves.

For transport by oil pipeline, PEMEX assets have been moved into the newly founded subsidiary PEMEX Logistica. The regulator CRE will assess requests and permits for transporting and distributing oil products on a case-by-case basis, and holds dispute resolution authority. How this works in practice will be driving the pace of further infrastructure development – for oil, products and natural gas. An important factor in ensuring a healthy and competitive market will be the effective regulatory control of the prohibition to disclose information from PEMEX Logistica to other parts of the integrated company.

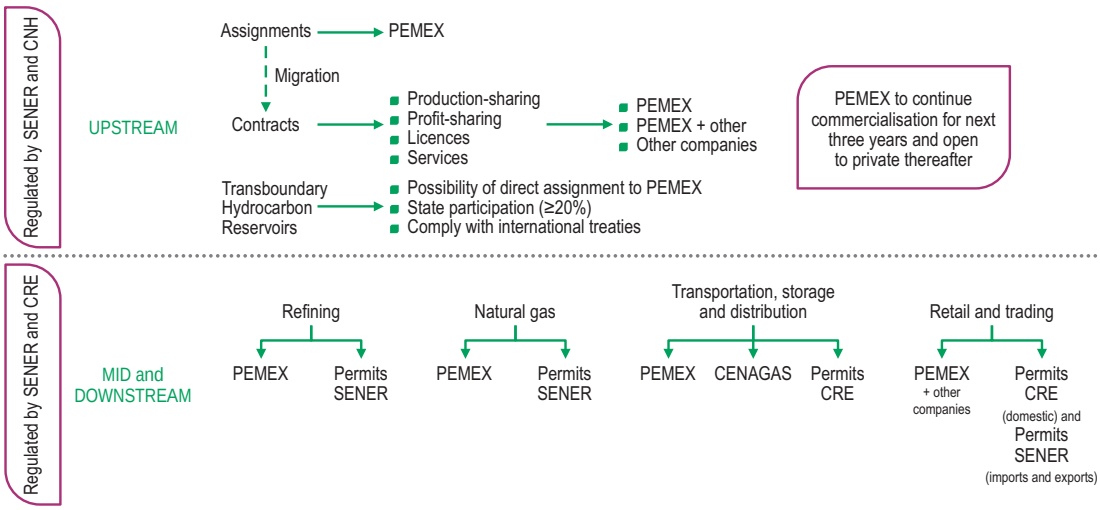
The PEMEX Law also specifies that PEMEX may carry out such activities as refining, transformation, transportation, storage, distribution, commercialisation, retail, exports and

[3]. Additionally, assignees should pay the right of sharing revenue at a rate of 65% of the difference resulting from reducing the value of hydrocarbons extracted during a year; the assignee is also obliged to pay monthly *a)* the right to extract hydrocarbons and *b)* the exploration rights for each area that is not in production.

imports of oil and hydrocarbons. On the other hand, the law allows the company to develop engineering projects, research and geologic activities, supervision and provision of services to third parties, but also the mid- and downstream activities performed by subsidiary companies, including marketing activities.

For its part, the **Foreign Investment Law** authorises foreign companies to commercialise gasoline, supply fuels and lubricants for transportation systems like ships, airplanes, and to build pipelines for oil transportation, and drilling.

Figure 5.6 Oil industry organisation



Source: IEA, adapted from a PEMEX presentation to the review team.

The services provision to the mid- and downstream activities of the hydrocarbons industry will require an integrated infrastructure system[4] that interconnects the transportation and storage facilities and that obliges them to operate under the same tariff scheme while facilitating their operation among different facilities. Only oil and petroleum products that have been transported, stored and sold by permit holders can be legally traded.

Furthermore, the providers of transportation and distribution services through pipelines and storage of oil products have to offer open access to their facilities and services, subject to their systems capacity. In addition, providers may make public the capacity that is not engaged or is not used to allow third parties to use it. The capacity will be published in electronic newsletters and will be managed by any interconnected system or an independent shipper duly qualified by CRE.

All mid- and downstream service providers performing activities for the oil industry are obliged to give open access to third parties. In this regard, CRE has issued a general regulation providing open access to PEMEX's transport and storage infrastructure. As long as PEMEX holds a dominant market position, the company will be subject to rules

[4]. An integrated infrastructure system as defined in the Hydrocarbons Law should be operated by an independent "manager" authorised by CRE. The manager will co-ordinate all authorised companies of a specific integrated system. A manager could be a public or private entity, or a public-private partnership in which the authorised companies of a specific integrated system can participate.

different from those of other firms operating transport and storage infrastructure – referred to as "asymmetric regulation".

In addition, PEMEX Logistica is required to provide open access to its transport and storage facilities through "open season offers of capacity. Until 2019, the transport and storage capacity assignments will consist of a 90% and 10% arrangement for contract carriers and common carriers respectively; as of 2020 this proportion will be set according to market competition.

Furthermore, the new regulation specifies three main types of usages: own-use (the capacity required by the operator to fulfil its obligations); reserved capacity (that resulting from open seasons); and common use (capacity that, if available, may be granted to a potential user at short notice). PEMEX's spare infrastructure capacity will be considered as common use.

Implementation

Mexican oil policy mainly derives from three national strategies: the National Development Plan, the Sectoral Energy Program, and the National Infrastructure Program. These plans are linked and aim, under the reform legislation, to strengthen the development and enhancement of the oil sector. In addition, exploration and extraction activities are performed according to the five-year plan that establishes bidding areas to be assigned in different bidding rounds. Fuel-pricing regulation (including an interim regulation through 2018), competition and anticorruption measures are important elements to achieve milestones throughout the oil value chain.

National plans and strategies

The **National Development Plan (NDP)** sets the general national goal "México Prospero" objective 4.6 of supplying "*the country with competitive process, quality and efficiency throughout the production chain"*, including the related strategy of "e*nsuring supply of crude oil, natural gas and petroleum demanded by the country".* This translates into the government's efforts at expanding the capacity in E&P activities, strengthening PEMEX, increasing reserves and raising their recovery rate (Gobierno de la República, 2013).

The **Energy Sectoral Program (PROSENER)** establishes further specific objectives and strategies to *optimise the production capacity and hydrocarbons processing*, through efficient and competitive processes; *develop the transportation infrastructure to strengthen energy supply security*, aiming to expand and enhance the industry, and contribute to economic growth (SENER, 2013). In addition, the **National Infrastructure Program 2014-2018 (NIP)** contains objectives, strategies and projects in infrastructure for priority sectors. In the energy sector, the NIP seeks to "ensure optimal development of infrastructure to provide sufficient power supply at competitive prices" (Presidencia, 2014). During the period, 262 projects are planned in the energy sector, particularly for improving and strengthening the two state productive enterprises: CFE and PEMEX.

With respect to PEMEX, the NIP considers the development of 129 projects with an investment of MXN 3.367 trillion (164.6 billion USD) to develop infrastructure for E&P activities in proven reservoirs; ensure the infrastructure for seismic studies development; implement best practices to manage declining production by applying secondary

recovery methods; manage resources to ensure the availability of equipment, products and supply materials for the extraction of hydrocarbons and conduct bidding rounds for allocating E&P areas in order to attract complementary investment.

The investment is divided into the following strategies, according to their implementation area (upstream, mid- and downstream):

- **Upstream:** Expand and develop existing infrastructure for E&P activities. Investment: MXN 2.426 trillion (USD 118.6 billion, 73% government, 27% private).
- **Midstream:** Increase and adapt the transformation process capacity of hydrocarbons for ensuring the supply and maximising the economic value. Investment: MXN 636 billion (USD 31 billion, 78% government, 22% private).
- **Midstream:** Boost the national petrochemical industry. Investment: MXN 50.4 billion (USD 2.4 billion, 74% government, 26% private).
- **Mid- and downstream:** Boost the development of fuels transportation and storage systems. Investment: MXN 227.2 billion (USD 11.1 billion, 25% government, 75% private).

It is worth noting that the main average investment (72%) is allocated to E&P activities. The NIP establishes indicators in order to track progress in implementation, including the upstream target of increasing crude oil production from 2.5 million barrels per day (mb/d) in 2013 to 3.0 mb/d in 2018 (SHCP, 2014).

With respect to the bid rounds, the **Five-year plan for exploration and extraction of hydrocarbons 2015-2019** (the Five-year plan) is a planning document which provides a basis for defining the hydrocarbons exploration and extraction areas to be put up for bids in rounds through contract schemes. This Plan is aligned with the National Development Plan 2013-2018 and the Energy Sectoral Program (PROSENER), and contains three main goals: *i)* maximise the participation of companies in the bidding processes, *ii)* increase the hydrocarbons industry's investment and production, and *iii)* increase the reserve replacement ratio and contribute to the generation of geologic information (SENER, 2015).

Bid rounds

The bidding mechanism foresees that contractors are selected on the basis of a first-price sealed-bid public auction with two bidding variables: contractual payment to the government and the increase over mandatory work programmes (see bid round guidelines published in the *Federal Gazette* in November 2014) (DOF, 2014). This is to guarantee that the definitive government take is set through a transparent and competitive process. The Ministry of Finance defines a reserve price before the bid to ensure that the nation receives a minimum take of the resource rent. The reserve price is defined on a project basis, taking into consideration the resource type and international benchmarks of government take.

Currently, the Five-year plan foresees the tendering of 333 areas, 96 of which refer to exploration projects (72 of conventional resources, and 24 of unconventional ones), and

237 related to the development of oilfields: 169 located in land areas, 12 in Chicontepec province,[5] 13 fields of extra-heavy oil; 39 in shallow water; and 4 in deep water (see Table 5.2). The five-year plan will be revised and updated on a yearly basis taking into account the market's economical and technical conditions, and also feedback obtained from the private sector and local governments.

E&P contracts require a minimum national content, which will gradually grow until reaching a national average of 35% within a scope of 10 years starting from 2015. The requirement considers that both personnel and physical infrastructure expenditure is set specifically for each field. For example, for deep-water developments, in the initial exploration period the national content requirement is three (3%), six (6%) for the first additional exploration period and eight (8%) for the second additional exploration period. Over time, the minimum requirements are expected to increase.

In the case of cross-border reservoirs, a mandatory 20% participation by PEMEX is required regardless of whether the state productive enterprise is the operating contractor or not. All contractors are required to submit information from their surveys and E&P activities to the Hydrocarbons Regulatory Commission (CNH). The submitted information will be treated as confidential.

The contracts also include a rescission clause that is not predicated on "gross negligence" as no legal definition of the term exists in Mexico.[6] They also include corporate guarantees to cover for potential failure to perform any contractual obligation that under certain circumstances may be capped. Under the different contract models, an average government take of 50% to 75% would fall within the spectrum of what the industry considers internationally competitive. By way of comparison, government take is 78% of net profit in Norway and 75% in Colombia (Samples, 2016).

Table 5.2 Bidding areas, their resources and surface area, by type of activity

Type of upstream activity	Bidding areas	Resources (mboe)	Area (km^2)
Extraction	237	65 944.50*	7 604.20
Exploration conventional	72	13 568.10**	192 635.60
Exploration unconventional	24	25 276.00**	34 830.10
Total	**333**	**104 788.60**	**235 069.9**

Note: mboe= million barrels of oil equivalent; km^2 = square kilometres; * = remaining resources; **= prospective resources.

Source: SENER (2015), "Five-year bid plan for exploration and extraction of hydrocarbons 2015-2019".

[5]. Chicontepec province represents 64% of the original volume remaining, which is 65 944.5 mboe.

[6]. The Hydrocarbons Law, Art. 20 HL, defines the following potential causes for administrative rescission:
- Contractor fails to commence activities for more than 180 days or suspends such activities for 180 days without just cause or authorization.
- Failure to comply with the minimum work program without just cause.
- Assigns all or a portion of the rights pursuant to the contract without prior authorization.
- Serious accident occurs as a result of the willful misconduct or fault of the contractor which causes *i)* damage to the facilities, *ii)* fatality, and *iii)* loss of production.
- The contractor provides in more than one occasion, willfully or without just cause, false or incomplete information or reports, or fails to disclose them to the authorities.
- Failure to comply with a final resolution of federal courts relating to the contract.
- Failure to make any payment or delivery of hydrocarbons to the state, in accordance with the periods and terms established.

According to the five-year plan, in addition to the Round Zero, four bidding rounds could be carried out in the period from 2015 to 2019, for a total volume of remaining resources of 65 944 mboe, and 38 844 mboe of prospective resources, totalling 104 788 mboe.

The tender areas are classified according to the type of activity (exploration or extraction) and categories: onshore (conventional and unconventional), shallow water (including heavy and extra-heavy oils) and deep water. Exploration areas are grouped by oil province and content area according to conventional and unconventional resources. To date, Round Zero and two additional bidding rounds have been released with the following final and partial results.

Round Zero

Round Zero was the initial step of the energy reform through which SENER, with assistance of CNH, assigned exploration and production areas of oil and gas to PEMEX. Round Zero aimed at endowing PEMEX with resources to ensure production levels and, as a result of the energy reform, PEMEX can seek out a partner through a farm-out procedure to increase investment in E&P activities in border and unconventional fields.

On August 2014, SENER granted PEMEX proved and possible reserves (2P) amounting to 20 589 mboe, 100% of the amount requested by PEMEX. In terms of prospective resources, PEMEX received 23 447 mboe, 68% of the requested amount. With these allocations, PEMEX accounts for 83% of 2P reserves and 21% of prospective resources of the total national resources. On the basis of an average production of 2.5 million mb/d), this would be sufficient to sustain production for the next 20.5 years.[7]

Round One

Round One was announced in December 2014, presenting four calls for bids, three of which have been concluded. According to the five-year plan, it initially included 109 exploration blocks and 60 extraction fields with a total area of 28 500 km2. Overall, the estimated investment for Round One, including PEMEX's farm-outs, is USD 12.6 billion per year from 2015 to 2018.

The first call for bids included 14 areas for exploration and production in shallow waters, but only two were awarded. This outcome was attributed to the low oil price, the nature of the fields on offer and the uncertainty added by the fact that the minimum state requirements, set by the Ministry of Finance for each field, were announced only after participants had made their offers. This aspect of the bid procedure led to several bids missing the minimum by only a small margin and to fields remaining unawarded despite receiving bids. Subsequently the procedure was changed in that the Ministry of Finance will announce minimum state take for each field in advance, so that participants can take this into consideration when making their offers. The second bid comprised five fields located in shallow waters of the Gulf of Mexico in the southeastern basins. It received 15 valid offers and allocated 67% of the contracts in competition. The winners were ENI International, a consortium formed by Fieldwood and Petrobal, and a consortium formed by Pan American Energy and E&P Hidrocarburos.

[7]. The 20.5 production years represent 15.5 years of production of the total amount of 2P reserves allocated, and 5 years of production of the prospective resources approved.

The first oil production from the first and second bids of Round One is expected for early 2018. The third bid included 25 contractual areas in three different onshore production regions: Burgos, Norte and Sur basins corresponding to hydrocarbons extraction fields and it concluded on 15 December 2015. In contrast with the first two bids, this bid favoured the participation of smaller and domestic companies and the hydrocarbons regulator CNH awarded licence contracts to all 25 onshore production fields, of which 18 were assigned to domestic companies.

Finally, the fourth bid offered 10 exploration areas in deep waters in Cuenca Salina and Cinturón Plegado Perdido basins in the Gulf of Mexico. The final selection and characteristics of these 10 areas took into consideration the industry's feedback in terms of blocks size, maximum depth, and some clarifications regarding contracts and conditions. Up to August 2016, 26 companies were registered to participate in this deep-water bidding round under a licence contract modality and which also will consider the establishment of farm-outs for deep-water exploration activities. The same bid round will also see the processing of the first farm-out requested by PEMEX for the Trión oilfield.

Round Two

The first call of Round Two was published on 19 July 2016 with an offer of 15 bidding areas located in shallow waters in the Gulf of Mexico in the oil provinces of Tampico-Misantla, Veracruz and Southeast basins an (Investment: of USD 11 250 million). The bid opening will be carried out in March 2017 (SENER, CNH, SHCP, 2016).

Moreover, the second call of Round Two was announced on 23 August 2016. This process foresees the offer of 12 onshore areas, through licence contracts. The bid opening is scheduled to take place in April 2017.

Fuel pricing in the new market

As a result of a tax-based fuel price stabilisation mechanism, which since 2005 most often acted as a subsidy, Mexican gasoline and diesel prices were kept artificially low. In 2008 the government began implementing weekly increases to the gasoline price in its first efforts to eliminate subsidies. During 2009, the government froze fuel prices due to the economic crisis, but resumed monthly price increases over the January 2010 - December 2014 period. Since January 2015, the price is set according to a price band, taking into account international oil prices and inflation. From 2018, the new legislation stipulates that prices will be set in accordance with international prices, "if market conditions allow".

In October 2016 the Mexican Congress approved the government's initiative included in the Federation Income Law 2017, which accelerates gasoline and diesel price liberalisation in those regions where the energy regulator CRE identifies competition conditions. CRE is yet to publish the criteria and schedule for those purposes. In the regions where CRE determines that competition conditions are not yet met, prices will remain regulated and the Ministry of Finance will define them, according to a methodology to be published before 31 December 2016. This methodology will take into consideration the international reference, logistic cost and quality differences.

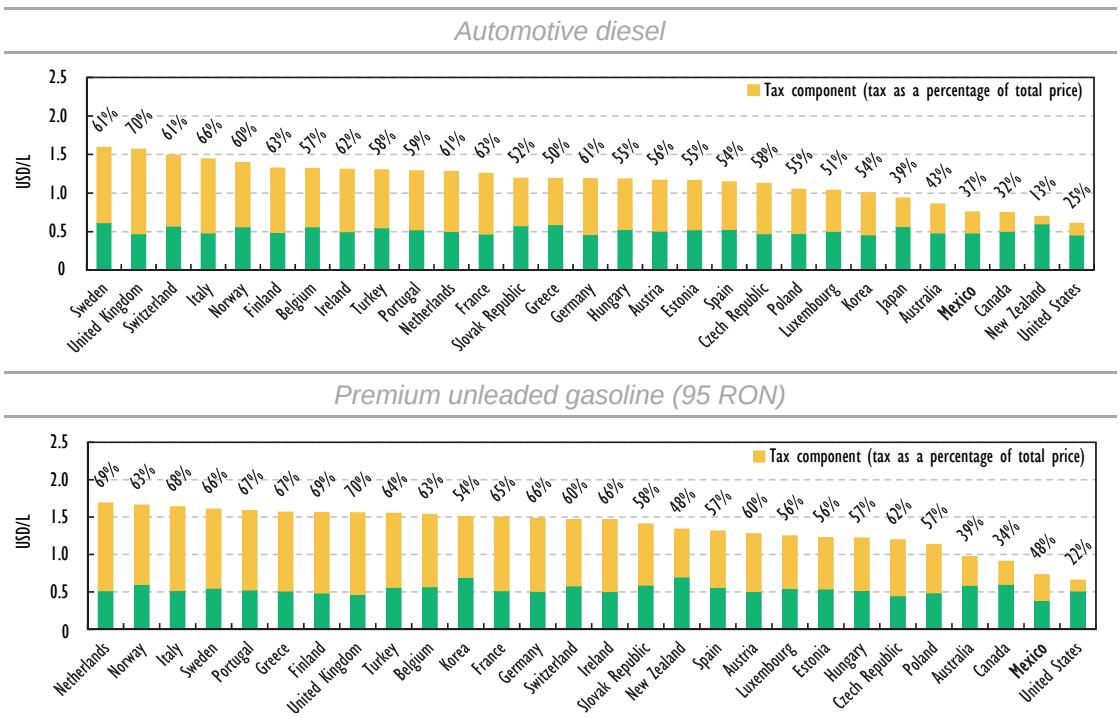
The interim maximum price framework allows for inflation adjustment and adjustment of the local price to international prices in the case of high volatility. During 2015, a gasoline price was fixed throughout the year: regular gasoline MXN 13.57/litre (USD 0.66); premium MXN 14.38/L (USD 0.70), and diesel MXN 14.20/L (USD 0.69). In 2016, the

Federal Revenue Law (LIF) and the Law on Special Tax of Goods and Services (IEPS) implemented a price scheme consisting of an interval of minimum and maximum prices for automotive fuels for the whole year, which fluctuate according to the expected inflation rate of 3%. According to IEPS Law, the regulation on maximum public prices for gasoline and diesel is based on the following formula:

Pmax = Preference + Margin + IEPS + Other concepts
where:

- *Pmax* is the maximum price.
- *Preference* is the component in pesos per litre to reflect the international reference fuel price.
- *Margin* corresponds to the amount in Mexican pesos equivalent to the value of sales margin, freight, losses, transport, quality adjustments and handling costs per litre.[8]
- *IEPS* is the special tax on production and services applicable to automotive fuels.
- *Other concepts* are quotas established in Article 2, fraction I, section H, 2-A of the IEPS law and VAT.

Figure 5.7 Fuel prices in Mexico and in IEA member countries, second quarter 2016



Note: Data not available for Japan (gasoline) and Denmark (diesel and gasoline). The tax rate for Mexico is preliminary and estimated by the IEA.

Source: IEA (2016d), *Energy Prices and Taxes 2016*, Q2, www.iea.org/statistics/.

[8]. This margin will be updated by the Ministry of Finance on a monthly basis according to the expected inflation. The margin is not a regulatory concept as it will not be regulating any supply tariff.

The prices are announced by the Ministry of Finance on a monthly basis. Among OECD countries, Mexico has the fourth-lowest prices of diesel and second-lowest prices of gasoline, thanks to a relatively low tax rate of 37% and 48% on these fuels, respectively.

Liquefied propane gas

In the case of liquefied propane gas (LPG), a price cap policy was implemented in 2000, as international prices were substantially higher than domestic prices. Every month, the government sets the maximum national final price, which until December 2014 was MXN 14.22 per kilogram (USD 0.695). In 2015 and 2016, prices increased only at the beginning of the year owing to inflation. In August 2016 the government decreased the price by 10% so that LPG users could benefit from the lower international prices. To liberalise the market, there is explicit mention of the need for a targeted support scheme for residential LPG users to be put in place by the end of 2016 at the latest. Until then, SENER will continue to set the LPG final prices. However, according to the Hydrocarbons Law, pricing will follow market conditions as from the beginning of 2017.

Competition

The active creation of competition is at the centre of the transition from a monopolistic market structure to an open and competitive one. The Federal Economic Commission on Competition (COFECE) has issued recommendations on competition on the new market (see Box 5.1). For its part, the CRE has designed instruments with asymmetric regulation conditions for PEMEX. As regards first-hand sales, i.e. those at refineries and import points, customers can terminate contracts with PEMEX at no cost with 30 days' notice. Furthermore, PEMEX is required to operate and maintain an information system on its operations to foster transparency, which in turn is the basis for a competitive market to develop.

In terms of contracts, PEMEX has already separated its provision and franchise contracts, as well as first-hand sales (i.e. those at refineries and import points) and commercialisation contracts, both of which are subject to the approval by the energy regulator. Customers and users will be able to terminate contracts with PEMEX at no cost with 30 days' notice. Furthermore, PEMEX will be obliged to offer the customers and users the replacement of its provision contract by a commercialisation contract or a first-hand sales one according to the contract model approved by CRE. In addition, PEMEX is in the process of separating its supply and franchise contracts and will be obliged to publish information on contracts and sales.

A key part of the transition regime is the application of economic regulations to PEMEX's transportation and storage activities: during 2017, 90% of PEMEX Logistica's capacity will be subject to open season tenders approved by CRE. PEMEX Transformación Industrial (PEMEX TRI) or any other PEMEX's marketing affiliates will compete in equal circumstances with other marketers for the logistics services of PEMEX Logística or other firms that own pipelines and storage facilities. If a third party acquires first-hand sale products from PEMEX, then PEMEX will have to deliver the necessary transport capacity to that third party. If a marketer acquires first-hand sales products from PEMEX, then he will have to purchase the necessary transport capacity or rent it from a transporter, independently of the mode of transport (railroad, pipeline, tank truck or ship).

Regarding transport, CRE has issued regulations concerning open access to pipelines, requiring that available capacity be allocated among interested users following public and

transparent processes. From January 2020 onwards, PEMEX Logistica's transportation activities will be regulated in the same way as the rest of permit holders. PEMEX Logistica's storage activities will be deregulated, "unless it exerts market power that affects market efficiency".

Box 5.1 Recommendations by the Federal Economic Commission on Competition (COFECE) on the transition to a competitive fuel market in Mexico

- Review and modify the current maximum price system in order to encourage imports and retail sale activities of operators other than PEMEX.
- For the "open season" process that will be carried out by PEMEX, ensure open access to the company infrastructure and transport through competitive mechanisms favouring the most efficient proposals, for instance through capacity auctions.
- Ensure open access to port terminals in order to facilitate imports.
- Remove restrictions to foreign investment in oil products transportation activities by land and sea, as well as to the supply of these products to ships, aircraft and railway equipment.
- Standardise official quality standards of gasoline and diesel with applicable international standards in relevant markets (United States and Europe), in order to promote imports and exchange of these products.
- Ensure that grouping schemes for service stations are fully compatible with the legal competition framework.
- Ensure that all provision contracts, franchise and commercialisation (current and future) between PEMEX and service stations are compatible with the existing legal regime and do not hinder mobility to alternative supply sources or independent models.
- Remove local restrictions limiting supply and providing undue advantages (for example requirements of minimum distances between service stations or minimum areas not backed by safety reasons) for their construction.
- Generate and publish information so that consumers can compare sales prices of gasoline and diesel (in person and online).

Source: COFECE (2016), *Transición hacia mercados competidos de gasolinas y diesel*. (Transition towards competitive markets of gasoline and diesel).

Anticorruption measures

At the heart of the fight against corruption in the energy sector stands the goal of fostering transparency by enhancing the flow of information on the sector's activities. In this regard, SENER's commitment to requiring the reporting of every transaction along the hydrocarbon value chain is evidence of the recognised value of transparency and of the need to curb theft from pipelines. This level of transparency will also be important in efforts to assess, assign and monitor hydrocarbon storage levels across the country in support of Mexico's energy security objectives. SENER, the hydrocarbons regulator CNH and the energy regulator CRE will publish monthly information on the hydrocarbons process chain, their core processes and procedures, including statistics, information, on

contracts ,authorizations, production and transportation volumes, and storage capacity. All this information is to be published in accessible electronic media.

Furthermore, key to the fight against corruption in the energy sector is the proper conduct of bidding processes and tenders. The phases of the bidding process are the following: *i)* Publication of the bidding invitation and terms; *ii)* Access to the information and data room; *iii)* Clarification on the bidding terms and contract; *iv)* Prequalification of companies; *v)* Changes to bidding consortia; *vi)* Delivery and opening of proposals; and *vii)* Contract execution. Interested companies are not to contact the CNH or any other state entity involved in the bidding round outside this formal bidding process. Once the bidding and contract terms have been announced, interested companies may submit clarifying questions on the bidding process and/or the contract terms. On the basis of the questions and feedback, CNH may revise the terms before they are deemed final.

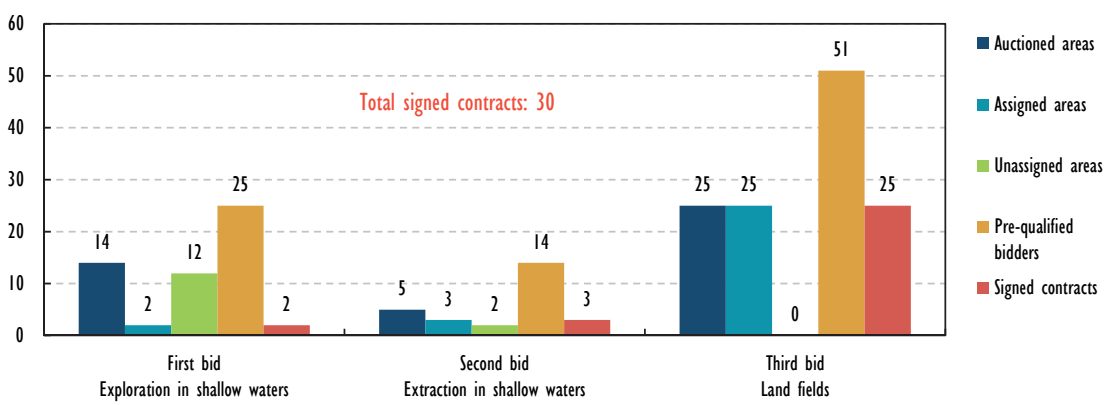
All procedures derived from E&P contracts or permits are to be carried out under the Hydrocarbons Law and its anti-corruption provision (Article 93 HL), which stipulates that individuals and companies, national or foreign, that improperly use their power or influence to obtain a contract or advantages in the process, will be sanctioned. In this regard, the new Law on the National Anticorruption System, published on 18 July 2016, sets out the principles, general rules, policies and procedures so that the authorities at all levels of government co-ordinate their actions to prevent, detect and punish acts of corruption and administrative offences, as well as to control public resources. The purpose of the law is to establish, co-ordinate and evaluate the policy in this area.

Industry structure

Upstream

In addition to PEMEX, there are 16 oil companies, nine of which are producing oil and the others have presented their work plans to CNH. As of August 2016, CNH has held three bidding processes as part of Round One, in which 44 areas were auctioned, with 30 of them assigned through new contracts. (Figure 5.8). The first deep-water bidding process was launched at the fourth bid opening of Round One, offering 10 contractual areas plus the *Trion* block. As of August 2016, 26 companies have met the requirements for participating in the bid.

Figure 5.8 Bidding results of Round One

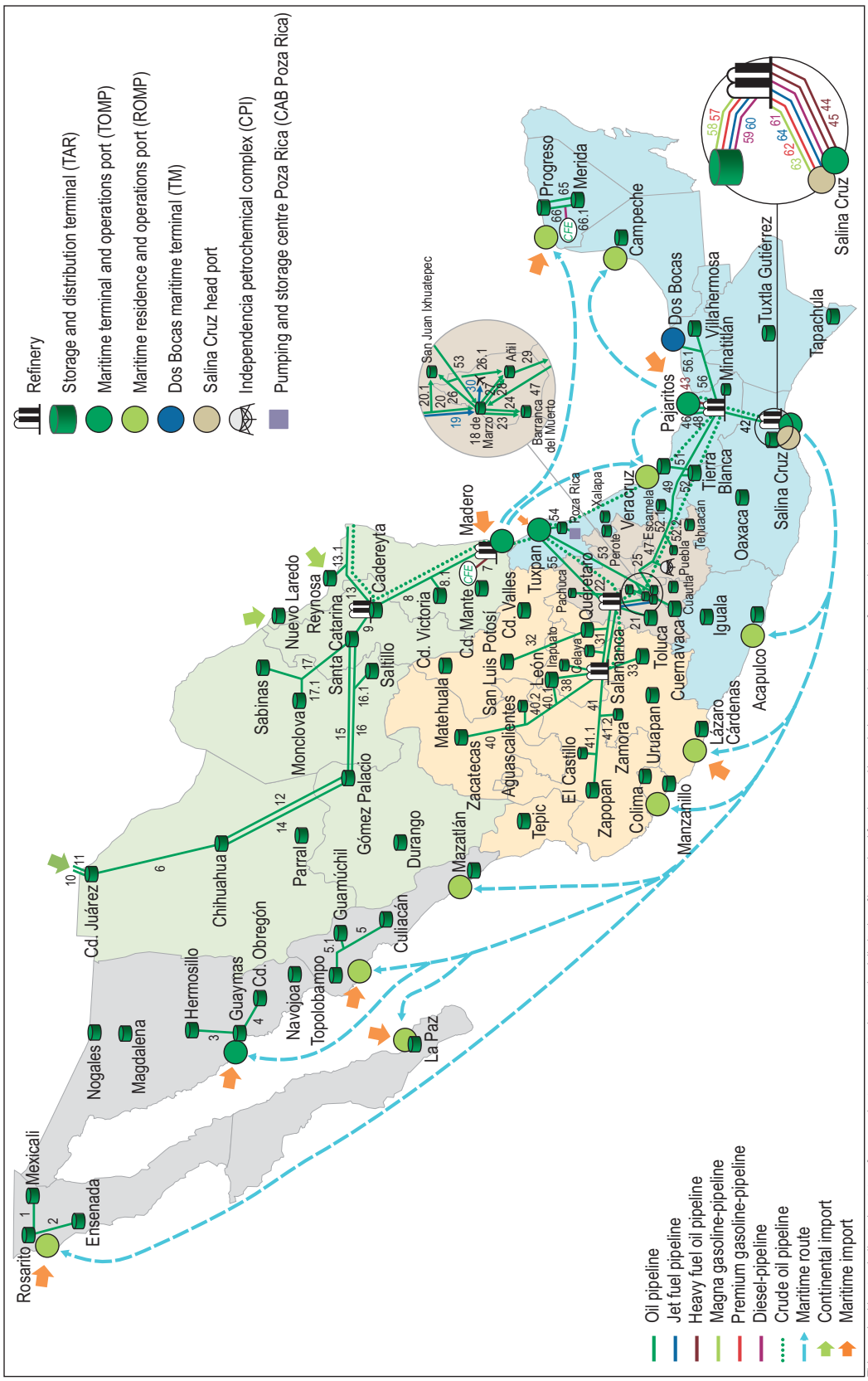


Note: Results of the first three bids up to July 2016. For more details see Table 5.3.
Source: IEA elaboration based on CNH information.

Table 5.3 Bidding results in detail

Number of areas		Company
First bid		
Production-sharing contracts		
2		Sierra Oil and Gas, Talos Energy and Premier Oil PLC
2		
Second bid		
Production-sharing contracts		
1		ENI international
1		Hokchi Energy - Pan American Energy, LLC and E&P, Hidrocarburos y servicios,-E&P
1		Fieldwood Energy LLC / Petrobal
3		
Third bid		
Licensing contracts		
2		Diavaz Offshore
1		Sistemas Integrales de Compresión, Nuvoil and Constructora Marusa
2		Consorcio Manufacturero Mexicano
2		Grupo Diarqco
3		Strata Campos Maduros
1		Servicios de Extracción Petrolera Lifting de México
1		Construcciones y Servicios Industriales Globales
2		Compañía Petrolera Perseus
1		Canamex Dutch B.V. - Perfolat de Mexico - American Oil Tools
1		Roma Energy Holdings, LLC with Tubular Technology and Geoscience Corporation
1		Grupo R Exploración y Producción in consortium with Constructora and Arrendadora México
3		Renaissance Oil Corp
4		Geo Estratos, S.A de C.V. in consortium with Geo Estratos Mxoil Exploración y Producción
1		Sarreal
25		

Figure 5.9 Midstream distribution infrastructure



Source: SENER (2016).

Mid- and downstream

Before the energy reform, the mid- and downstream sectors were fully operated by PEMEX, only retail was open to private participation under a PEMEX franchise system. With the reform, and according to the Hydrocarbons Law, private companies with a permit can participate throughout the mid- and downstream chain.

Mexico has six refineries (belonging to PEMEX Transformación Industrial), 77 storage and distribution terminals, 5 213 km of oil pipelines and 8 958 km of product pipelines, controlled by PEMEX Logística. Compared with industry benchmarks, PEMEX's refineries are significantly more energy-intensive, less efficient in distillate yield, and prone to more down time. Only three PEMEX refineries have deep-conversion technologies that allow for the transformation of lower-quality crude oil to gasoline. PEMEX refineries typically operate at 66% of capacity.

Future expansion plans of the refinery portfolio, include *i)* production of ultra-low sulphur gasoline and ultra-low sulphur diesel in all six refineries, *ii)* the reconfiguration of the Tula refinery to increase oil-processing capacity, *iii)* upgrading and expansion in Salamanca and Salina Cruz, and *iv)* cogeneration projects in Tula, Cadereyta and Salina Cruz refineries, as well as Chiapas natural gas processing facilities.

Oil product imports are introduced to the country mainly by two means: by sea, through 15 terminals along the Pacific Ocean and the Gulf of Mexico, and by land, by pipeline and tank cars across the northern border. Moreover, maritime import is performed by ship tanks in the Gulf of Mexico and the Pacific Ocean. In the Gulf of Mexico there are four import points: Madero in the state of Tamaulipas, the two points in Tuxpan and in Pajaritos in Veracruz, and Progreso in the state of Yucatan.

Table 5.4 Refineries in Mexico : Processing capacity and location, 2015

Refinery	Location	Crude distillation capacity (kb/d)	Technical configuration	Utilisation factor (%)	Relevant market
Ing. Antonio Dovalí Jaime	Salina Cruz, Oaxaca	330	Fluid catalytic cracking	72	Pacific coast, from Oaxaca up to Baja California
Miguel Hidalgo	Tula, Hidalgo	315	Fluid catalytic cracking	74	Mexico City Metropolitan Area
General Lázaro Cárdenas	Minatitlán, Veracruz	285	Coker	54	Southeastern states
Ing. Héctor R. Lara Sosa	Cadereyta, Nuevo León	275	Coker	57	Northeastern states
Ing. Antonio M. Amor	Salamanca, Guanajuato	220	Fluid catalytic cracking	68	Centre-West region
Francisco I. Madero	Madero, Tamaulipas	190	Coker	69	North and Southeastern states

Source: SENER (2016), Questionnaire response to the IEA.

The current infrastructure has five bidirectional pipelines, three of which are located in the Northeast (Chihuahua-Gómez Palacio, Matamoros-Cadereyta, Madero-Cadereyta), one in the Center-West (Tula-Salamanca) and one in the Southeast (Minatitlán-Salina Cruz). The pipelines account for 5 213 km for crude oil transportation and 8 958 km for oil products transportation, supplying 73 storage and distribution terminals (TAR). Currently, 40% of oil pipelines run at maximum capacity, making bottlenecks a common issue.

Theft of gasoline from pipelines in Mexico is high and growing: There were an estimated 3 600 illegal siphons in 2014, costing USD 1.16 billion to PEMEX. The company has embarked on a strategy of upgrading pipelines to improve monitoring, including with the installation of a supervisory control and data acquisition (SCADA) measurement system, which is designed to detect any drop in pipeline pressure. On January 2016, the *Ley Federal para Prevenir y Sancionar los Delitos Cometidos en Materia de Hidrocarburos* (Federal Law to prevent and punish crimes related to hydrocarbons matters) was published in the *Official Gazette*. This new law and related reforms to other laws establish additional civil and criminal penalties for the illegal tapping of pipelines, the theft of hydrocarbons and the alteration of hydrocarbons measurements systems, among other infractions.

Table 5.5 Mid- and downstream infrastructure in Mexico, 2015

Infrastructure in Mexico for oil product industry	
Refineries	6
Storage and distribution terminals	77
Maritime and land terminals	15
Pipelines (oil)	5 213 km
Pipelines (oil products)	8 958 km
Service stations	11 431

Sources: PEMEX (2014), Anuario Estadístico 2014; SENER (2016), *Diagnóstico de la industria de petrolíferos en México, 2016*.

In 2014 the volume of oil distributed was 2.3 mb/d, about half of which was sent to export terminals. In the total volume of oil for refining processes, heavy oil accounted for 42.5% and light oil for 57.5%. Regarding the type of oil sent to export terminals, 78% was heavy oil, 12% light oil and 8% extra-light oil. From April 2016, companies other than PEMEX will be allowed to import gasoline and diesel.

The country has 11 431 service stations (3 300 cars/station), which are run as PEMEX franchisees. With the opening of fuel distribution, new brands have entered the market. Although stations are being renamed, most market participants continue to sell PEMEX fuel for the time being.

Emergency preparedness and planning

Emergency response policy

The Energy Sector Coordination Council (ESCC) integrated by SENER, CRE, CNH, CENACE and the National Center for Control of Natural Gas (CENAGAS), has been formally announced as the National Emergency Strategy Organisation (NESO), in charge of providing recommendations in case of a crisis or emergency in supply and demand of oil, given the implications on public finances, prices and logistics. According to preliminary deliberations within SENER, the ESCC's decisions regarding oil supply disruptions would be taken according to a deliberative process which follows several phases:

- **Phase Zero or pre-alert phase**, characterised by international market imbalances and/or price volatility (either from unexpected supply rigidities or sudden increases in demand, for example, due to extraordinary meteorological conditions). During this phase, an Expert Council (EC) is appointed to review the market's situation and to request information from all market participants (from both supply- and demand-side players). The EC could be formed by government entities, PEMEX, and all other significant actors in the oil sector. It will report to the ESCC on market conditions and on its perception on the duration and scale of the imbalances.
- **Phase One**. Once evidence is obtained from the EC about continuous deterioration of market conditions and the persistence of price volatility, the ESCC will react with prompt and co-ordinated responses. During this phase, and in light of continuous deterioration of market conditions or as a response to a Contingency Response Plan (which is currently being elaborated), the ESCC will issue a recommendation to SENER.
- **Phase Two**. On the basis of ESCC´s recommendations, SENER might order the implementation of available mechanisms on both supply- and demand-side options, or a combination of those. Demand restraint mechanisms would be used as a last resort option, as they have a direct impact on final consumers.

Furthermore, for the implementation of demand restraint measures, the participation of the Ministry of Communications and Transport, and several local authorities, would be needed to co-ordinate their respective areas of influence.

Oil stocks, demand restraint and fuel switching

Mexico has an operational capacity in storage and distribution terminals of 14.6 mb, mainly gasoline and diesel. As of July 2016, Mexico held 26 days-worth of net gasoline imports and 30 days of diesel imports as stocks. Currently, there is no obligation on any market player to hold emergency stocks. The potential for switching from oil to gas in power generation in an emergency is limited. According to a SENER estimate assuming unlimited natural gas supply, the potential stood close to 36 thousand barrels per day (kbd), mostly fuel oil and some diesel, a figure which will probably be reduced in the future because of the general shift towards gas in power generation.

Assessment

Mexico's oil sector is dominated by PEMEX, the country's national oil company, founded in 1938. Its monopoly status changed with the implementation of the energy reform, although, in the foreseeable future, the company will remain the dominant energy player in the country, with fully integrated operations in exploration and production, refining, distribution, retail, and petrochemicals.

The restructuring of PEMEX as part of the energy reform, provides the opportunity for the company to adapt to its new responsibilities and priorities and to become a financially competitive organisation. Restructuring may face some hurdles due to a number of legacy issues ranging from vested interests, the company's risk aversion and reluctance to relinquish control of assets – all factors that can potentially delay the injection of much needed capital. This makes the pursuit of an active competition policy, including asymmetric regulation, and the implementation of PEMEX's option to establish joint ventures in order to strengthen its financial condition, all the more important.

As regards data collection, the opening of the sector will multiply the number of different players, including private ones. It will therefore be crucial to put in place the necessary guidelines and regulatory requirements to maintain the current level of information for policy making and sector monitoring. In legal terms, this will take the form of data collection guidelines issued by the Energy Sector Coordination Council, regulations and individual permits.

Upstream

The large increase in surface exploration, by 370% since 2014, at a cost of USD 2.1 billion, means that offshore Mexico is currently one of the most widely surveyed prospects in the world. The cost is borne largely by the offshore seismic industry as a speculative investment. Nonetheless, this increase is a good indicator of foreign interest in Mexico's resources. Timely development of resources is vitally important to check decline from ageing fields in the south of the country.

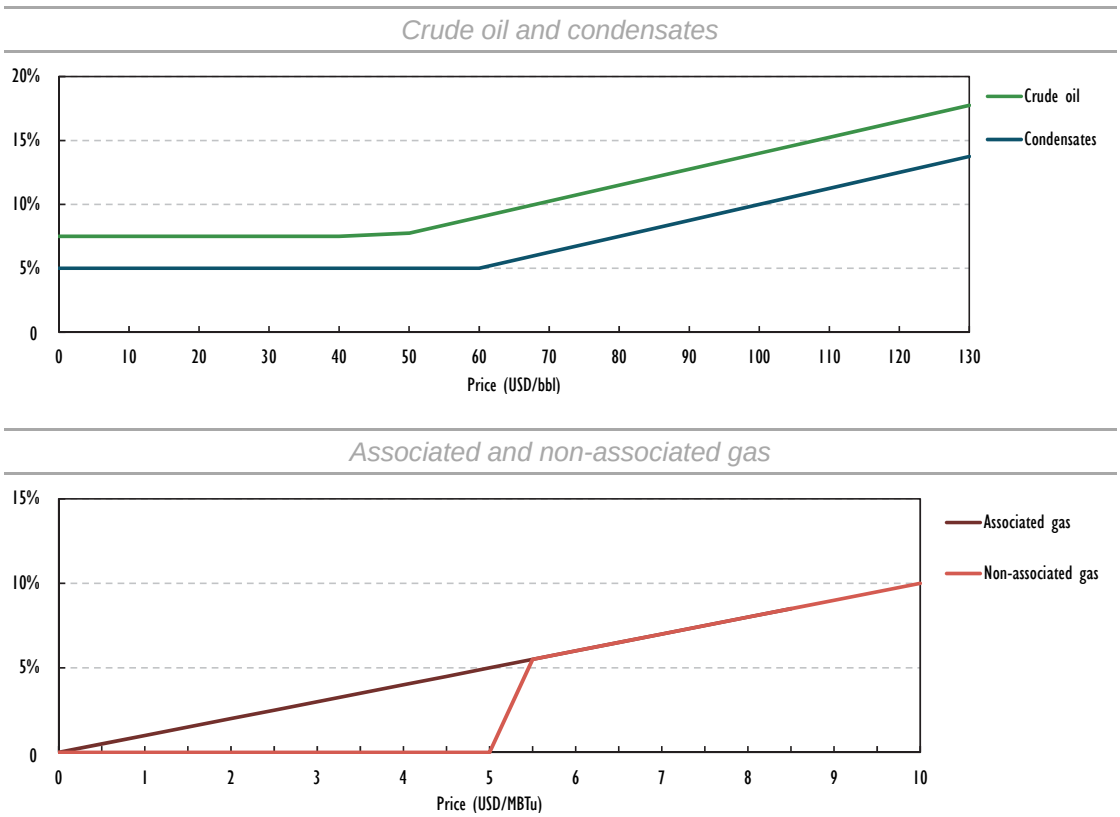
Reversing the decline in oil production requires boosting foreign investments and technology (especially for deep-water developments). In this regard it is important to ensure that the terms of contracts on offer are aligned with international best practices. The increasing success of the bid rounds so far is widely viewed as being a testament to SENER's ability to react to input from partners and to alter the terms of the contracts accordingly during the consultation phase foreseen for such changes. One aspect of the contracts which has been at the centre of industry feedback is a standard clause on "administrative rescission", which some players regarded as exposing investors to a level of risk that is not often seen across the industry. However, as the bid openings progressed, it appears that the terms offered have so far been sufficiently competitive, as also suggested by an international comparison of the base fiscal terms. That said, there is future upside potential for the state take in view of the progressivity of royalties.

At the time of writing, a fourth tranche was to be held in December 2016, and was eagerly anticipated by industry, as it offered, for the first time, deep-water offshore blocks.

As the long list of attributions to the regulators indicates − from preparing terms of the bidding rounds to enforcing all aspects of the contracts, administrating open seasons,

etc. − there is a large demand on these newly founded or reformed institutions. This applies particularly to the hydrocarbons regulatory agency ASEA, a technical arm of the Ministry of Environment that regulates safety and environmental performance along the entire value chain of the hydrocarbons sector. Its mandate spans from production to retail, and will require a vast field of technical regulation expertise. It will be important to make swift progress with the effective operation of the regulator in order to avoid any uncertainties about the regulations that fall under its remit.

Figure 5.10 Progressivity of royalties in the oil upstream as a function of the oil price



Source: SHCP, presentation to country review team, April 2016.

Mid- and downstream

Commercialisation, transportation, storage and distribution activities are parts of the Mexican oil and gas industry that receive less attention and investment than they deserve. Actions that need to be addressed to improve midstream performance include incorporating the use of advanced technologies to map and monitor Mexico's oil pipeline network, and a shift from corrective to preventive maintenance of existing oil transportation infrastructure. In order to attract more investment into the midstream sector, it will be important to clarify the cost assignment of infrastructure expansion to existing or new customers. At present, there is no clear policy addressing whether these costs will be assigned on a rolled-in or incremental basis.

As the market moves towards a competitive framework, third-party access will be a key concept to ensure the opening of spaces for new market entrants. In this regard, gathering is a particular part of the value chain where the regulatory framework is still

relatively opaque. However, the hydrocarbons regulator CNH has been working with PEMEX to designate selected facilities as open access, and to select those facilities that could be included in SENER's permitting process. Clarification of regulations in this area will be important in stimulating private investment in the upstream.

Gas flaring and venting is a significant issue in Mexico, which currently flares over 400 million cubic feet per day (mcf/d). CNH has set guidelines for PEMEX to reduce flaring, and these are expected to be enforced in 2016. Mexico is also part of a World Bank project seeking to eliminate flaring by 2030. ASEA is in the process of establishing the rules for new operators in the upstream sector.

With regard to the refining sector, and to industry benchmarks, PEMEX's refineries are significantly more energy-intensive, less efficient in distillate yield, and prone to more down time. Only three PEMEX refineries have deep-conversion technologies that allow for the transformation of lower-quality crude to gasoline. Investment plans include production of ultra-low sulphur fuels, reconfiguration and upgrading as well as cogeneration projects. However, lack of financial resources at PEMEX and investment priorities in the upstream sector have prevented major projects from being implemented. Therefore, despite increasing demand for products, no significant capacity additions are foreseen. Recent budget cuts at PEMEX have made the financing of upgrades even more challenging, highlighting the need to attract private investments to the sector. New standards for the quality of gas and fuels have been recently issued, however their implementation is still in process.

As regards the transition to a liberalised fuel price at the pump, starting in January 2017, a year earlier than originally planned, a gradual transition strategy should be put in place to prepare the market for the liberalisation of the price. In terms of competition in the downstream, the competition commission COFECE elaborated a document titled "Transition towards competitive fuel markets" with recommendations to promote competitive conditions in gasoline and diesel markets. The recommendations point out important issues regarding pricing, infrastructure, technical specifications, and retail sale regulation. Box 5.1 summarises some of the most relevant recommendations.

As far as emergency preparedness is concerned, current operational stocks held by PEMEX are relatively low. SENER is mandated by the Hydrocarbons Law to draft an oil stockholding policy to increase levels of domestic stocks. This policy will strengthen oil supply security as the market starts welcoming a multitude of private actors along the oil value chain. Mexico does not currently have a programme of measures to rapidly restrict oil consumption in an oil supply emergency.

Recommendations

The government of Mexico should:

- Clarify the practical approach to be taken by the hydrocarbons regulator ASEA in implementing its broad mandate of regulating the safety and environmental performance of hydrocarbon production, transport, storage and retail, and ensure it has resources that are commensurate with this mandate.
- Ensure that reporting requirements along the value chain are designed to efficiently and effectively collect information in a timely manner. Pay attention to international best practices on data surveys, analysis and public disclosure.
- Promote fact-based dialogue among federal and local governments, private industry, and the public to secure confidence in the sustained and responsible development of Mexico's hydrocarbons sector.
- Take into consideration the competition commission COFECE's recommendations on competition policy.

Upstream

- Ensure that the legal terms of the contracts offered to private companies are competitive and not drastically different from other global investment opportunities.
- Intensify efforts to move forward with the strategy of countering the oil production decline with the help of joint-venture and production-sharing farm-outs.
- Continue efforts to address gas flaring to reduce emissions by drawing on international best practice in oil and gas exploitation and development.
- Ensure that local content requirements in production contracts are designed in a way that reconciles the legitimate desire of the Mexican state to promote local industry, with Mexico's commitments as a member of the World Trade Organization.

Mid- and downstream

- Ensure effective third-party access to essential oil infrastructure.
- Develop a coherent and robust framework for responding to oil supply crises, including the development of emergency response policies and measures (such as oil stockholding and demand restraint).
- Clarify a strategy to attract partners for modernising PEMEX's existing refining capacity.
- Prepare a transition strategy for consumers with a gradual approach to fuel price liberalisation during 2017.

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6. Natural gas

Key data

(2015 estimated)

Natural gas production: 42 bcm, -1.9% since 2005

Net imports: 36.5 bcm, +301.3% since 2005

Share of natural gas: 35.1% of TPES and 59.8% of electricity generation

Consumption by sector (2014): 74.4 bcm (power generation 54%, other energy industries 23%, industry 21%, residential 1.4%, commercial and public services, including agriculture and fishing 0.4%, transport 0.03%)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Overview

Mexico has tried to boost its natural gas industry through different efforts over the past two decades. Long before the 2013 reform, Mexico's natural gas sector had undergone an initial opening in 1995, which, for the first time since the nationalisation of the sector, allowed foreign investments in gas transmission and distribution (IEA, 1996).

In recent years, the shift to gas has accelerated, fuelled by the low price of natural gas in the United States and the shift from fuel oil to gas in power generation. On several occasions, the pipeline system has reached saturation, highlighting the need for balanced future expansion.

With the new arrangement in the natural gas industry, Mexico hopes to achieve the following goals, among others: increase energy security by advancing coverage and gas availability, reduce costs, foster economic growth through the development of new infrastructure projects nationwide, meet increasing demand for natural gas, counter the increasing risk of bottlenecks and thus avoid possible future energy supply crises.

Reserves, supply and demand

Reserves

At the beginning of 2015, proven reserves, probable reserves and possible reserves (3P) natural gas totalled 54 889.6 billion cubic feet (bcf) − 68% associated gas and 32% non-associated gas − 64% of which was onshore. However, Mexico's proven gas reserves are on the decline: The proven, probable and possible (3P) natural gas reserves decreased by 4 775 bcf from 2014 to 2015, owing to production activities and as a result of water injection tests for secondary recovery implemented in fields at the

Gulf of Mexico. Furthermore, gas production has declined in recent years, falling by 11% since 2010 to 44.8 bcm in 2014.

Mexico has significant unconventional gas resources, part of which are in continuity with highly productive formations in the United States. Developing these resources by drawing on US experience and knowledge would make it possible to further expand gas use in the industrial sector in Mexico and to reduce import dependence. As of 2011, PEMEX considered that Mexico's basins could go from 150 to 459 trillion cubic feet (tcf). According to US EIA estimates Mexico's shale reserves could go up to 681 tcf of natural gas.

Table 6.1 Shale gas estimations (tcf)

Concept	EIA	PEMEX
Upper Cretaceous	507	54-171
Middle Cretaceous	8	0
Upper Jurassic	166	95-285
Total	**681**	**150-459**

Source: PEMEX (2016), *Informe Anual 2015* (Annual report 2015).

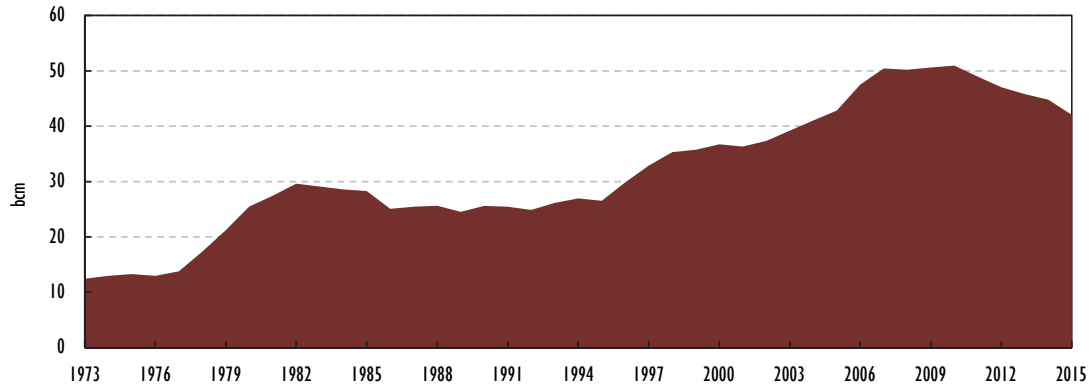
The energy reform introduces the prospect of private operators investing in upstream production, though the incentive to do so is diminished by the large increase in pipeline capacity to the United States and the prospect of abundant and relatively cheap gas. If supply from the United States tapers off, or prices rise, the case for domestic unconventional production will increase. However, shale development raises a number of issues that will require social acceptance, including those of land and water use. The federal government can set the tone for development through responsible regulation and suitable economic terms, but opposition at state and local levels may prohibit efficient development. Legislation to distribute revenue from upstream production has set a cap of 2% of profits from activities for gas operators and 3% for oil companies.

Because of the low oil price, Mexico suspended plans for its first-ever auction of unconventional gas fields under Round One in 2015. Overall, SENER's Five-Year E&P Plan includes 24 areas for unconventional hydrocarbons production, totalling 34 830 km^2, with prospective resources of 25 billion barrels of oil-equivalent (bboe) being offered.

Supply

Total supply of natural gas was 65.8 million tonnes of oil-equivalent (Mtoe) in 2015, or around 80 billion cubic metres (bcm). Natural gas represents around 35% of total primary energy supply (TPES), the second-largest energy source after oil. From being self-sufficient in natural gas in the 1970s and 1980s, Mexico has become more dependent on imports to meet its increasing gas demand. Domestic production grew by 90% from 1994 to a peak of 51 bcm in 2010, but since then the production has declined to 42 billion cubic metres (bcm) in 2015 (Figure 6.1).

Figure 6.1 Natural gas production, 1973-2015



Note: Data for 2015 are estimated.

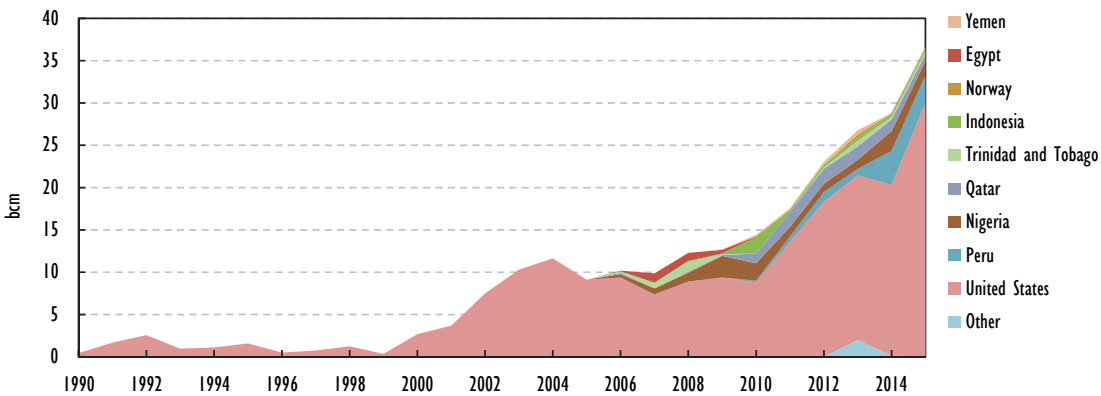
Source: IEA (2016a), *Natural Gas Information 2016*, www.iea.org/statistics/.

Imports and exports

Recent growth in demand has been met by a sharp increase in imports, which grew by 139.4% from 15.3 bcm in 2010 to 36.7 bcm in 2015 (see Figure 6.2). Most imports come from the United States, the only country exporting gas to Mexico until 2005. In the last decade, Mexico has diversified its imports, which now include gas from eight more countries. In 2015, the United States share of imports had declined to 82%, although volumes from the United States have continued to increase (see Figure 6.2). Imports in 2015 were also from Peru (9%), Nigeria (4.7%), Qatar (2%) and others.

Natural gas exports have declined rapidly from a peak of 1.4 bcm in 2007 to a low of only 0.13 bcm of gas in 2015, and only to the United States.

Figure 6.2 Natural gas net imports by country, 1990-2015



Source: IEA (2016a), *Natural Gas Information 2016,* www.iea.org/statistics/.

Demand

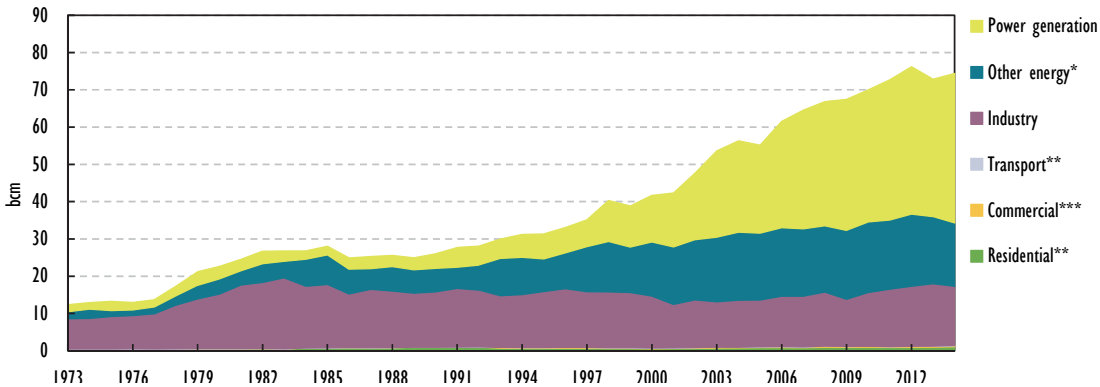
Natural gas is mainly used in three sectors in Mexico – power generation, which accounted for 53.9% of total consumption in 2014, other energy sectors including consumption in oil and gas extraction (22.8%), and the industry sector (21.4%) (Figure 6.3). The residential/commercial and public services sectors accounted for

1.4% and 0.4% of demand, respectively, in 2014, while the transport sector used negligible amounts of gas.

Total natural gas demand peaked at 76.2 bcm in 2012. From the late 1980s to 2012, natural gas demand increased on average by more than 4% per year, with a 4.4% decline in 2013 and a partial 2.1% recovery in 2014. Demand growth has largely been driven by a rapid increase in gas use in power generation. Natural gas has been the dominant fuel in Mexico's power generation since 2003, with the volume of consumption increasing by 73.2% over the 11 years to 2014.

Industry increased its natural gas consumption by 25.8% from 2004 to 2014. Demand from the residential sector was 40.2% higher while the commercial and public services sectors (including agriculture) doubled their natural gas consumption over the ten years. Conversely, gas use in energy industries other than power generation fell by 6.9%.

Figure 6.3 Natural gas supply by sector, 1973-2014



Note: TPES by consuming sector.

* *Other energy* includes other energy industries such as oil and gas extraction and energy own-use.

** Negligible.

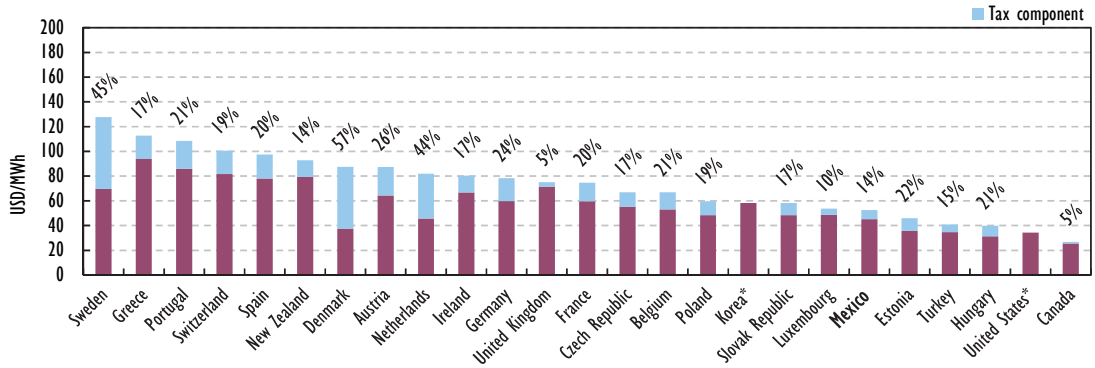
*** *Commercial* includes commercial and public services and agriculture.

Source: IEA (2016a), *Natural Gas Information 2016*, www.iea.org/statistics/.

Prices and taxes

In Mexico, the price of natural gas has decreased for the last two decades and is still among the lowest in terms of prices and tax components among OECD countries. Tax components are 14%, which is lower than the OECD average (approximately 21%). However, the price of Mexican natural gas remains higher than gas imported from the United States. Thus, the reliance on US imports could bring significant financial gains to the country. The government is actively pursuing this approach, having embarked on a large development programme of new pipeline capacity, cross-border and within Mexico (IEA, 2015b).

Figure 6.4 Household natural gas prices in Mexico and in IEA member countries, 2015

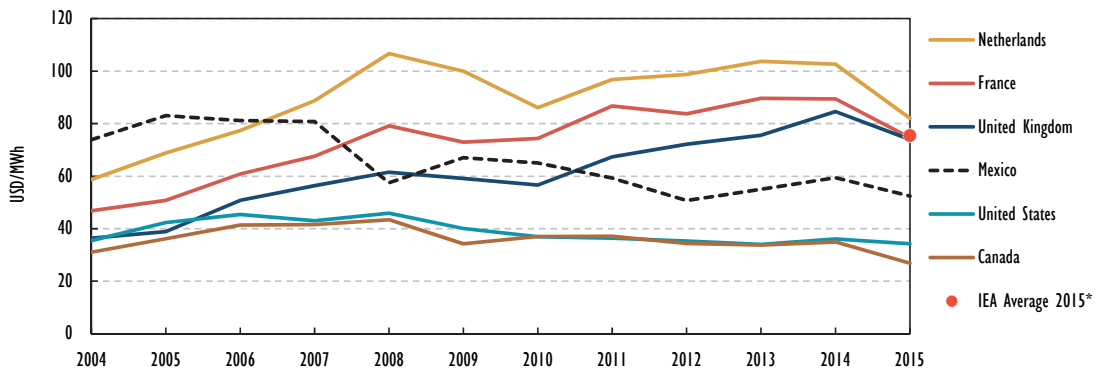


Note: Data not available for Australia, Finland, Italy, Japan and Norway.

* Tax information not available.

Source: IEA (2016b), *Energy Prices and Taxes 2016, Q1,* www.iea.org/statistics/.

Figure 6.5 Household natural gas prices in Mexico and in selected IEA member countries, 2004-15



*Estimated based on available data.

Source: IEA (2016b), *Energy Prices and Taxes 2016, Q1,* www.iea.org/statistics/.

Institutions

In terms of natural gas, **the Ministry of Energy (SENER)** is responsible for granting assignment areas and establishing contractual areas for exploration and extraction, following the framework described in Chapter 5 on oil. So far, bid rounds have been geared more towards oil exploration and production (E&P), but the applicable framework is the same. SENER's specific responsibilities in the gas sector include regulating and supervising, but also granting, modifying and revoking permits for natural gas processing and exports.[1]

SENER is furthermore responsible for issuing a **Five-year natural gas infrastructure expansion plan** (discussed further below) with technical assistance by the **Energy**

[1] On natural gas trade, SENER's decisions are taken under the terms of the Foreign Investment Law and with the support of the Ministry of Economy and the Ministry of Finance.

Regulatory Commission (CRE) and considering proposals of the **National Natural Gas Control Center (CENAGAS)**. SENER also issues emergency preparedness plans for the national gas grid, with inputs from CRE and CENAGAS. Furthermore, SENER is to be responsible for determining which public policy applies to the levels of storage in order to safeguard national security of supply. CRE is the authority responsible for issuing permits for transportation, storage, distribution, compression, decompression, liquefaction, regasification, integrated systems management, retail sales and marketing. It also has the authority to set the first-hand selling price, until competition conditions allow prices to be liberalised.

The **National Hydrocarbons Commission (CNH)** regulates, oversees and evaluates natural gas exploration and extraction, ensures that projects are carried out under conditions that allow increasing the recovery factor and maximising hydrocarbons production in the long term.

CENAGAS is the transmission system operator (TSO), responsible for managing and co-ordinating the operation of the integrated national gas pipeline system, SISTRANGAS[2] ensures the continuity and security of transmission and storage services, as well as most of the natural gas supply in the country. Additional supply to the country is transported through three other systems (Naco-Hermosillo, Sonora and Baja California Project) in the northern states. CENAGAS also proposes the draft of the Five-Year Plan for SENER's approval, incorporating CRE's opinion.

It is important to note that the build-up of CENAGAS as the TSO, in order to take control of PEMEX's natural gas pipeline network, is a gradual one: since CENAGAS signed the agreement in October 2015 that became effective on 1 January 2016, PEMEX has remained in charge of day-to-day operations. The transition to full CENAGAS responsibility over the network is expected to take place during the course of 2017.

Government policies

After the constitutional change in December 2013, the Congress issued a wide set of secondary laws in August 2014 which spelt out the legal and regulatory framework, allowing private capital participation along different activities in the Mexican energy industry. Among these activities are natural gas exploration and extraction, preserving national ownership of this hydrocarbon. The secondary laws relevant to the natural gas industry are the **Hydrocarbons Law** and the **Law of Coordinated Regulatory Entities on Energy Matters**.

Upstream Gas Processing: Legal framework

The new **Hydrocarbons Law** regulates the main activities of gas extraction, processing and sales. It also defines the functions of institutions in charge of regulating gas activities along the value chain and their relations among them. The terms of exploitation, processing and retail sales are also established. The new framework stipulates that the state, represented by CNH, can negotiate contracts with private

[2]. SISTRANGAS (Sistema de Transporte y Almacenamiento Nacional Integrado de Gas Natural) includes the pipeline systems that belonged to PEMEX as well as private pipelines integrated in the main system.

companies for E&P activities that represent a new model for hydrocarbons exploration and extraction and natural gas-processing activities.

Until 2014, the activities of processing sour-wet natural gas were performed exclusively in the gas processing complexes and refineries of PEMEX. With the changes, PEMEX can now enter joint ventures with private companies which will facilitate the modernisation of its infrastructure.

The revenues from E&P activities are governed by the **Hydrocarbons Revenues Law** − a by-law of the Hydrocarbons Law published in 2014 – that determines the types, terms and trade-offs of exploration and extraction contracts.

Mid- and downstream

Before the energy reform, natural gas transmission was in the hands of PEMEX, with two pipeline systems and several private companies, under regulations issued by the energy regulator CRE since 1995. Distribution was performed only by private companies in several distribution zones decreed by CRE. As regards gas storage, the only existing capacity is in liquefied natural gas (LNG) facilities. To date, Mexico has no liquefaction projects.

The new **Hydrocarbons Law** stipulates that the following activities need a permit issued by the regulator: transport; storage; distribution; compression; decompression; liquefaction; regasification; retail sales and integrated systems management; commercialisation; and marketing. Moreover, CRE will be responsible for regulating and supervising the management of the transmission and storage integrated systems, including the National Gas Transportation System and Integrated Natural Gas Storage (SISTRANGAS) managed and operated by the National Natural Gas Control Center of (CENAGAS).

Another aspect covered in the Hydrocarbons Law is the development of new natural gas transmission pipelines which are classified in three types*: i*) strategic projects, *ii)* social coverage projects and *iii)* non-strategic (commercial) projects (see below section on Implementation).

Asymmetric regulation

Before the energy reform, PEMEX was under first-hand sales regulation to restrict the price of natural gas sold by PEMEX through its subsidiary PEMEX Gas y Petroquímica Básica (PGPB). To ensure more private participation and an efficient and competitive market, the energy reform allows natural gas private production and marketing, where PEMEX will be another player subject to CRE's asymmetric regulation principles. PEMEX was forced to sell natural gas at a first-hand sales regulated price, calculated on the basis of the South Texas Price Indexes and transmission costs. Regulation of first-hand sales includes issuing and approving general terms and conditions, as well as the methodology to calculate prices (see below pricing section).

With respect to natural gas supply contracts, in order to limit PEMEX`s market power as sole trader, until more players enter and create an efficient and competitive natural gas market, CRE has issued asymmetric regulation, including a gas release programme, whereby PEMEX has to give up 70% of its contracts within a four-year period. In the

future, when the market has more participants, the asymmetric regulation will be lifted and PEMEX will be able to subscribe long-term contracts as a trader.

Permit holders of natural gas pipeline transmission may not trade hydrocarbons through their own infrastructure. CRE will regulate the market by avoiding entry barriers and mitigating PEMEX's market power. The restriction to vertical integration is intended to eliminate the potential conflict of interest between marketing and transmission activities, which can occur when the holder of a permit to transmit natural gas through pipeline competes with marketing companies that should guarantee open access to the pipeline, which can cause undue discrimination.

Open access

The new regulation allows CRE to issue permits for new integrated system managers, to regulate third-party access to natural gas transportation and distribution pipelines and storage. Furthermore, the law specifies the obligation for permit holders that provide natural gas pipeline transportation and distribution services, as well as storage services to grant open access to these infrastructure and services, according to the available capacity of their systems, besides the obligation to publish the information on available infrastructure.

CRE has the authority to request the certification of installed, used and available infrastructure for pipeline transportation, distribution and storage of hydrocarbons, oil products and petrochemical capacity, through an independent third party. Also, users who have contracts of reserved capacity and do not use it have to make the capacity available to the market through the respective permit holder, CENAGAS, open seasons or the secondary market. An open-season process will also be required for natural gas storage. All the above as defined by the administrative provisions published by CRE.

Implementation

The official **Gas Market Implementation Policy** *(Política Pública para la Implementación del Mercado de Gas Natural)*, published in July 2016, calls for the diversification and development of a competitive and efficient natural gas market. This policy stipulates that transportation and commercialisation activities, regulated by CRE, should operate as an open market, with free competition and clear pricing signals. Moreover, the policy points out the importance of fostering transparency by disseminating information on commercial transactions to facilitate an effective gas market.

The policy contains implementation objectives for the short-, medium- and long-term (see Box 6.1). Overall, a key instrument of the policy is the application of open tenders. The policy will guide implementation in order to set the bases for an open and competitive natural gas market by the end of 2016. By 2017, the focus will be on ensuring open access and efficient allocation of existing capacity in the SISTRANGAS system. Finally, a completely open and competitive natural gas market is expected by 2018 and, for 2020, it is foreseen for PEMEX to conclude the gradual transfer of contracts though a "Gas Release" programme.

According to the Hydrocarbons Law, gas infrastructure planning is carried out by CENAGAS via the **five-year expansion plan for the transportation system and**

national integrated storage of natural gas 2015-2019 (the five-year expansion plan), following determination of funding mechanisms by the Ministry of Finance (SHCP) and the approval of the bidding rules by the CRE. The five-year expansion plan serves to ensure the timely expansion of natural gas transportation in the country, after an assessment of natural gas supply and demand in the medium term.

For the period to 2019, the Five-year expansion plan includes more than 5 150 kilometres of gas pipelines. At the beginning of 2016, **technical provisions for defining targets for the use of associated natural gas** were published, to guide the implementation of the Five-year expansion plan. The document is of central importance for assignees and contractors who engage in exploration and extraction of hydrocarbons in Mexico, as it allows planning investments in line with infrastructure investments.

The implementation of the Five-year expansion plan will require careful monitoring and ensure that network expansion and storage keep in line with economic growth and demand development.

Box 6.1 Implementation actions foreseen by the Gas Market Implementation Policy

Short-term implementation actions are:

- **Reserve capacity and open access.** CENAGAS to commercially operate SISTRANGAS and, with authorisation from CRE, run an open season. Furthermore, for the last quarter of 2016, CENAGAS will publish the terms and general conditions for SINTRANGAS.
- **Commercial transactions report.** Permit-holders in retail sales will be required to report their commercial transactions – volumes and prices. CRE will publish the applicable administrative provisions to comply with this action.
- **Gradual transfer of PEMEX's contracts.** CRE will approve the programme for gradual contract transfer and will promote the bundling of packages.

Implementation actions by 2017:

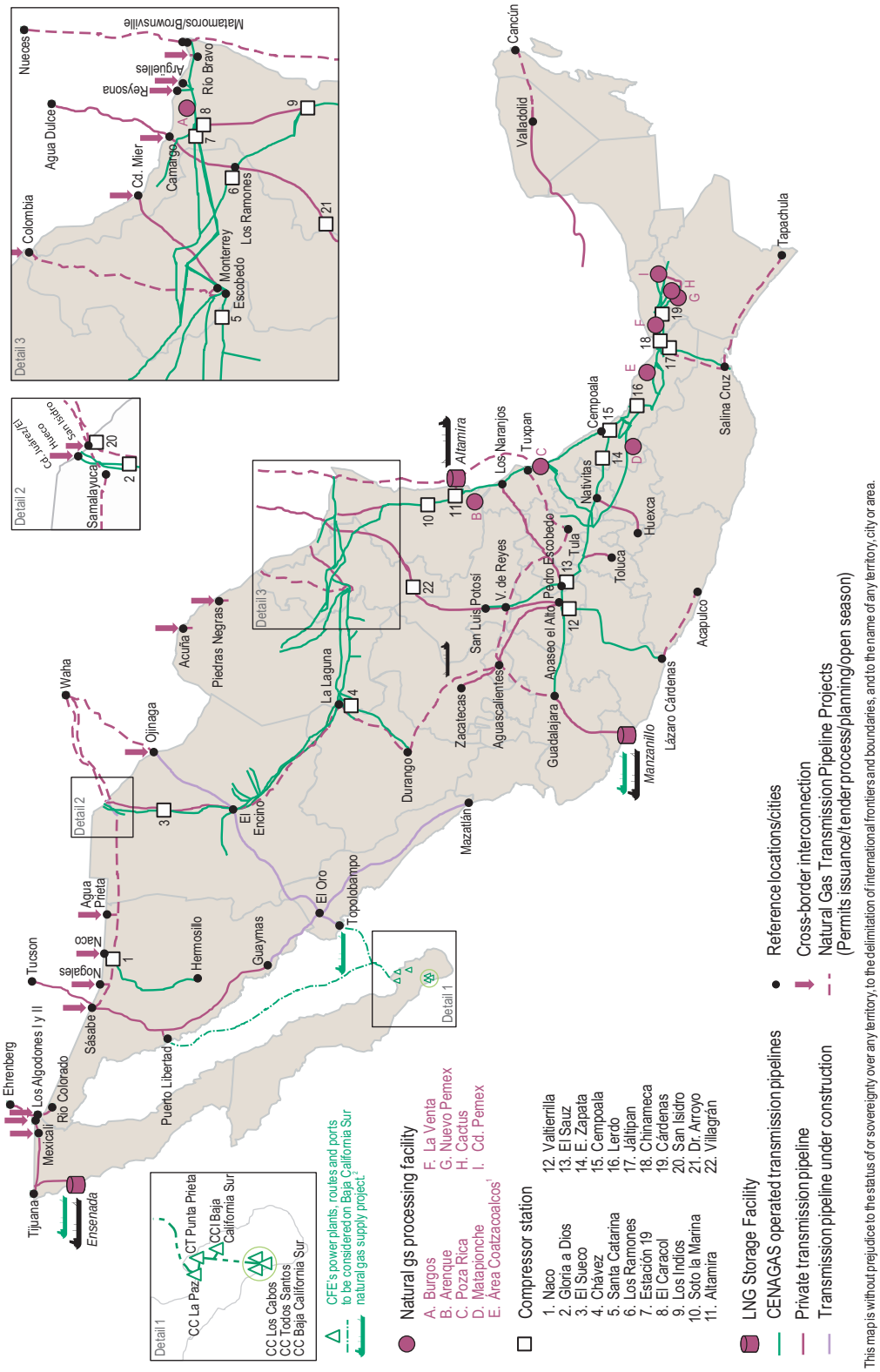
- **Reserve capacity management and effective open access.** CENAGAS will start new contracts under reserve capacity, and participants should use all the tools and mechanisms developed for the actions above.
- **Partial liberalisation of the natural gas price.** With more participants in the market, CRE could eliminate the first hand sale price and authorise PEMEX's retail sales according to the market price.

Further implementation actions by 2018:

- **Total liberalisation of the natural gas price.** CRE could eliminate the first-hand sale price formula in all the country, leaving price formation to the market.
- **Tariff reconfiguration of SISTRANGAS.** With the new market conditions, CENAGAS will request CRE to review the transportation tariff configuration by zone.

Source: SENER (2016b).

Figure 6.6 Natural Gas Infrastructure (2016)



Source: SENER (2016b).

Open season

According to the general administrative provisions regarding open access and service delivery of pipeline transportation and storage of natural gas, published by CRE on 13 January 2016, holders of natural gas transportation permits have the obligation to grant open and non-discriminatory access to infrastructure and services, subject to capacity availability in their systems. In order to allocate the available system capacity, before construction of the infrastructure begins, the permit holder is obliged to carry out an open season, in line with the following procedure:

1. Permit holders will submit an open-season procedure to the CRE for its approval.
2. Once the procedure is approved, permit holders will publish the open season in an electronic bulletin and national newspapers announcing the beginning and precise terms of the open season.
3. Permit holders shall hold at least one public meeting in which all information regarding the open season will be presented to potential users.
4. The open season will last for at least 10 business days.
5. Potential users will submit applications, which will be evaluated by the concessionaire, and the accepted applications will receive an official proposal.
6. The open season results will be transmitted to CRE.

Noteworthy, CRE approves the terms and general conditions that every concessionaire needs to fulfil, in compliance with the regulation, in order to provide transportation services. These terms and general conditions contain rights and obligations for both users and concessionaire.

Pricing

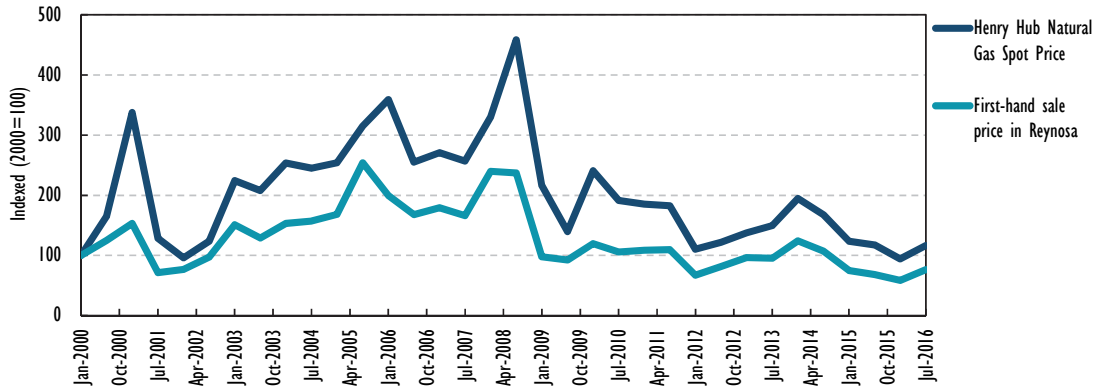
In compliance with the Hydrocarbons Law, CRE will determine maximum first-hand sale prices for natural gas and related activities such as transportation, local distribution and storage tariffs. CRE will continue to hold the first-hand sales of hydrocarbons to the principles of asymmetric regulation, the purpose being to limit the dominant power of PEMEX, until greater involvement of economic agents is achieved so that efficient and competitive markets can be developed. The first-hand sale is the first transfer, on the national territory, made by PEMEX, or any other firm on behalf of the Mexican state, to a third party or between them. The rationale to regulate first-hand sale maximum prices is as follows:

- Increase participation of economic agents in the natural gas market.
- Reflect the conditions of a competitive market and the opportunity cost and conditions of the international market and the place where the sale is taking place.
- Avoid price arbitrage between different zones in the country.

The natural gas market prices considered are those registered in the Houston Ship Channel, Henry Hub and Southern Texas indexes. Transmission costs between the border in Reynosa and Southern Texas pipelines are incorporated depending on whether a deficit or surplus in Mexico's natural gas balance of trade exists, which is relevant for the determination of the opportunity cost of natural gas first-hand sale.

With regard to the natural gas commercialisation and marketing activities of private entities, the price is liberalised. Once different companies involved in these activities obtain the appropriate permits from CRE, market competition will be open for commercialisation and marketing activities.

Figure 6.7 Natural gas price index, Henry Hub and Reynosa



Source: EIA, SENER SIE.

The procedure to determine a maximum transportation tariff requires that permit holders present the revenue requirement contained in their business plan approved by CRE. The tariff is calculated by dividing the revenue requirement (which is a projection of the income needed to cover operation and maintenance costs, taxes, depreciation on capital expenditure and a reasonable rate of return) by the transportation capacity.

Trading

Before the energy reform, the activities related to trading and marketing of natural gas were not subject to specific regulation and could be performed by PEMEX and private companies. However, all the natural gas trading activities in SISTRANGAS were performed by PEMEX. Any trading by other companies was done after a previous commercial activity with PEMEX or in a pipeline other than the SISTRANGAS system.

After the energy reform, these activities require a permit issued by CRE that will enforce some obligations with the regulator to ensure fair conditions between players in the gas market and related markets such as power generation. In the case of natural gas sales resulting from contracts of profit and production sharing, the state, through the Hydrocarbons Commission (CNH), can hire *subsidiary state enterprises* or other companies to perform such activities. This selection will be made through a public tender.

In 2015, CRE issued 21 permits for natural gas trading, including the Electricity Commission (CFE) and PEMEX through their respective subsidiaries (Table 6.2).

Table 6.2 Natural gas trading permit holders in Mexico, 2015

Natural gas trading permit holders		
JM and Ral Energy Mexico	Shell Trading Mexico	IEnova LNG
Accesgas	World Fuel Services Mexico	Igasamex Bajío
CFEnergía	CH4 Energía	PEMEX Transformación Industrial
Gas del Litoral	Gas Natural Servicios	GDF Suez Mexico Comercializadora
KNG Ultra, S.A. de CV	Petro Smart Combustibles	Cía. Comercializadora de Hidrocarburos y Gas Natural
Shell Mexico Gas Natural	Servicios Industriales de Energía	Iberdrola Energía Altamira de Servicios
Energas de Mexico	Abastecedora de Combustibles del Pacífico	Enerpiq

Industry structure

Upstream

Although private players are allowed to produce natural gas in the country; PEMEX will continue to be the main producer in the foreseeable future. The current bidding rounds for exploration and production (E&P) activities are the instrument for new companies to enter the market. In the third bidding round, 25 onshore fields were awarded for gas and oil production. Up to date, 19 contracts have been signed. All production of natural gas is to be supplied to transportation pipelines for its final marketing.

Mid- and downstream

As of 2015, Mexico has a network of 12 995 kilometres of natural gas transmission pipelines. CENAGAS owns and operates a network of 9 386 km named SISTRANGAS, including the transmission network formerly owned by PEMEX and four transmission systems interconnected and integrated for tariff purposes. The remaining 3 610 km belong to non-integrated systems: 2 341 km physically interconnected with SISTRANGAS and 1 268 km all over the country.

While PEMEX was obliged to transfer the ownership of its pipelines to CENAGAS, for the time being it is operating them on behalf of the transmission system operator, until CENAGAS has built up the necessary structures to take over full operations. Important private market participants are IENova (11%), TransCanada (7%), ENGIE GDF (7%), Fermaca (6%). (see Table 6.3)

As regards the **development of new gas transmission pipelines**, the Hydrocarbons Law refers to three types of natural gas transmission infrastructure projects: strategic, social coverage and non-strategic.

The **strategic projects** will be developed by CENAGAS through public international tenders. CRE will approve terms and conditions of the tenders and the infrastructure

must be developed by third parties. CENAGAS could carry out the tender process with the support of a state enterprise and/or private companies.

Projects of social benefits are proposed by SENER for implementation by PEMEX, CFE and CENAGAS. These projects need prior approval of SHCP and will be financed by investment mechanisms determined by SENER and the Ministry of Finance.

The two kinds of above projects should be the object of long-term contracts and it is expected that 20% of the projected natural gas demand of 9 403 mcf/d in 2018 will be covered by such agreements.

Table 6.3 Natural gas transportation pipelines

Pipeline	Length (km)	Capacity (mcf/d)	Commercial operation	Owner
National Transmission System*	8 778	5 107	1999	CENAGAS
Mayakan	700	300	1999	ENGIE (GDF)
Tarahumara	381	850	2013	Fermaca
Naco-Hermosillo System	340	110	1999	CENAGAS
Manzanillo-Guadalajara	321	310	2011	TransCanada
Gasoducto Rosarito	302	1 434	2002	IENova
Sásabe-Guaymas	515	160	2015	IENova
Gasoductos del Bajío*	204	90	2001	ENGIE (GDF)
Tejas Gas Toluca	175	96	2003	Fermaca
Gasoducto de Zacatecas*	172	20	2014	SIIMSA
Gasoducto Morelos	160	320	2015	Elecnor/Enagas
KM Monterrey	137	375	2003	Kinder Morgan
Ramones (phase 1)*	116	2 100	2014	GdC**
Gasoducto Tamaulipas*	114	1 000	2003	GdC**
Gasoducto del Río	57	410	2003	Mitsui
Gasoductos de Chihuahua	38	322	1997	GdC**
Baja California	36	300	2000	IENova
Gasoducto Agua Prieta	12	200	2002	IENova
FINSA Energéticos	4	6	1998	FINSA
IGASAMEX	3	13	1998	IGASAMEX
Conceptos Energéticos	2	10	2003	CEM
Total	**12,995**	**----**	**---**	**---**

* SISTRANGAS pipelines.

** Gasoductos de Chihuahua (GdC) is a 50-50 joint venture between PEMEX and IENova. By end of 2016, PEMEX will sell its equity participation to a third party.

Source*: Prospectiva de Gas Natural y Gas L.P. 2015-2029*.

For **non-strategic projects or commercial projects**, private companies or state enterprises could develop the infrastructure at their own risk. These projects could be carried out under short-term transmission services agreements.

In the coming years, new natural gas transmission pipelines will be developed by CFE and PEMEX in co-ordination with CENAGAS. These projects will expand considerably the SISTRANGAS transmission capacity across the country. Several projects are expected to be implemented by 2019 (Table 6.4).

Table 6.4 Natural gas transportation pipelines projects

Projected pipeline	Length (km)	Investment (million USD)	Capacity (mcf/d)	Status	Year of operation
Los Ramones (phase 2, North and South sections)	738	2 508	1 430	In construction	2016
El Encino-Topolobampo	536	1 008	521	In construction	2016
Guaymas-El Oro	328	429	510	In construction	2016
El Oro-Mazatlán	414	405	204	In construction	2016
Ojinaga-El Encino	205	299	1 350	Awaiting permit	2017
El Encino-La Laguna	423	630	1 500	Awaiting permit	2017
San Isidro-Samalayuca	23	109	1 135	Awaiting permit	2017
Samalayuca-Sasabe	650	571	472	Awaiting permit	2017
Tuxpan-Tula	283	458	886	Awaiting permit	2017
Villa de Reyes-Aguascalientes-Guadalajara	389	294	886	Tender process	2018
Tula-Villa de Reyes	455	554	886	Tender process	2018
La Laguna-Aguascalientes	600	473	1 189	Tender process	2018
Nueva Era	306	TBD	504	Open season	2017
Jáltipan-Salina Cruz	247	643	90	In project	2017
South Texas-Tuxpan	800	3 100	2 600	Tender process	2018
Lázaro Cárdenas-Acapulco	331	456	33	In project	2018
Salina Cruz-Tapachula	440	442	40	In project	2018
Los Ramones-Cempoala	855	1 980	TBD	In project	2019
Mérida-Cancún	TBD	TBD	TBD	In project	TBD
Total	**7 134**	**14 359**		**---**	**---**

Note: TBD - to be determined.

Source: CFE and SENER (2016), *First annual review of the fifth year SISTRANGAS Plan 2015-2019* (*Primera revisión anual del Plan quinquenal del SISTRANGAS 2015-2019*), p. 21.

Storage

Mexico has three liquefied natural gas (LNG) terminals with a combined regasification capacity of 2.0 bcf/d: Manzanillo (Pacific coast); Ensenada (Pacific coast), and Altamira (Atlantic coast). These terminals are also the only gas storage sites, accounting for only 2.4 days of demand (OECD average: 83 days).

LNG imports began in 2006 and reached 0.735 bcf/d in 2015, representing 22% of Mexico's total imports. LNG terminals are supplied under long-term contracts from Qatar, Peru, Nigeria and Indonesia, among others.

LNG facilities offer open access to third parties. Each facility has firm storage and interruptible regasification services. However, in all cases they are only being used by carriers that hold capacity contracts. For the development of storage activities by third parties, as is the case for any new infrastructure development, CRE will assess the project and grant the permits, and then those interested in obtaining infrastructure permit must present to SENER a social impact evaluation, analysing activities and infrastructure needs in the region.

Table 6.5 Gas storage terminals in 2015

Terminal	Location	Regasification capacity (mcf/d)	Terminal storage capacity (cft LNG)	Titleholders
Altamira	Altamira, Tamaulipas	500 – 760	10 594 400	Bopak / Enagas
Energía Costa Azul	Ensenada, Baja California	1 000 – 1 300	22 951 500	IENova
KMS	Manzanillo, Colima	500	10 594 400	Korean Gas Corporation Mitsui & Co. Ltd Samsung C&T Corporation

Note: mcf/d- million cubic feet per day; cft- cubic feet of LNG.
Source: SENER's response to IEA questionnaire.

Emergency preparedness

The Hydrocarbons Law defines SENER's role in developing and implementing a national natural gas security policy. The elaboration of such policy is pending. Although there is currently no explicit natural gas security policy, SENER co-ordinates a series of short-term and medium-term measures to deal with unforeseen natural gas supply disruptions, in co-operation with a working group that includes CENAGAS, PEMEX, CFE and CENACE. According to SENER (2016a) the policy considers all possible gas disruption scenarios (accidents, natural disasters and contractual disputes) and a natural gas emergency response with measures such as minimum requirements for natural gas storage.

Assessment

Natural gas accounts for 35% of Mexico's TPES and faces growing domestic demand. Its share in overall energy consumption is high (33%), above the OECD average (25%).

In parallel with oil production, Mexico's natural gas production has declined in recent years, while gas demand more than doubled from 2000 to 2014.

According to official projections (SENER, 2016a), gas demand is expected to increase by 2.5% per year in the period 2014-29, reaching 106 bcm as a result of a complete switch from fuel oil in power generation (at 11% of electricity generation in 2014), and growing use in industry and in the residential sector. Increasing gas demand will give more prominence to matters of upstream supply, storage and transport in policy discussions.

Production is currently not commensurate to the large domestic resource base. As a consequence of demand rising faster than production, Mexico's imports of natural gas have been increasing, accounting for about 40% of consumption today compared to less than 10% in 2000. In 2014, US natural gas exports accounted for approximately 69% of Mexican natural gas imports, versus 24% of consumption. Between 2008 and 2013, US pipelines to Mexico doubled their capacity, reaching 4.9 bcf/d. By the end of 2016, that capacity is expected to reach 8.4 bcf/d.

Mexico will become increasingly dependent on US natural gas supplies to meet its growing demand, although the government has introduced fiscal measures to increase the attractiveness of developing domestic shale gas resources rather than importing gas from the United States: production of non-associated gas will be free of royalties when prices are below or equal to USD 5 per million British thermal units (MBtu). In order to prepare the ground for the development of such resources, there needs to be regulatory action to address key issues such as water use in arid parts of the country and the engagement with local communities.

Crucial for the implementation of the competitive market is the creation of competition beyond PEMEX and the Federal Electricity Commission (CFE), the practical implementation of open access and tariffs for the gas pipeline system, ensuring more private participation in natural gas trading and marketing.

In the new market model, national utility CFE also has the right to sell natural gas and to launch tenders for the construction of new pipelines, which should challenge PEMEX's dominance in these areas. As in the power sector, the reform introduces open access to the gas network where private producers can also enter bilateral long-term contracts with large customers, in direct competition with PEMEX and CFE. A transparent tariff regime and dispatching lower-cost gas units will be crucial to ensuring a competitive and liquid gas market.

A fundamental element of the market opening is the gas release programme, under which PEMEX will have to reduce its market share to 30% by 2020. In the interest of the competitiveness of the market – and by extending its attractiveness to investors – focus should be put on the consistent implementation of the gas release programme, closely adhering to the principles defined by the CRE for this purpose: transparent public proceedings and homogeneous sets of contracts included in the programme at each step.

As regards gas transportation, the expansion of the pipeline network has lagged behind the boom in gas demand. Expanding the system is urgent, as it has already reached saturation on several occasions: between 2012, when maximum capacity was first exceeded, and 2014, PEMEX issued 35 critical alerts, which resulted in the interruption

of imports and limitation of the gas national supply. These shut-downs have often forced the power sector to use more fuel oil, with estimated losses due to the limitations of the pipeline grid of USD 1.4 billion in 2012 alone.

These bottlenecks and saturation situations in recent years have highlighted the need for storage in the system, to allow for balancing short-term demand and supply discrepancies between the different service areas. Attracting private financial resources will require active investment promotion, based on a sound regulatory framework.

It will be important to ensure that the quick growth in pipeline capacity and the number of private players, along with the ongoing transition of the operatorship between PEMEX and CENAGAS do not lead to instability and/or inefficiencies in the daily operations of the gas pipeline network. Therefore, efforts should be made to guarantee the transparency of operations (flow of information) and the co-operation between private players and CENAGAS with the joint objective of ensuring the secure and efficient organisation of network operations.

In view of rapidly growing imports, from an energy supply security standpoint, consideration should also be given to developing domestic gas resources. As experience from other countries shows, sound regulation and public communication are key to the successful deployment of unconventional gas production. In the Mexican case, issues of particular importance for careful regulation are the questions of land use and water issues in the north of the country.

Recommendations

The government of Mexico should:

- Take into account IEA's policy recommendations on unconventional gas (IEA, 2012) in the elaboration of new regulations for this sector, especially regarding water use and community engagement.
- Continue to actively create a competitive gas market, in particular by consistent implementation of the gas release programme for PEMEX.
- Ensure consistent implementation of the Five-year expansion plan for the National Gas Transportation System SISTRANGAS through constant monitoring.
- Work to expand gas storage facilities and encourage private investment to this end.
- Enhance integration of the national gas grid by encouraging close co-operation and information flows between CENAGAS and private pipeline owners.

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7. Coal

Key data

(2015 estimated)

Production: 3.2 Mt of hard coal and 12.1 Mt of brown coal

Net imports: 7.7 Mt, +5.7% since 2005

Share of coal: 7.3% of TPES and 11% of electricity generation

Inland consumption (2014): 12.7 Mtoe (power generation 65.6%, iron and steel 17.7%, non-metallic minerals 1.2%, non-specified industry 15.5%)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Supply and demand

Supply

Total supply of coal was 13.6 million tonnes of oil-equivalent (Mtoe) in 2015, or 7.3% of total primary energy supply (TPES). Coal supply peaked at 14.5 Mtoe in 2011, declined by 12.6% in 2012, levelled off in the two following years and increased by 7.4% in 2015. Overall, coal supply was 6.6% lower in 2015 than in 2011. Before 2011, coal supply was growing steadily for decades, albeit with high year-on-year volatility in the mid- to late-2000s (Figure 7.3).

Production

Coal supply consists of domestic and imported coal. In 2015, Mexico produced 8 Mtoe of coal, or 59% of total supply. The production consisted of 3.2 million tonnes (Mt) of hard coal and 12.1 Mt of brown coal.[1] From 2005 to 2015, hard coal production contracted by 9.8%, while brown coal production grew by 21.5% (Figure 7.1). Both peaked in 2011, with an annual surge of 43% in hard coal production and 22% in brown coal production.

The north-east of the country (Coahuila) is the centre of coal production, with mines in the Sabinas basin (coking coal mostly for steel mills) and in the Fuentes-Río Escondido basin (mostly thermal coal for power generation), producing more than 90% of Mexico's coal. Coal is produced mostly in underground mines, and in some opencast mines.

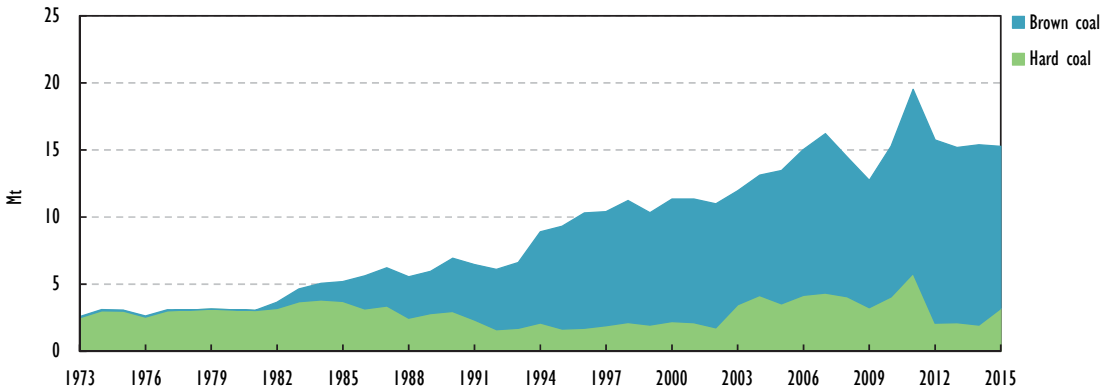
Coal is mined by private companies; the large steel companies operate their own coal mines. Production is not subsidised, but the State of Coahuila supports small mining

[1]. In IEA coal statistics, brown coal comprises sub-bituminous coal and lignite, while hard coal comprises anthracite and bituminous coal.

companies with prepayment schemes. Total employment in the coal mining industry is estimated at 7 300 people. All coal mined in Mexico is used in the country.

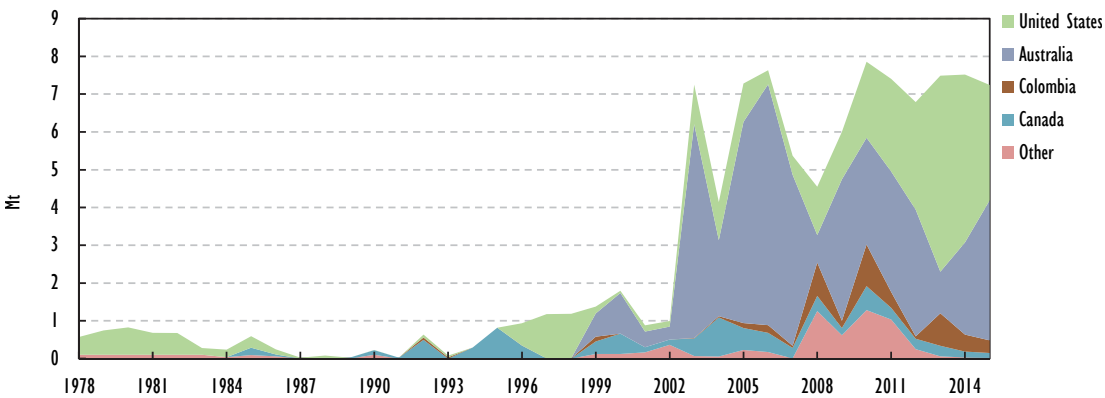
Mexico holds an estimated 1 160 Mt of hard coal reserves and 3 000 Mt of hard coal resources. Its hard coal reserves are ranked the 20th largest in the world. Lignite reserves are estimated at 51 Mt with an unknown level of resources (BGR, 2015).[2]

Figure 7.1 Hard coal and brown coal production, 1973-2015



Source: IEA (2016a), *Coal Information 2016*, www.iea.org/statistics/.

Figure 7.2 Hard coal imports by country, 1973-2015



Source: IEA (2016a), *Coal Information 2016*, www.iea.org/statistics/.

Imports

Coal net imports totalled 5.3 Mtoe in 2015, consisting of 7.3 Mt of hard coal and 0.4 Mt of brown coal. Before 2003, Mexico was importing 1 Mt to 1.5 Mt per year for a decade and only hard coal. In 2003, imports from Australia increased dramatically as some coal-fired power plants capacity was switched to using higher-quality imported coal. As a result, total imports of hard coal surged to 7.3 Mt and have varied between 4.5 Mt and 7.5 Mt per year since, with large annual volatility (Figure 7.2). In 2015, Mexico for the first time imported brown coal in significant quantities, only from the United States.

[2]. In this study, hard coal includes sub-bituminous coal, bituminous and anthracite.

Hard coal imports originated mainly from Australia (51.1%) and the United States (42.2%), as well as from Colombia (4.6%), Canada (1.8%) and other smaller shares. Imports from the United States have tripled over the ten years to 2015, while imports from Colombia have surged from negligible levels in 2005. Imports of Australian coal rose by 84% over the same period (Figure 7.2).

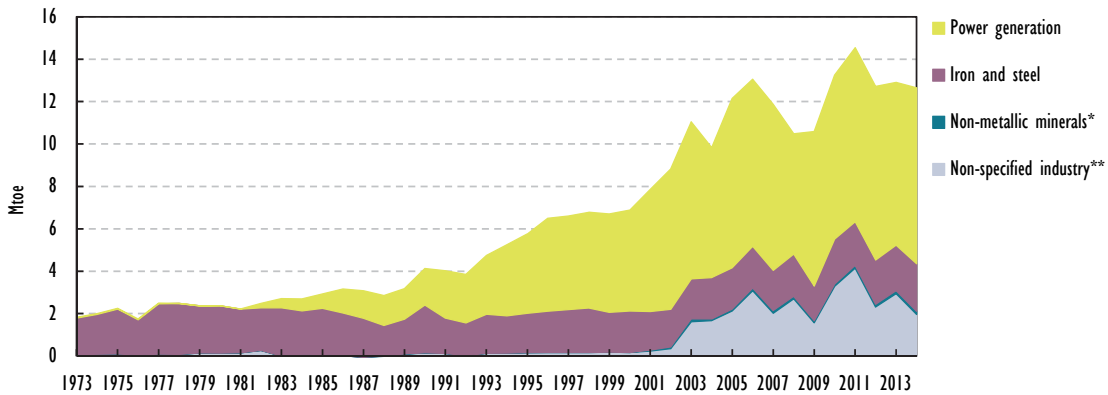
Demand

In 2014, 67.5% of coal was used in power generation, an increase of 30% since 2004, with a sharp decline (by 29%) in 2007 and full recovery the year after (Figure 7.3).

The *iron and steel industry* consumed 17.7%[3] of coal in 2014, an increase of 2.7% from 2004. In 2008, coal consumption in iron and steel declined by 18.4% and surged by 30.7% in 2009.

The *non-metallic minerals industry*, mainly cement and other construction materials, consumed 1.2% of coal in 2014. Its share in total coal demand has remained relatively unchanged over the past decade.

Figure 7.3 Coal demand by sector, 1973-2014



Notes: TPES by consuming sector. Electricity produced from coke oven gas or blast furnace gas and used in the iron and steel industry is calculated as power generation, not as consumption in the iron and steel industry.

* *Non-metallic minerals* manufacturing represents mainly cement, but includes other building materials.

** *Non-specified industry* use reflects incompleteness of coal consumption data.

Source: IEA (2016b), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Coal-fired power generation

Coal-fired power generation in Mexico started in 1982 at two power plants with a combined capacity of 2 600 megawatts (MW), near the coal mines in the north-east. Coal is transported by conveyer belts and trucks to the power plants. In 1993, a third coal plant (2 800 MW) was commissioned on the Pacific coast and burns imported coal only. Of the 15 coal-fired units currently operating in Mexico, 14 operate with a relatively low thermal efficiency of around 35%. The exception is unit 7 of the Petacalco power plant, which is a supercritical unit with higher efficiency of around 39% to 40%. Plans for new

[3]. Around 15.5% of IEA coal consumption data in 2014 are attributed to non-specified industry use, due to incompleteness of data submissions. As such, the calculated statistics for iron and steel and other specific industry consumption may not be complete.

coal-fired power plants (or conversion of existing oil-fired plants to coal) to reduce dependence on (imported) natural gas have not eventuated.

As the coal-fired power plants are some 20 to 35 years old, they are not expected to be closed in the short term. In the Mexican government's *Electricity Outlook 2016-2029,* coal-fired power generation represents 3.7% of installed capacity at the end of the Outlook period. This implies a reduction in coal-fired power generating capacity from 5 600 MW currently to some 4 000 MW in 2029.

Assessment

Coal plays a relatively modest role in the Mexican energy mix, accounting for 7.3% of TPES and 11% of electricity generation in 2015, which is well below the OECD average. Mexico sources its coal from domestic mines in the north of the country and by importing from stable countries, primarily the United States and Australia.

Coal has advantages when considering security of electricity supply. It can be sourced domestically and from many countries around the world, and it is easy to store. It is also a relatively inexpensive source of energy, if the externalities associated with its use are not internalised in its price. Coal use in Mexico, however, causes local air pollution and subcritical units produce twice as much carbon dioxide per megawatt-hour as combined-cycle gas-fired power generation. Energy and climate policy in Mexico increasingly incorporates these externalities. Coal use for electricity generation is facing pressure from clean energy sources and natural gas.

Around two-thirds of coal is used for power generation. The government foresees that the capacity of these power plants will be reduced from 5 600 MW currently to some 4 000 MW in 2029. This reduction in capacity will be determined by the market, as there is no explicit government policy to phase out coal-fired power generation. Therefore, future coal-fired generation will depend on the relative price of coal compared to other sources (for example natural gas), the price of capacity, and the price of imported electricity.

The application of carbon capture and storage (CCS) technologies could substantially reduce emissions from future coal-fired power plants. To date, most of the focus of CCS in Mexico has been on gas-fired generation and there are currently no plans to equip the existing coal fleet with CCS. Power plants with CCS could be eligible for clean energy certificates (CECs) if they achieve emission levels below 100 kg CO_2/MWh; however, this will be challenging for existing subcritical coal units. For example, a subcritical unit operating at 35% efficiency and capturing 90% of CO_2 could be expected to achieve emission levels of around 130 kg CO_2/MWh.

The government's *Electricity Outlook* (PRODESEN) highlights that total generating capacity is expected to grow from 65.4 GW in 2014 to 110.2 GW in 2029, with more than 50% of new capacity to come from (mainly variable) renewable energy. With such strong growth in generation, it is possible that existing – or potentially new – coal capacity could be relied on for security of supply beyond 2029. Providing greater clarity around this longer-term role for coal as a fuel for electricity generation could help to evaluate the investments needed in technology options to reduce the associated externalities; for example upgrading units to improve efficiency and emissions performance, or considering CCS retrofitting.

Recommendations

The government of Mexico should:

- Assess the future use of existing coal-fired power generating capacity against the trade-off between energy security and climate goals.
- Encourage upgrading coal-fired power plants to higher efficiency standards and reduced emissions levels, if it is anticipated these plants will be needed in the generation fleet for decades to come.
- Set strict limit values for local air pollution from coal-fired power plants.

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8. Electricity

Key data

(2015 estimated)

Total electricity generation: 307 TWh, +22.6% since 2005

Electricity generation mix: natural gas 59.8%, coal 11%, oil 10.2%, hydro 10%, nuclear 3.8%, wind 2.6%, geothermal 2%, biofuels and waste 0.5%, solar 0.1%

Installed capacity: 67.3 GW, +28.3% since 2005

Peak demand: 39.8 GW

Electricity consumption (2014): 257 TWh (industry 55.4%, commercial and public services and agriculture 21.4%, residential 21%, energy sector 1.8%, transport 0.4%)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Overview

Mexico has a fast-growing electricity sector, with demand increasing on average by 2.8% per year since 2000 and expected to increase by more than half by 2029. Natural gas is the main source for electricity, benefiting from low gas prices in North America. Power generation from renewable sources is set to increase significantly, thanks to targets and support for clean energy and exceptionally good wind and solar resources. In contrast, oil use for electricity has declined dramatically over the past 15 years, but remains higher than in many other Organisation for Economic Co-operation and Development (OECD) countries; 98.5% of the population has access to electricity.

The 2013 energy reform is fundamentally changing the electricity sector which was built on the monopoly of the state-owned Federal Electricity Commission (CFE, *Comisión Federal de Electricidad*). The reform seeks to reinforce the sector by introducing wholesale and retail market competition. This, in turn, should reduce electricity generation costs and end-user prices and enable the phase out of end-user subsidies without dramatic price increases. At the same time, the reform introduces mechanisms to help ensure that investment keeps pace with fast-growing demand and that an increasing share of electricity is generated from clean sources.

Supply and demand

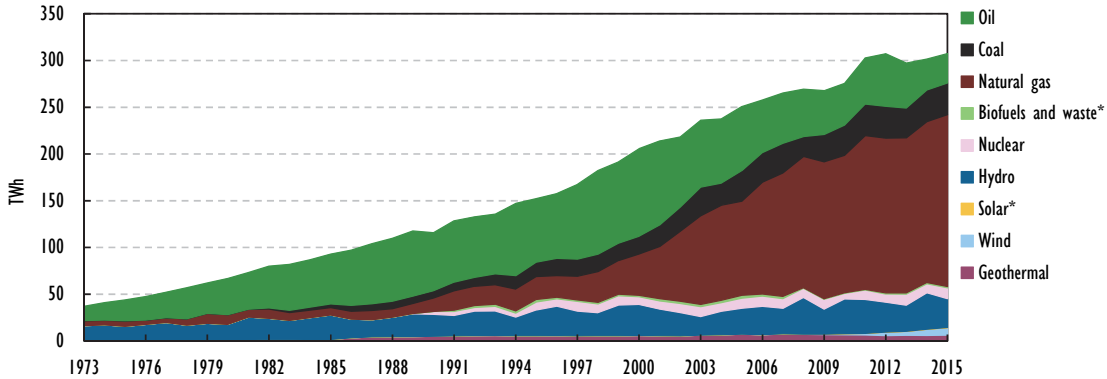
Generation

Mexico's electricity generation reached a record of 307 terawatt-hours (TWh) in 2015. Generation has grown steadily for decades, with only two slight contractions, 0.6% in

2009 and 3.2% in 2013 (Figure 8.1). Over the ten years to 2015, electricity generation grew by 22.6%.

Around 60% of Mexico's electricity comes from natural gas, compared to 40% in 2005. Natural gas use in generation has been growing rapidly, by 82.6% from 2005 to 2015.

Figure 8.1 Electricity generation by source, 1973-2015

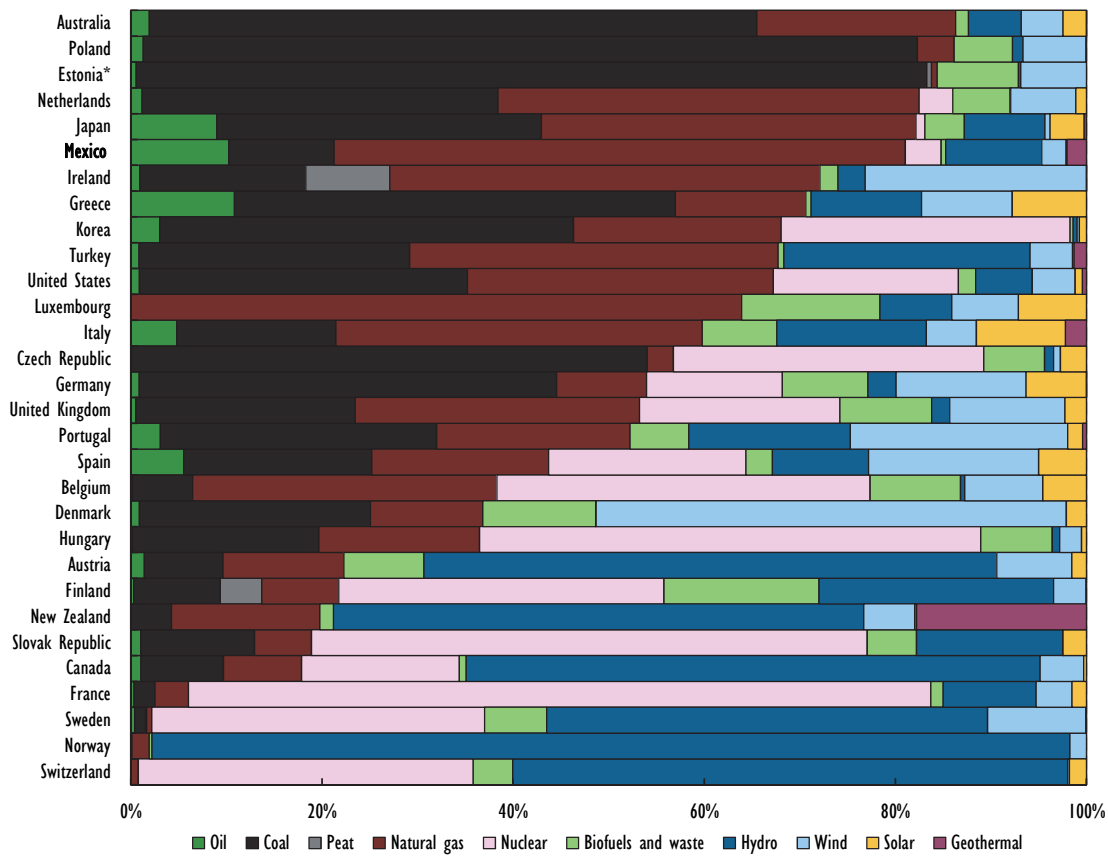


Note: Data are estimated for 2015.

* Negligible.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 8.2 Electricity generation by source in Mexico and in IEA member countries, 2015



Note: Data are estimated.

* Estonia's coal represents oil shale.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Coal, oil and hydro account for around 10% of total generation each. Over the ten years to 2015, electricity produced from coal increased by 3.5% and from hydro by 11.5%, while electricity generated from oil declined by 54%. As the use of both coal and hydro has increased at a slower rate than gas use, their share in total generation has fallen from the 2005 levels of 13% for coal and 11% for hydro. Similarly, the share of oil in generation has declined from 27% in 2005.

Nuclear energy accounts for 3.8% of total generation in Mexico, while renewables other than hydro represent 5.2% and comprise wind (2.6%), geothermal (2%), biofuels and waste (0.5%), and solar (0.1%). Nuclear power generation increased by 7.1% over the past decade, but its share in total generation fell from 4.3% in 2005 because of faster-growing gas use. The share of renewables in electricity generation remained unchanged in 2015 compared to 2005, as declines in the use of bioenergy and geothermal energy were offset by increases in wind and solar power generation.

In comparison to IEA member countries, Mexico's share of fossil fuels in electricity generation was sixth-highest in 2015 (Figure 8.2), with the second-highest share of natural gas (behind Luxembourg) and oil (behind Greece) and the third-highest geothermal share.

Generating capacity

In 2015, installed capacity in Mexico's national electricity system amounted to 67.3 gigawatts (GW), up by 28% from 2005.

Table 8.1 Electricity generating capacity, 2000-15 (MW)

Energy source	2000	2005	2010	2015
Natural gas	4 887	16 147	19 854	21 107
Liquid/gas	6 984	10 330	11 787	12 107
Liquid fuels, including refinery gas	11 418	7 871	9 358	10 062
Solid/liquid	410	425	428	575
Coal	4 700	4 700	5 440	5 474
Other combustible fuels	42	67	47	96
Total combustible fuels	**28 441**	**39 540**	**46 914**	**49 421**
Nuclear	1 365	1 365	1 365	1 510
Hydro	9 653	10 598	11 597	12 223
Wind	17	18	519	3 271
Geothermal	855	960	965	854
Solar photovoltaics (PV)	14	16	29	54
Total capacity	**40 345**	**52 497**	**61 389**	**67 333**

Note: Some coal-fired power capacity that previously has been reported as *Solid/liquid* is here moved to the *Coal* category for consistency.

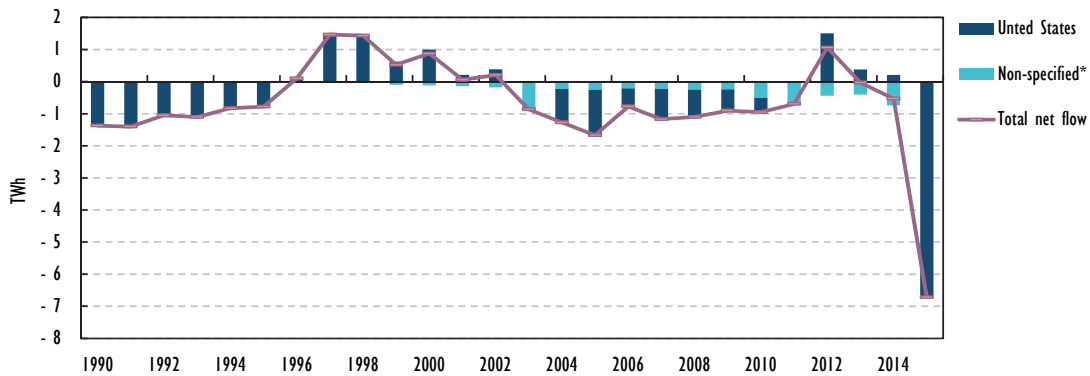
Source: IEA (2016b), *Electricity Information 2016*, www.iea.org/statistics/.

Combined-cycle gas turbines accounted for 51% of installed capacity and other fossil fuel-fired capacity for 22%. Hydropower capacity stands at 18% of the total and the two nuclear reactors at 2% of total installed capacity. Wind, geothermal and solar power together account for 6% of installed capacity. Most of the capacity belongs to the state-owned CFE, and more than one-third of installed capacity is privately owned (see section below on industry and infrastructure). The government's *Electricity Outlook 2016-2029* (by the National Electricity System Development Program, PRODESEN) highlights that total generating capacity is expected to grow from 65 GW in 2014 to 110 GW in 2029, with more than 50% of new capacity to come from (mainly variable) renewable energy.

Imports and exports

In 2015, Mexico's net exports of electricity amounted to 6.7 TWh, corresponding to 2.2% of the country's electricity generation. Exports totalled 9.2 TWh and imports of 2.4 TWh. Net exports increased markedly in 2015, as a 524 MW power plant in Frontera, Texas started exporting to Mexico (Figure 8.3). In the 25 years from 1990 to 2014, electricity trade in Mexico ranged from net exports of 1.4 TWh (2005) to net imports of 1.5 TWh (2012). The United States is Mexico's main electricity trading partner, although there are also interconnections to Guatemala and Belize.

Figure 8.3 Net electricity imports to and exports from Mexico, 1990-2015



Notes: Data are estimated for 2015.

* *Non-specified* represents trade data for which the source or destination is not reported.

Source: IEA (2016b), *Electricity Information 2016*, www.iea.org/statistics/.

Demand

Mexico's electricity consumption amounted to 257 TWh in 2014 (the latest sector-specific IEA data available). Demand has grown steadily for several decades (Figure 8.4), and increased by 37.5% in the ten years since 2004. According to the Ministry of Energy (SENER), demand was 263 TWh in 2015.

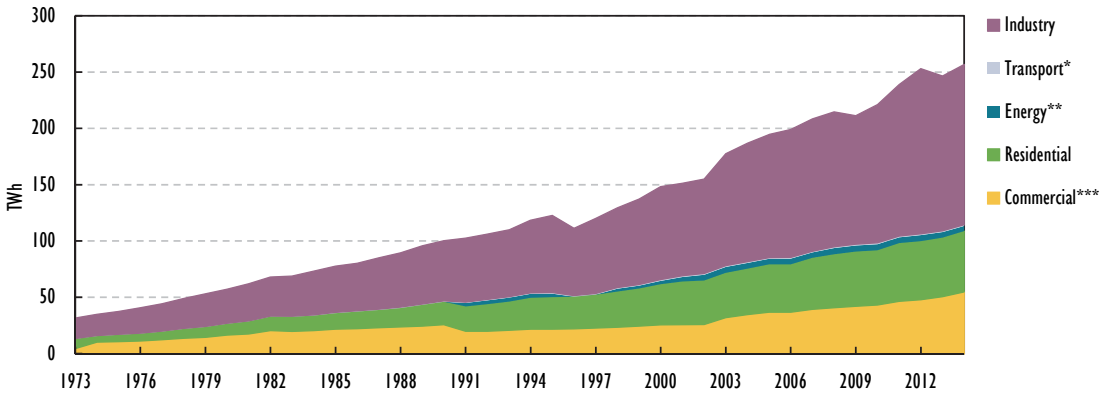
Industry is the largest electricity-consuming sector, accounting for 55.4% of total demand. The share is high in comparison to other OECD countries, as Mexico has a large export-oriented manufacturing sector and as this category also includes consumption from large commercial buildings directly connected to the medium- and high-voltage grid. Demand in this sector reached 147 TWh in 2012 (58% of the total) with a 6.4% contraction in 2013 and a 3.6% recovery in 2014.

Commercial and public services (including agriculture) accounted for 21.4% of demand and the residential sector for 21%. Since 2004, demand from both sectors has increased,

by 32.4% in services and by 58% in the residential sector. The commercial sector gained in share of total demand, up from 18% in 2004, while the residential sector share slightly contracted from 22.5%.

The energy sector, mainly petroleum refining, consumed 1.8% of total demand, while transport consumed 0.4% in 2014. Demand from refining is volatile, averaging around 2.3% of total demand over the ten years to 2014. In the two years since 2012, its electricity consumption declined by 15% in total, finishing 12% lower in 2014 than in 2004. Demand from transport is growing slowly over time and was 3.5% higher in 2014 than in 2004.

Figure 8.4 Electricity consumption by sector, 1973-2014



* Negligible.

** *Energy* includes coal mining, oil and gas extraction, and refining.

*** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Source: IEA (2016b), *Electricity Information 2016*, www.iea.org/statistics/.

Electricity demand peaks in summer (June to August) because of the use of air-conditioning, especially in the north of the country. In contrast, demand is lowest at the end of the year. In 2015, the peak occurred on 14 August at 39 840 MW. This was 2.2% higher than in 2014. CENACE, the system operator, projects electricity demand to grow by 3.5% per year from 2015 to 2029 and to reach 472 TWh in 2029. Over the same period, it projects peak demand (in the interconnected system) to grow by 4.0% per year to reach 69.9 GW in 2029.

Outlook to 2040[1]

The *2016 World Energy Outlook Special Report on Mexico* (IEA, 2016c) includes a long-term scenario for the Mexican power sector based on the reform implementation (New Policies Scenario). In the New Policies Scenario, electricity demand in Mexico grows at an annual average rate of 2.4% between 2014 and 2040, a pace that is more than three times faster than the OECD average. Consequently, per capita electricity demand also grows by around 50% from 2014 to 2040.

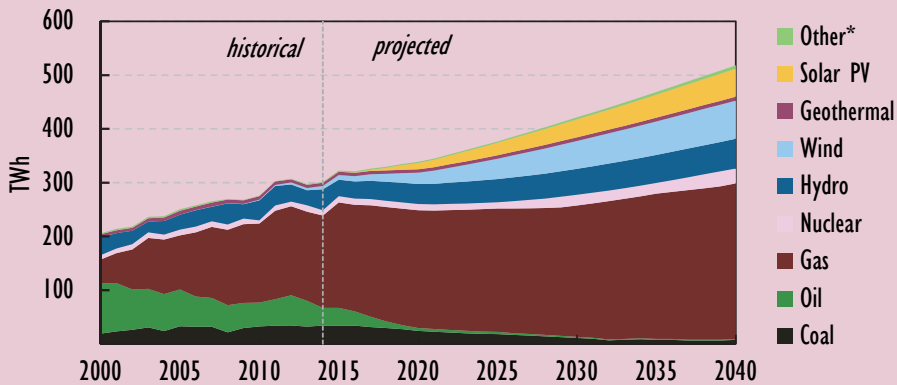
[1]. This section is based on the IEA 2016 *World Energy Outlook Special Report on Mexico* (IEA, 2016c).

Industry remains by a small amount the largest electricity-consuming sector, accounting for 50% of electricity demand in 2040, although this represents a decrease from just over 56% in 2014.

Box 8.1 Mexico's power market outlook to 2040

In the New Policies Scenario, power generation in Mexico rises to more than 500 terawatt-hours (TWh) in 2040, at an annual average growth rate of 2.1%, three times faster than the OECD average of 0.6%. As renewables-based capacity grows, the generation mix in Mexico becomes increasingly diverse and less reliant on fossil fuels, and the share of fossil fuel-based power generation falls from 79% in 2014 to 58% in 2040. Gas remains the dominant source of power, accounting for around 60% of total electricity generation over the projection period, as additional capacity and import infrastructure become available. While the contribution of oil and coal fades, renewables play a much greater role, their share in total electricity generation more than doubling to 37% in 2040 and accounting for two-thirds of the rise in electricity generation to 2040. Wind and solar PV lead the growth in renewables-based power generation: the contribution of wind energy grows from 6.4 TWh in 2014 to 71 TWh in 2040, while that of solar PV jumps from 0.2 TWh in 2014 to 52 TWh in 2040. The electricity reform that opens the door to private investment in power generation is instrumental in the rapid transition to the power mix.

Electricity generation by source in the New Policies Scenario, 2014-40



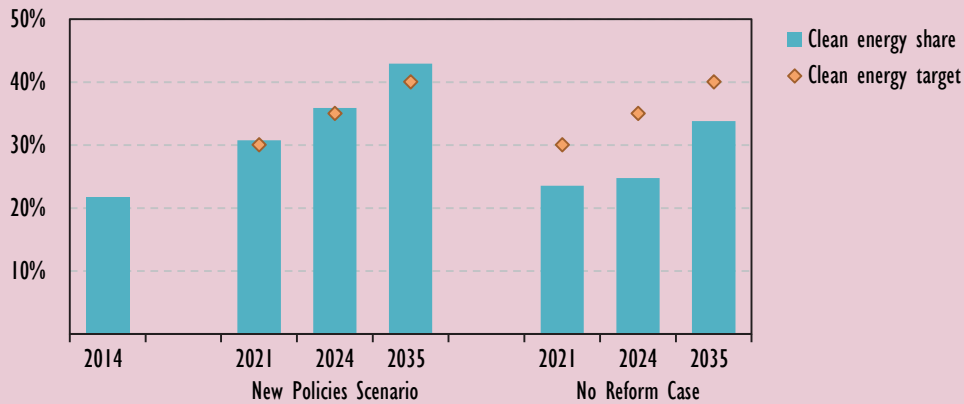
* Negligible.
Source: IEA (2016c), *World Energy Outlook Special Report on Mexico*.

As in the oil sector, the *Special Report on Mexico* also includes a scenario for the Mexican electricity sector in the absence of the reform implementation (No Reform Case). The key elements that are missing in a No Reform Case are the unbundling and restructuring of the Federal Electricity Commission (CFE) and the introduction of competitive electricity markets for energy, capacity and clean certificates. Their absence puts the power market in Mexico on a different trajectory and leads to a different electricity mix, compared with the New Policies Scenario. In terms of generation, even though electricity demand in 2040 is around 2% lower than in the New Policies Scenario, almost the same amount of power needs to be generated in the No Reform Case, because losses and inefficiencies in the network are not addressed with the same effectiveness.

Box 8.2 Implications of a "No Reform Case" for the Mexican power sector

Without specific policies to increase the role of clean energy in power generation, notably the introduction of clean energy certificates and the long-term auction system, the No Reform Case has a slower uptake of clean energy for power generation, especially of wind and solar power. Although efforts are assumed (encouraged by global cost reductions in renewable energy technologies) to deploy more renewable resources, the share of clean energy in power generation falls short of the government target of 40% by 2035 (as well as its intermediary targets in 2021 and 2024) (figure below). CO_2 emissions from the power sector also increase, by around 20% in 2040, relative to the New Policies Scenario, undermining the government's ambitions to cut greenhouse gas emissions through the increased use of clean energy. Mexico's capacity to meet the obligations included in its COP21 climate pledge would be undermined.

Share of clean energy in power generation in Mexico in the No Reform Case



Note: Clean energy includes nuclear, hydropower, other renewables and efficient cogeneration. Clean energy targets for 2021 and 2024 are based on the Energy Transition Law. The clean energy target for 2035 is based on the Law for the Development of Renewable Energy and Energy Transition Financing.
Source: IEA (2016c), *World Energy Outlook Special Report on Mexico*.

Fuel switching from oil continues in the No Reform Case, as this is a continuation of a policy push that dates back to the late 1990s. However, the pace at which oil is replaced by gas is slow, which, together with the slower improvement in transmission and distribution losses and lower operational efficiency, increases electricity prices in a No Reform Case: electricity prices for industrial consumers are around 14% higher in 2040 than in the New Policies Scenario.

For residential consumers, we assume end-user prices at the same level as in the New Policies Scenario, in which electricity subsidies are phased out by 2035. In practice this translates into an additional subsidy bill in the No Reform Case (felt either as losses absorbed by CFE or explicit subsidies financed by the state budget) as the system as a whole is less efficient. The average cost of generating and delivering power to residential consumers in a No Reform Case is around 16% higher than in the New Policies Scenario. The cumulative additional subsidy bill over the period to 2040 is around USD 50 billion.

Source: IEA (2016c), *World Energy Outlook Special Report on Mexico.*

Regulatory framework

Mexico is undergoing an historic reform of its electricity sector, moving away from a vertically integrated utility to a competitive market framework designed to attract clean energy investments. In December 2013, Mexico reformed its Constitution with a deep transformation of the oil, gas and electricity sectors. In August 2014, the Electric Industry Law was promulgated as part of the energy reform,. The law's main goals are to reduce the costs of electricity and to increase the share of clean energy generation.

The challenge is as huge as CFE itself; indeed, the state-owned monopoly employs 92 000 people, owns 62% of generating capacity, produces around 55% of all electricity and is the sole retail supplier in the country. While not the most visible part of the overall energy market reform, the electricity reform is expected to deliver important efficiency gains for the country and to be instrumental in meeting Mexico's energy policy ambitions.

The development of clean energy has been an integral part of the power reform from the onset. In contrast, most other OECD countries have introduced decarbonisation policies years after opening their markets to competition. In Mexico, these objectives have been integrated into the design of the electricity market reform itself in the form of quota obligations for clean energy certificates (CECs), a market design that informs investors about the value of investments in new clean energy investment by time and location. They also include competitive tenders for long-term contracts to reach the clean energy objectives at least cost.

The electricity reform is also largely driven by the aim to increase efficiency, and address concerns about electricity prices, high subsidies and high network losses. Almost all the population now has access to electricity, but 21.3% of the energy generated is not charged, owing to technical and non-technical losses, for instance because bills are not paid. The diagnosis of the Ministry of Energy is that, back in 2013, the average CFE tariffs were 25% higher than the average tariffs in the United States, and without subsidies they would have been 73% higher. The state-owned CFE is plagued by high costs and lack of transparent information about costs and deficits - in short, many issues that the reform is addressing.

This reform is not the first attempt to introduce competition in the power sector. Since 1992, independent power producers have been allowed to own and operate power plants, and to sell their generation under long-term power purchase agreements to CFE, which retained a legal monopoly over the retailing of electricity. In addition, large industrial consumers can "self-supply" their power, including with long-term contracts. Independent power producers accounted for 21% of installed capacity and self-supplied around 10% in 2015. Despite these initial steps in opening up the sector, however, inefficiencies have persisted.

The 2013 reform is much more ambitious than the previous ones as it introduces competition on generation, supply and, eventually, retail electricity activities. In this perspective, the reform takes steps to unbundle the historical monopoly, not only between networks, generation and supply, but also by creating different competing generation companies out of CFE (see below). The electricity reform relies on several levers to achieve the stated objective of reducing prices while promoting clean energy. This includes the restructuring of CFE and its unbundling, the introduction of competitive nodal electricity market prices for energy, a capacity market, ancillary services, financial

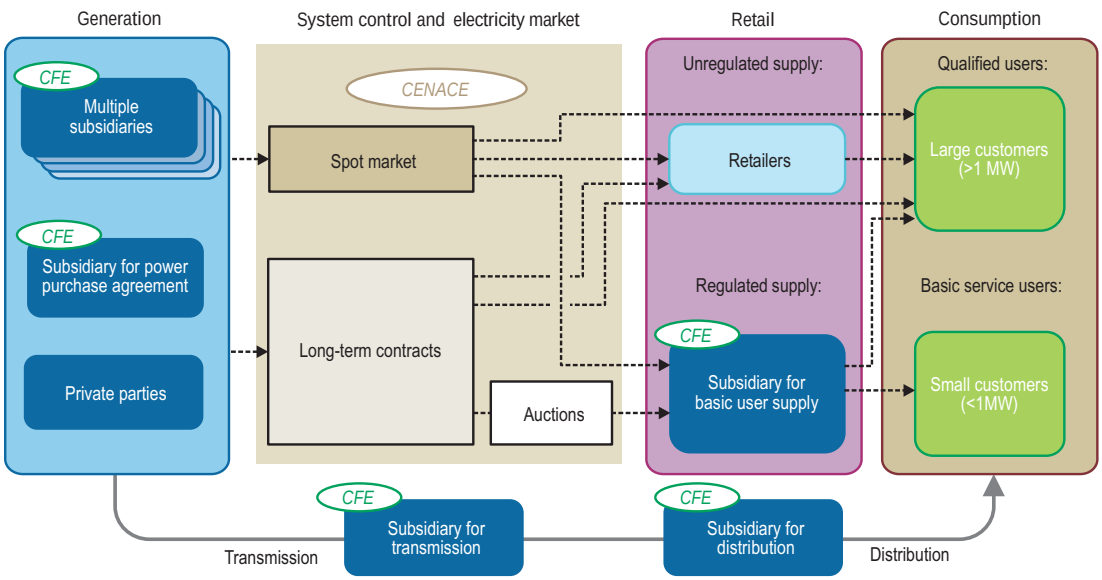
transmission rights and clean energy certificates. In addition, the government will continue to rely on long-term contracts for new investments in generation.

The electricity reform is being carried out at full speed. The energy reform required first a modification of the Mexican constitution to abolish the CFE monopoly. This was done in 2013. Less than three years later, the new wholesale electricity market was launched in January 2016 and the first long-term electricity auction was organised in March 2016.

In the meantime, most of the regulated electricity tariffs had already declined sharply between 2013 and 2016 in most categories. Already at the early stage of the reform, CFE has accelerated investments to enable some power plants to use natural gas instead of expensive and polluting fuel oil. Within two years from 2013 to 2015, the consumption of fuel oil dropped by almost 50% and this trend is expected to continue.

The reform is implemented in stages and some of its important elements are yet to be introduced. These include the real-time market, the capacity market and the clean certificates market, all to be introduced in 2017-18. The long-term success of the reform rests on the definition of detailed rules and implementation. However, some important steps have been taken, including the publication of Market Rules in September 2015 and the manuals and other regulations published through 2016.

Figure 8.5 The new structure of the electricity industry



Source: SENER.

Institutions

The Federal Ministry of Energy (SENER) is the main body responsible for the co-ordination of the electricity sector. There is no split of responsibility with states. The ministry is in charge of the electricity market reform, including preparing laws and decrees, and implementing them. It has also contributed in many of the initial decisions on market design and prepared the organisation of long-term auctions, responsibilities that will be transferred to the regulator or the system operator at a later stage of the reform.

Before the 2013 reform, supplying electricity was a government responsibility. The vertically integrated regulated utility, the **Federal Electricity Commission (CFE***, Comisión Federal de Electricidad*) was an integral part of the government, owning most of generating capacity and procuring, through Power Purchase Agreements, additional electricity from independent power producers. As part of the reform, CFE has been transformed into a state productive enterprise that SENER will continue to control. SENER will also regulate its unbundling. Indeed, the mandate of the **Energy Regulatory Commission (CRE)**, does not allow it to control state-owned companies.

The regulator CRE's main tasks are to calculate network tariffs (transmission and distribution), other regulated activities (for example, operation of the basic service suppliers; the electricity system operator CENACE), as well as the final basic supply tariffs. CRE enjoys technical, operational and managerial autonomy and can dispose of its own revenues coming from a tax, not from the state budget. CRE has a clearly defined but limited set of additional responsibilities (dispute resolution, inspection and control rights, and an advisory role) and a very detailed governance structure, including limiting the term of CRE's President Commissioner to 14 years.

The **Ministry of Finance and Public Credit (SHCP)** has powers to overrule CRE's retail tariffs for the basic service suppliers. The unbundling of CFE and the introduction of regulated network tariffs are expected to increase transparency about costs of the CFE. Responsibility for subsidies to electricity end-users will also be transferred from CFE to the Ministry of Finance and Public Credit and they will be paid out from the government budget.

The **National Center for Energy Control (CENACE),** the electricity system operator, will be the cornerstone of the future system organisation. CENACE is an autonomous body, formerly part of CFE. It was created in 2014 and is responsible for operating the national electricity system and the wholesale electricity markets. CENACE does not own transmission assets which remain the property of CFE, but CENACE operates the wholesale electricity market to ensure least-cost dispatch of all power plants in adherence to economic considerations such as free competition, transparency and market efficiency. Similar to independent system operators (ISOs) and regional transmission operators (RTOs) in the United States, it also plays a key role in the planning of the power system, including investments in transmission, to define capacity requirements, operate capacity markets and run the long-term auctions.

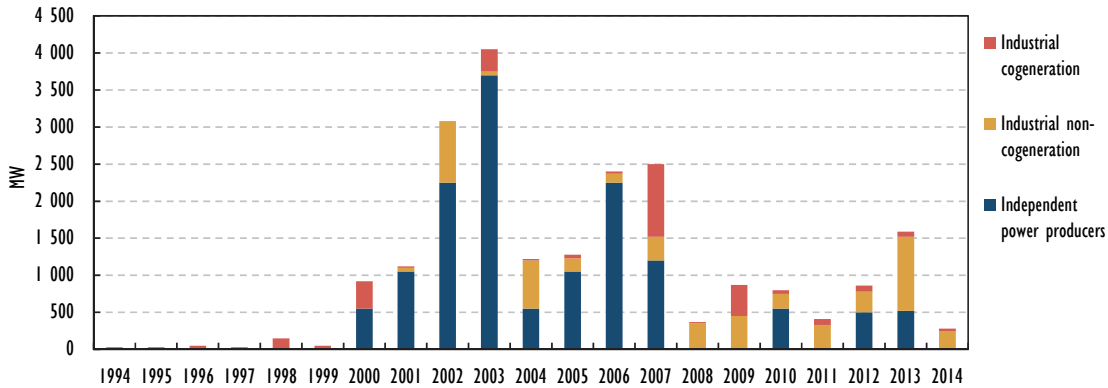
SENER issues every year a planning document for the electricity sector: the National Electricity System Development Program (PRODESEN). PRODESEN includes an indicative programme for the installation or closure of power plants. It also includes the expansion and modernisation programmes of the national transmission grid and general distribution networks. The programme is based on all public and private projects to increase generating capacity and includes projects for transmission and distribution on a time horizon of 15 years. It provides transparency to all market participants and is also a basis used for long-term auctions (see below under Auctions for long-term contracts).

Industry and infrastructure

Privately owned capacity and CFE unbundling

Private participation in electricity generation has been progressively opened through independent power producers (IPPs) in long-term contracts with CFE and permits for self-supply for large industrial consumers, but also small producers. The share of privately owned capacity has been increasing since 2000 and has reached more than one-third of total capacity. The remaining share is owned by CFE.

Figure 8.6 Privately owned electricity generating capacity by installation year, 1994-2014



Note: Distributed or self-supplied generation and cogeneration facilities in Mexico are largely concentrated at industrial facilities. Other electric capacity that is not owned by the state-owned corporation includes small generators and capacity for import or export across the Mexican border.

Source: U.S. Energy Information Administration, based on the Comisión Reguladora de Energia.

In February 2015, CFE, a government entity, became a state productive enterprise. With this new status, CFE gained management autonomy and corporate governance similar to a private business. It is expected that in power generation, this new status will lead to a more profit-oriented investment and operation decisions, and increase efficiency. This lays the groundwork for improvement of CFE's performance and for developing its potential in the new competitive environment.

In January 2016, SENER issued the terms to unbundle CFE and to enable it to participate in the market.

First, CFE is vertically separated between its network, generation and retailing activities. This unbundling is limited to a legal separation, with the creation of a subsidiary for transmission, another for distribution, yet another for basic supply, and several for generation. In addition, CFE may establish other subsidiaries and affiliates as deemed necessary. The unbundling remains partial as it is carried out at legal, not ownership, level. The only ownership unbundling concerns the system operator CENACE which became a state owned enterprise and does not belong to CFE's holding group.

Second, CFE will also be horizontally unbundled: over 2016-17. It will constitute a total of six generating companies,[2] including one subsidiary managing existing IPP contracts, and five companies to perform the activities of conventional power plants. CFE power plants will be allocated to each generation company in a way that creates competitive conditions in each regional location of the power system and limit market power issues. Each of the five generating companies should have similar conditions of financial sustainability and profitability, a balanced mix of technologies and remaining technical lifetime. This horizontal separation of generation should lay the foundation for competition in the electricity market.

Table 8.2 Installed electricity supply capacity by category, 2015

Producer	Total capacity, GW	Share of total capacity, %
CFE	41.90	61.6
Independent producers	12.95	19.0
Self-supply	7.13	10.5
Small producers	0.065	0.1
Cogeneration	3.65	5.4
Exports	1.40	2.1
Other	0.95	1.3
TOTAL	**68.0**	**100.0**

Source: SENER.

The legal unbundling rules define a governance framework for CFE's subsidiaries, so as to ensure independent operations and effective competition. In particular, each CFE company will have its own governing board accountable for investment decisions, with rules to ensure its independent operation, including staff and buildings matters, in order to prevent collusion and illegal transfer of information. The terms of legal unbundling impose many restrictions to CFE operations. Each company will be subject to periodic audits carried out by the Ministry of Energy. If needed, the ministry can impose further restrictions on the relationship between CFE and its affiliates and among them.

To ensure a competitive market, the bids in the electricity wholesale market must be based on costs, which means that generation companies will not be allowed to bid above their short-term marginal costs in this market. Each megawatt-hour generated will be paid the clearing price that reflects the corresponding energy, losses and congestion components at every node. This cost-based market approach is designed to prevent not only the exercise of market power, but also the setting of scarcity prices during tight system conditions, and limits the participation of the demand side in electricity markets.

[2]. In addition, one subsidiary will manage the legacy interconnection contracts.

The evaluation and control of marginal production costs, fuel costs and power plant efficiency are performed by SENER on the basis of information provided by CENACE. In addition, SENER is designing bilateral contracts to be signed between CFE's regulated retailers and existing CFE generation. The length of these contracts will differ for each plant to prevent market power and to allow a smooth transition to a fully implemented market. Finally, the Market Surveillance Unit at SENER hired an independent market monitor in order to ensure the efficient and competitive operation of the market. This function is being performed by SENER during 2016, but will be transferred to the regulator CRE in 2017.

The opening of the electricity sector to a competitive market will be progressive, since CFE has not been fully unbundled IPPs have kept their long-term contracts with CFE, and the construction of new power plants by competitors will take time. At the beginning of the reform, the only competitors on the generation segment are self-suppliers, at least at the first stage. Retail suppliers will be able to buy electricity on the wholesale market and will have to compete with regulated tariffs.

At the end of 2016, there are already retail suppliers providing services to customers whose demand is above or equal to the minimum threshold of 1 megawatt (MW). In September 2015, SENER also published the Market Rules, providing the regulatory framework for the Mexican wholesale electricity market which started operations in January 2016. CRE has the authority to modify the market Rules that SENER publishes.

Transmission

The entire Mexican transmission and distribution network is owned by CFE. The transmission system is operated by the independent system operator CENACE (*Centro Nacional de Control de Energía*).

The overall electricity system is referred to as the national electricity system (SEN). The national interconnected system (SIN) covers the main transmission network of Mexico, excluding Baja California and Baja California Sur which are not physically connected to the rest of the country (Figure 8.9).

Mexico benefits from an already well developed transmission network. Electricity is transmitted over long distances which can lead to high thermal losses. Reducing network losses is therefore an important objective for dispatching. High-voltage lines of 230-400 kilovolts (kV) cover 51 184 km (5.8% of total), equalling the total of 69 kV and 161 kV lines. Mexico City forms a central node in the high-voltage network.

Apart from the Yucatan peninsula, there are few network congestions. In Yucatan, local gas-fired power plants experience difficulties related to natural gas supply as pipelines tend to be congested or unavailable. Electricity transmission capacity is not sufficient to import cheap power from the rest of the country, requiring the region to operate more expensive local plants that use fuel oil or diesel.

As part of the sector reform, the transmission network is legally separated from CFE's competitive activities. Unbundling is designed to ensure access to the transmission network on equal terms with other CFE subsidiaries and their competitors. Open access is key to eliminating barriers for the installation of new power plants and to attract new investments in the power sector. The transmission network tariffs will be regulated by CRE.

Mexico's transmission network development plan is described in great detail in PRODESEN's *Electricity Outlook*. The interconnection of the isolated system of Baja California to the Northwest system is one of many projects. Transmission investment plans amount to USD 14.2 billion over the period 2016-30, representing 12% of total investments in the electricity sector. The energy reform allows the private sector to invest in transmission assets.

Cross-border connections

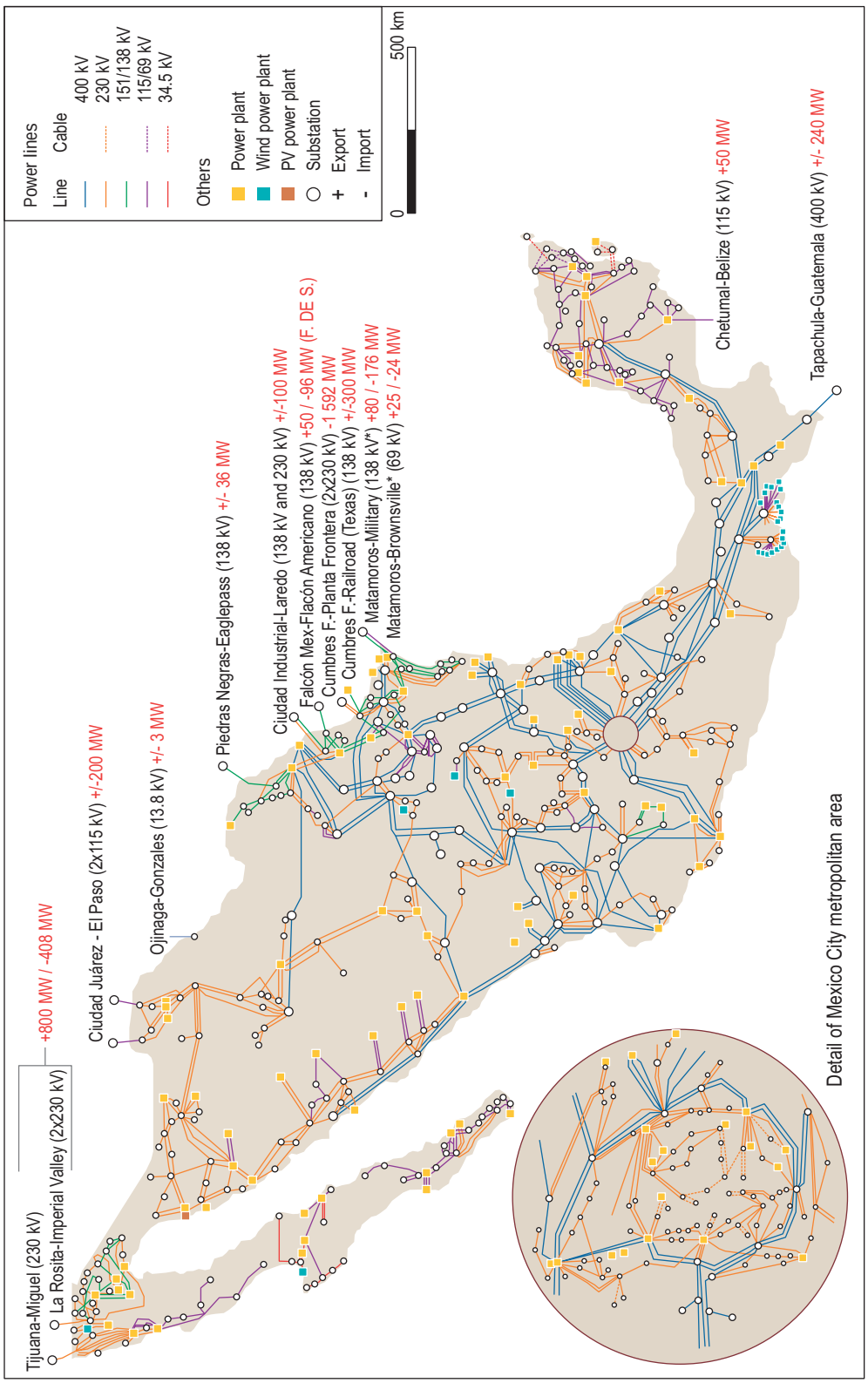
Mexico is currently interconnected with its neighbouring countries by 13 transmission lines, 11 with the United States, one with Belize and one with Guatemala. However, of the 11 interconnections with the United States, five are not available for cross-border trade, but only for emergency support (Figure 8.9). Excluding interconnections used mainly for mutual emergency support, overall import capacity is 3 175 MW and export capacity 1 887 MW.

The PRODESEN long-term power sector plan places a premium on increasing interconnections and working towards more intensive transmission grid integration with Mexico's neighbours. To the south, Mexico is already an important supplier to Guatemala and Belize, but there is a great deal of potential to increase its position as a key energy exporter in the region, for example by joining the Central American Interconnection System (SIEPAC) which, since 2013, has linked the grids of six countries across the region. Enhanced integration would allow a more efficient flow of energy, potentially preventing shortages associated with variable renewables supply, and would allow companies in Mexico to monetise any excess energy they generate. Enhancing electrical and gas interconnections between Mexico and Central America could presage a structural shift in electricity generation, with a shift from oil to gas, helping to reduce prices while reducing the carbon intensity of the generation mix.

To the north, electricity trade with the United States has been rather limited, yet it has on occasion played an important role in maintaining power security, when wheeled through the grid as an emergency response to electrical outages. The energy reforms allow, for the first time, private power producers in the United States to sell their electricity on the Mexican wholesale market (such producers were restricted to selling to captive producers, or to CFE, under the previous regulatory regime). This trend has already started: in 2015, the 524 MW Frontera power plant in Texas began exporting power to Mexico, with the intention of allocating its entire capacity to the Mexican market.

Increasing connectivity would allow Mexico to capture some of its most important renewable resources, for example in Baja California which has some of the best wind and solar conditions in the country, but whose population is small and sparse. An example is the Sierra Juarez project in Baja California, a 155 MW wind farm that exports exclusively to the San Diego Gas and Electric Company through a 20-year power purchase agreement. Such a project would likely not have seen light of day had it been restricted to sales to the Mexican market.

Figure 8.7 Map of Mexico's electricity network, 2016



Source: CENACE.

Distribution

CFE is currently responsible for electricity distribution. There are 16 geographical divisions in charge of distribution. At the end of 2014, the Mexican transmission and distribution grids covered an overall length of around 880 000 km, providing electricity to nearly all the Mexican population.

Energy losses are the main challenge for CFE. As of December 2015, CFE estimated annual losses to be MXN 42.2 billion. CFE has reduced distribution losses from 16.1% in 2010 to 13.1% in 2015 which is still far more than the OECD average of 6.3%. Technical losses caused by the poor state of the current network are high, accounting for 6% of total generation. Non-technical losses of almost 8% were caused by theft, non-payment or inadequate billing arrangements.

The government aims to cut the losses further to 9% by 2020. It has introduced several measures to this end, including *i)* improving metering by compliance verification programmes of existing meters and the replacement of electromechanical meters by electronic meters, and by implementation of new measurement technologies (AMI, advanced metering infrastructure). *ii)* strengthening business processes to ensure the quality and timeliness of billing and collection; and *iii)* normalising the situation of users and villages connected irregularly.

Distribution network tariffs are regulated by CRE. The existence of 16 different distribution divisions within CFE will create the opportunity to gather information for comparative analysis of performance and efficiency of operations, and to benchmark the level of performance of each business unit. The CRE will be able to use this information to encourage cost reduction through the regulation of distribution companies.

Smart grids

Investment in smart grid infrastructure is being driven by a programme developed by the regulator CRE. Modernising the country's power grid is one of CRE's duties and the 2015 Energy Transition Law obliges CENACE to prepare a smart grid programme every three years and submit it to SENER for adoption.

The business opportunity for investing in smart grid infrastructure in Mexico is strong as, in some parts of the country, non-technical electricity losses are very high. CFE, the only energy supplier in Mexico, is looking to implement smart metering and other related investments to reduce these losses and improve operational efficiency.

Wholesale market structure and design

The energy reform introduced a number of products that are traded on a long-term basis: electricity, clean energy certificates (CECs), and generating capacity. By introducing competition for the supply of these products, the energy reform seeks to foster private-sector investment in clean energy technologies while minimising the associated cost. In addition, the energy reform also introduced auctions of long-term contracts for the construction of new generating capacity needed to supply regulated consumers (basic service consumers). Other long-term contracts are expected between generators and non-regulated consumers (qualified consumers) as competition develops. These long-term contracts for generating capacity and clean certificates will be critical for attracting

investment. Long-term auctions, in particular, are an integral part of the market design created to achieve clean energy goals.

The introduction of wholesale markets facilitates trading in energy and ancillary services, allowing market participants to correct for imbalances. The wholesale market consists of day-ahead and real-time markets. At a later stage in the reform, hour-ahead markets will also be introduced. Market participants can also trade financial transmission rights (FTRs) and CECs.

The newly established independent system operator CENACE manages the wholesale market, which started operating in early 2016. The market reform will be fully implemented by 2018.

Nodal energy market

The electricity market reform established a wholesale market open to private participation. It started operating in January 2016 and is expected to be fully operational by 2018. Several energy products are traded on the day-ahead market (DAM) and will be traded on the real-time market (RTM), or by means of bilateral contracts. Products are traded in hourly blocks and prices are set for each node of the network, in order to reflect the marginal cost of generating electricity at each location. CENACE calculates hourly energy and ancillary service prices for each node of the transmission grid, taking into account the cost of network losses and potential network constraints. Marginal prices are therefore calculated on the basis of three components: energy, congestion and network losses. This model refines the dispatching tool used previously by CFE.

In the day-ahead market, energy products are based on hourly bids. Market participants can choose to buy or sell, accept the market price (fixed offer), or submit conditional bids that are subject to predefined market conditions. The system operator CENACE can ask power plants selected in the DAM to cancel or change their allocation for reliability reasons.

Reflecting the high degree of concentration, this market is cost-based, which means that the bids of each power plant must reflect its costs. Bids are monitored by SENER, during the first year of operation of the wholesale electricity market, and by CRE beginning in the second year.

Starting in 2018, real-time market offers can have prices different from those on the day-ahead markets. Around this time, the day-ahead and real-time markets will be complemented by an hour-ahead market. Once fully implemented for the real-time market, this locational marginal pricing model will ensure economic dispatching of the least-cost power plants, while reflecting the security constraints of the grid. In addition, the energy price will reveal the value of generation at different locations of the system, thus sending locational signals for investments in new clean generation.

Financial transmission rights

In order to allow market participants to hedge against congestion-related price risks, financial transmission rights (FTRs) were introduced in 2015 as part of the market rules. FTRs provide the holder with the right and obligation to collect or pay the difference between the values of the congestion component of the nodal marginal price from a node of origin to the node of destination. CENACE, the system operator, will issue and sell

FTRs and it is expected that retail companies and large consumers will buy them as a hedge against the volatility of nodal prices.

FTRs are a new measure market participants are not yet familiar with. This is why they were planned to be introduced at a later stage of the reform, the first auction taking place in late 2016 or early 2017. They are expected to have quarterly durations (January to March, April to June, July to September and October to December), for the remainder of the year in which they were auctioned, a year or a period of three years.

Capacity market

In addition, capacity products have been introduced. The objective is to ensure the installation of adequate capacity by remunerating the fixed costs not recovered on the energy market (which is based on marginal costs, and at this stage of the reform, does not rely on scarcity prices during shortages of capacity). Suppliers and qualified consumers must comply with certain minimum capacity requirements, either by providing these directly or by obtaining them separately via the various channels.

A capacity market operated by CENACE will calculate capacity prices once a year. It will only remunerate capacity which was available during the 100 critical hours of the system. It will also remunerate clean energy power plants, in particular wind and solar, according to their actual availability and generation.

A unique characteristic of this market is that it is an *ex post* market. This is justified by the need to avoid market power issues with CFE. It will enable to pay only the capacity that is actually available when the system needs it.

Clean energy certificates

The reform introduced clean energy certificates[3] (CECs) for each megawatt-hour of clean electricity generated. Clean energy technologies include renewable energy, nuclear energy, efficient cogeneration and fossil-fired generation with carbon capture and storage (CCS). A market for CECs has been introduced to create a separate revenue stream for low-carbon generators. CECs will continue to be awarded for the next 20 years and generators can hold them indefinitely.

Mexico's objective is to increase the share of clean energy in electricity generation from 20% in 2015 to 35% by 2024 and 50% by 2050. Given the low level of the carbon tax in Mexico (around USD 3 per tonne of CO_2) and the absence of such a tax for natural gas, CECs are an important support for clean power generation technologies. Only capacity commissioned after August 2014 is eligible in order to encourage new investments.

The targets to 2024 are to be met through a quota and a clean energy certificate system. Retail suppliers (currently only CFE) and large consumers that do not use retail suppliers will be obliged to obtain a given share of their electricity supply (for large consumers, a share of electricity consumption) from clean sources. SENER sets the annual quota obligation which is increased it every year. For 2018, the quota is 5% and for 2019, 5.9%. CECs are bankable and do not expire.

[3]. The CEC system and the related targets and quotas are explained in more detail in Chapter 9 on renewable energy.

2018 is the first year of quota obligation and trading in an annual CEC market will then also begin. Before 2018, CECs can be marketed in direct bilateral transactions and through long-term auctions. New investment in electricity generation is expected to be driven by long-term contracts and the market for clean energy certificates will be a residual one.

Auctions for long-term contracts

A centrepiece of the reform effort is the system of auctions for energy, capacity and clean energy certificates, a system that allows investments from both established and new players into the market on a competitive basis. The auctions offer long-term contracts (15 years for energy and capacity, 20 years for clean energy certificates) that provide a degree of stability over future cash flows for generation companies, reducing risks and therefore also the cost of capital. The auctions are technology-neutral; the buyer (which in practice is CFE at this stage) sets out the requirements for basic service users in terms of energy, capacity or CECs, and the choice of technology is left to the market.

Auctions are held at least once a year for delivery starting three years later. When bidding, project developers may bid with a single offer for capacity, energy and CECs. For each auction, the regulator CRE may establish a ceiling price (per megawatt, megawatt-hour and CEC). For energy and capacity products, successful sellers sign a 15-year contract and contracts for CECs are valid for 20 years (after this period, energy and CECs can be sold at market price). The bids may be denominated in Mexican pesos or US dollars. Winning bidders must enter their projects into operation within three years after the auction, which gives wind and solar PV a distinct advantage over other technologies.

The Mexican clean energy auction system is one of the most sophisticated procurement mechanisms for renewable energy. Distinctively, it seeks to capture the relative value of the system of different generation technologies by location and production profile. Projects located in higher-price areas of the country, or capable of delivering power at times of day when it is particularly needed, would offer higher revenues and therefore attract more attention from potential investors. For this purpose, SENER has developed a sophisticated system of location- and time-dependent adjustment factors.

A project located in a congested node with higher locational marginal price could expect higher future energy revenues and bid at a lower fixed price in the auction. Similarly, a technology such as solar PV is producing more when there is sun, which coincides with higher demand and higher electricity prices in Mexico. Solar PV generators can expect higher energy revenues over their lifetime and therefore bid at a lower level of support in the auction.

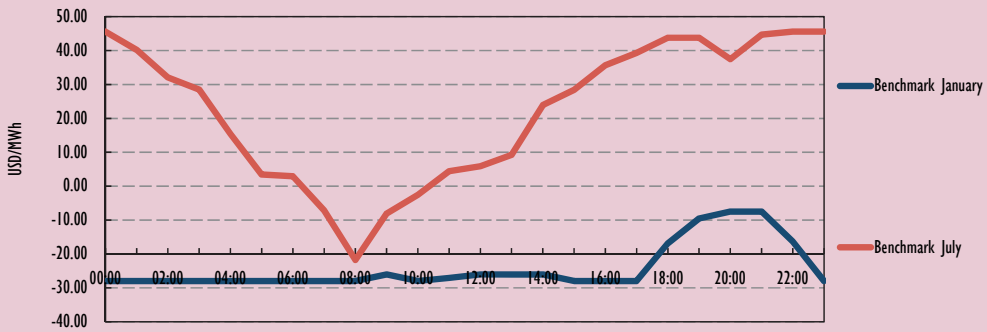
In addition, variable renewable electricity projects are subject to time-dependent price benchmarks to determine their revenues during operation, which means that projects are encouraged to produce power when it is most valuable to the system (see Box 8.1). The use of multi-technology auctions ensures that the most-suited technology will be deployed at competitive prices. As a consequence, the auction system strikes a delicate balance between the need for long-term revenue certainty and the competitive procurement of technologies with the highest system value.

The government is responsible for organising the auctions, but the roles and responsibilities of the various entities involved will remain in transition until 2017-18. The first three auctions are organised by CENACE in co-operation with SENER, and after that, from the fourth auction on, they will be organised jointly by CENACE and the regulatory commission CRE. In January 2017, CRE will become responsible for market monitoring. In 2018, it will also assume the responsibility for administering the CECs.

Box 8.3 Price benchmarks during operation applicable to variable renewable energy

In the first auction in March 2016, location-specific correction factors pushed project development to favour specific regions. Once in operation, the energy price for "intermittent" technologies is time-dependent. These time-dependent correction factors are established by SENER with the input of the system operator CENACE for each hour of each month for the entire power purchase agreement (PPA), length of a project, and differ for each region. If the expected price exceeds the average marginal price of electricity, the intermittent producer receives the value of the bid plus the benchmark value. Similarly, if the project feeds power into the grid at a moment when the benchmark price is negative, this amount will be deducted from the contract price. As a consequence, the revenues of the generator give an indication of the system value of electricity produced during each specific hour of the year. Benchmark prices are updated for each new auction to account for the evolution of local supply and demand considering the (future) commissioning of previously awarded projects. This system of price calculation pushes bidders to design their plants in a way that optimises both their day-to-day revenues, as well as the system value of electricity production.

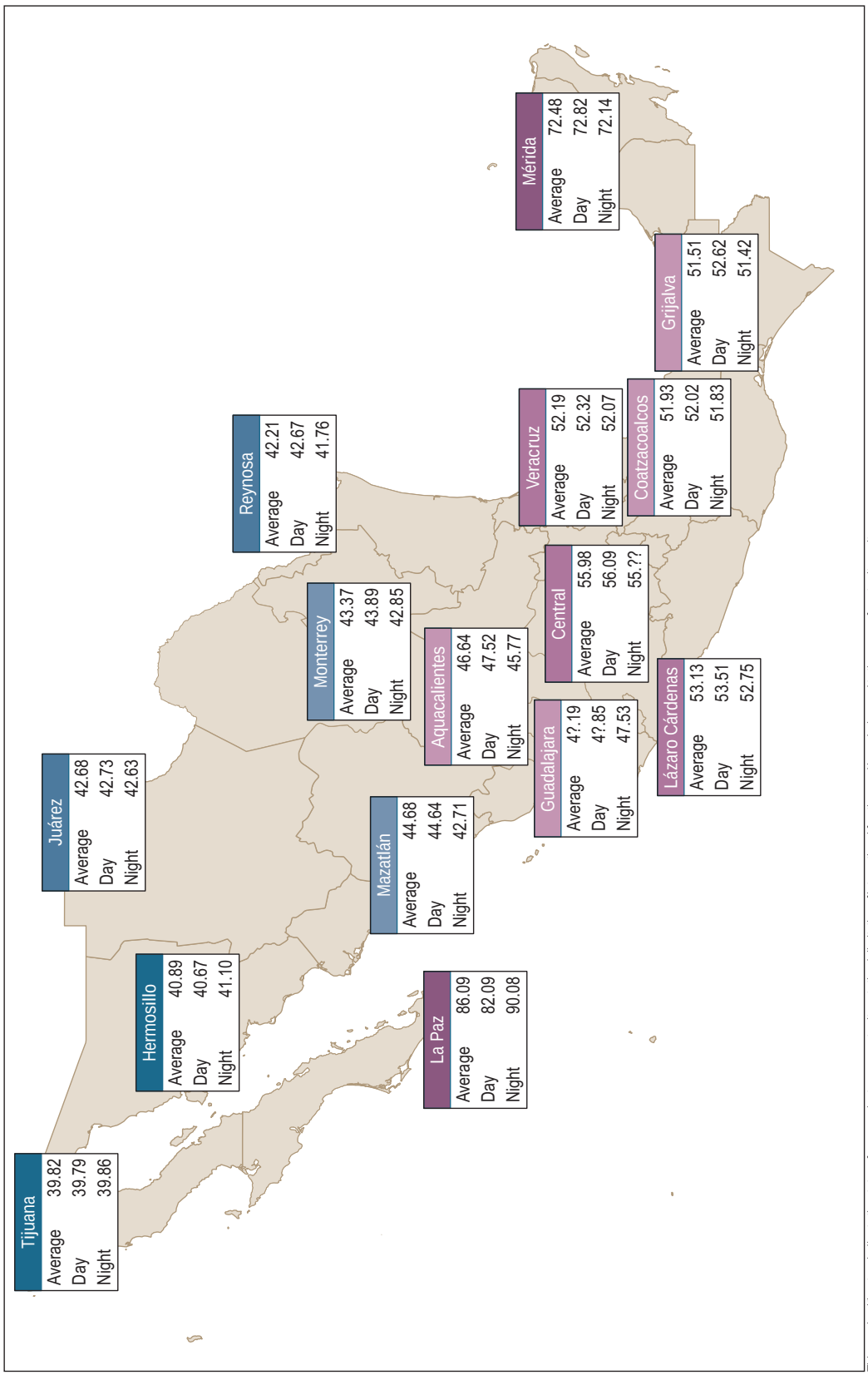
Example of benchmark application for intermittent energy: Area of Los Cabos, 2017 values.



The price benchmark varies on an hourly basis and can be positive or negative. In this example, a wind power plant with a USD 40/MWh bid associated to its contract would receive, in January, USD 12/MWh at 01:00 (tariff *minus* USD 28/MWh), while, in July, at 23:00 the final revenue would be USD 95.5/MWh (tariff *plus* USD 45.5/MWh). In essence, those producers offering electricity with a higher-than-average value can reduce their bids in two steps. In the first step, project developers consider the time-related benchmarks that will apply in the location of their choosing. They will incorporate this into the price they bid into the auction. In the bid selection, the regulator applies a correction factor related solely to location.

Source: IEA (2016d).

Figure 8.8 Expected electricity prices by location and time in the first auction (March 2016)



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

The first long-term auction

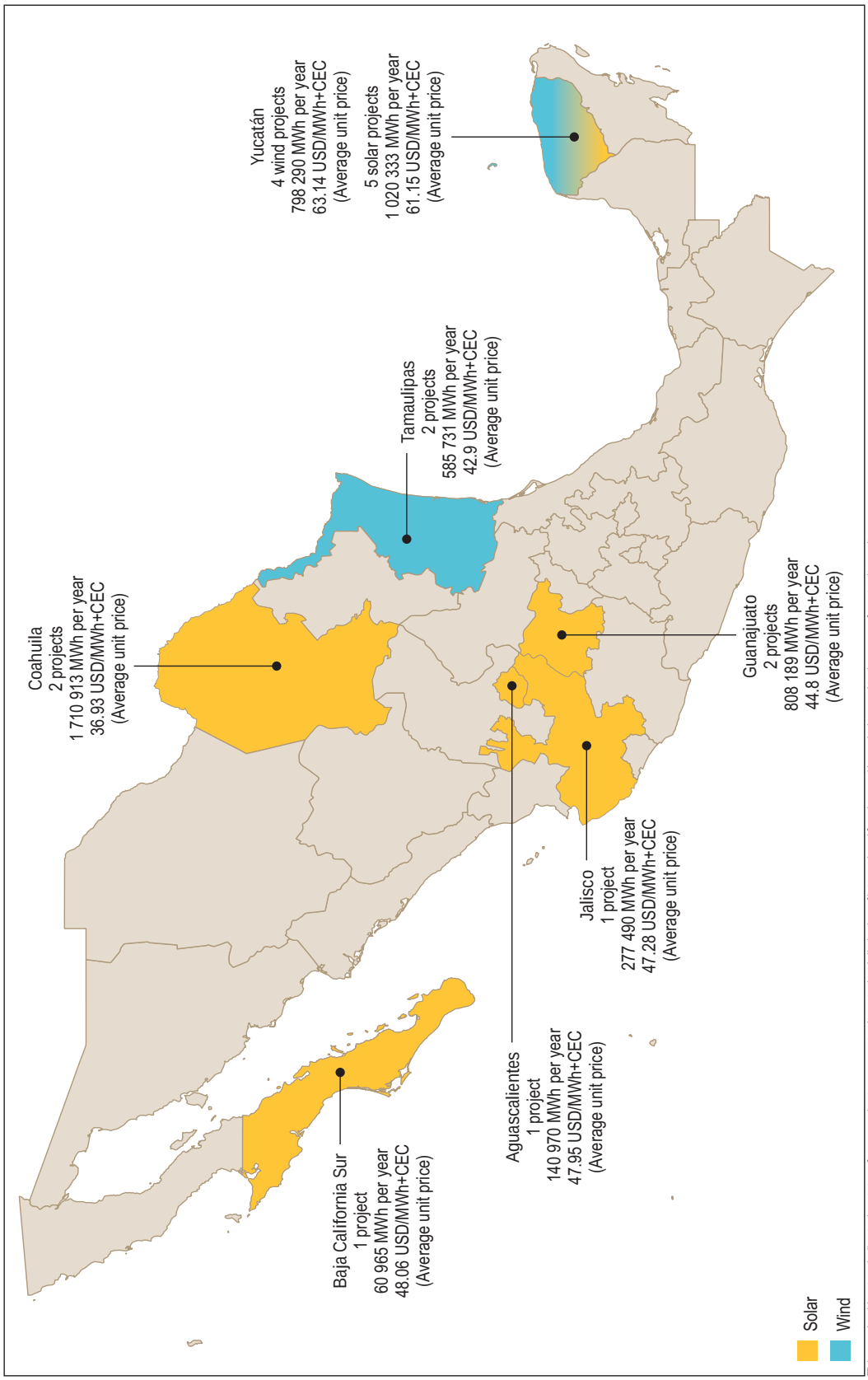
The first long-term auction was held in March 2016 and the second in September 2016. In the first auction, SENER calculated future energy prices for different locations across Mexico to assess the expected value of new investments and adjusted bids in the auction on this basis. The impact of this assessment could be seen in the outcome. The lowest prices for solar PV were reportedly around USD 40 per MWh – a resounding vote of confidence in Mexico's market design and its solar potential. But there were also several solar PV projects selected at higher cost (some USD 60 per MWh) in the Yucatan peninsula (where future electricity prices were expected to be higher), because of their higher value to the system as a whole. As more clean energy is deployed and markets become more mature, the government will have the possibility to move to a system in which market participants are exposed directly to locational price signals coming from the market. The aim is not just to generate investment, but to ensure that the choice of site and technology brings the most benefit.

The first auction in March 2016 attracted wide interest from national and international companies. In the energy auction, out of a maximum of 6.3 TWh, 5.4 TWh was procured. Wind and solar PV were the only winning technologies. The average prices submitted by successful bidders in the first auction were among the lowest ever recorded globally so far (BNEF, 2016a). The results reveal a wide variation in awarded contract prices, with ranges of USD 35.5 to USD 67.5 per MWh for solar PV and USD 42.8 to USD 66.9 per MWh for wind. When accounting for the adjustment factor, nearly all projects lie in the USD 35 to 50 per MWh range (BNEF, 2016b). Remarkably, contracted capacities came to 394 MW for wind and 1 718 MW for solar. This result is not in line with the initial planning document of SENER (the National Electricity System Development Program, PRODESEN), highlighting the benefits that the auction system provides for competitive price discovery.

The 5.4 million CECs, which are linked to the total energy procured, cleared at USD 47.6 per MWh. No successful bids were offering capacity, signalling that the ceiling price of USD 577 per MW per year may have been too low to trigger market interest. The low ceiling price for capacity reflects the fact that there is no shortage of dispatchable capacity and CFE did not wish to procure capacity (BNEF, 2016b).

The significance of the location correction was much higher than that of the time-adjustment factors in the first auction. By clearly indicating the spatial value of electricity production through price benchmarks (Figure 8.8), it encourages generators to develop projects that provide power in locations that optimise the overall system value. Correction factors ranged from USD 34.28 to USD 10.67 per MWh. These adjustment factors are based on SENER's calculations for the future nodal energy price by node over 30 years, to assess the expected value of new investments by location.

Figure 8.9 Map of the results of the March 2016 long-term auction



Source: SENER.

The second long-term auction

The second long-term auction, held in September 2016, resulted in 8.9 TWh of electricity being purchased by CFE, the only buyer in the auction. The supply will come from a total of 23 companies, including CFE, from 11 countries. By source, solar accounted for 54% of the volume of energy, wind for 43% and geothermal for 2%. The government expects total investments of around USD 4 billion in 2.9 GW of new generating capacity. The average price for a combination of energy and CEC was USD 33.47 per MWh, a 20% decrease from the already low USD 41.80 per MWh in the March auction. Moreover, in the second auction, 1 187 MW of capacity per year was purchased, of which 72% is combined cycle, 15% solar, 11% wind and 2% geothermal.[4]

By region, projects were awarded to 15 of Mexico's 27 states. In total, the March and September 2016 auctions are expected to lead to investments of around USD 6.6 billion in around 5 GW of new clean electricity capacity by 2019. The government has been positively surprised by the competitive level of prices per megawatt-hour discovered through the auctions.

Nuclear power in the auctions

There is no specific financing mechanism for nuclear energy, and for the moment the intention is that nuclear power projects in Mexico be financed with the same mechanism of energy prices, capacity prices and clean energy certificates as other new energy investments. The price levels from the auction held thus far, the lead time for the investments to be completed in three years, and the duration of the contracts available (15 years for energy and 20 years for clean energy certificates) raise questions about whether nuclear power plants will be forthcoming under the current system.

Retail prices and subsidies

Electricity use has traditionally been subsidised in Mexico, mostly for households, and this is still the case. From 2010 to 2015, net subsidies to end-users amounted to USD 37.6 billion, according to CFE. Taxes covered 54.4% of this, but the remaining 45.6%, or USD 17.1 billion, had to be covered by CFE. In 2015, subsidies to residential and agricultural consumers represented around 17% of the cost, with a total value of USD 3.8 billion, 100% covered by CFE now as a state productive enterprise.

The energy reform has transferred part of the subsidy burden from CFE to the Treasury, introducing it as an item in the national budget. This will increase oversight and inject impetus into finding ways of reducing the bill in the future. Reducing electricity costs is one of the main goals of the energy reform, which sought to introduce a profound restructuring of the industry in a way that captures opportunities for efficiency improvements and stimulates competition that drives costs lower, and alleviates the burden of the subsidies bill on the state (or CFE).

A decomposition of the current cost structure shows that, in certain areas, significant savings could still be made. Bringing down, for example, technical and non-technical

[4]. For capacity, the auction also received bids from combined cycle plants and for the Clean Energy Certificates there were offers from hydropower plants.

losses, which are currently significantly higher than those seen across the OECD, would reduce the need to invest in additional generating capacity, while improvements in the operational efficiency in the newly unbundled CFE could significantly reduce the retailing component of the cost structure. For example, 6% of electricity billed is not paid. To improve its profitability, CFE is implementing an aggressive strategy of *i)* signing payment agreements, *ii)* collecting payment agreements, and *iii)* suspending electricity services.

Two separate factors − lower imported gas prices and the increasing switch from fuel-oil to gas in power generation − have decreased the cost of power generation in 2014-15 by 37% which in turn has helped reduce the average cost of supply by almost 20% since 2013. This reduction in cost has not reduced the subsidy bill, with the savings instead being passed on to consumers, leading to a 12% reduction in the average tariff.

Table 8.3 End-user electricity subsidies (USD million), 2010-15

Energy source	2010	2011	2012	2013	2014	2015
Residential	6 624	6 974	6 820	7 567	7 641	5 149
Tariffs 1 to 1F	6 624	6 974	6 820	7 567	7 641	5 149
Tariff DAC	0	0	0	0	0	0
Commercial	0	0	0	0	0	0
Services	204	179	129	168	113	0
Agricultural	813	1 019	971	1 016	1 010	600
Industrial	440	0	0	0	0	0
Medium-sized businesses	390	0	0	0	0	0
Large industries	50	0	0	0	0	20
Total gross amount	**8 082**	**8 172**	**7 920**	**8 751**	**8 764**	**5 769**
Minus the surplus in tariffs (cross-subsidy)	505	1 075	1 347	1 569	2 170	1 618
Minus the fiscal supports and other (net) *			724	403	107.5	344
Net amount of the subsidies **	**7 577**	**7 097**	**5 850**	**6 779**	**6 487**	**3 807**
Public use taxes	4 412	4 612	3 400	3 603	4 423	0
Write-off of tariff insufficiency not covered by public use taxes	3 165	2 485	2 449	3 176	2 064	3 807

* Transfers to cover the cost of fuel and differences between products and export costs and portering.

** Recorded in the financial statement audited by an independent auditor.

Sources: SENER, with data from Federal Electricity Commission (CFE).

Before the reform in 2013, retail electricity prices in Mexico were relatively high. According to SENER, the average rates were 25% higher in Mexico than in the United States. In particular, industrial prices were 84% higher in Mexico than in the United States, raising concerns about the competitiveness of industry in the country (only the large industry was allowed to self-supply its electricity relying on efficient new combined-cycle gas turbines). Retail prices for both industry and households have recently decreased significantly. Electricity prices declined by 24% in 2015 and 2016, reducing the gap with electricity prices in the United States.

The retail price reductions were decided by the government and reductions in generation costs were passed on to final consumers. Another option to use the margin from declining generating costs would have been to reduce subsidies to final consumers. Retail electricity prices remain a politically sensitive issue in the country.

The electricity reform is also opening the perspective of retail competition for small consumers. As a first step, however, price regulation remains for households and smaller industrial consumers, called “basic service users”. At this stage, CFE is the only supplier to basic service users, but the Electricity Law enables other suppliers to provide this service. SENER continues to regulate the prices based on the historical costs of existing plants and, for new load, CFE must acquire new energy through auctions. Only qualified users (i.e. large industry) can buy electricity directly from the market, but these consumers may still remain under regulated tariffs. In addition, large industrial consumers may also continue to self-supply their consumption, as was the case before the reform, or enter into bilateral agreements “off market”.

The initial degree of competition on the retail market remains low, with few qualified consumers having left CFE for other new entrants. The regulated tariff is also available for large consumers in the basic service, which has hindered the development of retail competition. Given the decline in prices in 2013-15, other generators have struggled to compete with CFE, even for industrial consumers, which represented 55% of electricity consumption in the country in 2014.

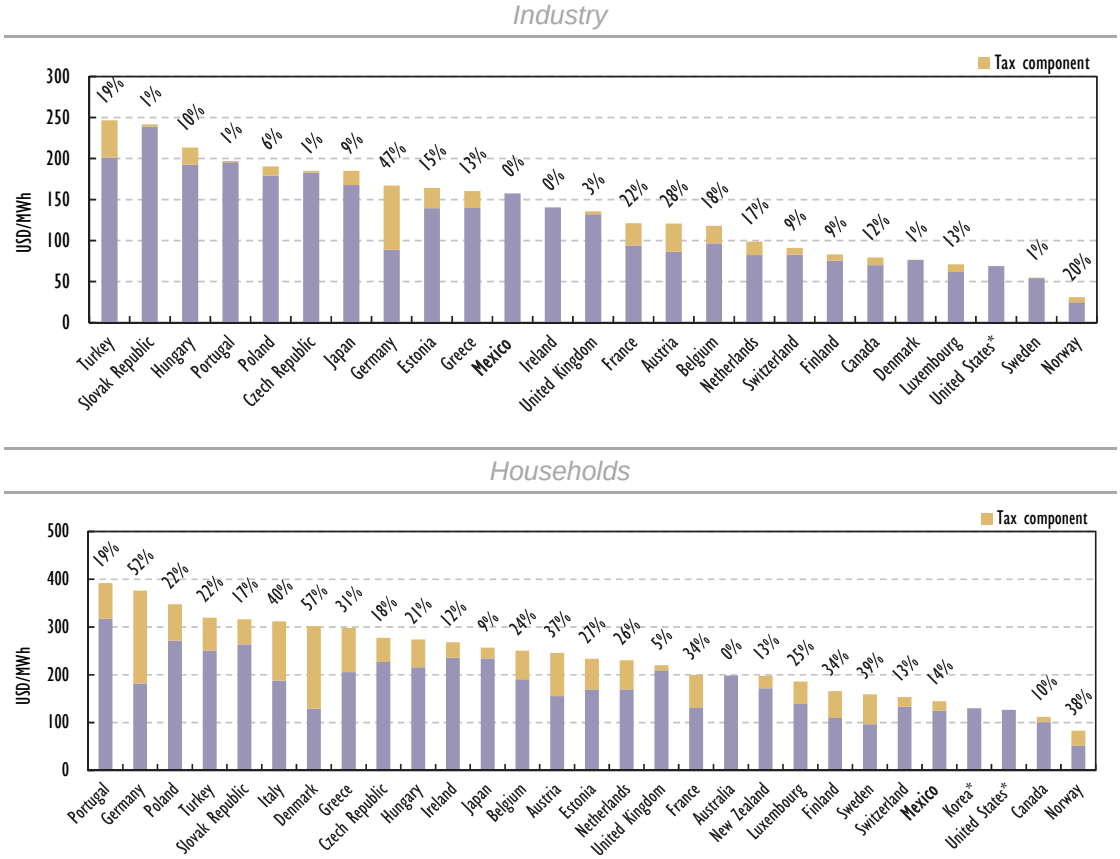
The reform is set to stimulate retail competition, however, as the government lowered the threshold to define qualified consumers from 2 MW to 1 MW in August 2016 it will possibly lower it further in the future. The market share of alternative suppliers is expected to increase as the reform is effectively implemented. The development of retail competition will depend on the evolution of electricity and gas prices, the progressive extension of competition to new qualified consumers and the level at which the government will set regulated tariffs.

Historically, electricity tariffs for industrial, commercial and large residential users have been automatically adjusted monthly, under a process known as the “automatic adjustment formula” which takes into account changes in fuel prices and domestic inflation. This adjustment formula has been applied over the last two decades to reflect the evolution of supply costs, with some periodic changes every five years. Since 2012, the weighting coefficients used in the adjustment formula automatically reflect the changes in the share of different energy sources of power generation. Electricity tariffs for services, agricultural and small residential users are not subject to variation in fuel prices; therefore, they have been adjusted historically with fixed factors.

Tariff structure

The tariff structure depends on the voltage of the connection, the type of usage and region. For residential consumers, the general tariff is national and subsidised but there are specific tariffs for communities located in regions with hot summers. There is also a higher tariff for households with a high comsumption level. These residential consumers with high consumption can, however, reduce their bill by installing rooftop solar PV. The tariff structure for companies depends on the time of use. There is one component for the maximum demand that is metered during the month and rates differ for base, intermediate and peak periods. There are also interruptible contracts available (see section below on generation adequacy).

Figure 8.10 Electricity prices in Mexico and IEA member countries, 2015

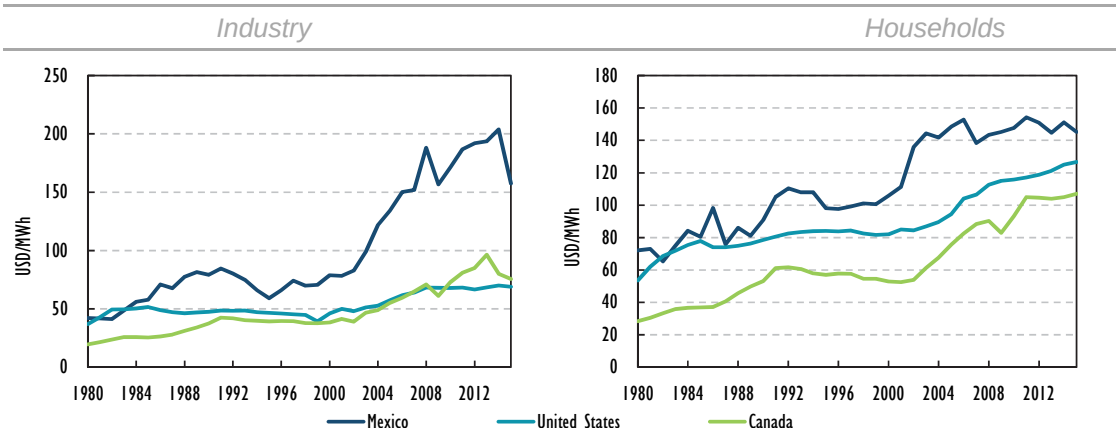


Note: Industry: data not available for Australia, Hungary, Italy, New Zealand and Spain. Households: data not available for Spain.

* Tax information not available.

Source: IEA (2016e), *Energy Prices and Taxes 2016*, Q2, www.iea.org/statistics/.

Figure 8.11 Electricity prices in Mexico, the United States and Canada, 1980-2015



Source: IEA (2016e), *Energy Prices and Taxes 2016,* Q2, www.iea.org/statistics/.

Behind-the-meter rooftop solar PV

A net metering scheme is in force, whereby retail customers connected to the low- or medium-voltage grid receive bill credits for injected electricity. Low-voltage grid users receive a bill credit for the equivalent of the energy provided. The credit balance is reset after 12 months.

Behind-the-meter investments have been mostly limited to large residential consumers who are paying a higher price for the higher portion of their consumption. Households with large consumption invest in rooftop solar just enough to go back to the subsidised rates.

The net metering system is available for households (with installed capacity under 10 kW) and for commercial users (capacity lower than 30 kW) connected to the grid at a voltage lower than 1 kV. The net metering mechanism is also applicable to medium-scale renewable generators and efficient cogeneration systems (installed capacity under 0.5 MW) connected at a voltage between 1 kV and 69 kV.

Further development of rooftop solar PV will depend on the decline of subsidies for households and agricultural consumers, and on solar PV costs decline. The design of retail prices that better reflects the structure of distribution costs and the hourly variations of electricity prices would send more accurate signals to invest in distributed generation.

Electricity security

SENER has the overall responsibility for the security of electricity supply, and therefore in practice for the task to ensure that electricity security, which used to fall on CFE, as it was an integral part of the ministry. CFE´s new mandate also includes fostering the reliability of the national electric system. The main instruments SENER has for ensuring long-term security of supply are *i)* the planning document, the "National Electricity System Development Program" (PRODESEN), *ii)* the capacity market, which is designed to price in capacity needed, and *iii)* the long-term auctions for new power plants.

The current level of electricity security of supply is good, thanks to good fuel security, a margin of adequate reserve capacity and a strong network. The level of non-technical losses, however, remains high, although CFE is implementing measures to reduce it.

Fuel security

Until the beginning of the last decade, Mexico relied heavily on domestic oil for electricity generation. As this oil is replaced by natural gas imported from the United States, import dependence is increasing. In 2015, around 60% of power generation came from natural gas, 46% of which was imported, mainly through a limited number of pipelines. Power generation from other fuels is well diversified, including around 10% each from oil, , coal, hydro, and other renewables and nuclear. Increasing gas-fired generation will also necessitate strong co-ordination between the development of the gas infrastructure and the location of new gas-powered plants.

Generation adequacy

Mexico's electricity system enjoys a comfortable reserve margin. In 2015, installed capacity reached 66 GW, including less than 3 GW of variable wind and solar power, while peak demand did not exceed 40 GW (39.84 GW on 14 August at 17:00). Most of the capacity has been installed recently and the dominance of flexible gas-fired capacity facilitates the integration of high shares of variable renewables.

As more renewables are introduced into the system, Mexico has plans to move away from the deterministic reliability standard based on reserve margins. The objective is to define a target in terms of loss-of-load probability, that will be used to calculate the level of capacity required in the system.

The determination of adequate capacity will also have to take into account the contribution of solar PV to system adequacy. Solar PV will play a more important role in reaching the clean energy targets than initially anticipated, according to the results of the two first auctions. As solar PV generates electricity when it is sunny, it will allow to meet demand for air conditioners which frequently peaks during daytime.

The demand side is also contributing to resource adequacy through interruptible contracts. The government will also introduce further market rules to enable the demand side to participate in capacity markets and long-term auctions, and to receive the same compensation as generators, thus creating a level playing field between different capacity resources.

Ministries and system operators tend to be conservative and overestimate future capacity requirements. This tends to lead to continued over-investment in capacity. The capacity market introduced by the reform will put a price on capacity and will help increase transparency about potential excess capacity.

Network adequacy

Network adequacy is also an important dimension of electricity security of supply. The existing network is well developed and even if network losses have to be reduced given the length of the lines, congestion is scarce, with the exception of the Yucatan peninsula. Several cross-border connections are currently only used in case of emergency, not for electricity trade. In addition, several new projects are designed to interconnect Baja

California with the main electricity grid. The network needs to anticipate the integration of increasing shares of wind and solar power in some regions.

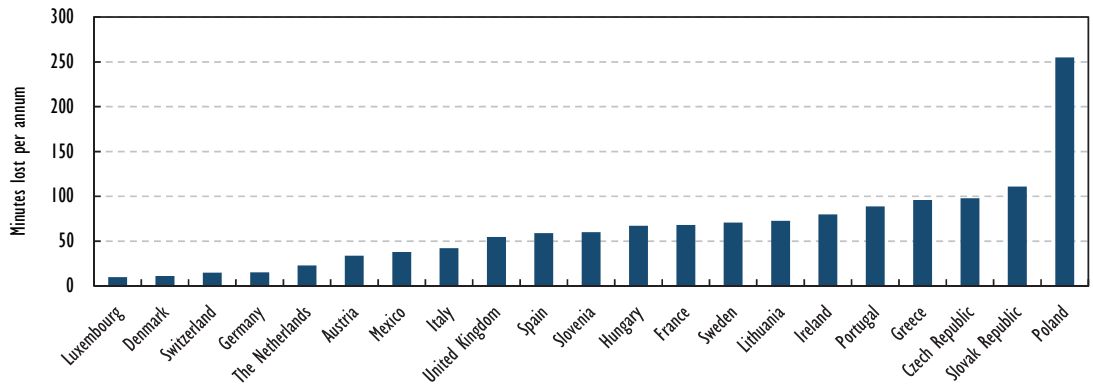
The modernisation of the distribution network has improved the quality of service and significantly reduced the interruption time per user (TIU), as shown in Table 8.4. An international comparison from 2013 shows TIU in Mexico was below the median (Figure 8.12).

Table 8.4 Annual average interruption time by user, 2006-15

Indicator	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Interruption time per user	minutes	79	84	79	71	60	50.06	45.9	38.7	36.65	34.74

Source: SENER.

Figure 8.12 Electricity supply interruption time per user in Mexico and in selected IEA member countries, 2013



Note: Excluding exceptional events. All data from 2013 except for Ireland (2010) and Spain (2011).
Sources: CEER (2015), SENER.

Assessment

Natural gas is by far the largest source for generating electricity in the country, accounting for almost 60% of total generation in 2015, and it will continue to play a key role. Natural gas has enabled the country to switch from expensive and more polluting oil-fired generation, which has already declined from 27.5% of generation in 2004 to 8.8% in 2015 and this trend will continue. In addition, Mexico has ambitious plans to increase the share of electricity from clean sources to 35% by 2024, with 21% coming from renewables and nuclear in 2014.

Industry consumed around 55% of electricity in 2014, while consumption in the residential, agricultural and service sectors remains relatively low by OECD standards. Electricity prices for industry used to be high and were cross-subsidising residential consumers, but they declined by 23% in 2015, largely thanks to lower fossil fuel prices. As of August 2016, electricity prices for industry were USD 72.0/MWh, practically at the same level as in the United States, where the average price for industrial consumers was USD 72.3/MWh.

Electricity prices remain subsidised for households and agricultural consumers. In 2015, net subsidies amounted to USD 3.8 billion, or 17% of supply costs. Also, network losses are very high by OECD standards and reached a maximum of 16.1% in 2010. CFE is making progress in reducing network losses and has gradually reduced them from 16% in 2012 to 13% in 2015. CFE is committed to further reducing network losses to 11% or 10% by 2018. In addition, it has developed a strategy to improve bill recovery.

CFE has historically been a legal monopoly in charge of electricity supply. As a result of attempts to reform the electricity sector over the past 20 years, independent power producers (IPPs) have been allowed and are selling their output to CFE under power purchase agreements. IPPs, small generators and other non-CFE entities now represent 20% of installed capacity. In addition, self-supply, cogeneration and other capacity represent 16% of installed capacity.

The primary stated objective of the electricity reform initiated in 2013 is to guarantee the efficient and safe operation of the electricity industry for the benefit of consumers through reducing costs and prices. Another important objective is to attract investors in Mexico in order to achieve the objective of 35% clean electricity by 2024. Achieving the objective to reduce prices and subsidies at the same time is challenging. In particular, efficiency gains and cost reductions have been used to lower prices. In order to reduce subsidies in the longer term, more importance should be given to communicating to the public that electricity subsidies are a highly regressive measure, benefiting mainly the well-off. Together with the fact that part of the subsidy bill is now subject to a yearly debate in Congress, this can trigger a serious reconsideration of the welfare effects of the subsidy and potential alternative uses of the resources. Any phase-out of the subsidy should be designed in a gradual manner with support mechanisms put in place to cushion the effect on vulnerable groups (IEA, 2016f).

CFE is being transformed into a for-profit state productive enterprise and its operations are separated both horizontally and vertically. Network activities are only legally unbundled from generation. Power generation is separated into five generation companies (including the nuclear company) and one company managing the power purchase agreements. These companies are supposed to compete on the wholesale market, while only legally unbundled from their owner CFE. According to the government and CFE, the mandates governing legal separation follow the best practices of legal unbundling established internationally.

An important structural change is the creation of an independent system operator to ensure open access to the networks on an equal footing with all market participants. The National Energy Control Center (CENACE) is now an autonomous body separated from CFE and will also operate the spot market (day-ahead and real-time), dispatching power plants and calculating locational marginal prices (LMPs). In order to address market power issues on the wholesale market, bids are subjected to an offer cap that reflects their short-term marginal costs. In addition, financial transmission rights (FTRs) will be introduced to enable retailers to hedge against nodal price differences.

Furthermore, as a result of the electricity market reform, markets have been created to put the right price on capacity and to value clean energy, benefiting from lessons learnt in other countries.

- A capacity market is designed to ensure capacity adequacy and remuneration for the fixed costs that are not recovered on the energy-only market.
- Clean energy certificates are an integral part of the electricity market design to ensure the development of clean electricity generation.

While the energy, capacity and certificates markets aim at getting short-term prices right, most of the investments in new capacity will come from long-term contracts and auctions. Long-term auctions are one of the most sophisticated clean energy support mechanisms and are well integrated in the design of the electricity market itself. Auctions are simultaneous for energy, capacity and certificates. Long-term contracts lock in prices for generators for a period of 15 years for energy and 20 years for CECs and for capacity.

A unique characteristic of the long-term auctions is that adjustment factors are used in order to capture the value of the energy produced, differentiated by hours and by location. The objective is to ensure the system-wide efficiency of new investments.

It is important to note that the adjustment factors are not the outcome of the energy market but are calculated by SENER and serve as input to the auctioning process.

Overall, the electricity reform is one of the most ambitious, comprehensive and well-developed reforms in the world since the 1990s. It has been designed from the onset with targets for clean energy and has been implemented at full speed in only three years, benefiting from lessons learned in other markets. Industry and other stakeholders have been widely consulted during the reform process.

The reform process has preserved the previous contracts, building confidence among industry participants. As the first long-term auction results for basic services show, the new framework is already effective in opening up the generation activity to competition and attracting investments, although this is in part due to relatively lenient pre-qualification criteria. New solar PV and onshore wind plants have been selected at an average price of USD 41.80 per MWh in the first auction and USD 33.50 per MWh in the second auction, highly competitive levels by international comparison.

The strategy pursued by the reform is guided by a clear commitment to market mechanisms. The new market design combines efficient short-term markets with long-term auctions that provide predictability for investors, creating a model that seems fit for the transition of the electricity system. Furthermore, the long-term auctions seek to capture the value of electricity for the system by time and location.

Most of the remaining challenges now lie in the decisiveness and speed of the reform implementation, including the necessary adjustments and improvements that are likely to be required after the first years of experience.

First, many decrees and regulatory decisions are still to be published. Important dimensions of the regulatory framework are pending in the coming months or years, such as the implementation of financial transmission rights or the creation of the market rules for clean energy certificates; detailed rules need to be carefully drafted, and this can take time.

Second, the regulation of reliability still has to be adapted for high shares of variable renewables. Probabilistic reliability standards, such as loss of load probability, is more

suitable for the assessment of resource/capacity adequacy, and expected to be implemented in 2017. Furthermore, time-of-use and dynamic pricing should be promoted and provide incentives for demand response.

Third, calculation of the value of electricity by location and by time (adjustment factors) is critical for selecting technologies and projects, but the information available to SENER to calculate these parameters is incomplete and asymmetric. Once the market is more mature, long-term contracts can be better integrated into energy markets and rely more on market-based signals to drive investments.

Fourth, the auctions still rest on the definition of the needs and procurement strategy defined by CFE for basic service consumers. CFE can influence the result of the auction by deciding to procure more or less energy, certificates or capacity.

Related to that, CFE has only been legally unbundled. Transforming the company into a commercial state company and its legal unbundling are already huge steps in the right direction. Under this set-up, ensuring the creation of effective independence between its several subsidiaries requires restrictions in CFE's operations. Legal, operational and accounting barriers are designed to guarantee that CFE´s companies will not share information, employees or even workspace. Each subsidiary will have an independent board of directors.

The reform still gives a prominent role to SENER for network investments. Investment needs are determined by SENER in the PRODESEN Program, based on proposals and information from the systrem operator CENACE and CFE. Despite continued growth in electricity demand and ambitious clean energy targets, the planned investments remain low (less than one billion US dollars per year for transmission), while substantial network reinforcements with the Yucatan could likely reduce the price difference with the rest of the country. Cost-benefit analysis from the point of view of society could help assess whether additional network investment would be merited.

New transmission lines can in principle be auctioned in order to create competition and attract new investors. Such auctions are expected to be organised by CFE. This, however, could create competition issues, as CFE remains the owner of the existing infrastructure. The rules of such transmission auctions have not been defined.

In terms of governance, the regulatory commission CRE has been strengthened, as it now defines transmission and distribution access tariffs, develops grid codes and also puts obligations on suppliers to enter into long-term contracts for energy, clean energy certificates and capacity. CRE has and will have many new tasks and may face resource constraints as more and more new regulated actors enter the sector.

Retail tariffs are not yet calculated by summing up network tariffs, retailing costs and the cost associated with the energy required for basic supply. The Ministry of Finance continues to set tariffs below total supply cost for residential and agricultural consumers in order to decrease end-use electricity prices that foster wasteful consumption. Qualified consumers have not been historically subsidised.

Mexico allows net metering for rooftop solar PV. To date, behind-the-meter investments have been mostly limited to large domestic consumers. Looking ahead, when subsidies are removed and solar PV costs decline, a possible massive development of distributed generation can be expected given the high solar resource in the country. Retail prices

should better reflect the structure of distribution costs and the hourly variations of electricity prices, in order to send the right signals to invest in distributed generation.

The main Mexican electricity system is not well interconnected with the United States and Central America. Increasing the interconnectivity of the region is expected to play a major role in the transformation of electricity systems, and markets are progressively integrating higher shares of wind and solar power.

Recommendations

The government of Mexico should:

- Put into practice all aspects of the ambitious sector set-up in a decisive manner, including:
  - implementing financial transmission rights
  - monitoring the performance of the long-term auctions, ensuring transparency regarding input assumptions and calculation mechanisms, and increasing the transparency regarding future requirements of the long-term auctions
  - considering to gradually expose generators to market price signals and market risks, while maintaining sufficient investment certainty for capital-intensive technologies.
- Work towards effective unbundling of CFE, both vertically and horizontally, tasking CRE with the monitoring of this process and ensuring the absence of cross-subsidies and distortion of competition between generators. In that perspective, ensure sufficient independence and human and financial resources for the regulator (CRE) and for the system operator (CENACE).
- Intensify efforts to modernise and expand the distribution and transmission networks to reduce local congestion and to integrate clean energy. In this context, clarify the rules for transmission and distribution network auctioning.
- Reform retail pricing of electricity by:
  - phasing out electricity subsidies, while providing targeted support to vulnerable groups
  - changing the structure of tariffs to better reflect the structure of distribution costs and the hourly variations of electricity prices in order to ensure the efficient development of distributed resources, such as rooftop solar PV, storage and demand response.
- Develop a strategy to better interconnect the country in the broader region, including Central America and the United States. Include in the strategy the development of market rules, more cross-border connections and the co-ordination of electricity security.

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9. Renewable energy

Key data

(2015 estimated)

Total supply: 15.5 Mtoe (8.3% of TPES) and 46.7 TWh (15.2% of electricity generation), IEA average: 10% of TPES and 23.5% of electricity generation

Biofuels and waste: 8.7 Mtoe (4.6% of TPES) and 1.4 TWh (0.5% of electricity generation)

Geothermal: 3.2 Mtoe (1.7% of TPES) and 6.3 TWh (2% of electricity generation)

Hydro: 2.7 Mtoe (1.4% of TPES) and 30.8 TWh (10% of electricity generation)

Wind: 0.7 Mtoe (0.4% of TPES) and 7.9 TWh (2.6% of electricity generation)

Solar: 0.3 Mtoe (0.2% of TPES) and 0.2 TWh (0.1% of electricity generation)

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Supply and demand

Renewable energy accounted for 15.5 million tonnes of oil-equivalent (Mtoe) or 8.3% of Mexico's total primary energy supply (TPES) in 2015. Biofuels and waste and geothermal energy were the main renewable sources with 8.7 Mtoe or 4.6% of TPES and 3.2 Mtoe or 1.7% of TPES, respectively, in 2015. Hydro accounted for 1.4% of TPES, wind power for 0.4% and solar energy for 0.2% in the same year (Figure 9.1).

Renewable energy supply increased by 4.9% over the ten years from 2005 to 2015, a rate that is relatively subdued compared to other IEA countries. This is mainly because of declines in the production of geothermal energy and energy from biofuels and waste.

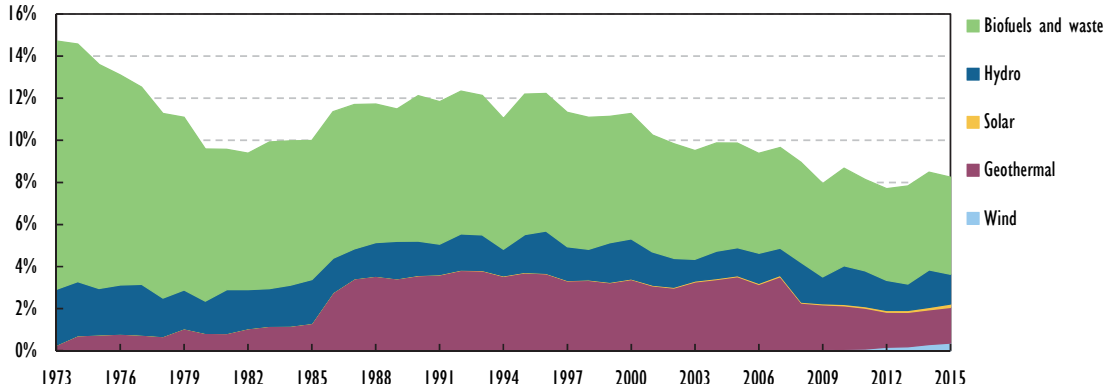
Geothermal energy supply was 49.3% lower over the ten years to 2015, reaching a peak of 6.4 Mtoe in 2007, with a steep decline in the following years to 3.2 Mtoe in 2015.

The supply of biofuels and waste energy declined by 2.6% from 2005 to 2015, albeit with moderate year-to-year volatility. The average production was 8.5 Mtoe over the decade, which is only slightly lower than the 8.8 Mtoe average during the previous decade from 1995-2005.

Hydropower generation varies year-on-year according to water availability. Despite the volatile trend, data show that Mexico's hydro production has been growing slowly over time, by 11% more in 2015 than in 2005. The average production was 2.8 Mtoe per year during the decade, which is about 16% higher than the 2.4 Mtoe average in the previous decade.

Wind and solar power production has boomed in the last ten years. Wind power production has surged since 2009, increasing from a negligible level to 7.9 terawatt-hours (TWh), or 0.7 Mtoe in 2015. Conversely, solar power production surged in the early 2000s, with average annual growth of 13.3% during 2005-15, although from a very low base.

Figure 9.1 Renewable energy as a percentage of TPES, 1973-2015

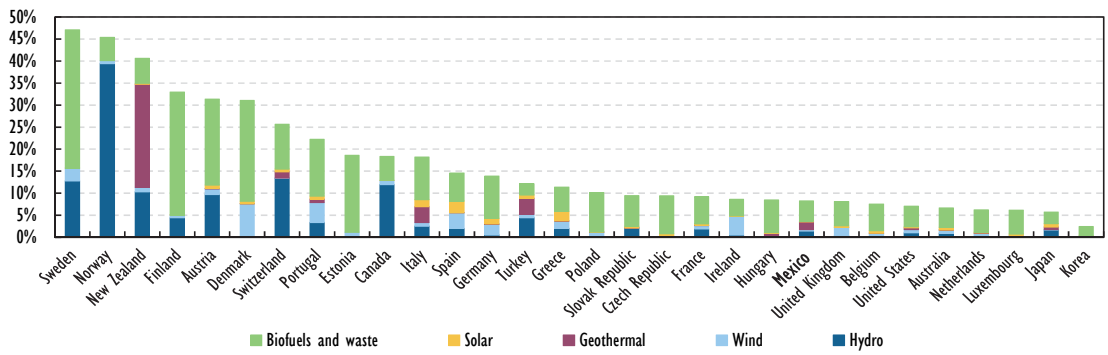


Note: Data are estimated for 2015.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Mexico's share of renewables in TPES is similar to that of the United Kingdom and Hungary (see Figure 9.2). Only three IEA countries have a higher share of geothermal power (New Zealand, Turkey and Italy). Compared to IEA countries, Mexico's shares of wind and solar power and biofuels and waste are relatively low.

Figure 9.2 Renewable energy as a percentage of TPES in Mexico and in IEA member countries, 2015



Note: Data are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

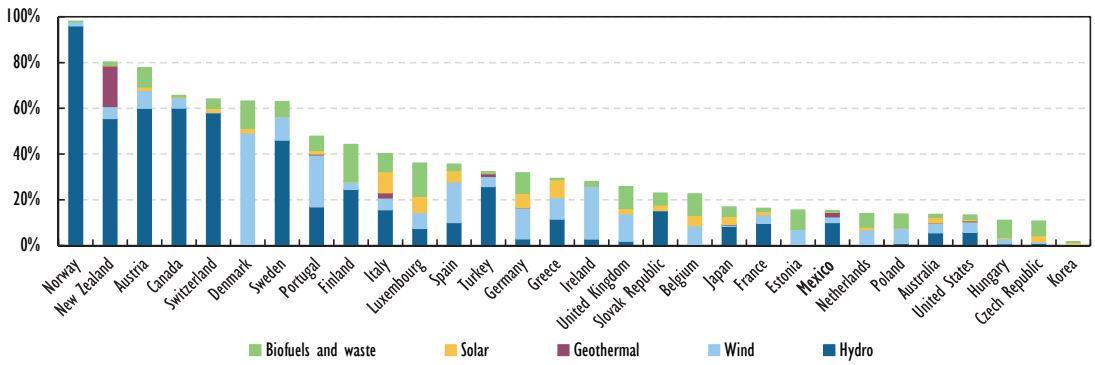
Electricity from renewable sources amounted to 46.7 TWh in 2015, or 15.2% of total generation. Renewables in electricity generation are made up of hydro (30.8 TWh or 10% of the total), wind power (7.9 TWh or 2.6%), geothermal energy (6.3 TWh or 2%), biofuels and waste (1.4 TWh or 0.5%) and solar power (0.2 TWh or 0.1%).

Electricity from renewables has increased by 22.7% over the ten years to 2015, largely thanks to an increase in hydropower (the largest source of renewables in electricity) and a surge in wind and solar power. The decline in geothermal energy production and in

biofuels and waste has a smaller effect on electricity generation patterns, as both represent a relatively small share of total electricity generation; while geothermal is only used in electricity generation, biofuels and waste are mainly consumed for heat purposes in the residential sector.

Seven IEA countries have a lower share of renewables in electricity generation than Mexico (Figure 9.3). The country's share of geothermal power is second to only New Zealand and Italy, and the share of electricity generated from hydro equals the IEA median. In contrast, the shares of wind, solar, and biofuels and waste in electricity generation are relatively low.

Figure 9.3 Electricity generation from renewable sources as a percentage of all generation in Mexico and IEA member countries, 2015



Note: Data are estimated.

Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Table 9.1 Renewable electricity generating capacity, 1990-2014 (MW)

Technology	1990	2000	2005	2007	2008	2009	2010	2011	2012	2013	2014
Hydro	7 838	9 653	10 598	11 577	11 433	11 474	11 597	11 571	11 626	11 633	12 464
Wind	3	17	18	101	101	425	519	601	1 815	2 122	2 569
Geothermal	700	855	960	960	963	965	965	887	824	823	813
Solid biofuels	0	321	473	473	389	301	384	351	406	478	569
Solar PV	5	14	16	19	19	25	29	36	53	67	99
Biogases	0	8	10	11	15	17	21	31	39	38	55
Industrial waste	0	0	0	0	0	14	16	31	83	54	42
Total capacity	**8 546**	**10 868**	**12 075**	**13 141**	**12 920**	**13 221**	**13 531**	**13 508**	**14 846**	**15 215**	**16 611**
Solar collectors surface (1 000 m^2)	0	373	643	994	1 160	1 393	1 666	1 938	2 208	2 501	2 810
Capacity of solar collectors (MW_{th})*	0	261	450	695	812	975	1 166	1 356	1 545	1 750	1 967

* Converted at 0.7 kW_{th}/m^2 of solar collector area, as estimated by the IEA Solar Heating and Cooling Programme.

Source: IEA (2016b), *Renewables Information 2016*, www.iea.org/statistics/.

Resources for electricity from renewable sources

Mexico has abundant renewable energy resources, that – with the exception of hydropower – it has barely started to tap. Hydropower capacity, now at 12 gigawatts (GW), has been a longstanding part of Mexico's power generation mix, but arid conditions across much of the country leave relatively little scope to expand this further. CFE has, however, identified around 100 river basins deemed suitable for hydropower development, and is carrying out pre-feasibility studies on several sites. By contrast, reliance on sources such as solar photovoltaics (PV), wind and geothermal has been modest thus far, but the potential for growth is enormous and policies are increasingly supportive.

Mexico's solar resources are among the best in the world, with annual daily solar irradiance levels ranging between 4.4 kilowatt-hours per square metre and 6.3 kWh/m^2 and the entire country lying between 15° and 35°, commonly considered the band most favourable for solar resources (with the lowest average levels in the country comparing favourably with the highest averages in Germany and Japan, the world's second- and third-largest solar producers). Mexico's total solar resources are estimated at 5 000 GW, according to the Ministry of Energy (SENER), equivalent to 75 times the total installed power generating capacity today.

Mexico's total wind power potential is estimated at around 30 GW, mainly spread across the states of Oaxaca (which currently holds around 80% of total installed capacity) and Baja California. The quality of the resource means that capacity factors for wind power are currently over 20% higher than the global average, and are estimated to increase by one-fifth over to 2040, reflecting the ample availability of suitable sites for turbines across the country (IEA, 2016c).

Geothermal is a well-established power source in Mexico. It benefits from high capacity factors (averaging around 80%, compared to 14% for solar PV and 29% for wind). With around 1 GW of operating capacity, Mexico is the fifth-largest producer of geothermal energy in the world (after United States, the Philippines, Indonesia and New Zealand). According to the government, Mexico has around 13.4 GW of geothermal resources (though only 3% of this is considered proven). High capital expenditure requirements have impeded developing geothermal capacity, but this could change in the coming years. In 2014, the **Geothermal Energy Law** was approved, providing a legal framework for further geothermal energy development and allowing private-sector participation. In July 2015, SENER provided concessions to develop 13 geothermal sites to CFE, which could increase installed geothermal capacity by 450 MW.

Institutions

The **2014 Electricity Law** defines specific roles for several government bodies in the renewables and clean energy sectors. These bodies include the Ministry of Energy, the Energy Regulatory Commission, the National Center for Energy Control, the Ministry of Economy and the Federal Electricity Commission.

The **Ministry of Energy (SENER)** designs, leads and co-ordinates national energy policy that includes renewables. It elaborates sectoral programmes, such as the National Electricity System Development Program (PRODESEN) which includes an indicative plan for renewable energy capacity additions. Regarding clean energy certificates

(CECs), SENER establishes requirements and criteria to credit CECs. It also opens access to loans and other financial mechanisms for distributed generation schemes. As for social issues, SENER is responsible for calling public consultations and for evaluating the "social impact manifestation" required of projects with a capacity of at least 500 kW.

The **Energy Regulatory Commission (CRE)** is responsible for granting power generation permits, including for renewable energies with an installed capacity of at least 500 kW and those below this capacity that intend to participate in the wholesale market. It also issues standards, directives, methodologies and further administrative procedures for renewable and clean energy technologies. As for CECs, CRE will grant, regulate and monitor the fulfilment of the requirements.

The **National Center for Energy Control (CENACE)** will be in charge of operating the wholesale electricity market and will also propose an indicative expansion plan for generation and transmission Infrastructure for SENER's approval. CENACE will also operate the CEC markets and the long-term auctions for electricity, capacity and CECs.

The **Ministry of Economy (SE)** has created a special Unit for National Content and Support to the Supply Chain and Investment in the Energy Sector. This unit is responsible for the methodology and follow-up process of national goals required by the **Electricity Industry Law**. It also co-ordinates and monitors the operation of the Trust Fund for the Development of National Energy Industry Suppliers and Contractors.

SENER also has the main responsibility for formulating and implementing policy on renewable energy use for heat and transport. So far, however, these sectors have not been a focus of government action.

Policies and measures

General strategies and programmes

Mexico has entered a new phase in the deployment of renewable energy under the comprehensive energy reform which emphasises the use of clean energy sources. The 2014-2018 Special Program for the Use of Renewable Energy (PEAER,) was published in April 2014. It is the main planning instrument for renewable energy policy in Mexico. It was developed under Mexico's Consultative Council for Renewable Energies Advice (CCER). PEAER has the following five objectives:

1. To enhance power capacity and generation from renewable energies.
2. To increase public and private investment in power generation and construction/ reinforcement of interconnection infrastructure.
3. To increase the use of biofuels in the domestic energy matrix.
4. To boost technology development, capacity development and renewable energy value chains.
5. To grant access to renewable energies for rural electrification projects, social participation and renewable energy use for thermal applications.

Every year CCER monitors progress towards the 2018 goals set by the PEAER (see Table 9.2). Mexico also has several ongoing initiatives intended to facilitate the business environment for renewables and other clean energy technologies. These include:

- **The National Inventory of Clean Energies:** it is a statistical and geo-referenced service that shows renewable energy potential and operational projects in Mexico. So far it includes a resource and a project database for wind, solar, geothermal, hydro, bioenergy and ocean resources.
- **The National Atlas of Potential Zones for Clean Energy Deployment:** the Atlas is intended to provide information on potential zones for power generation from renewable and other clean energy technologies. It is a geo-referenced tool that incorporates exclusion zones based on technical, environmental and social constraints. It is also meant to help plan the expansion of the national transmission and distribution grids.
- **The Electronic One-Stop Window for Renewable Energy Projects** aims at reducing from 620 to 465 on average the number of days required for licensing, permitting and constructing a renewable energy project.

Table 9.2 Main indicators in the 2014-18 Special Program for the Use of Renewable Energy

Indicator	Base line (year)	2014	2018 goal
Renewable energy and clean energy technology as a share of total installed capacity	28.4% (2013)	27.7%	34.6%
Renewable energy as a share of total installed capacity	25.32% (2012)	25.0%	32.8%
Renewable energy as a share of total electricity generation	14.78% (2012)	18.0%	24.9%
Optimisation of administrative procedures required for licensing and permitting renewable energy projects	620 (2013)	620	465
Added to retired capacity ratio for geothermal projects (proven reserves)	1.05 (2013)	1.26	2.0
Increased power generation with biofuels (GWh/year)	974 (2012)	1 379	2 142
Value chain and renewable energy services index	2.6 out of 5 (2013)	2.8 out of 5	3.2 out of 5
Renewable energy jobs (Including large hydro projects)	5 530 (2012)	6 606	8 150
Share of renewable energy in rural electrification projects.	6% (2013)	4.16%	≥ 8%
Increased power generating capacity with efficient cogeneration projects (MW)	0 (2012)	218	1 480

Source: SENER.

The **2015 Energy Transition Law** requires SENER to prepare a special programme on energy transition. Akin to the Special Program for the Use of Renewable Energy (which will be replaced by this Energy Transition Program) there will be specific targets for different renewable energy technologies.

- The Transition Strategy to Promote the Use of Cleaner Technologies and Fuels will integrate policy recommendations to boost the transition, including with the co-operation and advice of international and national experts. It will include goals to reduce emissions and lower the country dependence on fossil fuels as the primary energy source.
- The Special Program for Energy Transition will consist of activities and projects derived from the strategy to ensure its economic viability. It will comprise the Clean Energy Goals, identified actions of the strategy, the instruments required to boost the installation of clean distributed energy, energy efficiency measures, and actions related to financial and regulatory incentives to ensure the fulfilment of the Clean Energy Goals.
- The National Program for the Sustainable Use of Energy will set the actions, projects and activities derived from the strategy that contribute to meet the goals in terms of energy efficiency.

Electricity

Clean energy targets and certificates

Renewable sources of energy are promoted under Mexico's plans to increase the share of clean electricity generation. Clean energy includes renewable energy, nuclear energy, high-efficiency cogeneration and fossil fuel-fired generation with carbon capture and storage (emitting maximum 100 grams of CO_2/kWh generated). In its *Electricity Outlook to 2029*, the government foresees renewable sources to account for more than 50% of new generating capacity from 2014 to 2029.

The targets for clean energy are set in the 2014 Electricity Law. The minimum share of clean energy in electricity generation is 25% for 2018, 30% for 2021 and 35% for 2024. The 2024 target had been set previously in the 2008 Law on the Use of Renewable Energy (LAERFTE) and in the **2012 General Climate Change Law**. The 2008 Law also set a target of 40% for 2035 and 50% for 2050. The 2015 Energy Transition Law has since replaced LAERFTE.

The targets to 2024 are to be met through a quota and a clean energy certificate (CEC) system. Retail suppliers (currently only CFE and large consumers that do not use retail suppliers will be required to have a given share of their electricity (for large consumers, a share of their consumption) from clean sources. In practice, they must buy CECs to demonstrate that they have complied with the quota obligation.

Clean electricity projects developed after August 2014 receive one certificate for each megawatt-hour of clean energy produced. In consequence, generators of clean electricity will obtain additional revenue by supplementing their sales of electricity with the sales of CECs. Also, clean power plants developed before August 2014 that increase their capacity will obtain one CEC for each extra megawatt-hour of clean energy they produce and for the energy that was excluded from a legacy contract and has a permit according to the Electricity Industry Act.

SENER sets the annual quota obligation and increases it every year. For 2018, the quota is 5% and for 2019, 5.9%, corresponding to around 12 million certificates in 2018 and 14 million in 2019. Unlike in many other certificate systems, the CECs are bankable and do not expire. This is expected to add stability to the market for CECs. It also helps

suppliers to prepare for possible rapid increases in electricity demand and the resulting rise in the need for CECs. Failing to meet the quota obligation leads to a fine, the level of which is set by the energy regulator CRE and may range from six to 50 times the daily minimum wage of MXN 70 (USD 4.41), or up to MXN 3 500 (USD 220.48) per certificate.

The CEC system will become fully operational in 2018 when the first CEC requirements become effective. The first certificates will be awarded to generators and the spot market for CECs will start. The market, operated by the system operator CENACE, will enable meeting the required annual quota of CECs in a liquid and transparent manner.

Until 2018, CECs are marketed in direct bilateral transactions and through long-term auctions. The long-term auctions are designed as a way to help generators avoid the risks of volatile short-term prices and to benefit from a stable revenue in order to finance their investments. The auctions are unique in that they allow clean generators to offer energy, CECs and capacity simultaneously. They are explained in more detail in the Chapter 8 on electricity. For CECs, the auctions are for a 20-year term (for energy and capacity, the term is 15 years). In the long-term auctions, adjustment factors for time and location are used in order to capture the value of electricity for the system (see Chapter 8).

The first long-term clean energy auction was held in March 2016 and awarded 15-year contracts for 5.4 million CECs (equaling 5.4 TWh of electricity), which is expected to require 1.8 GW of new capacity. Three-quarters of the CECs awarded went to solar PV and the remainder to wind power projects. The second long-term auction was held in September 2016 and awarded contracts for 9.3 million certificates. This capacity consists of solar PV (53%), wind (41%), hydropower (3%) and geothermal (2%) projects. The second auction is expected to lead to the addition of around 2.9 GW of new generating capacity. The heavy focus on solar PV and wind in the first two auctions reflects the large untapped cost-effective potential in the country, but also the current CEC terms under which projects must be operational within three years, a relatively short time (see Chapter 8).

Other policies and measures

Before the 2013 energy reform, renewable energy was supported under the **2008 Law on the Use of Renewable Energy (LAERFTE)**. The main instruments for the development of renewable electricity were a self-supply regime and auctions for 20-year power purchase agreements with CFE. The 2008 Law triggered only a modest increase in renewable energy use, as renewable electricity generating capacity increased by 2.3 GW, or 18%, from 2008 to 2013.

Geothermal energy is regulated under the **2014 Geothermal Energy Law** and its Regulation. Before 2014, it was regulated under the National Water Law. The 2014 Law creates 30-year geothermal concessions and regulates the stages of surveying, exploration, development and production of geothermal resources. The concessions may be extended. They cannot be sold, but can be transferred after formal notification.

Regarding tax incentives, the **Income Tax Law** stipulates that the machinery and equipment used to generate electricity from clean sources have a 100% accelerated depreciation. Furthermore, the 2015 **Energy Transition Law** establishes that SENER

has powers to propose additional tax or financial mechanisms to the Ministry of Finance to promote energy-efficient technologies and clean distributed generation when these bring savings for the treasury and consumers or reduce carbon prints.

Funding for renewable energy projects is available from the Energy Transition and Sustainable Energy Use Fund which was mandated in the 2008 LAERFTE and created in 2009. The Fund has allocated around MXN 9 billion (USD 567 million) from the federal government budget that was distributed among mostly energy-efficiency projects, but also among renewable energy projects that received 20% to 25% of total funding. Examples of renewable energy projects include the creation of a national inventory of renewable energy and the publication of an atlas of Mexico's renewable energy potential.

In addition, soft loans are granted by the National Development Bank and other private financiers. A risk-mitigation mechanism is available for potential geothermal projects during the exploration stage.

Heat

Mexico does not appear to have a national strategy or policy regarding renewable energy use for heat production. According to the *IEA Medium-Term Renewables Market* report, the only instruments in place are soft loans and, at state level, building obligations.

Traditional firewood remains an important energy source in rural areas where around half the households – some 15% of the total population – rely on biomass for cooking and water heating, so that biomass represents almost one-third of overall residential energy demand (IEA, 2016c).

Mexico possesses a major potential for solar heating and geothermal solutions. As a result of the improved regulatory framework for geothermal energy, SENER is developing guidelines for the deployment of geothermal energy for direct uses. This will open possibilities for space heating/cooling in Mexico, which is an area of opportunity that so far has not been explored.

Transport fuels

The legal framework for developing and producing biofuels is provided by the **2008 Law for the Promotion and Development of Bioenergy**. The law prohibits the use of corn for biofuels except during years of surplus crops. This explains why the focus of biofuels produced in Mexico has been on sorghum and sugar cane.

The government does not directly subsidise producers and consumers of biofuels in the transport sector. However, there are support schemes for the production of biofuels and their feedstocks to promote research, development and use of biofuels.

Mexico's biofuels programme is still in its infancy. PEMEX launched in 2015 bids to procure up to 123 million litres (32 million gallons) of bioethanol per year over ten years from domestic producers. The bioethanol will be used for a pilot programme to supply a 5.8% ethanol blend. The ethanol will be produced from sugar cane in the state of Veracruz and sorghum in the state of Tamaulipas. The blend will be sold in the same states as well as in the state of San Luis Potosí.

PEMEX expects that ethanol blending in gasoline will benefit the country in several ways. Ii is expected to create jobs, improve energy security as gasoline imports are reduced. It is also expected to expand agriculture to drier or underutilised land, and to more resilient and multiple harvesting crops such as sweet sorghum. The pilot programme should also motivate the scientific and technological community to develop biofuels. Finally, PEMEX expects bioethanol to help avoid greenhouse gas emissions from transport, arguing that it would mean 35% less emissions than fossil fuels would.

There is no long-term vision to increase the blend share further. Under the energy reform, imports of oil products were liberalised in April 2016, after which it is also possible to import biofuels blends. The challenge for biofuels in Mexico, however, is their high price in a market where end-user prices for transport fuels have been regulated at relatively low levels.

Assessment

Renewable energy accounted for around 8% of TPES and 15% of electricity generation in 2015. Renewable energy is used more for heat than for electricity generation, amounting to around 10 Mtoe, but mainly comprising traditional biomass use, which remains common in certain rural regions. Unlike in many other OECD countries, renewable energy is so far not used commercially in the transport sector in Mexico.

In 2015, electricity generated from renewable sources amounted to 52 TWh. Hydro accounts for 10% of total power generation in Mexico, wind power 2.6%, geothermal 2%, and bioenergy and solar power combined less than 1%. Thanks to Mexico's current push to develop clean energy sources, however, electricity generation from renewables, in particular from solar and wind, is set to increase rapidly in the coming years.

The 2015 Energy Transition Law sets targets for the share of clean energy in electricity generation: 25% by 2018, 30% by 2021 and 35% by 2024. No specific target for renewables has been set. The definition of clean energy is broader than renewable energy and comprises also nuclear, CCS and efficient cogeneration. In 2014, the share of clean energy was 20.4%. A long-term target of 50% by 2050 has been set in the General Law on Climate Change. No overall target for clean or renewable energy has been set for the energy sector as a whole, neither for the transport nor for the heating and cooling sector.

The main instrument to support the development of renewable energy in the electricity sector is the newly introduced clean energy certificates. The demand for CECs is created by introducing an obligation on retail suppliers and on qualified consumers to buy a certain share of their electricity requirement from clean sources. The quota is announced three years in advance of the compliance period. The certificates will be a source of income for clean electricity producers together with the revenue from selling electricity and capacity. As part of the electricity reform, long-term auctions of CECs, electricity and electricity generating capacity have been introduced as a way to bring revenue-certainty to investors in these relatively capital-intensive projects. Certificates can also be sold under bilateral contracts and, from 2018 on, in an annual market.

The electricity sector reform opens a real opportunity for developing renewable energy capacity. This has been proven by the results of the two first long-term auctions, held in

2016, in which more than 14 TWh of CECs were sold. Solar PV was granted the majority of CECs, followed by wind power, and these two technologies, for which Mexico has a large untapped potential, accounted for almost all CECs. The costs for solar PV were among the lowest worldwide, which offers an encouraging prospect for the development of clean energy and may also contribute to the effectiveness of the country's climate policies.

The auctions were successful in terms of the high number of participants and the resulting competition. However, the high number of participants can be explained in part by the relatively low hurdles of pre-qualification, resulting in the risk for project delays during implementation (permitting, local consultations, etc.). Also, the bank guarantees required for the pre-qualification of projects for the long-term auctions are the same for different projects regardless of the maturity of the project, and this may be a barrier for the qualification of good but capital-intensive projects developed by small investors.

The deployment of renewable electricity will depend on the proper design of the different markets and auctions for energy and CECs, and to some extent also for capacity. The definition of the adjustment factors will have a major impact on the location of solar and wind power developments. As the volume required for CECs depends on electricity demand, which may increase fast, the government should take measures to minimise the risk that the clean energy targets are not reached.

In addition to the CECs, several other support instruments for renewable energy are available. These include a tax incentive allowing for a 100% income deduction for investments made in renewable energy and efficient cogeneration, and for net metering for installations with installed capacity under 500 kW, soft loans, a regional pilot project to introduce 5.8% blending of ethanol in gasoline in three regions, a Sustainable Energy Fund to promote projects on energy efficiency and renewable energy (see Chapter 11 on energy technology research, development and demonstration) and a risk-mitigation mechanism for potential geothermal projects during the exploration stage. Non-financial instruments include knowledge-sharing and administrative procedures, such as the National Inventory of Clean Energy, the National Atlas of Potential Zones for Clean Energy Development and an electronic online portal for processing renewable energy project permits.

Mexico possesses a major potential for solar heating and geothermal solutions. However, the IEA is not aware of major policies for promoting renewable energy for heating and cooling. Firewood remains an important energy source in some rural regions, and efforts to promote more efficient and sustainable use are to be encouraged.

In the transport sector, renewable sources may offer a cost-effective option for displacing oil, all externalities considered. Mexico's road transport sector is almost 100% dependent on fossil fuels; studying options for limiting oil use by various means, including renewable energy, is worth considering in the name of curbing air pollution, GHG emissions and import dependence.

Recommendations

The government of Mexico should:

- ☐ Ensure the liquidity of clean energy certificates markets and minimise the risk that the target for clean energy generation is missed because of potentially large increases in the volume of the certificates required.
- ☐ Consider defining more stringent minimum requirements, including those related to permits, for pre-qualification for future long-term auctions, making use of lessons learnt from the first long-term auctions.
- ☐ Explore the cost-effective potential for increasing the use of renewable energy in the heating and cooling sector, in order to reduce the use of fossil fuels and thus help limit emissions and increase energy security.
- ☐ Develop a long-term strategy and a roadmap for alternative fuels in the transport sector, including increased use of renewable energy and electrification, and assessing the role the transport sector should play in achieving Mexico's overall energy and climate objectives.

References

IEA (International Energy Agency) (2016a), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2016b), *Renewables Information 2016*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2016c), *World Energy Outlook Special Report on Mexico*, OECD/IEA, Paris.

10. Nuclear energy

Key data

(2015)

Number of reactors: 2

Installed capacity: 1 620 MW_e

Electricity generation: 11.6 TWh, +11.5% since 2005

Share of nuclear: 1.6% of TPES and 3.8% of electricity generation

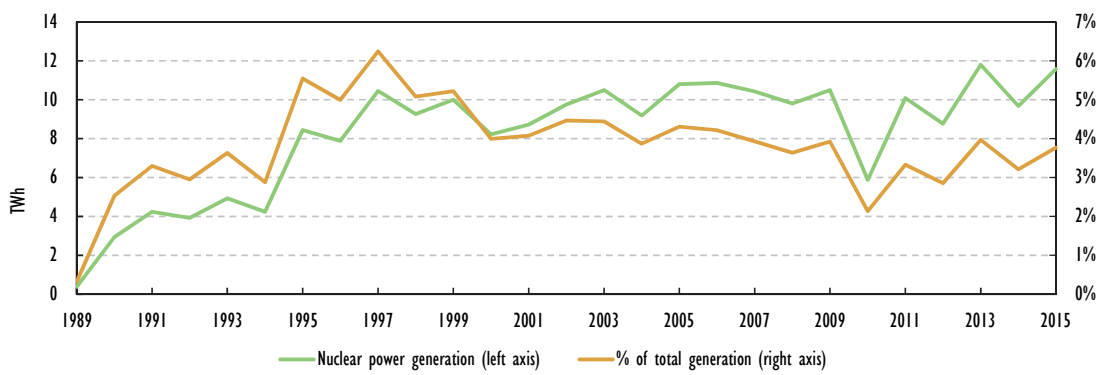
Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Overview

Mexico has one nuclear power plant (NPP), Laguna Verde, located on the Gulf of Mexico. It consists of two boiling water reactors, each with a capacity of 810 megawatts electric (MW_e). The first unit has been operating since 1990 and the second one since 1995. Both operate under a 30-year licence which can be extended by 20 or 30 years. Initially, both reactors had a capacity of 704 MW_e, but the uprated capacity was authorised for unit 2 in December 2014 and for unit 1 in March 2016.

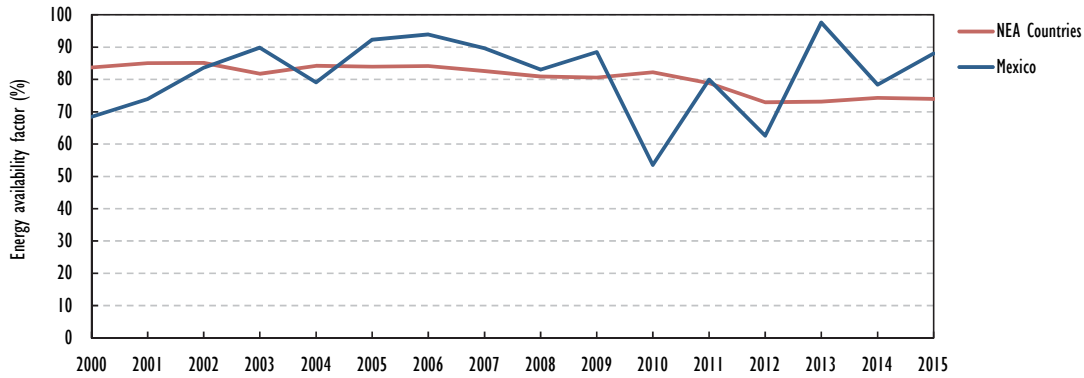
The NPP typically generates 11-12 TWh a year and its capacity factor since 2000 averages 79%, just below the 80% average for OECD/NEA member countries (Figures 10.1 and 10.2). The Laguna Verde reactors are owned by the Mexican government and operated by the CFE. In addition to the two commercial reactors, there is a 1 MW_e TRIGA MARK III research reactor at the National Nuclear Research Institute (Instituto Nacional de Investigaciones Nucleares, ININ).

Figure 10.1 Nuclear power generation and percentage of total power generation, 1989-2015



Source: IEA (2016), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

Figure 10.2 Energy availability factors of NPPs in Mexico and in OECD/NEA member countries, 2000-15



Note: NEA: OECD's Nuclear Energy Agency.
Source: OECD/NEA, based on IAEA PRIS database.

Institutions and legislation

Institutions

The **Ministry of Energy (SENER)** is responsible for the definition of nuclear policies regarding the use of nuclear energy. The **Federal Electricity Commission (CFE)** is responsible for the safe and secure operation of nuclear power plants.

Under SENER, the regulatory authority for nuclear energy is the **National Commission for Nuclear Safety and Safeguards (CNSNS)**. It is responsible for regulating and overseeing of nuclear and radioactive installations and practices. This includes reviewing, evaluating and authorising the siting, design, construction, operation, modification, closure and dismantling of nuclear and radioactive facilities, including radioactive waste management. The regulatory authority is engaged in the licensing activities related to assessment of applications for long-term operation and preparing for the safety review of new reactors.

As for the **National Nuclear Research Institute (ININ),** its primary objective is research and development in the field of nuclear sciences and technologies. The Institute also promotes the peaceful use of nuclear energy and its inclusion in the economic, social, scientific and technological development of the country.

Legislation

The Regulatory Law of Article 27 of the Constitution on Nuclear Matters regulates all nuclear activities in Mexico. The law regulates exploration, exploitation and benefits of radioactive ores, the use of nuclear fuels and energy, research in nuclear science and technology, the nuclear industry and all related matters.

According to the Mexican Constitution (Article 27), prospecting for mining and using radioactive ores will not be subject to any concession or contract. Only the state may carry out such activities, in accordance with the relevant law. The siting, design, construction, operation, modification, shut-down, decommissioning and dismantling of nuclear and radioactive installations require an authorisation granted by SENER.

Licences for the construction and operation of such installations are valid for a limited period, and their renewal, modification, suspension or cancellation are regulated by the provisions of the relevant legislation.

The conditions for the licensing of radioactive installations are laid down by the General Radiological Safety Regulations of 22 November 1988. The CNSNS, under the Ministry of Energy, is the licensing authority for such installations. It issues, renews, revokes and suspends permits or licences.

For the licensing process of nuclear installations, the regulations of the country of origin are followed. Therefore, the siting, design, construction, operation, modification, shut-down and decommissioning of the Laguna Verde NPP follows the Code of Federal Regulations of the United States, since both units were designed by General Electric.

In the aftermath of the Fukushima accident, the CNSNS requested CFE to conduct an in-depth safety assessment of the Laguna Verde NPP in order to assess any weakness related to external hazards and identify potential safety improvements. Safety measures were identified and are being implemented to provide additional means of supplying alternating and direct current for emergency systems in a station blackout scenario, additional means to remove residual heat and means to control overpressure.

According to the Mexican Constitution, the use of nuclear fuel for nuclear power generation is a strategic activity reserved to the nation, along with the responsibility for the safe and secure regulation of nuclear energy, including applications of ionising radiation. Although the energy reform extends the participation to private investors in the energy sector, nuclear power generation remains under the exclusive domain of the government-owned CFE.

Outlook for new nuclear capacity

The government considers nuclear energy as an important baseload power source for Mexico and sees it as helping to diversify the energy mix and reduce emissions of carbon dioxide (CO_2) in a cost-efficient way.

Mexico is concerned by climate change issues and recognises the need to minimise the environmental impacts of emissions from the production and use of energy. The trends in energy supply and use were seen as unsustainable, with ever greater levels of energy and electricity consumption, ever greater dependence on fossil fuels, and escalating CO_2 emissions and environmental impacts. Therefore, an **Energy Transition Law** was published on 24 December 2015, setting targets for the generation of electricity from clean sources of energy, 25% by 2018, 30% by 2021 and 35% by 2024. The E**lectricity Industry Law**, published in August 2014, defined nuclear energy as clean energy.

Consequently, the National Electricity System Development Program 2016-2030 (PRODESEN), issued in May 2016, foresees an expansion in nuclear power capacity. The PRODESEN tentatively foresees three new NPP units in Veracruz to enter into commercial operation by 2028, 2029 and 2030.

Building new capacity would be encouraged through the clean energy certificate (CEC) system (see Chapter 8). Under the terms of the first two long-term auctions, projects have to become operational within three years, which in practice excludes nuclear

projects. The government retains the possibility to revise the terms of future long-term auctions for electricity, capacity and CECs to enable nuclear power projects to compete better.

CFE has previously uprated the capacity at Laguna Verde through a USD 600 million joint project by Iberdrola and Alstom. It has further plans for refurbishment as the NPP moves into long-term operation. Extending the operational life of the Laguna Verde NPP will require additional investment and in consequence it will be eligible for CECs. The government is also introducing new investment means (FIBRA-E) to enable CFE to raise capital for new projects.

Public acceptance

According to an opinion poll carried out in 2013, the most recent one, 35% of the respondents were in favour of building new nuclear power capacity in Mexico, while 39% were against, and 26% were neither against nor in favour. In the same poll, only 28% of respondents knew that Mexico already had a nuclear power plant.

The government has developed and will implement a communication strategy in order to inform and engage the general public, local communities and the different stakeholders on the importance and need of increasing nuclear capacity in Mexico to mitigate climate change and to meet the targets for clean electricity generation.

Regulatory process for a new nuclear

In order for a new NPP to operate in Mexico, it has to obtain a licence from SENER, granted on the basis of a technical assessment of the National Commission for Nuclear Safety and Safeguards, the Mexican regulatory authority.

Any new NPP in Mexico will be licensed within the same regulatory framework, regardless of the country of its origin. The United States Nuclear Regulatory Commission (U.S.NRC) has two licensing processes for new reactors. The two-step process under the 10 CFR Part 50 and the one-step process under the 10 CFR Part 52.

The two-step licensing process requires both a construction permit and an operating licence. The one-step process essentially combines a construction permit and an operating licence, with certain conditions, into a single licence. Under either process, before an applicant can build and operate a nuclear power plant in Mexico, it must obtain approval from the CNSNS.

The CNSNS has defined the two-step process to follow for the licensing of new reactors in the country.

The CNSNS issues a construction permit that allows an applicant to begin building a nuclear power plant, after it completes its review and is satisfied with the safety of the preliminary plant design and the suitability of the prospective site.

Final information on design and plans for operation are developed during the construction of the plant. The applicant then submits an application to the CNSNS for an operating licence. The application contains a final safety analysis report and an updated environmental report. The safety analysis report describes the plant's final design, safety evaluation, operational limits, anticipated response of the plant to possible accidents, and plans for coping with emergencies. At this stage of the review, the CNSNS examines the

final design of the plant, verifies its proper construction, and inspects the applicant's testing and other operational programmes and plans for coping with emergencies. Finally, SENER issues an operating licence if, on the basis of the CNSNS´s assessment, all safety and environmental requirements are met.

Nuclear fuel cycle, radioactive waste and decommissioning

Nuclear fuel cycle activities in Mexico are limited to the use of nuclear fuel for nuclear power generation. Efforts have not been devoted to enrichment, nuclear fuel fabrication and reprocessing. A pilot project was developed to construct a limited number of fuel assemblies for use in the Laguna Verde NPP but was abandoned in 2003, as the project was not economically attractive. Mexico has not defined a decommissioning plan for the Laguna Verde NPP.

Waste management

SENER is engaged in the development of safe, sustainable and broadly acceptable strategies for the long-term management of all types of radioactive waste. It is preparing to create a national company to manage radioactive waste. The government is also planning to sign the International Atomic Energy Agency (IAEA) Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, but had not done so by mid-2016, according to the World Nuclear Association.

Low- and intermediate-level waste

Around 90% of the low- and intermediate-level radioactive waste is produced by the Laguna Verde NPP and the Electricity Commission CFE is responsible for their treatment and management within the NPP site. The rest of the low- and intermediate-level waste is managed by Nuclear Research Institute and stored at the Radioactive Waste Storage Center (CADER), an interim repository. SENER is also considering possible options for a permanent repository for low-and intermediate-level waste. There are currently no concrete plans for such permanent repository.

High-level waste

The federal government is yet to define a strategy for spent fuel and decide whether spent fuel will be reprocessed or managed as waste. Depending on this decision, spent fuel will be stored either temporarily or permanently. As part of the strategy, CFE will have to assume the total cost of waste management. For this purpose, a trust fund for the integrated management of radioactive waste will be set up and maintained.

Spent fuel from Laguna Verde is stored temporarily in the spent fuel pools of both NPP units. These pools were reconstructed in order to increase their capacity. Nonetheless, considering the potential lifetime extension of both units, the need for alternative storage has emerged. CFE has opted for dry cask storage to increase spent fuel storage capacity. Dry cask storage allows spent fuel that has already been cooled in the spent fuel pools for at least one year to be surrounded by inert gas inside a container (the cask), typically a steel cylinder. The cylinder provides a leak-tight confinement of the spent fuel. Each cylinder is surrounded by additional steel, concrete, or other material to provide radiation shielding. Some of the cask designs have already been assessed and the dry storage installation inside the Laguna Verde NPP is being licensed by the regulatory authority.

Assessment

The **1985 Nuclear Activities Law** regulates all nuclear activities in Mexico. A licence is required for the siting, design, construction, operation, and modification, shut-down, decommissioning and dismantling of nuclear and radioactive installations. The National Commission for Nuclear Safety and Safeguards, under SENER, is responsible for regulation and oversight of nuclear and radioactive installations and practices. It is also the licensing authority for radioactive installations, while SENER is the licensing authority for nuclear installations based on the safety assessment of the safety commission.

Mexico has one NPP, Laguna Verde, located in Veracruz on the Gulf of Mexico. It consists of two boiling water reactors, each with a capacity of around 810 MW. The first unit has been in operation since 1990 and the second one since 1995. The Laguna Verde plant is owned by the Mexican government and is operated by CFE. The plant generates around 11 to 12 TWh of electricity per year, corresponding to around 4% of electricity supply. The units are operated under a 30-year licence, and an application to extend this to 50 or 60 years is being reviewed by the regulator.

A 2012 OECD study has shown that a lifetime extension of nuclear plants is the lowest-cost option available for power generation (OECD, 2012). Several utilities in OECD member countries have already obtained the licence to operate their nuclear plants beyond 40 years or are in the process of submitting an application to the safety authorities.

The government is in favour of expanding the country's nuclear power capacity to meet the targets of clean energy, to help avoid CO_2 emissions and to control the costs of generating electricity. CFE also plans to refurbish Laguna Verde in the coming years as it moves into long-term operation. More importantly, the National Electricity System Development Program 2016-2030 foresees two or three new NPP units at the Laguna Verde site to start commercial operation by 2028, 2029 and 2030.

Investment in new capacity and expanding existing capacity will be encouraged by the long-term contracts for energy (15 years), capacity and clean electricity certificates (20 years). It remains to be seen how this system will work in practice for nuclear, as under the current rules the projects must be ready to generate power within 3 to 5 years from the auction. The government is aware that this timeframe is not compatible with its nuclear development plans, and the rules should be adapted if nuclear projects are to be competitive in the clean energy auctions.

A major issue with investing in new nuclear capacity concerns the availability and cost of capital. By law, nuclear power generation remains CFE's monopoly, but the company's financial position will probably not allow to invest billions in new nuclear units in the near future. If, according to its plan, the government wishes to see new nuclear coming online in the next decade, private investment will be required. Indeed, legislation allows private-sector participants as contractors in nuclear capacity. Innovative financing mechanisms have been created to that effect.

Nuclear fuel cycle activities in Mexico are limited to the use of nuclear fuel for power generation. Efforts have not been devoted to enrichment, nuclear fuel fabrication and reprocessing. Regarding radioactive waste management, the Laguna Verde NPP produces the vast majority of low- and intermediate-level radioactive wastes in the

country, the management of which is CFE's responsibility. Any plans to extend the operating life of the current reactors or to construct new ones should be accompanied by plans on how to manage the resulting additional waste.

SENER is engaged in the development of safe, sustainable and broadly acceptable strategies for the long-term management of all types of radioactive waste, including the search of a permanent repository for low- and intermediate-level waste. The government has yet to take a decision on how to deal with spent fuel (reprocessing versus final disposal). It plans to set up a trust fund to collect resources dedicated to covering future liabilities for radioactive waste management and decommissioning. The rules for operating the fund should be clear about how and by whom it is managed and how it is ensured that the fund is sufficient to cover all future costs. Liabilities should also be reassessed regularly, and the fund should be diversified to a high degree.

As in other sectors, the government should ensure the independence and adequate funding of the regulator. It is also essential to continue to ensure the availability of qualified human resources for the nuclear sector.

Recommendations

The government of Mexico should:

- Regularly review and, if necessary, revise the incentives to invest in nuclear power capacity to ensure they help meet the government's energy policy goals.
- Continue the efforts to establish and implement a national policy on long-term management of radioactive waste and on ultimate disposal of high-level waste.
- Set up a fund to cover future liabilities related to waste management and decommissioning; regularly review that the funding is adequate and, following international best practice, ensure that the dedicated fund is ring-fenced and well-diversified.

References

IEA (International Energy Agency) (2016), *Energy Balances of OECD Countries 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

OECD (2012), *The Economics of Long-term Operation of Nuclear Power Plants*, OECD Publishing, Paris.

11. Energy technology research, development and demonstration (ETRD&D)

Key data

(2015)

Government energy RD&D spending (nominal): USD 234 million

Government energy RD&D spending (adjusted): USD 351 million in 2014 PPP

Mexican peso (MXN): On average in 2016, MXN 1 = USD 0.054; USD 1 = 18.627 MX

Overview

Mexico's ratio of investment in scientific research and technological development projects to gross domestic product (GDP) has remained virtually constant for several years without exceeding 0.5% GDP, which is well below the Organisation for Economic Co-operation and Development (OECD) median. In the past three years, spending on research and experimental development rose from 0.43% to 0.57% of GDP; this is still low by comparison with other OECD countries (OECD, 2014; CONACYT, 2016).

Mexico ranks relatively low on other general research, development and demonstration (RD&D) indicators as well. Other indicators scoring in the bottom half of OECD average per GDP are: tertiary education expenditure, trademarks, triadic patent applications, business R&D expenditure, industry-financed public R&D expenditure; Mexican's doctoral graduation rate in science and engineering is also at the bottom five of OECD countries. However, Mexico scores well in the area of public R&D spending, which is to be expected as most energy sector activities have so far been concentrated in state monopolies.

ETRD&D policy framework: Objectives and strategies

The Mexican government recognises the big challenge of building a knowledge economy and more specifically innovation in the energy sector, which requires a more comprehensive approach to energy R&D. The **National Development Plan 2013-2018 (NDP**), in its third national goal "Mexico with a Quality Education", established the objective of making *scientific research, technological development and innovation the pillars of sustainable economic and social growth, and add efforts to develop a knowledge economy*. Thus, the NDP initiated a renewed push for science and technological infrastructure (funding went up from MXN 285 million (USD 13.9 million) per year under the previous plan to MXN 1.1 billion (USD 53.8 million) in 2013).

The Mexican *Law on Science and Technology* is the basis for the **National System of Science, Technology and Innovation (NSSTI)** to implement the state policy on scientific, technological and innovation activities, defined by the **General Council for Scientific Research, Technological Development and Innovation (GCSTI)** which is chaired by the President of Mexico with the participation of ministers, representatives of national academic associations, research institutes and the corporate sector.

Special Programme for Science, Technology and Innovation 2014-2018 (PECiTI)

GCSTI is in charge of approving and updating the **Special Programme for Science, Technology and Innovation 2014-2018 (PECiTI)** [*Programa Especial de Ciencia, Tecnología e Innovación*] which is a programme Law that guides Mexico's transition to an economy based on knowledge, according to the **Law on Science and Technology**.

The PECiTI's guiding objectives derive from NDP's objective. These are:

1. Contribute to national investment in scientific research and technological development for reaching a share of 1% of GDP in 2018.
2. Contribute to the formation and strengthening of highly skilled human capital.
3. Promote the scientific, technological and local innovation capacities, to strengthen sustainable and inclusive regional development.
4. Contribute to the transfer and use of knowledge provided in higher education institutions and research centres to the public, social and private sectors.
5. Contribute to strengthening scientific and technological infrastructure.

Likewise, PECiTI contains a long-term vision with a 25-year scenario to be updated every three years. It considers proposals from the main science, industrial and enterprises associations, at national and state levels, including:

The **Scientific and Technological Consultative Forum** which aims to promote the consolidation of Mexico's scientific, academic and technological community, including the private sector, to inform policy proposals and programmes of scientific research, technological development and innovation.

The **National Conference of Science, Technology and Innovation (CNCTI)** aims to contribute to the governance of the NSSTI at the state level. It is formed by state-level representatives involved in the promotion of scientific research.

Furthermore, PECiTI constitutes a key instrument with linkages to different sectoral programmes, including the **Energy Sectoral Programme 2013-2018 (PROSENER)** and its objective of *strengthening operational safety, support activities, knowledge, training, financing in energy industry, to benefit the energy sector with technological innovation.* In particular, PROSENER should contribute to PECiTI's objectives 1, 2 and 4 mentioned above.

Energy R&DD priorities

The training of human capital in the energy sector addresses the objectives set by PECiTI and aims to close the gap between supply and demand of specialists that will be required by the energy sector in the following years. Furthermore, PECiTI considers sustainable energy consumption, development and use of renewable and clean energy, and extraction and production of hydrocarbons, as priority topics for ERD&D: The

government created the **Strategic Training Program of Human Capital on Energy 2014-2018 (PEFRHME)** which seeks to generate incentives and establish a management system to co-ordinate actions among NSSTI members to improve and scale up training offers for the energy sector, aligned with international standards.

As regards ERD&D activities on sustainable energy development, the **Energy Transition Law (ETL)** has the potential to become a key driver, as, for the first time, it enshrines the target of *35% clean energy in electricity production in 2024 (50% in 2050)*. The firm target means that the Mexican energy system will be confronted with fundamental changes that require new solutions and technologies capable of handling intermittent renewables such as wind and solar power. For wind only, an additional 12 gigawatts (GW) is expected to come online by 2029, according to the Ministry of Energy (SENER). The need for well-designed RD&D strategies is thus becoming increasingly pressing.

Regarding ETRD&D activities on hydrocarbons, priority themes with opportunities for research and development (R&D) are: in the upstream sector, the development of advanced materials, submarine corrosion prediction, monitoring and controlling, insulating materials, welding in extreme environments, among others. In the mid-downstream sector: refineries upgrading and optimisation, process integration, low energy intensity and bioprocesses for crude processing and environmental impact reduction.

In addition to the national ETRD&D objectives, Mexico has joined **Mission Innovation,** an initiative of 20 countries across the world which have pledged to accelerate global clean energy innovation by 2020. Mexico reaffirms its commitment adopted in Paris in December 2015 and plans to *more than double its investment in clean technologies R&D over the next five years with the aim of lowering the cost of clean energy* (from USD 62.1 million in 2015 to USD 310.1 million in 2020).

Institutions

In 2013, the **Co-ordination of Science, Technology and Innovation** was created in the President's office, aimed at improving the co-ordination of Science, Technology and Innovation (STI) policies and implement the R&D strategies contained in the National Development Plan (NDP) and determined by the NSSTI.

CONACYT is the main body responsible to elaborate, promote and co-ordinate science and technology policies in Mexico, including PECiTI and promotes ERD&D activities through its own programmes and sectoral funds.

In the energy sector, the principal participating ministers are: the Ministry of Energy – (**SENER)** to seek the accomplishment of ERD&D objectives and indicators announced in its sectoral programme; the Ministry of Education (**SEP)** to lead education, research and innovation topics in the country; the Ministry of International Affairs (**SRE)** to co-ordinates multi- and bilateral alliances among institutes and governments of different countries to enforce ERD&D potential and deployment; and finally the Ministry of Finance and Public Credit (S**HCP)** is in charge of budget allocations for ERD&D activities.

Other institutions involved in energy RD&D activities in the country under SENER are:

The **Mexican Petroleum Institute (IMP**), a public institution undertaking basic and applied research and providing human resource capacity building, all specifically for the petroleum industry (and PEMEX).

The **National Nuclear Research Institute** (**ININ)** conducts R&D in nuclear science and technology in electricity, health, environment, development of renewable energy, and also high-level research in this field.

The **National Institute of Electricity and Clean Energy (INEEL**), that was formerly the Electric Research Institute, co-ordinates and conducts research projects and studies with strategic aspects focused on energy efficiency, planning and expansion of the national electricity system, as well renewable energy and implementation of new information technologies. Moreover, INEEL seeks to promote and disseminate criteria, methodologies and technologies for pollution prevention in the electricity industry; it contributes to training specialists and researchers in the electricity industry.

ETRD&D funding and financing

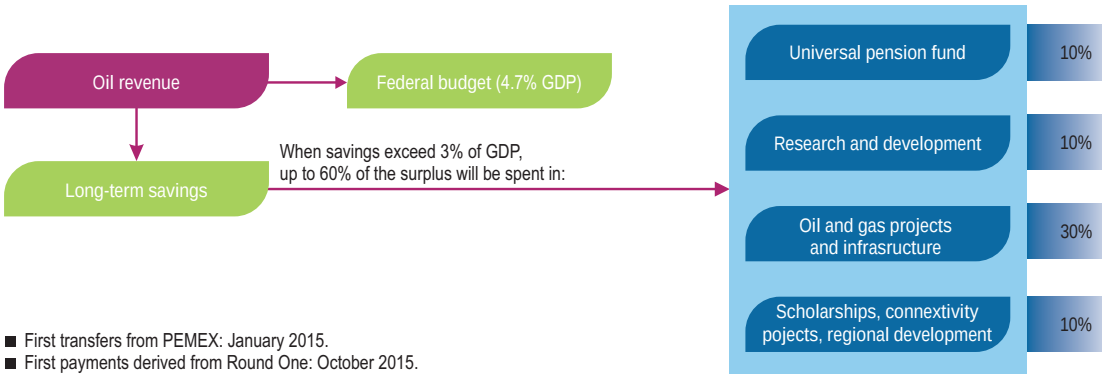
The ETRD&D contribution to GDP's growth is directly linked to the resources allocated to the Energy Funds, for both hydrocarbons and sustainable energy. These funds resulted from a set of new laws taking place in 2008, where the government enacted that the main source of public energy RD&D funding will be based on a 0.65% levy on extracted oil and gas, of which 65% is assigned to a Hydrocarbons Fund (FH), 20% to a Sustainable Energy Fund (FSE) and 15% to the Mexican Petroleum Institute (IMP), from which 5% is for energy R&D activities. Other important sources for R&D funding consist of other ministers' budgets, state-government funds, private and international co-operation.

Mexican Petroleum Fund (FMP)

FMP, the Mexican Petroleum Fund for Stabilisation and Development (*Fondo Mexicano del Petróleo para la Estabilización y el Desarrollo*) is an instrument resulting from the recent energy reform, in charge of managing resources from oil revenues[1], managing exploration and production contracts and their financial aspects, and establishing and managing long-term economic savings when oil incomes amount to 4.7% of GDP. When savings exceed 3% of GDP, up to 60% of the surplus will be spent on oil and gas projects and infrastructure (30%), pension funds (10%), research and development (10%), scholarships, connectivity projects and regional development (10%).

[1]. Oil revenues are obtained from the selling price less the cost of oil extraction.

Figure 11.1 Mexican Petroleum Fund mechanism



- First transfers from PEMEX: January 2015.
- First payments derived from Round One: October 2015.

Source: SENER, 2016.

The Fund's Technical Committee has a board comprising the Ministers of Finance and of Energy and the Central Bank Governor, as well as four independent members whose aim is to ensure that the Fund will have the necessary tools to perform its functions; these are to determine the payments from exploration and extraction contracts among enterprises and government; and to invest the resources from oil revenue for generating long-term savings. One part of the savings can be used to help the government to cover expenses related to these activities and another part will remain in the long-term savings account. The transparency with which the Fund operates is notable, making available all information on the oil revenues management through its website.

Table 11.1 FMP resources for energy funds

Sectoral fund	2015 MXN million	2016 MXN million
Hydrocarbons Fund	**3 194.5** (USD 156 million)	**2 053.5** (USD 100 million)
Sustainable Energy Fund	**982.9** (USD 48 million)	**631.9** (USD 30.9 million)
Mexican Petroleum Fund	**737.2** (USD 36.1 million)	**473.9** (USD 23.2 million)
Total FMP contribution	**4 914.6** (USD 241 million)	**3 159.3** (USD 154.8 million)

Source: Public Finance Studies, Centre of the Deputy Chamber, 2016; Sener, 2016.

According to the Federal **Law on Federal Budget and Fiscal Responsibility (LFPRH**), sectoral funds will not receive more resources than the amounts transferred in January and February by the Mexican Petroleum Institute (FMP), because the amount of 0.65% of the levy on oil from the total amount assigned to the fund in 2016 by law was already covered (Article 88 LFPRH). The income received by the Institute between March and December 2016 will be principally covered the Federal Expenditure Budget, including oil audits performed by the Federal Auditing Agency to the Hydrocarbons Extraction Fund and to the municipalities located near borders or coastlines.

The Hydrocarbons Fund and the Mexican Petroleum Institute (IMP)

The Hydrocarbons Fund has three main objectives: *i)* to promote scientific and technological research applied to exploration, production and refining of hydrocarbons and petrochemical products; *ii)* to adopt, innovate and develop technology in **the field of**

hydrocarbons, and *iii)* to train human capital in oil industry. Its main areas are exploration, extraction, refinement and petro-chemistry.

The Hydrocarbons Fund has a Technical and Administrative Committee (CTA) with seven members, including a representative of the Mexican Association of Hydrocarbon Companies (AMEXHI). The Fund's current outstanding projects are: a deep-water technology centre; assimilation and development of technologies in design, acquisition, processing and interpretation of seismic data for shale plays in Mexico; and a training centre of production processing.

Regarding the Mexican Petroleum Fund's resources allocated to the **Institute**, only 5% is allocated to energy RD&D activities which are used for developing technologies applicable to the oil industry and for training specialised human capital, providing support to PEMEX in finding and exploiting new oilfields and producing fuels according to international specifications.

The Sustainable Energy Fund (FSE)

The objective of this fund is promoting science, technology and innovation in energy sustainability through five different axes:

1. training of specialised human resources
2. strengthening research infrastructure
3. consolidation and linking of scientific and technological capabilities
4. promoting maturation of knowledge
5. fostering innovation focused on industrial and/or commercial application.

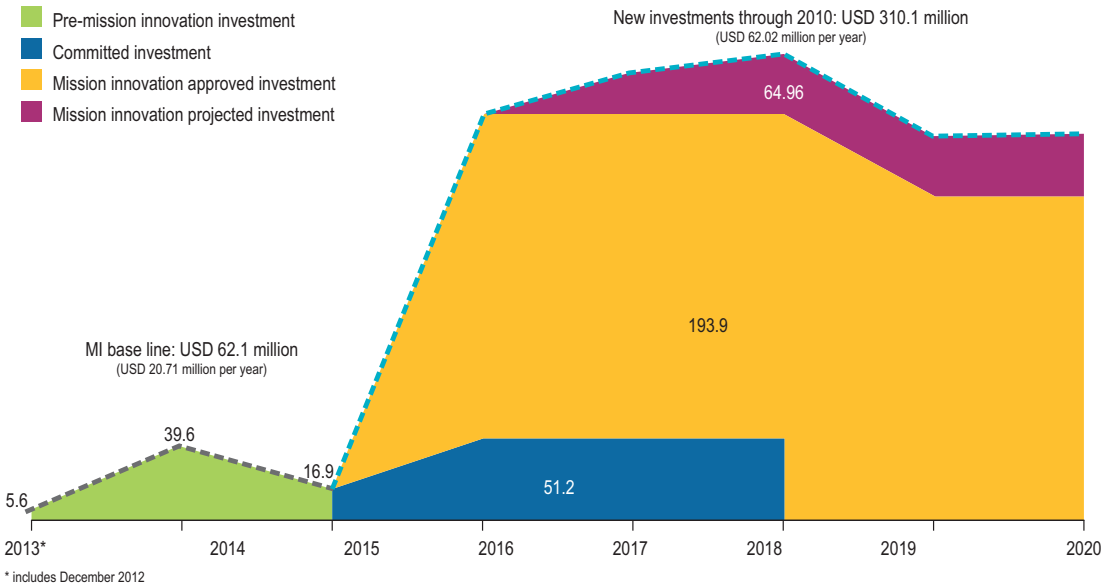
The priority areas are on energy efficiency, renewable energy, use of clean technologies and diversification of primary energy sources. The FSE allocates its resources through calls for project proposals. Since its creation in 2008, the FSE has published 26 calls for proposals, 118 projects from which have been approved and a major number of projects are currently in the evaluation process.

In 2014, energy R&D activities focused on clean energy technology and energy transition received remarkable funding, when the Fund has historically awarded from 2014 to 2020 over USD 150 million for the creation of the Mexican Energy Innovation Centres (CEMIEs) in renewable energy sources, including: solar (USD 9.9 million), wind (USD 6.6 million), geothermal (USD 23.6 million), bioenergy (USD 40.1 million) and ocean energy (USD 19.8 million), carbon capture, use and storage (USD 28.6 million) and Smart Grids (USD 25.7 million). The Centres will receive an additional contribution from public and private organisations for a total amount of USD 58 million.

The creation of CEMIEs was an important step towards boosting ER&D activities with a committed funding for the next four years, which gives an initial basis to R&D of clean and renewable energy in Mexico. However, in the medium term, the linking of ER&D investments to the country´s taxes on hydrocarbons production makes funding uncertain, given fluctuations in oil prices.

Likewise, in accordance with the commitment enhanced under the Mission Innovation initiative, the Fund is expected to double its resources in the next five years.

Figure 11.2 Mission Innovation Initiative – ERD&D investment



Source: Mexico in Mission Innovation, May 2016.

Other funds and sources

The **CFE-CONACYT Fund for Research and Technology Development in Energy** was created to support the growth and strengthen the national electricity sector through promoting research and technological development. Projects are focused on assets optimisation (generation, transmission and distribution infrastructure); availability and sustainable use of fuels; and alternative and renewable energy sources and sustainable development.

CONACYT has also two main budget lines to support regional development through innovation: The **Mixed Funds (FOMIX)** and the **Institutional Fund for the Regional Development of Science, Technology and Innovation (FORDECYT)**. The former was set up by the federal government, as a joint CONACYT-state funds. It promotes applied research at state and municipal levels. The latter was created in 2009 to complement FOMIX by supporting science, technology and innovation projects in universities, research centres and companies, helping them to integrate excluded regions in the national innovation system.

Furthermore, arising from the energy reform, the Sustainable Energy Fund is now able to support projects on research and technology development led by **private enterprises** as long as these projects are aligned with objectives of the Fund. The calls that will follow in the years to come will be designed to support both public and private actors, allowing the country to accelerate the development of the energy sector. (Mission Innovation Initiative, 2016)

Education and training on energy

A key challenge for the energy reform is to ensure sufficient human capital to update and expand the workforce of Mexico's companies, regulators, laboratories and agencies. In 2014, the National Council for Science and Technology (CONACYT) in

co-ordination with the Ministry of Energy, the Federal Energy Commission, PEMEX and the Ministry of Education developed the "Strategic Training Program of Human Capital in Energy 2014-2018" (PEFRHME) to address the challenges of human capital in the coming years in the energy sector, because of Mexico's needs to train a minimum of 135 000 high-level professional experts (20%) and technicians (80%) in various fields over the next four years to cover direct sector demand, are to develop new mechanisms for connecting human capital supply and demand, especially between universities and companies (SENER, 2014).

In order to follow up on the work under this programme, a committee was established along with a "talent observatory", to monitor the performance of education and training in the energy sector and to identify trends and technological opportunities in order to define priority areas and academic specialities in the medium term. The PEFRHME lays out objectives and actions in the short, medium and long term which are supported with national and sectoral planning instruments. Some actions that have already been set in motion, for instance the evaluation of needs in human resources, challenges and opportunities developed for both the hydrocarbons and the sustainability subsectors (SENER, SEP and CONACYT, 2015).

Other actions are the opening of the Energy Funds to new public tenders for projects related to the creation and strengthening of training programmes. One of the proposals recently approved through these tenders is the creation of the Binational Laboratory *(Laboratorio Binacional para la Gestión Inteligente de la Sustentabilidad Energética y la Innovación Tecnológica*) which focuses on training and research for the electricity sector. This project will be led by Tecnológico de Monterrey working with the Electricity Commission, the University of California Berkeley and the Arizona State University.

The Energy Funds have also set aside funding for masters, doctoral and post-doctoral scholarships as well as internship programmes. Since the creation of the Energy Funds, the number of scholarships has risen to 824 grants from which 605 were related to hydrocarbons topics and 219 for energy sustainability topics. This disparity is due to the fact that, before 2013, scholarships were only awarded for topics in hydrocarbons. For the coming years the Energy Funds plan to provide up to 1 720 scholarships annually to post-graduate degrees, and even 4 000 scholarships to graduates, and specialised degrees on high priority topics.

Regarding the enrolment of students in undergraduate and high-level technical programmes in the field of energy, in 2014 the country accounted for 540 000 students, with an annual output of 70 000 students; while graduate and post-graduate programmes on energy in 2013-14 accounted for 19 500 students. In March 2014, CONACYT reported a total of 7 004 scholarship-holders in high-quality programmes directly related to energy.

Mexico created the National System of Researchers (SNI, *Sistema Nacional de Investigadores)* in 1984. SNI supplements the salaries of the most productive researchers. Currently, researchers receive recognition – and a significant part of their incomes – by being a member of SNI. This programme remains actively up to date with more than 20 000 researchers (investment in 2015: MXN 4 billion).

Other programmes

The *Thematic Research Networks Program (Programa de Redes Temáticas de Investigación*) aims to create national networks in relevant topics or fields of science, with the purpose of developing platforms where views, interests, objectives and knowledge in each specific subject can converge. Some Thematic Research Networks are clearly environment-oriented and seek to design and implement programmes for research, technological development, education and dissemination in prioritised subjects linked to green growth. One main initiative carried out by this programme is in nano- and bio-technology fields (CONACYT, 2014).

The *Research Centre in Advanced Materials (CIMAV)*, a CONACYT public research centre, performs research and trains human resources in the areas of advanced materials, energy and environment to contribute to regional and national sustainable development. Some of the institutional programmes include nanotechnology and renewable energy.

R&D evaluation system

In general, the monitoring of all government strategies, including RD&D, is done periodically and published annually in reports announced by the Presidency. However, a periodic independent and in-depth evaluation of ERD&D activities in the country is lacking, as well as other instruments with which to track of the progress of objectives, actions and indicators.

CONACYT will design a national strategy to broaden the access to all scientific and technological information and strengthen the national capacities of scientists, researchers and academics. As a complement to this strategy, CONACYT is currently working to develop a national repository system to track, monitor and evaluate all institutions related to R&D activities, using public funds. The repository will operate by using international standards, ensuring the collection, preservation and management of information and high-quality content produced by all actors of the National Science, Technology and Development (NSSTI) to make information accessible and available to society in general. CONACYT will be in charge of the implementation and operation of the national repository.

In terms of transparency, the CONACYT counts with the National System of Scientific and Technological Evaluation (SINECYT) to guarantee a transparent and objective evaluation of proposals of the sectoral funds. SINECYT contains the Register of CONACYT's Assessors Accredited (RCEA) which contains the register of the members of the National System of Researchers (SNI), technologists, and accredited experts, national and international. RCEA is an instrument which intends to streamline the process of electronically evaluating support applications, facilitating the allocation of evaluators.

International collaboration

Mexico's international co-authorship and co-invention rates are close to OECD median levels, indicating a well-developed international network for science, technology and innovation collaboration. CONACYT's international scholarships programme for graduate

studies helps promote international linkages among researchers, as do efforts aimed at improving the quality of the Mexican education system.

Energy is one of the national priorities for providing international scholarships to form human capital. Mexico has promoted the participation and co-operation with international research institutes, high-tech universities and foreign experts to develop prioritised projects on energy and the environment. Collaboration agreements to develop ERD&D activities were signed, and funding initiatives were launched to address the risk of a human resource bottleneck across the public and private energy sector, triggered by the energy reform. Mexico is engaged in multi-disciplinary collaboration with institutions around the world, mainly in Canada, the United States, the European Union and Australia.

In the frame of the *Strategic Training Programme of Human Capital on Energy*, two calls for international scholarships are proposed for promoting and training human resources in energy sustainability and hydrocarbons sector to increase scientific, technological and innovation capacity in the country. In 2015, 164 international scholarships were granted by these calls.

Another relevant initiative is the *International Co-operation Fund for Science and Technology between the European Union and Mexico (FONCICYT)*, aimed at strengthening the scientific and technological capabilities of Mexico, in order to contribute to the solution of environmental and socio-economic problems. FONCICYT helps support the internationalisation of universities and public research institutions and centres, by encouraging the design and planning of joint projects between Mexican institutions and their counterpart in the European Union countries. The main co-operation projects have been supported in sectors like agriculture, biomedicine, biotechnology, environment, manufacturing industries and electronics.

Individual initiatives with Mexican participation

World Bank collaboration: In 2013, the Ministry of Energy, in collaboration with the World Bank and through support by the Global Environmental Facility (USD 18.4 million), developed the project Mexico's Sustainable Energy Technologies Development for Climate Change, whose objective is to support and complement the activities of the Sustainable Energy Fund in three different components: regional diagnosis to identify existent capacities, infrastructure and technological areas; identification of mature projects with high insertion potential into the market or industrial application; and project management along all phases.

IEA Technology Network: Mexico is also part of international RD&D clusters for aligning ER&D activities to international standards, and experiences or practices that seek innovative responses to current challenges for the society. This includes, for instance, Mexico's participation in 11 IEA Technology Collaboration Programmes (TPCs) and the participation in IEA forums to discuss paths for energy transition as well as learning best practices from the member countries.

European Union: Another initiative that Mexico has joined is the EU Horizon 2020 programme to attend top sectors, including the energy sector. This initiative is funded by the Netherlands Organisation for Scientific Research (NWO), which distributes a major

share of competitive research funding to Dutch universities and other knowledge institutes (OECD, 2014). Mexico is also collaborating with the European Union in a joint call in geothermal energy, with an investment of EUR 20 million, as well as by signing an agreement with the European Research Council to allow post-doctoral trainees supported by CONACYT collaborating with European peers.

Recently, in the international arena, Mexico joined the **Mission Innovation** initiative that provides a platform in terms of access to a large pool of insights on R&D programmes and innovation structures. The timing is excellent considering the initial stage that much of Mexico's energy innovation structure is in. Mission Innovation also offers a unique opportunity for Mexico to participate in joint research undertakings.

Assessment

Investments in energy research, development and deployment can make a major contribution to achieving national energy policy goals, providing secure and reliable energy and reducing greenhouse gas emissions. To date, the Mexican energy RD&D landscape has been dominated by public entities, in line with the largely monopolistic sector structures.

In order to make a transition to a system with greater private involvement, in parallel to the entry of such players into the market, a well-designed policy framework for energy-related RD&D should provide the basis for such efforts, and should ideally be embedded in the broader energy policy in order to strengthen synergies between the different policy levers, ultimately helping ensure that medium- and long-term targets are met. A recent example of such a policy framework is the European Union's **Energy Union** of 2015, which provides a strategy with five mutually-reinforcing and closely interrelated pillars, where "research, innovation and competiveness" makes up the fifth pillar.

Additionally, a persistent and focused effort on R&D aiming at delivering cost-effective energy technologies can play a critical role for Mexico in its quest for providing clean and affordable energy, as well as energy security. The current split in funding at 80%/20% for hydrocarbons/clean energy should move in a direction which favours clean energy, in line with the new Energy Transition Law. Implicit in this recommendation is the assumption that RD&D for hydrocarbons should increasingly be undertaken by the private sector, favoured by the opening of an energy market which attracts more investments. The fluctuating nature of the source of public funding, which is paid out on an annual basis, is hardly compatible with providing reliable and predictable funding for projects, an issue which should be urgently addressed.

Both the Hydrocarbons Fund and the Sustainable Energy Fund launched their first projects in 2009 and it is too early to assess their full-scale impact. According to the Funds managers, projects will be subject to an impact assessment five years after their completion, and the only tangible results so far are patent applications, scientific publications as well as an output of Masters and PhD graduates. It is now important for fund managers to proceed urgently to t an overview of the main impacts (e.g. "success stories") beyond the initial quantitative indicators and feed any lessons and adjustments back into the operations of the Funds. This highlights the need for periodic and independent evaluations of the Funds, in order to ensure the alignment of activities with energy policy priorities.

The organisational set-up of the Funds is well-designed in terms of their funding pipelines, with a relatively lean application process and independent evaluation committees and peer review mechanisms. The involvement of the private sector is critical in assessing the business potential behind prospective projects. Another important feature is the amount of competition for funding (hit rate), where high competition provides high-quality projects. The Hydrocarbons Fund and the Sustainable Energy Fund should do their best to attract players from the private sector to participate in projects, as there are indications that their participation is relatively low.

Some remarkable movements towards a society of knowledge are the creation of the Energy Innovation Centres and Mexico's commitment in the Mission Innovation initiative. The Innovation Centres are important in that they groom an ecosystem of innovation, where Mexico has so far lacked a decisive strategic approach. The themes of the CEMIEs seem to be well picked when looking at the longer-term scenarios of Mexico's energy sector, such as the *Electricity Outlook 2015-2029*. Also, the CEMIEs have fostered private-sector investments for a cleaner and renewable energy production. In this regard, Mexico's joining the Mission Innovation initiative to lower the cost of clean energy is an opportunity to speed up the internationalisation of its profile – something that would have been much more difficult to do without Mission Innovation. However, the variable budget for Mexican energy RD&D risks undermining the goal to double spending in 2020 and a solution should be found.

Recommendations

The government of Mexico should:

- Develop an integrated energy RD&D policy framework and strategy to address the key challenges and opportunities concerning Mexico's energy system and to reinforce and support the long-term energy goals.
- Strike a new balance in RD&D between hydrocarbons and clean energy so as to reflect the stated objective of energy transition.
- Establish a system of periodic independent evaluation of public energy RD&D, including through user surveys, in order to ensure an optimal impact from investing in energy RD&D projects.
- Consider ways to provide more stable and predictable funding for energy RD&D.
- Strengthen efforts to mobilise the private sector to facilitate a quick commercialisation and uptake of energy RD&D results.

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ANNEX A: Organisation of the review

REVIEW CRITERIA

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex D.

REVIEW TEAM

The IEA in-depth review team visited Mexico from 4 to 11 April 2016. The team met with government officials, energy suppliers, interest groups and other organisations. This report was drafted on the basis of the review team's preliminary assessment of the country's energy policy and information on subsequent policy developments from government and private-sector sources. The members of the team were:

IEA member countries

Mr. Drew Leyburne, Canada (team leader)

Ms. Gro Anundskaas, Norway

Ms. Kimberly Ballou, United States

Dr. Pieter Boot, the Netherlands

Ms. Eva Centeno López, Sweden

Dr. Paula Gant, United States

Mr. Jeppe Lundbæk, Denmark

International Energy Agency

Mr. Aad van Bohemen

Mr. Ali Al-Saffar

Dr. Manuel Baritaud

Dr. Joerg Husar

Mr. Toshiyuki Shirai

Mr. Miika Tommila

The team is grateful for the co-operation and assistance of the many people it met throughout the visit. Thanks to their kind hospitality, openness and willingness to share information, the visit was highly informative, productive and enjoyable. The team wishes to express its gratitude to Secretary Pedro Joaquín Coldwell, Undersecretary of Planning and Energy Transition, Leonardo Beltrán Rodríguez, Undersecretary of Electricity, Dr. César Emiliano Hernández Ochoa, Undersecretary of Hydrocarbons, Dr. Lourdes Melgar Palacios, and their staff at SENER. In particular, the team wishes to thank the SENER co-ordination group, namely Fernando Zendejas Reyes, Alejandro Amerena Carswell, Giovanni Anguiano Serrano, Veronique Deli Meadows, Javier Flores Duron Lizaola, Dr. Cesar Alejandro Hernández Alva, Juan Herrera Romero and Alberto Ramon Villanueva for organising the team visit, for their ability to respond to the team's many requests, and for their patience throughout the week.

Joerg Husar and Miika Tommila co-ordinated and co-led work across the report. Joerg Husar drafted chapters 2, 4 (with David Morgado), 5, 6 and 11 (with Aidana Velazquez). Miika Tommila drafted

chapters 1, 3, 7 (with Samantha McCulloch), 9 and 10. Chapter 8 was drafted by Manuel Baritaud. The section on CCS in Chapter 3 (climate change) was drafted by Samantha McCulloch. Sonja Lekovic drafted the supply and demand sections of the report.

The report was prepared under the guidance of Aad van Bohemen, Head of Country Studies Division. Helpful comments and updates were provided by review team members Drew Leyburne, Pieter Boot and Eva Centeno Lopez and the following IEA staff: Ali Al-Saffar, Toril Bosoni, Rachael Boyd, Omar Estefan, Carlos Fernandez Alvarez, Paolo Frankl, Nathan Frisbee, Rebecca Gaghen, Tim Gould, Christina Hood, George Kamiya, Markus Klingbeil, Cuauhtémoc López-Bassols, Duncan Millard, David Morgado, Simon Mueller, Erica Robin, Rodrigo Pinto Scholtbach, Toshiyuki Shirai, and Laszlo Varro, Ana Lepure (consultant) and Marco Cometto (OECD/NEA). Aidana Velazquez provided research and drafting support throughout the report.

Oskar Kvarnström and Bertrand Sadin prepared the figures. Roberta Quadrelli, Loïc Coënt, Rémi Gigoux, Gianluca Tonolo and Urzsula Ziebinska provided support on statistics. Therese Walsh managed the editing process, and Astrid Dumond managed the production process.

ORGANISATIONS VISITED

Acciona

AMEXHI

ASEA

BP

CASEDI/ONNCCE

CCE

CENACE

CENAGAS

Centro Mario Molina

CESPEDES

CFE

CIDAC

CIDE

CNH

CNSNS

CONACYT

CONUEE

CRE

EDF

Engie México

Fisterra Energy

Fundación IDEA

Grupo Dragón

Gas Natural Fenosa

Iberdrola

IENOVA

IHS

IIE

IMCO

IMP

Impulsa Generación Renovable
INECC
INEGI
ININ
LARCI
Ministry of Energy (SENER)
Ministry of Environment (SEMARNAT)
PEMEX
Ministry of Finance (SHCP)
Shell
Tec de Monterrey
Transparencia Mexicana
UNAM
World Bank

ANNEX B: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2013	2014	2015E
TOTAL PRODUCTION		**47.27**	**195.54**	**227.30**	**214.43**	**216.54**	**208.27**	**196.07**
Coal		1.50	3.74	5.68	8.01	7.68	7.75	7.96
Peat		-	-	-	-	-	-	-
Oil		27.49	153.28	169.20	147.16	150.28	144.79	134.67
Natural gas		10.54	22.75	33.38	42.57	40.47	37.26	34.96
Biofuels and waste[1]		6.21	8.55	8.94	8.12	8.95	8.74	8.65
Nuclear		-	0.77	2.14	1.53	3.08	2.52	3.02
Hydro		1.39	2.02	2.85	3.19	2.41	3.35	2.65
Wind		-	-	0.00	0.11	0.36	0.55	0.68
Geothermal		0.14	4.41	5.07	3.63	3.14	3.10	3.18
Solar/other[2]		-	0.02	0.04	0.12	0.18	0.21	0.30
TOTAL NET IMPORTS[3]		**5.24**	**-71.69**	**-75.14**	**-39.56**	**-24.20**	**-19.16**	**-10.44**
Coal	Exports	-	0.01	0.00	0.08	0.00	0.00	0.00
	Imports	0.27	0.24	1.99	5.19	5.01	5.09	5.25
	Net imports	0.27	0.24	1.99	5.12	5.00	5.09	5.25
Oil	Exports	1.37	75.58	96.65	83.02	76.50	74.05	75.44
	Imports	7.10	5.17	21.22	30.12	29.19	30.34	34.69
	Int'l marine and aviation bunkers	-0.73	-1.77	-3.96	-3.54	-3.85	-4.07	-4.29
	Net imports	4.99	-72.17	-79.40	-56.44	-51.16	-47.78	-45.04
Natural Gas	Exports	0.05	-	0.21	0.79	0.03	0.04	0.10
	Imports	-	0.37	2.41	12.64	21.98	23.62	30.03
	Net imports	-0.05	0.37	2.20	11.85	21.95	23.58	29.94
Electricity	Exports	-	0.17	0.02	0.12	0.11	0.23	0.79
	Imports	0.03	0.05	0.09	0.03	0.10	0.18	0.21
	Net imports	0.03	-0.12	0.08	-0.08	-0.00	-0.05	-0.58
TOTAL STOCK CHANGES		**0.04**	**-0.17**	**-2.17**	**-0.11**	**-0.24**	**-1.14**	**1.69**
TOTAL SUPPLY (TPES)[4]		**52.56**	**123.68**	**150.00**	**174.76**	**192.10**	**187.98**	**187.33**
Coal		1.82	4.13	6.88	13.26	12.91	12.65	13.59
Peat		-	-	-	-	-	-	-
Oil		32.47	80.79	88.52	90.67	98.92	96.40	90.08
Natural gas		10.49	23.12	35.47	54.22	62.15	60.51	65.76
Biofuels and waste[1]		6.21	8.55	8.94	8.12	8.95	8.74	8.65
Nuclear		-	0.77	2.14	1.53	3.08	2.52	3.02
Hydro		1.39	2.02	2.85	3.19	2.41	3.35	2.65
Wind		-	-	0.00	0.11	0.36	0.55	0.68
Geothermal		0.14	4.41	5.07	3.63	3.14	3.10	3.18
Solar/other[2]		-	0.02	0.04	0.12	0.18	0.21	0.30
Electricity trade[5]		0.03	-0.12	0.08	-0.08	-0.00	-0.05	-0.58
Shares in TPES (%)								
Coal		*3.5*	*3.3*	*4.6*	*7.6*	*6.7*	*6.7*	*7.3*
Peat		-	-	-	-	-	-	-
Oil		*61.8*	*65.3*	*59.0*	*51.9*	*51.5*	*51.3*	*48.1*
Natural gas		*20.0*	*18.7*	*23.6*	*31.0*	*32.4*	*32.2*	*35.1*
Biofuels and waste[1]		*11.8*	*6.9*	*6.0*	*4.6*	*4.7*	*4.6*	*4.6*
Nuclear		-	*0.6*	*1.4*	*0.9*	*1.6*	*1.3*	*1.6*
Hydro		*2.6*	*1.6*	*1.9*	*1.8*	*1.3*	*1.8*	*1.4*
Wind		-	-	-	*0.1*	*0.2*	*0.3*	*0.4*
Geothermal		*0.3*	*3.6*	*3.4*	*2.1*	*1.6*	*1.7*	*1.7*
Solar/other[2]		-	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.2*
Electricity trade[5]		*0.1*	*-0.1*	*0.1*	-	-	-	*-0.3*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015E**
TFC	**39.74**	**83.32**	**95.27**	**117.25**	**119.57**	**118.26**	**..**
Coal	1.37	1.09	0.89	4.04	3.77	2.61	..
Peat	-	-	-	-	-	-	..
Oil	22.19	51.14	61.09	74.51	72.35	73.07	..
Natural gas	7.26	13.91	12.57	12.94	14.93	13.73	..
Biofuels and waste[1]	6.21	8.55	8.18	7.09	7.58	6.97	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	0.02	0.04	0.12	0.17	0.19	..
Electricity	2.71	8.62	12.50	18.55	20.77	21.69	..
Heat	-	-	-	-	-	-	..
Shares in TFC (%)							
Coal	*3.4*	*1.3*	*0.9*	*3.4*	*3.2*	*2.2*	..
Peat	-	-	-	-	-	-	..
Oil	*55.8*	*61.4*	*64.1*	*63.6*	*60.5*	*61.8*	..
Natural gas	*18.3*	*16.7*	*13.2*	*11.0*	*12.5*	*11.6*	..
Biofuels and waste[1]	*15.6*	*10.3*	*8.6*	*6.0*	*6.3*	*5.9*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	..
Electricity	*6.8*	*10.3*	*13.1*	*15.8*	*17.4*	*18.3*	..
Heat	-	-	-	-	-	-	..
TOTAL INDUSTRY[6]	**16.47**	**34.85**	**35.16**	**40.10**	**41.73**	**39.68**	**..**
Coal	1.37	1.09	0.89	4.04	3.77	2.61	..
Peat	-	-	-	-	-	-	..
Oil	5.34	14.12	13.82	12.66	10.73	11.31	..
Natural gas	6.88	13.10	11.96	11.95	13.93	12.62	..
Biofuels and waste[1]	1.33	1.95	1.38	0.90	1.48	0.90	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	0.00	0.00	0.01	0.01	0.01	..
Electricity	1.56	4.59	7.11	10.55	11.82	12.24	..
Heat	-	-	-	-	-	-	..
Shares in total industry (%)							
Coal	*8.3*	*3.1*	*2.5*	*10.1*	*9.0*	*6.6*	..
Peat	-	-	-	-	-	-	..
Oil	*32.4*	*40.5*	*39.3*	*31.6*	*25.7*	*28.5*	..
Natural gas	*41.8*	*37.6*	*34.0*	*29.8*	*33.4*	*31.8*	..
Biofuels and waste[1]	*8.0*	*5.6*	*3.9*	*2.2*	*3.5*	*2.3*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	-	-	..
Electricity	*9.5*	*13.2*	*20.2*	*26.3*	*28.3*	*30.8*	..
Heat	-	-	-	-	-	-	..
TRANSPORT[4]	**12.41**	**28.31**	**35.84**	**51.09**	**51.13**	**51.29**	**..**
OTHER[7]	**10.87**	**20.16**	**24.27**	**26.06**	**26.72**	**27.29**	**..**
Coal	-	-	-	-	-	-	..
Peat	-	-	-	-	-	-	..
Oil	4.47	8.78	11.53	10.88	10.61	10.59	..
Natural gas	0.39	0.81	0.60	0.99	0.99	1.10	..
Biofuels and waste[1]	4.88	6.60	6.81	6.19	6.10	6.07	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	0.02	0.04	0.11	0.16	0.18	..
Electricity	1.13	3.96	5.30	7.89	8.85	9.35	..
Heat	-	-	-	-	-	-	..
Shares in other (%)							
Coal	-	-	-	-	-	-	..
Peat	-	-	-	-	-	-	..
Oil	*41.1*	*43.5*	*47.5*	*41.7*	*39.7*	*38.8*	..
Natural gas	*3.6*	*4.0*	*2.5*	*3.8*	*3.7*	*4.0*	..
Biofuels and waste[1]	*44.9*	*32.7*	*28.0*	*23.8*	*22.8*	*22.2*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	*0.1*	*0.2*	*0.4*	*0.6*	*0.7*	..
Electricity	*10.4*	*19.6*	*21.8*	*30.3*	*33.1*	*34.3*	..
Heat	-	-	-	-	-	-	..

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015E**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	7.12	27.46	49.55	57.13	60.70	60.22	..
Output (Mtoe)	3.19	9.96	17.69	23.70	25.57	25.93	26.44
Output (TWh)	37.10	115.84	205.68	275.54	297.33	301.50	307.42
Output Shares (%)							
Coal	*0.6*	*6.7*	*9.2*	*11.7*	*10.7*	*11.2*	*11.0*
Peat	-	-	-	-	-	-	-
Oil	*41.1*	*53.6*	*45.5*	*16.2*	*16.2*	*10.9*	*10.2*
Natural gas	*14.2*	*12.5*	*21.5*	*53.3*	*55.7*	*57.0*	*59.8*
Biofuels and waste[1]	-	-	*0.8*	*0.3*	*0.4*	*0.5*	*0.5*
Nuclear	-	*2.5*	*4.0*	*2.1*	*4.0*	*3.2*	*3.8*
Hydro	*43.6*	*20.3*	*16.1*	*13.5*	*9.4*	*12.9*	*10.0*
Wind	-	-	-	*0.4*	*1.4*	*2.1*	*2.6*
Geothermal	*0.4*	*4.4*	*2.9*	*2.4*	*2.0*	*2.0*	*2.0*
Solar/other[2]	-	-	-	-	-	*0.1*	*0.1*
TOTAL LOSSES	**13.45**	**35.90**	**55.09**	**60.49**	**65.80**	**64.97**	**-1.08**
of which:							
Electricity and heat generation[9]	3.93	17.50	31.86	33.43	35.13	34.29	..
Other transformation	2.58	5.77	1.59	-0.09	3.79	5.87	-1.08
Own use and transmission/distribution losses[10]	6.94	12.63	21.64	27.15	26.88	24.82	..
Statistical Differences	**-0.63**	**4.46**	**-0.36**	**-2.98**	**6.73**	**4.75**	**..**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015E**
GDP (billion 2010 USD)	333.99	617.85	869.29	1049.93	1150.98	1176.66	1205.66
Population (millions)	57.09	87.07	100.90	114.26	118.40	119.71	121.10
TPES/GDP (toe/1000 USD)[11]	0.16	0.20	0.17	0.17	0.17	0.16	0.16
Energy production/TPES	0.90	1.58	1.52	1.23	1.13	1.11	1.05
Per capita TPES (toe/capita)	0.92	1.42	1.49	1.53	1.62	1.57	1.55
Oil supply/GDP (toe/1000 USD)[11]	0.10	0.13	0.10	0.09	0.09	0.08	0.07
TFC/GDP (toe/1000 USD)[11]	0.12	0.13	0.11	0.11	0.10	0.10	..
Per capita TFC (toe/capita)	0.70	0.96	0.94	1.03	1.01	0.99	..
CO_2 emissions from fuel combustion ($MtCO_2$)[12]	117.6	256.9	359.6	438.0	448.1	430.9	..
CO_2 emissions from bunkers ($MtCO_2$)[12]	2.2	5.3	12.0	10.7	11.6	12.3	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-12**	**12-13**	**13-14**	**14-15**
TPES	5.2	1.9	1.5	4.7	0.2	-2.1	-0.3
Coal	4.9	5.2	6.8	-2.1	1.5	-2.0	7.4
Peat	-	-	-	-	-	-	-
Oil	5.5	0.9	0.2	6.4	-3.5	-2.6	-6.6
Natural gas	4.8	4.4	4.3	4.6	4.8	-2.7	8.7
Biofuels and waste[1]	1.9	0.4	-1.0	1.5	7.1	-2.4	-1.0
Nuclear	-	10.8	-3.3	22.2	34.5	-18.0	19.6
Hydro	2.2	3.5	1.1	-7.3	-12.2	38.9	-20.7
Wind	-	-	48.9	72.1	13.6	53.6	22.8
Geothermal	22.6	1.4	-3.3	-6.2	-1.6	-1.1	2.5
Solar/other[2]	-	10.0	10.5	15.6	14.5	16.5	39.2
TFC	4.5	1.3	2.1	0.8	0.3	-1.1	..
Electricity consumption	7.0	3.8	4.0	7.2	-2.5	4.5	..
Energy production	8.7	1.5	-0.6	0.9	-0.9	-3.8	-5.9
Net oil imports	..	..	..	..	..	..	..
GDP	3.7	3.5	1.9	4.0	1.4	2.2	2.5
TPES/GDP	1.4	-1.5	-0.4	0.7	-1.2	-4.3	-2.8
TFC/GDP	0.7	-2.1	0.2	-3.0	-1.0	-3.3	..

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprises solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.

2. *Other* includes tide, wave and ambient heat used in heat pumps.

3. In addition to coal, oil, natural gas and electricity, total net imports also include peat, biofuels and waste, and trade of heat.

4. Excludes international marine bunkers and international aviation bunkers.

5. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.

6. Industry includes non-energy use.

7. *Other* includes residential, commercial and public services, agriculture/forestry, fishing and other non-specified.

8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.

9. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and solar thermal, 10% for geothermal and 100% for hydro, wind and solar photovoltaic.

10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.

11. Toe per thousand US dollars at 2010 prices and exchange rates.

12. "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach from the 2006 IPCC Guidelines. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2013 and applying this factor to forecast energy supply. Projected emissions for coal are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

ANNEX C: Energy efficiency standards

Transport

Existing emission standards applicable to the transport sector (vehicles sold in Mexico).

NOM-044-SEMARNAT-2006, which establishes the maximum permissible emissions limits for total hydrocarbons, non-methane hydrocarbons, carbon monoxide, nitrogen oxides, particles and smoke opacity from the exhaust of new engines using diesel fuel and to be used for the propulsion of new motor vehicles with a gross vehicle weight of 3 857 kg, as well as new units GVWR greater than 3 857 kg equipped with this engine. In 2018, NOM 044 is foreseen to be updated, stating that all new trucks will require EPA certification equivalent to EURO VI.

NOM-041-ECOL-1999, which establishes the maximum permissible limits of emission of pollutants from the exhaust gases of motor vehicles in circulation that use gasoline as fuel.

NOM-045-ECOL-1996, which establishes the maximum permissible levels of smoke opacity from the exhaust of motor vehicles in circulation that use diesel or mixtures that include diesel fuel.

NOM-047-ECOL-1993, which establishes the characteristics of the equipment and the measurement procedure for verification of the emission levels of pollutants from motor vehicles in circulation that use gasoline, liquefied petroleum gas, natural gas or other alternative fuels.

NOM-050-ECOL-1993, which establishes the maximum permissible levels of emission of pollutants from the exhaust gases of motor vehicles in circulation that use liquefied petroleum gas, natural gas or other alternative fuels as fuel.

NOM-076-ECOL-1995, that establishes the maximum permissible levels of emissions of unburned hydrocarbons, carbon monoxide and nitrogen oxides from exhaust, and evaporative hydrocarbons from the fuel system, using gasoline, liquefied petroleum gas, natural gas and other alternative fuels and to be used for the propulsion of motor vehicles with a gross vehicle weight of 3 857 kg.

NOM-163-SEMARNAT-ENER-SCFI-2013, emissions of carbon dioxide (CO_2) from the exhaust fume and its equivalent in terms of fuel efficiency, applicable to new motor vehicles of gross vehicle weight of up to 3 857 kg.

Buildings NOMs regulate energy efficiency in the sector.

CODE		Applied to
Applied to systems	**NOM-007-ENER-2014** Energy efficiency of lighting systems in non-residential buildings.	**Non-residential**
	NOM-008-ENER-2001 Energy efficiency in buildings, non-residential building envelope.	**Non-residential**
	NOM-020-ENER-2011 Energy efficiency in buildings, building envelope for housing.	**Residential**
	NOM-024-ENER-2012 Thermal and optical features of the glass and systems glazes for buildings. Labelling and testing methods.	**Non-residential**
	NOM-009-ENER-2014 Energy efficiency in industrial thermal insulation systems.	**Non-residential**
Applied to equipment	**NOM-011-ENER-2006** Energy efficiency in air conditioners central rate, package or split. Limits, testing methods and labelling.	**Non-residential**
	NOM-017-ENER/SCFI-2012 Energy efficiency and security requirements of ballasted compact fluorescent lamps. Limits and testing methods.	**Non-residential**
	NOM-018-ENER-2011 Thermal insulation of buildings. Characteristics, limits, and testing methods.	**Non-residential**
	NOM-021-ENER/SCFI-2008 Energy efficiency and safety requirements for user type room air conditioners. Limits, testing methods and labelling.	**Residential**
	NOM-023-ENER-2010 Energy efficiency in air conditioners split type, free download without air ducts. Limits, testing methods and labelling.	**Residential**
	NOM-024-ENER-2012 Thermal and optical characteristics of the glass and glazing systems for buildings. Labelling and testing methods.	**Residential and non-residential**
	NOM-028-ENER-2010 Energy-efficient lamps for general use. Limits and testing methods.	**Residential and non-residential**
	NOM-030-ENER-2012 Luminous lamp efficiency of light emitting diodes (LED) integrated for general lighting. Limits and testing methods.	**Residential and non-residential**
	NOM-032-ENER-2013 Stand-by limits for equipment and appliances.	**Residential and non-residential**
	NOM-015-ENER-2012 Energy efficiency in refrigerators and freezers .Limits and test methods.	**Residential**

	NOM-003-ENER-2011 Thermal efficiency in water heaters for domestic and commercial uses.	**Residential and non-residential**
	NOM-004-ENER-2014 Energy efficiency for a motor-pump for domestic use (potency from 0.180 kW to 0.750 kW). Limits, testing methods and labelling.	**Residential**

ANNEX D: International Energy Agency "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

ANNEX E: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

AC	alternating current
ALENER	Alliance for Energy Efficiency
AMEXHI	Mexican Association of Hydrocarbon Companies
AMF	Mexican Association of Railroads
AMI	Advanced Metering Infrastructure
AMIA	Mexican Association of the Automotive Industry
ANCE	National Association for Standardization and Certification of the Electricity Sector
ASEA	National Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector
BAU	business-as-usual
BUR	Biennial Update Report
CADER	Radioactive Waste Storage Center
CASEDI	Quality and Sustainability in Buildings
CCER	Consultative Council for Renewable Energy
CCGT	combined cycle gas turbine
CCS	carbon capture and storage
CCUS	carbon capture, use and storage
CEC	clean energy certificate
CEMIE	Energy Innovation Centre
CENACE	National Electricity Control Center
CENAGAS	National Control Center for Natural Gas
CFE	Federal Electricity Commission (*Comisión Federal de Electricidad)*
CFL	compact fluorescent lamp
CICC	Commission on Climate Change
CIMAV	Research Centre in Advanced Materials (under CONACYT)
CMIC	Mexican Chamber of Construction Industry
CNCTI	National Conference on Science, Technology and Innovation
CNH	National Hydrocarbons Commission
CNSNS	National Commission for Nuclear Safety and Safeguards
COFECE	Federal Economic Commission on Competition
CONACYT	National Council for Science and Technology
CONAPO	National Council of Population
CONAVI	National Housing Commission

CONUEE	National Commission for the Efficient Use of Energy
CRE	Energy Regulatory Commission
CTA	Technical and Administrative Committee
DAM	day-ahead market
E&P	exploration and production
EC	Expert Council
EITI	Extractive Industries Transparency Initiative
ENCC	National Climate Change Strategy
EOR	enhanced oil recovery
ER&D	energy research and development
ESCC	Energy Sector Coordination Council
ESCO	energy services company
ETL	Energy Transition Law
EV	electric vehicle
FH	Hydrocarbons Fund
FIDE	Trust Fund for Electricity Savings
FIPATERM	Trust for Thermal Insulation
FMP	Mexican Petroleum Fund
FOMIX	mixed funds
FONCICYT	International Co-operation Fund for Science and Technology between the European Union and Mexico
FORDECYT	Institutional Fund for the Regional Development of Science, Technology and Innovation
FOTEASE	Fund for Energy Transition and Sustainable Energy Use
FSE	Sustainable Energy Fund
FTR	financial transmission rights
GCSTI	General Council for Scientific Research, Technological Development and Innovation
GdC	*Gasoductos de Chihuahua*
GDP	gross domestic product
GEF	Global Environmental Facility
GHG	greenhouse gas
IAEA	International Atomic Energy Agency
IEPS	Special Tax on Goods and Services
IMP	Mexican Petroleum Institute
INDC	intended nationally determined contribution
INECC	National Institute of Ecology and Climate Change
INEGI	National Institute of Statistics and Geography
INERE	National Inventory of Renewable Energy
INFONAVIT	Institute for National Fund of Workers' Housing
ININ	National Nuclear Research Institute

IPP	independent power producer
ISO	independent system operator
LAERFTE	Law on the Use of Renewable Energy (2008)
LED	light-emitting diode
LFPRH	Federal Law on Federal Budget and Fiscal Responsibility
LGCC	General Law on Climate Change
LH	Hydrocarbons Law
LIF	Federal Revenue Law
LMP	locational marginal prices
LNG	liquefied natural gas
LORCME	Law of Coordinated Energy Regulatory Agencies
LULUCF	land use, land-use change and forestry
LPG	liquefied propane gas
MDS	motor-driven systems
MEPS	minimum efficiency performance standards
MOU	memorandum of understanding
MRV	monitoring, reporting and verification
NACEI	North American Cooperation on Energy Information
NAFTA	North American Free Trade Agreement
NAMA	Nationally Appropriate Mitigation Action
NDC	nationally determined contribution
NDP	National Development Plan
NEA	Nuclear Energy Agency (OECD)
NESO	National Emergency Strategy Organization
NGL	natural gas liquids
NIP	National Infrastructure Program 2014-2018
NOM	Mexican official standard
NPP	nuclear power plant
NSSTI	National System of Science, Technology and Innovation
ONNCCE	National Standardisation and Certification Body for Buildings and Construction
PAESE	Program of Energy Savings in the Electricity Sector (*Programa de Ahorro de Energía del Sector Eléctrico*
PEAER	Special Program on the Use of Renewable Energy 2014-2018
PECC	Special Program on Climate Change 2014-2018
PECITI	Special Program for Science, Technology and Innovation
PERFHME	Strategic Training Program of Human Capital in Energy (*Programa Estratégico de Formación de Recursos Humanos en Materia Energética)*
PEMEX	*Petróleos Mexicanos*
PEMEX TRI	*PEMEX Transformación Industrial*
PGPB	*PEMEX Gas y Petroquímica Básica*

PPA	power purchase agreement
PPP	purchasing power parity
PRODESEN	National Electricity System Development Program
PRONASE	National Program for the Sustainable Use of Energy
PROSENER	Energy Sectoral Program
PV	photovoltaics
RCEA	Register of CONACYT's Assessors Accredited
RD&D	research, development and demonstration
RTM	real-time market
RTO	regional transmission operators
SAGARPA	Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food
SALUD	Ministry of Health
SCADA	supervisory control and data acquisition
SCT	Ministry of Communications and Transport
SE	Ministry of Economy
SEDATU	Ministry of Agricultural, Territorial and Urban Development
SEMARNAT	Ministry of Environment and Natural Resources
SEN	national electricity system
SENER	Ministry of Energy
SEP	Ministry of Education
SHCP	Ministry of Finance
SHF	*Sociedad Hipotecaria Federal*
SICSE	Energy Sector Shared Information System
SIE	Energy Information System
SIN	National Interconnected System
SINACC	National Climate Change System
SINECYT	*Sistema Nacional de Evaluación Científica y Tecnológica*
SISTRANGAS	Natural Gas Transportation System and Integrated Natural Gas Storage
SLCP	short-lived climate pollutant
SME	small and medium-sized enterprises
SNI	National System of Researchers
SRE	Ministry of External Relations
STI	science, technology and innovation
TAR	storage and distribution terminal
TFC	total final consumption
TIU	interruption time per user
TPES	total primary energy supply
TSO	transmission system operator
UNFCCC	United Nations Framework Convention on Climate Change
UPAC	high-energy consumer

Units of measurement

bcm	billion cubic metres
GJ/t	gigajoules per tonne
GW	gigawatt
GWh	gigawatt hour
kbd	thousand barrels per day
m^3	cubic metre
mboe	million barrels of oil-equivalent
MBtu	million British thermal units
mcf/d	million cubic feet per day
Mt	million tonnes
$MtCO_2$-eq	million tonnes of carbon dioxide-equivalent
Mtoe	million tonnes of oil-equivalent
MW	megawatt
MWh	megawatt-hour
MW_{th}	megawatt-hour of thermal capacity
PJ	petajoule
tcf	trillion cubic feet
TWh	terawatt-hour
W	watt


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ENERGY POLICIES BEYOND IEA COUNTRIES

Mexico

2017

This first review of Mexico's energy policies by the International Energy Agency comes at a momentous time for the country's energy sector. The broad-based Energy Reform, beginning with the Constitutional changes of December 2013, has continued at a steady and impressive pace. Its reach and scope amounts to one of the most ambitious energy system transformations in decades. The IEA applauds the government of Mexico for the progress made to date.

Starting from a largely closed and monopoly-driven energy market, the reform has taken concrete steps to harness market forces to attract investments and increase production while ensuring transparency and rule of law, improving energy security and strengthening the environmental sustainability of the energy sector.

Some policy areas, such as promoting competition and redesigning emergency preparedness, will have to remain a priority. The transition to open energy markets should continue in a transparent manner, and with regulatory certainty. The new roles and responsibilities for the public and private entities, in particular for energy supply emergencies and energy data collection, should be defined well. It is also critical to ensure sufficient resources for the several new or strengthened regulatory authorities.

For the long term, as Mexico's population, cities and economy are projected to grow strongly, a cross-sectoral approach is required to limit the increase in energy demand and energy-related greenhouse gas emissions. This review analyses the energy policy challenges facing Mexico and provides recommendations for further policy improvements. It is intended to help guide the country towards a more secure, sustainable and affordable energy future.