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Climate change policy and power sector reform in Mexico under the 'golden age of gas'

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Abstract: Mexico's low-carbon technology perspectives show lack of coherence with the rising ambition in climate change commitments, for which Mexico is internationally praised. The comparison of two recent energy reforms, corresponding to two administrations, explains this lack of coherence by, on the one hand, the permanence of a strong climate institutional framework devised as a means to increase energy security and, on the other hand, the political commitment to reduce electricity tariffs through the access to low-priced gas in North America. This paper underscores the political economy trade-offs between the need for a strong climate commitment that provides a stable long-term energy transition pathway and the political and economic short-term benefits derived from low electricity tariffs.

Keywords: power sector, climate change, renewable energy, natural gas, market reform, energy transition
JEL classification: L98, O33, P48, Q48

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1 Introduction: climate change, energy transition, and energy reform

In the last quarter century, Mexico has undergone a series of major institutional and technological changes in the power sector. Since the early 1990s, and as in other restructured markets, Mexico's power sector has gradually evolved into an open-market regime where natural gas has gained a dominant market share (Carreón-Rodríguez et al. 2006; Fuentes and Bowler 2014). During the same period, climate change emerged as a global priority. However, it was not until the late 2000s that Mexico developed economy-wide mitigation programmes and policies.

Although not having mitigation obligations under the Kyoto Protocol and being responsible for <2 per cent of global carbon emissions,[1] even before the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21—UNFCCC) in Paris, Mexico had assumed voluntary commitments to reduce greenhouse gas (GHG) emissions for 2020 and 2050. Besides hosting COP16 in Cancún and helping restore the trust in the multilateral climate negotiations, Mexico was the only non-Annex I country to have established a comprehensive climate change law—a far-reaching institutional framework that includes an array of planning instruments—and submitted five national communications under the convention (Fekete et al. 2013: 78). It was also the first developing country to present its Intended Nationally Determined Contribution (INDC; Gobierno de la República 2015) with conditional and unconditional pledges (CAT 2015).

Despite its leadership on climate issues, Mexico's ambition to promote clean energies is less certain. By the time the constitutional amendments that reformed the oil and power sector were enacted (in December 2013), Mexico had already benefited from the investment of a small but rising private renewable energy industry (IRENA 2015: 14–15). However, observers have noted the lack of certainty about the role that renewable energy will play in the short- and long-term development of the power sector. The 21st Century Power Partnership, under the Clean Energy Ministerial (2015), depicted Mexico's type of process as 'restructuring', committing to deep transformation of the power sector structure, but with a limited or average approach regarding the ambition for clean power transition. Power sector reform is still centred on a large-scale, centralized, fossil fuel-based generation model, with moderate commitments to increased shares of variable renewable energy (Zinaman et al. 2015). Veysey et al. (2015) concluded that achieving Mexico's long-term climate change mitigation goals would require the power sector to become virtually zero emissions by 2050. This entails a very clear plan on how current investment choices will affect long-term options for mitigation.

Mexico's decreasing power sector emission intensity, from 0.608 to 0.499 tCO_2e/MWh between 2003 and 2013 (SEMARNAT et al. n.d.), contributed to a complacency narrative. Emission reductions are still primarily driven by a hustle to power Mexico with natural gas, and marginally by an expansion of wind energy based on ad hoc regulatory benefits rather than a clear, long-term policy for a robust and diversified portfolio of electricity sources.

The energy reform created a series of mechanisms that could be the basis for potential long term growth of low-carbon technologies. They include an independent system operator, the binding character of clean energy obligations and certificates, and long-term auctions for clean energy. The first of these mechanisms is a key component to the wholesale electricity market, and the

[1] In 2012, Mexico had the lowest carbon dioxide emissions per capita in the OECD (Organization for Economic Co-operation and Development), with 3.7 tonnes per capita (OECD 2015a).

other two are fundamental policies to contain the costs associated with increasing clean energy shares.

However, the central energy policy objective of the current administration in Mexico is to lower power production costs, mainly grasping the benefits of low-cost gas in North America. This policy objective discouraged the administration from embracing ambitious climate change mitigation commitments that might increase electricity prices, thus hurting the main support base of the energy reform coalition—a broad spectrum of industries and businesses eager to access competitive tariffs.

This paper presents a narrative on the challenges of energy transition policies when fossil fuel prices remain competitive, a circumstance that could be a regular feature in global energy markets in the near future. The research shows the changing nature of political commitments and rationale behind the economics of energy and climate change mitigation goals and their potential costs. A climate policy devised on the basis of the economic co-benefits could be easily undermined if these co-benefits become less clear under a power market driven by low fuel prices. We underscore the link between climate policy and energy reform from the perspective of energy security. A primary question addressed in this paper is how the price dynamics of natural gas and the political significance of the shale revolution across the border fed into the expectation from industries and government in Mexico to deliver low energy costs, thus exacerbating the existing ambiguity of government climate policies in the electricity sector.

2 Energy transition and climate change agenda as a political necessity (2008–12)

2.1 Race between demand and energy reforms

In the last 30 years, Mexico's energy consumption has grown steadily, at a rate of about 2 per cent annually. Fossil fuels represent >92 per cent of the total national energy consumption. Between 2000 and 2010, electricity generation increased by 33 per cent, the population increased by ~66 per cent, and the total energy consumption more than doubled whereas electricity consumption almost tripled. Per capita electricity consumption reached 2 MWh per capita, from 0.9 MWh per capita, as described in detail in Table 1.

Table 1: Key indicators of energy production and demand

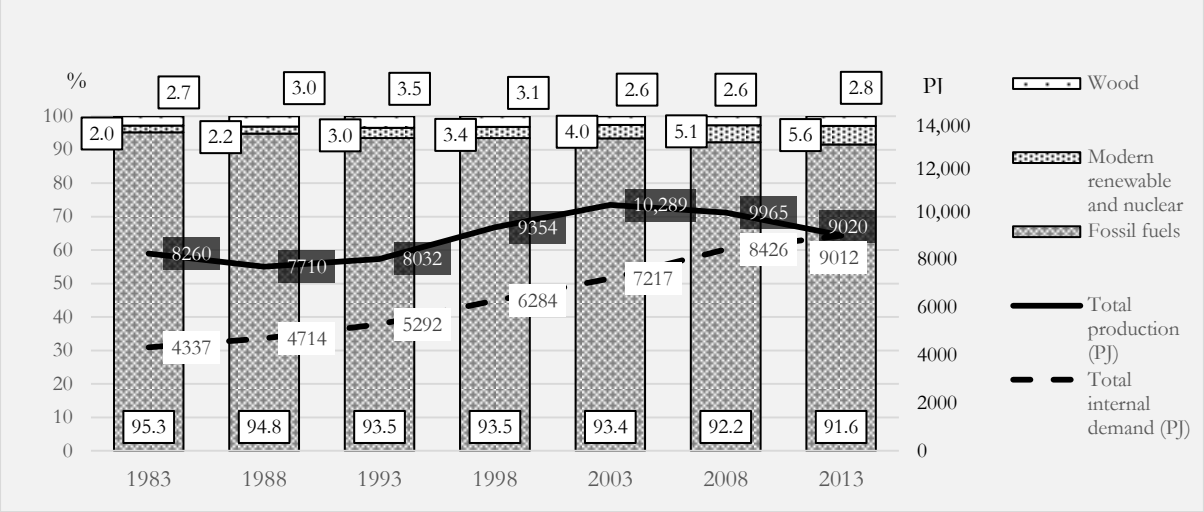
	1983	2003	2013
National energy consumption (petajoules)	4383.8	7216.9	9011.8
Population (millions)	71.8	104.7	118.4
Energy consumption per capita (gigajoules/person)	61.1	68.9	76.1
Electricity consumption (gigawatt-hour)	61,183.3	176,718.5	235,158.6
Electricity consumption per capita (kilowatt-hour/person)	852.2	1687.5	1986.2
Energy production (petajoules)	8260.0	10,289.4	9020.2
Relation between production and demand	1.9	1.4	1.0

Source: SENER (2015e).

Although the growth in demand comes as no surprise, the pace of Mexico's energy imports merits consideration. Through 2011–13) Mexico faced problems with the reliability of and access to natural gas because of the Mexican oil company Petróleos Mexicanos (PEMEX) (Auditoría Superior de la Federación 2014) limited ability to increase gas production and expand the natural gas pipeline network. Since 2002, the fuel mix for power generation shifted from oil products to natural gas, which became the main fuel source. The share of natural gas in the total electricity output increased from 12 per cent in 1990 to over 50 per cent in 2010.

In 2013, the difference between the total production of energy and the total internal demand was almost equal, with a negligible difference as seen in Figure 1. Thirty years ago, in 1983, production was 90 per cent higher than total demand because domestic sources met consumption demand and Mexico was already a large crude oil exporter. Wood has remained at an equivalent rate driven by population growth, but nuclear and modern renewables, including hydropower, have gained market share. With a modest secular demand growth, significant inflexion points in energy production and consumption are explained by the dynamics of oil and gas production, increasing until 2003 and diminishing later on.

Figure 1: Total energy production and internal demand in Mexico (1983–2012)



Source: Sistema de Información Energética (SENER 2015e, retrieved 20 June 2015).

The oil and gas production collapse and subsequent stagnation set the stage for public debates on the energy sector in Mexico in the decade 2003–13. Also, concerns about the ecological and economic sustainability of an oil-driven energy sector started to challenge the status quo (Sen and Upadhyaya 2014).

2.2 Climate change in the context of energy politics

In 1992, the Mexican Congress approved a sweeping energy reform that defined new areas for the participation of private investment in power generation in two forms: (i) generation under a 'maquila' framework, with the Federal Electricity Commission (Comisión Federal de Electricidad, CFE) assuming risks for gas distribution and purchasing the production of electricity at previously agreed rates per megawatt-hour delivered; and (ii) generation for self-supply (Hernández 2006). However, from that point on, the political context in Mexico was quite adverse, frustrating efforts to pass a comprehensive energy reform. In 1999, 2002, and 2008, the presidency submitted three energy reform proposals to the Mexican Congress. The first two failed, while the third, proposed by President Felipe Calderón (2006–12), was approved, but only because it was a fairly limited reform that did not change the energy sector profoundly.

The 2008 reform is noteworthy because it was accompanied by two distinctive laws that determined the first clear political step for clean energy: (1) Law for Sustainable Use of Energy (Ley para el Aprovechamiento Sustentable de la Energía, LASE) and (ii) Law for the Use of Renewable Energy and Financing of Energy Transition (Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética, LAERFTE). The laws shaped a new institution for the promotion of energy efficiency, created a new financial vehicle for the deployment of energy transition initiatives independent from the state-owned enterprises,

and firmly provided a legal support to many regulatory decisions that could have been contested by future governments from opposing parties.

In an adverse political context and in the face of rapidly growing energy demand and limited energy resources, renewable energy and energy efficiency emerged as key elements of the Calderón administration's strategy to achieve Mexico's energy security and economic development goals (Gobierno de la República 2007). Boosting renewable energies, particularly in the electricity sector where private investment was partially allowed, became a priority goal in the Sectorial Energy Programme for 2007–12 (SENER 2007: 6). As the former Minister of Energy Georgina Kessel stated in 2009, energy security is reinforced by diversifying primary sources and reducing the uncertainty generated by the volatility of fuel prices (Kessel 2009).

It has been argued that the personal beliefs of President Calderón and a strong sense of global responsibility drove the dynamic climate agenda that unfolded during his presidency (Torres 2014). After all, Mexico is the second largest GHG emitter in Latin America and ranks 10 among the world's highest levels of GHG emissions, excluding land-use change and forestry (World Resources Institute 2015). It is estimated that 15 per cent of Mexico's territory, 68 per cent of the population, and 71 per cent of gross domestic product (GDP) 'are highly exposed to climate change risk' (OECD 2013).[2] Embracing the fight against climate change could help improve Mexico's world image, which had been severely affected by the violence linked to Calderón's war against the drug cartels, and could potentially generate concrete benefits, such as financial resources to support the energy transition, thus explaining Mexico's strong promotion of the Green Climate Fund.[3]

Although all of these factors could have played a role in understanding the wide array of new institutions for climate policy-making developed during the Calderón administration, they do not explain the features that became the backbone of his climate policy. Calderón's power sector transition policy was a child of necessity and a by-product of the political constraints that impeded his government from fully opening Mexico's energy sector to private investment as a means to achieve the twin goals of energy security and economic growth. Climate change mitigation was not a primary goal, but rather, as Fekete et al. have argued, 'a secondary political goal' that opened up 'new potentials to achieve other primary development goals' (2013: 2).

In the early 2000s, the Energy Regulatory Commission (Comisión Reguladora de Energía, CRE) was vested with new powers to foster the deployment of alternative sources of energy, including an energy bank that allowed self-suppliers to carry over excess capacity from one year to the next; predictable wheeling fees and lower capacity back-up fees levied on self-supply generations; net metering at small scale; capacity payments for CFE contracts with independent power producers (IPPs); and new bidding mechanisms for the private sector to cover the costs of new

[2] The highest costs from climate events in Mexico (in terms of human losses and economic impacts) were registered in three years between 2000 and 2010: 2005 (hurricanes Stan, Wilma, and Emily), 2007 (hurricane Dean, and several episodes of rain that caused floods in Tabasco), and 2010 (cyclones Karl, Matthew, and Alex). The years 2005 and 2010 were particularly devastating because of a combination of environmental events (hurricanes, heavy rains, and above-normal summer and frost) that resulted in economic losses exceeding losses of the 1985 earthquake. Additionally, in 2009 drought affected nearly 385,000 hectares, whereas in 2011 the figure rose to over 805,000 hectares. According to official data, from 2000 to 2010, the economic impact of climate disasters in Mexico was a loss of 229,547 million pesos, an annual average of 20,870 million pesos, in contrast with an annual average of 730 million pesos from 1980 to 1999 (Cavazos 2015: 22; CENAPRED 2012).

[3] As of 2014, Mexico has pledged US$10 million towards the Green Climate Fund (GCF 2015).

CFE grid capacity (Davis et al. 2012). In addition, since 2005, the Federal Income Tax Law has allowed 100 per cent depreciation of capital expenses for renewables in a single year.

New mandates in 2008 allowed the CRE to finally push for the rapid development of wind energy self-supply contracts that allowed wind energy to surpass 2000 MW in 2014 (IRENA 2015: 16). Companies such as Grupo Bimbo, Cemex, FEMSA, and Walmart in Mexico leveraged their AAA credit ratings to become off-takers from renewable self-supply generation projects, accruing 5–20 per cent less than the applicable electricity rate (Yale School of Management 2012). Nearly all of these were clean development mechanism projects, through which these companies received funding. Short of a comprehensive energy reform, their continued investment in these projects would depend upon the continuation of the clean development mechanism, the establishment of a comparable funding source (e.g. feed-in tariffs or other incentives) after 2012, or the adoption of the new methodologies developed by CFE to include environmental costs and benefits in its determination of the 'least cost' electricity (Davis et al. 2012).

The limited engagement of CFE on renewable energy investment was formally justified by the requirement to purchase electricity at the lowest cost, based on self-defined and uncontested levellized cost of energy. Also, CFE disregarded the mandate by law to incorporate the value of externalities into this levellized cost. Private investment was limited not only by the size of the self-supply market but also by the requirement that surplus production is sold to CFE at a discounted price, the lack of transparency on the administrative proceedings for interconnection to the grid, and CFE's unwillingness to build transmission infrastructure in remote resource-rich areas (WWF et al. 2013).

In fact, the difference in renewable energy investments from the private sector and the CFE is staggering. By 2014, the CFE installed 597 MW of wind energy, through IPP contacts, whereas self-supply development accounted for 1439 MW (SENER 2015b). This difference underscores the opportunity that renewable energy represented to large consumers willing to invest away from the taxing tariff. These electricity prices incentivized private investment in renewable energy projects for self-consumption, particularly large wind 'demonstration' projects in the southern part of Mexico (Oaxaca), which were co-financed by grants from the Global Environmental Facility, the World Bank, and the Inter-American Development Bank and promoted by the Mexican government as an opportunity to reduce their electricity bills.

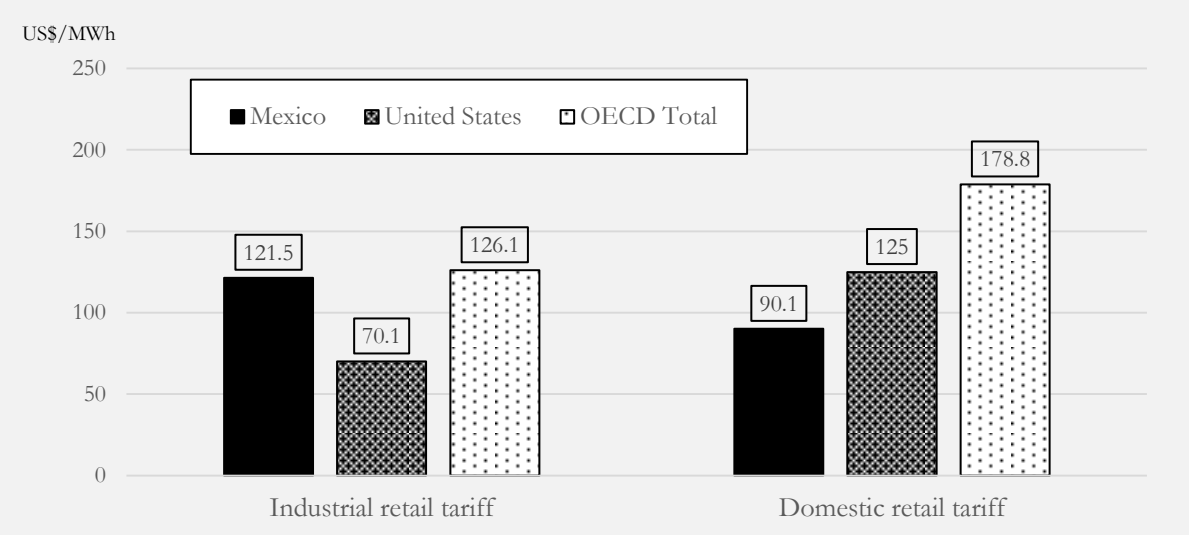
With a lack of transparency it is possible to state that the high tariffs for industrial and commercial users are also based on a form of cross-subsidy. Over 95 per cent of residential users and agricultural users benefit from large subsidies, estimated at US$10 billion in 2012 or 1 per cent of Mexico's GDP,[4] heavily undermining public finances and the balance sheet of CFE.

For 2014, as seen in Figure 2, in contrast to the United States (US) and OECD (Organization for Economic Co-operation and Development) countries, Mexico's household tariffs were lower than electricity prices accessible to industrial users. Owing to subsidies, Mexican households benefit from tariffs substantially lower than those in OECD Europe and the US. By contrast, industrial users pay for electricity at rates that are similar to those amongst OECD countries, but substantially higher than those in the US. The role that cross-subsidy played remains unclear, but there are grounds to assume that to some extent CFE finances were kept afloat based on taxing tariffs to the industry, thus providing a disincentive for distributed generation and an incentive

[4] As noted in 2012, the subsidies provided to residential customers have increased by 46 per cent since the last tariff reform in 2002 (Höhne et al. 2012).

for large-scale self-supply schemes under the previous legal framework and for wholesale market reform.

Figure 2: Electricity prices in Mexico, US, and OECD countries for 2014 (US$/MWh)



Source: IEA (2015).

2.3 Climate change: much ado about nothing

GHG emissions in Mexico grew by 40 per cent between 1990 and 2006. Without additional policy measures, total emissions were projected to rise by 37 per cent by 2020, 50 per cent by 2030, and 70 per cent by 2050, compared to emissions recorded in 2000 (SEMARNAT 2009), with transport and electricity generation being the biggest contributors to growth in GHG emission. Carbon emissions from electricity alone grew by 68 per cent between 1990 and 2009 (SEMARNAT 2012).

The most significant legacy of the Calderón government was the enactment of the General Climate Change Law (Ley General de Cambio Climático, LGCC) in 2012, which was seen as an avenue to provide continuity to the institutional framework, the programmes and plans, as well as the mitigation commitments adopted since 2006. This law offers a holistic and long-term vision to climate policies, programmes, and budgets, elements that were lacking in previous policies, such as the 2007–12 Special Programme on Climate Change (Programa Especial de Cambio Climatico, PECC). PECC had been criticized for its limited impact owing to the short time horizon and its piecemeal approach (Höhne et al. 2012), but the overall institutional build-out was significant.

The LGCC created a comprehensive institutional framework and climate change system by consolidating a number of institutions that had been previously created (e.g. Inter-Ministerial Commission on Climate Change, Council on Climate Change), as well as planning instruments (e.g. National Strategy on Climate Change, PECC) and evaluation and funding instruments, including a climate fund. Beyond actions pertaining to the federal government, the LGCC made it obligatory for sub-national governments to develop their climate change mitigation and adaptation plans.

Other policy instruments refer to the requirement for mandatory emissions reporting and the creation of a public emissions registry for all sectors, as well as the reform of subsidies by 2020. The most important features of the LGCC include the confirmation of pre-existing mitigation

targets; that is, the reduction of GHG emissions below a business-as-usual (BAU) scenario by 2020 and by 50 per cent by 2050 from levels in 2000, conditional on international financial support; 35 per cent of electricity from clean energy sources by 2024; as well as the possibility of establishing an emissions market and entering into emission trading agreements with other countries.[5]

An official report stated that PECC achieved the mitigation of 46.8 $MtCO_2e$, or 80 per cent of the mitigation target for 2012 set at 51 $MtCO_2e$ below a BAU scenario. The achieved mitigation represented ~6.5 per cent compared to the BAU scenario (SEMARNAT 2012; see also Auditoría Superior de la Federación 2010; Fekete et al. 2013). Most assessments of the PECC have asked for caution, pointing to the lack of transparency in the methodology used in these results.[6]

Whatever the mitigation results from PECC, it is clear that Calderón's climate strategy failed to set a de-carbonization pathway for the Mexican economy, although carbon intensity (the amount of carbon emissions per unit of GDP) remained about the same between 2010 and 2013.[7] Even with diminishing fossil fuel resources, Mexico continues to be a top oil-producing country in the world. Oil continues to be dominant in the energy mix at 50 per cent, even if the proportion of natural gas has increased from 20 per cent in 2000 to 34 per cent in 2013, with energy-related emissions accounting for 67.4 per cent of the total in 2013 (OECD 2015b). Wind power installed capacity grew from 2 MW in 2006 to 1012 MW in 2012, but the renewable energy target set at 8 per cent for 2012 was not achieved. Non-hydropower renewables for 2012 were only 2.9 per cent of total power capacity (IGS-EGADE 2014).

At least two groups of factors explain the poor results of the Calderón climate policies. The first is the continuation of energy subsidies, despite the government reiterated goal in many international high-level forums, such as the G20[8] that it would end them. Energy subsidies are one of the most significant obstacles for reducing emissions in the energy sector and for setting the Mexican economy on a path to de-carbonization (OECD 2013). These subsidies in the power sector discouraged spending on energy saving and encouraged electricity demand from subsidized users.

The opposition of key industrial sectors to the adoption of more radical climate policies was the second factor that explains Calderón's limited success in setting Mexico on the course to a low-carbon economy. For example, the Mexican auto industry, a key manufacturing sector representing about 6 per cent of Mexico's GDP and 18 per cent of total manufacturing

[5] For a comprehensive analysis of this and other energy and climate-related laws, see Fekete et al. (2013: 74–80), Mauleón Medina and Saito (2012), and Nachmany et al. (2014).

[6] Reductions are also shown in relation to the baseline provided with the original PECC in 2008, based on the 2006 GHG inventory, and does adjust for changes in overall economic activity, especially the economic crisis in 2008–09 (Fekete et al. 2013: 86). The latest greenhouse gas (GHG) emissions official data in Mexico's Fifth Official Communication to the United Nations Framework Convention on Climate Change is for 2010. The methodology for calculating the emissions inventory for 2013 changed and it is not comparable with official data from previous years. See also statistics by 2012 IEA in Fekete et al. (2013: 74).

[7] Carbon intensity improved between 1990 and 2000, and increased between 2000 and 2010 (PWC 2013, 2014, 2015).

[8] During the 2009 G20 meeting in Pittsburgh, PA, US, the member leaders agreed to eliminate subsides on fossil fuels (SRE n.d.: 19).

production, effectively blocked for three years the adoption of a fuel efficiency standard in Mexico.[9]

Similarly, energy-intensive industrial sectors strongly opposed the mitigation targets proposed in the original text of the LGCC. Some industrial associations, especially Mexico's National Steel Chamber (Cámara Nacional del Acero, CANACERO 2011), were particularly vocal in their opposition against the strong reductions proposed by the LGCC. They were concerned that ambitious targets would restrict Mexico's ability to continue growing and compromise their competitiveness in the absence of a global agreement that set similar commitments from other countries (CESPEDES 2013). Although the LGCC received multi-party support in both houses of the Mexican Congress (280 versus 10 in the Deputy Chamber and 78 versus 0 in the Senate), it took three years to be approved. The legislation underwent changes that addressed the concerns of these sectors, making the mitigation commitments stated in the law aspirational and subject to the availability of international finance, and assumed a gradual approach for the adoption of climate change mitigation actions, starting with the least-cost ones.

3 Energy reform and climate policies by legal fiat (2012–15)

3.1 Low energy prices: political priority of energy reform

Once the political constraints faced by President Calderón for comprehensive energy reform were removed, based on the political manoeuvring that led to a multi-party agreement known as the 'Pact for Mexico' (Pacto por México), a comprehensive energy reform was possible under the incoming government of President Enrique Peña Nieto (2012–18). Simultaneously, the government moved away from the previous administration's strategy to link climate change policy to energy security. By contrast, the reduction of energy prices became the top priority of Peña's energy reform (Gobierno de la República 2013: 3). Climate policies were designed by legal fiat, resulting from implementing the LGCC.

As Alvarez and Valencia (2015) have argued, little over 60 per cent of the Mexican industry's energy consumption consists of gas and electricity, almost in equal share. Most industrial sectors (steel and chemical industries as well as glass, pulp, paper, beer, and plastic production) largely depend on gas for their production processes. The automotive sector, another critical manufacturing industry in the Mexican economy, is more dependent on electricity than gas. As over 50 per cent of electricity is generated with gas, the Mexican industry has a large stake in maintaining and expanding the availability of low-cost gas.

In 2006, César Hernández, the present incumbent Under Minister for Electricity, wrote about the full value of subsidies serving the purpose of compensating for the inefficiency of the power industry, and not for gains to consumers: 'The problem is not the subsidy, it is a charade—the problem is the cost of production' (Hernández 2006: 32). This diagnosis underscores a clear-cut expectation by the government. The efficiencies from the operation of the wholesale market are estimated to represent electricity service cost reductions between 26 and 48 per cent.[10] Whether

[9] Although there are mandatory emission standards addressing air pollutants for new cars (NOM 042 and NOM 044) and for used vehicles (NOM 041 and NOM 044), mandatory fuel efficiency standards were adopted in June 2013, after almost three years of negotiations (CEMDA 2012; see also ICCT 2013).

[10] The government has been cautious of not releasing the numbers to a wide audience. These were presented as part of the official consultation process to publish the new market rules that will apply to the wholesale electricity market (SENER 2015c).

this is fully accurate, it might not necessarily be due to the operation of the wholesale electricity market, but other structural adjustments, as hinted by Pollitt (2012). For Mexico, two relevant structural adjustment are evident: (i) the displacement of heavy fuel oil and (ii) the reduction of technical and non-technical losses.

Technical and non-technical losses represented 16 per cent of the power moving into the national grid in 2012, with most non-technical losses arising disproportionately from the greater metropolitan region of Mexico City, which consisted of a third of the country's population. Until 2010, this region had been served by a different state-owned enterprise named Luz y Fuerza del Centro (LyFC), known historically for having a strong independent union that systematically confronted the federal government. During that year technical and non-technical losses in the region were reported to be >30 per cent.

In 2010, the federal government announced the disappearance of the company, mandating CFE to take over every facility under the previous control of LyFC. As a result losses have been greatly reduced, and current average losses in the country resembled pre-2010 statistics for the rest of the region under the responsibility of CFE, barely >13 per cent, with a long-term target of 8 per cent (SENER 2015d).

3.2 Political effects of natural gas price cycles

In 2011, the International Energy Agency (IEA) published optimistic conclusions on the future of gas production in North America. According to IEA (2011), characteristics of the gas market and the lack of substantial liquefied natural gas (LNG) infrastructure adequate for exports would allow for gas abundance in the region and low prices for the foreseeable future. The following years proved the diagnosis correct overall, with prices rapidly falling by 2012.

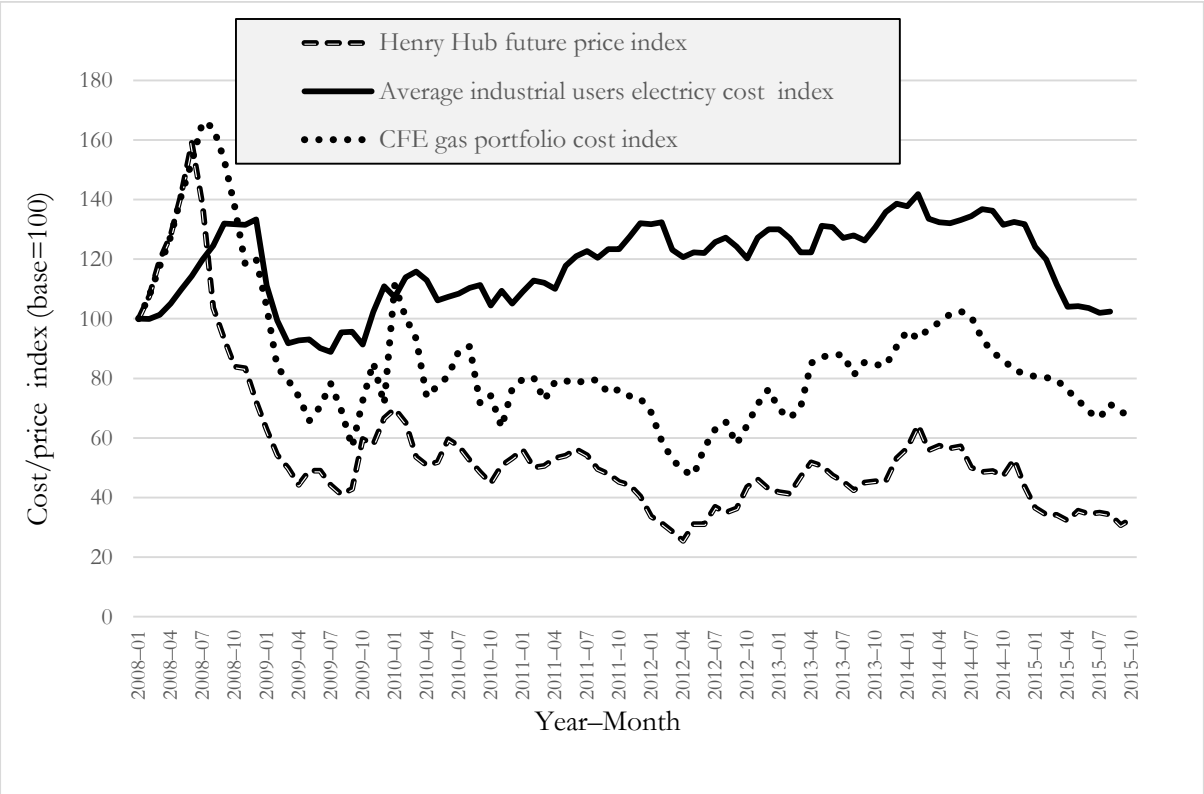
The price of natural gas is especially important in restructured markets because of its role in determining the marginal cost of electricity, which influences the prices of bulk energy in the wholesale market. Based on 20 years of comparative data among US states, Borenstein and Bushnell identified that the gap between average cost (under regulated markets) and marginal price (under wholesale markets) generates a specific economic expectation: 'consumer and political sentiment has tilted toward whichever regime (regulation and markets) offered the lower prices at the time' (2015: 1). Hence, they argue that the impetus of reform is stronger when low gas prices are observed because large consumers, in particular, industrial users, observe the benefits competitors can have during those periods.

The consumer and political sentiment explained by Borenstein and Bushnell (2015) could certainly be significant in Mexico on the basis of two considerations: (i) the proximity of competitors across the US border with access to power prices from wholesale markets; and (ii) the fact that the self-supply regime in Mexico allowed for large consumers with access to reliable natural gas supply (mostly in the northeast of Mexico) to access power prices that resembled those of restructured markets, owing to on-site generation using the Henry Hub indexed natural gas. This in itself could explain the impetus for reform in 2013, but also has implications for the deployment of clean technologies that have not been fully analysed.

Clean energy auctions with long-term contracts are an 'average cost' approach to energy procurement. This is the model that is politically castigated during periods of low gas prices and low marginal costs of generation, but is desirable when natural gas prices increase. Thus, if Borenstein and Bushnell's (2015) argument is right, we should expect opposition to the average cost approach during the period when gas prices are low, at least from large consumers. This is observed in the case of Mexico.

As seen in Figure 3, since 2008, when the previous reform was drafted and approved, the progression of industrial tariffs and natural gas prices diverged, with natural gas prices increasing to levels that spur debate on the need for a diversified energy matrix. In 2012, the year of the incumbent presidential election, the gap was so significant that gas prices accessible to CFE diminished by >50 per cent, whereas tariffs for industrial users were up by >20 per cent in nominal terms.

Figure 3: Gas prices and industrial tariffs



Source: CFE (n.d.) and SGM (2015).

In recent years, a gap between the index of gas prices (in Mexican pesos) at the Henry Hub and those accessible to CFE have also grown because of exchange rate and the use of LNG in the generation mix, thus adding to the expectation from power consumers and the incumbent government to benefit from the abundance of natural gas in the region. During the second half of 2013, CFE purchased LNG at more than US$16 per million of British thermal unit, five times higher than the discounted Henry Hub prices agreed years earlier with the European energy company Iberdrola. This is explained by the slower gas output from PEMEX and the growth of domestic gas demand by industrial users. Purchasing LNG reduced stress to the system, but at a significant cost to CFE (Auditoría Superior de la Federación 2014), making evident that gas transport constraints were still unmanageable before the reform. As a result, expectations for further cost reductions increased.

3.3 Climate change by legal fiat

The 2012 LGCC dictated a battery of policies and programmes aimed at achieving the 2030 and 2050 mitigation goals, which are to be implemented by the government, regardless of political convictions.

In 2013, the National Climate Change Strategy (Estrategia Nacional de Cambio Climático, ENACC), which first appeared in 2007, was updated and the Second Special Programme on Climate Change (2014–18, PECC II) was published. PECC II operationalizes the ENACC for 2014 and 2018, providing mitigation and adaptation goals for particular sectors. The programme outlines the federal government's contribution towards the mitigation targets set out in the LGCC. It sets a goal of reducing, through exclusively federal government actions, 83.2 $MtCO_2e$ by 2018, although consolidating national climate policy by coordination efforts of state entities, municipalities, legislative authorities, and society is one of its five objectives.

Although climate analysts have applauded this comprehensive institutional framework dictated by the LGCC, an effective climate change mitigation policy in an oil production country such as Mexico requires that 'price signals' provide adequate and strong incentives to reduce GHG emissions, particularly in a context where energy policies are set to promote higher production and consumption of fossil fuels through low energy prices.

The LGCC included the possibility of developing a carbon market and linking it to carbon markets in other countries. However, it is unclear that these markets will develop before the end of the incumbent administration in 2018. In October 2015, President Peña Nieto joined the World Bank's initiative to put a price of carbon, stating that Mexico is 'setting a price of carbon that is just' and referring to Mexico's leadership as having already created a carbon tax on the sale of several fossil fuels (Presidencia de la República 2015). The tax rates, which are very low (less than US$3.50, the lowest in the world), were set according to the carbon content of propane, gasoline, diesel, and coal relative to gas. Natural gas was exempted from the tax, confirming the federal government's strategy to rely heavily on gas as the 'transition' fuel (Gobierno de la República 2013; Guerra Abud 2014; Pierre-Marc 2014). Also evidencing the alignment of government policies and industrial interests, the originally proposed tax rates were significantly modified to pass through the Mexican Congress, with a 92 per cent reduction for oil coke and 85 per cent for coal (Kossoy et al. 2015). With a negligible environmental impact, the carbon tax in Mexico was introduced mainly for revenue purposes and not as a strategy to invest in clean energy or to affect consumer preferences for fossil fuels.

Although Mexico has gained the title of being the first developing country to present its INDC (Gobierno de la República 2015), it is not clear if Mexico's current energy policies and future economic growth will allow for fulfilling these commitments. Mexico proposed an unconditional commitment to mitigate 22 per cent of GHG from a BAU scenario that implies about 45 per cent increase from 2013 emissions. The characterization of emissions in year 2013, 2030 BAU, and the INDC unconditional and conditional pledges are presented in Table 2.

Table 2: INDC emissions and pledges (2013–30) ($MtCO_2e$)

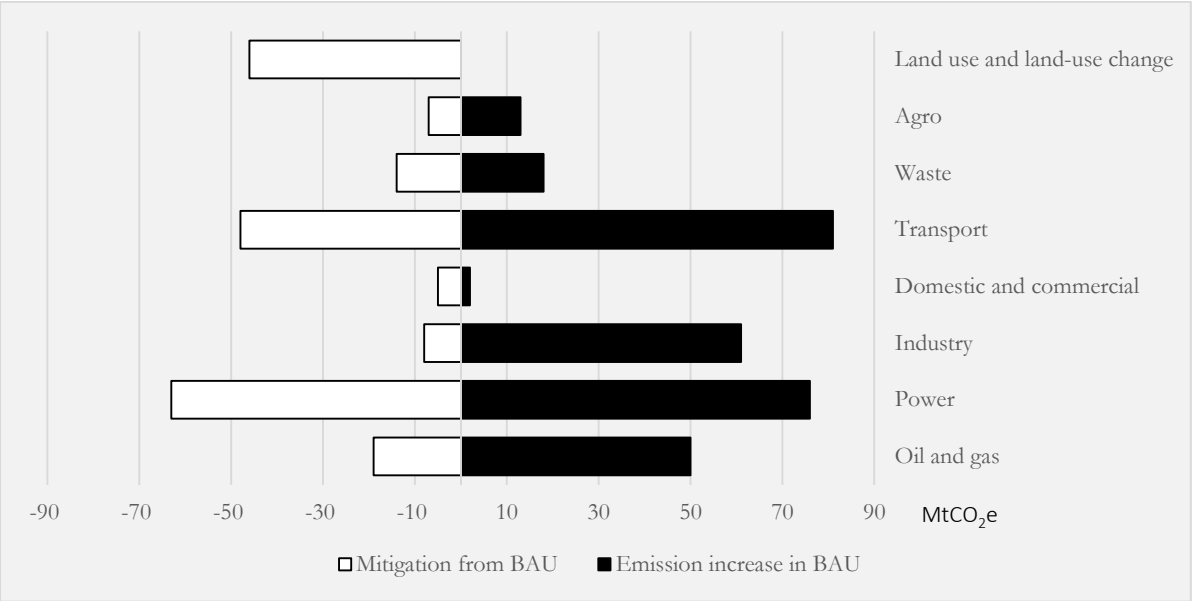
	2013	2030 BAU	INDC unconditional	INDC conditional
Oil and gas	87	137	118	Undefined
Power	126	202	139	
Industry	141	202	194	
Domestic and commercial	26	28	23	
Transport	148	229	181	
Waste	31	49	35	
Agro	80	93	86	
Land use, land-use change, and forestry	33	32	–14	
Total	672	972	762	622

Source: Gobierno de la República (2015).

The unconditional commitment entails an actual increase of about 15 per cent of economy-wide emission from 2013 to 2030. Within the unconditional pledge, Mexico has published an indicative distribution of emissions and mitigation by sector as part of the INDC. The power

sector would then be expected to mitigate 31 per cent from a BAU scenario, resulting in a total emission of 139 $MtCO_2e$ in 2030, rather than the BAU scenario of 202 $MtCO_2e$, compared with 127 $MtCO_2e$ in 2013. By contrast, expected mitigation from other sectors are: oil and gas, 14 per cent; transport, 21 per cent; and industry, 4 per cent. These three sectors, despite unconditional mitigation pledges, will have significant emissions growth as seen in Figure 4.

Figure 4: Emissions increase in BAU and unconditional mitigation in 2030



Note: BAU, business-as-usual.

Source: Gobierno de la República (2015).

However, there remains the question of how different sectors will participate in achieving the conditional goal of 36 per cent reduction of GHG emissions, which would require an additional 140 $MtCO_2e$ and which is equivalent to that of the total power sector emissions in the 2030 INDC. Although the allocation of these additional emissions reductions has not been defined, it is certain that the power sector will have to play a relevant role.

According to Bloomberg New Energy Finance (2015), Mexico's unconditional 2030 target does not rank highly compared with commitments of other countries in terms of absolute emissions reductions. However, Mexico will still have to achieve significant abatement to achieve its post-2020 target if emissions grow in line with these estimates that are much higher than the official estimates of the country.

3.4 Walking half-way on clean energy deployment

Although Mexico has abundant renewable energy resources and in spite of all government efforts towards climate, the share of renewables in electricity generation decreased from 25 to 14 per cent in 1990–2013 (OECD 2015a, b). According to some estimates, it would not be until 2018 that the proportion of renewable energy will increase to 1990 levels. The reorganization of the electricity sector with the energy reform missed the opportunity to remove existing impediments to further develop renewables, particularly by removing large subsidies for electricity consumption.

The Law of Electric Industry (Ley de la Industria Eléctrica, LIE), which was enacted in the summer of 2014 with a tight schedule to start trading at the wholesale market in January 2016,

introduced a number of mechanisms that would, in principle, facilitate the development of renewable energy. The LIE created an independent system operator, dis-incorporated the dispatching operations unit from the CFE, and provided legal and operational capacities to perform traditional system operation activities, while also acting as the clearinghouse for market operations and developing the transmission infrastructure plan. The CFE will be unbundled according to guidelines of the Secretariat of Energy (Secretaría de Energía, SENER), and plants will be independently represented in the market to provide for liquidity, with market supervision from SENER and the regulatory commission.

Two instruments—clean energy mandates with tradable certificates and energy auctions for the general service—are meant to foster the expansion of clean energy technologies and meet the underlying target of 35 per cent clean energy by 2024.

The mandates and tradable certificates will also contribute to Mexico's climate change commitments. Utilities and large consumers (i.e. qualified consumers) will have to acquire a mandated percentage of clean power generation, which has been established at 5 per cent by 2018 (SENER 2015a). Generators with >0.5 MW of installed capacity under the new LIE will receive certificates tradable at the wholesale market. The 5 per cent target is well within the planned development of new renewable projects as included in the Special Programme for Renewable Energy published in 2014, based on a pipeline of projects that would reach 25 per cent of renewable energy by 2018, up from 15 per cent in 2012 (SENER 2013).

Auctions will be conducted for clean energy three years in advance of the time for delivering energy, so as to provide sufficient time for the development of energy projects. These auctions could represent an improvement for the large deployment of clean power, as they will be managed by independent entities such as the National Energy Control Centre and CRE, rather than through the CFE's IPP bidding processes that were previously used.

The length of contracts to be signed with clean power generators has been controversial. The original proposal established 10-year contracts. Most renewable energy companies have been concerned about the limited benefits that could come from contracts of <20 years. SENER settled for 15-year contracts.[11] The financial impact of a 15-year contract rather than a 20-year contract will require further consideration once the first auction is completed in April 2016. However, it might feed into a negative self-enforcing cycle, where renewable energy investment cannot access lower financial costs or achieve economies of scale, undermining the business case for renewable energy planning. This is particularly worrisome for a new market, like the Mexican electricity market, with no price information that could be used by financiers to assess the risks and conditions of finance renewable energy projects.

Moreover, the definition of clean power in the LIE became problematic, and could undermine the potential benefits of the law. The LIE defined clean power with a list of low-carbon technologies that included renewables, large hydropower, nuclear energy, and carbon capture and storage. However, it also included high-efficiency cogeneration, which even if less carbon-intensive per net energy output is still a carbon-emitting technology. With high-efficiency cogeneration expected to grow >7 GW, generation could reach close to 10 per cent of the total power demand by 2024. This would leave low-carbon technologies a potential market share of

[11] Among the most active renewable energy companies in Mexico, the following provided comments to the issuance of the market rules regarding the auctions for clean energy: EDF, Iberdrola, Itertect, Sonora Energy, S2E, as well as the only wind energy association AMDEE, and the major solar photovoltaic developers association ASOLMEX. See SENER (2015c) for a summary of the comments and replies.

only 25 per cent out of the 35 per cent of clean energy mandated by law (CESPEDES–PwC 2015: 44). In 2014, large hydropower and renewable energy accounted for almost 17.2 per cent and nuclear energy for 3.2 per cent (SENER 2015b).

The Mexican government has repeatedly presented natural gas as the 'cleanest fuel',[12] contributing to the confusion generated by the inclusion of efficient cogeneration into the definition of clean energy by the LIE. It also nurtured concerns that the government would take advantage of an administrative leeway, included in the LIE, for defining the natural gas combined cycle as clean energy technology. The CANACERO even proposed a definition for clean energy that included technologies with emission levels equivalent to 400 kg of carbon dioxide per megawatt-hour. This would have certainly made new natural gas combined cycle plants qualify as clean energy (CANACERO 2015).

However, the larger opposition party, the right-wing National Action Party, presiding over the Special Commission on Renewable Energy and the Commission on Climate Change, presented a proposal for a new Law on Energy Transition (Ley de Transición Energética, LTE). This law replaced the renewable energy and energy efficiency laws (LAERFTE and LASE) that had been approved in 2008 and which were not consistent with the new energy reform. LTE would supersede both laws and integrate them into a coherent legal instrument that would be aligned with the LIE. The LTE also created new specific obligations for renewable energy and energy efficiency programmes. In addition to limiting the range of potential technologies to be regarded clean by the authority, the LTE also considered intermediate goals for clean energy: 25 per cent by 2018, 30 per cent by 2021, and 35 per cent by 2024.

The LTE was approved in both chambers of the Mexican Congress, as COP21 was taking place in Paris. Although the CANACERO aggressively lobbied against its approval, an amendment to the LTE blocked any future efforts to undermine the definition of clean energy. The amendment stated that no new technology can be accredited as clean energy if emissions surpass the 100 kg of carbon dioxide per megawatt-hour threshold (Cámara de Diputados 2015).

However, in the negotiations with the lobby against the LTE, the senate approved a flexible mechanism regarding clean energy certificates. During the first four years, those liable will be able to transfer up to 50 per cent of the certificate obligations to the following year at no cost, if either the cost of certificates goes over US$20 or if the number of certificates issued during the given year is <75 per cent. Owing to the nature of this provision, if the flexibility mechanism kicks in, the increment of certificate obligations will be postponed and the clean energy goals will not likely be met in the short term.

However, markets have proven political fears inadequate, at least partially, after the results of the first long-term energy auction, which allocated around 2000 MW of installed capacity of solar and wind energy prices. Mexico called for the first auction in November 2015, immediately after the manual was issued to purchase a total of 6.3 TWh of energy, 6.3 million certificates of clean energy (Certificados de Energía Limpia, CEL) and only 500 MW of capacity (CENACE 2016).

The auction was finally run by CENACE on 29 and 30 March 2016. The process was design for the possibility of iteration, but it was not necessary based on pre-defined criteria regarding the economic return of the offers. In total, 227 offers from 69 bidders were evaluated, resulting in

[12] A common practice by Juan Jose Guerra, Minister of Environment from December 2012 to August 2015, was to focus on natural gas as clean energy during public presentations; this occurred even in fora dedicated to renewable energy (SEMARNAT 2014).

total winning bids representing 5.4 TWh/years of energy and CEL. Winning offers on energy and CEL were in the low range of 600 Mexican pesos, or below US$40 per megawatt-hour plus CEL, which was normally considered a threshold only seen for natural gas combined cycle. Among the winning projects, seven corresponded to solar photovoltaic and four to wind energy (CENACE 2016). No capacity contract was awarded. The auction demonstrated a large competitive resource base for renewable energy expansion, and showcased that policy precaution regarding renewable energy expansion goals might be counterproductive to the development of a more competitive power system.

4 Conclusion: the way forward and the challenge for political coherence

As presented in this paper, evidence confirms the conclusion of Zinaman et al. (2015). Mexico's power reform is ambitious about restructuring but modest about the commitment to clean power transition, despite the ratcheting of climate commitments and the favourable trends in renewable energy investment in the country (Appendix Figure A1).

The energy reform in Mexico has indeed created formal means of achieving transition to a low-carbon power system, mainly through clean energy certificates, mandates, and auctions. Despite this, as shown, the government has only embarked on limited commitments, maintaining leeway to reduce the pace of power sector transformation in the future and providing a dubious outlook on low-carbon power sector transition.

For decades, underinvestment in the oil industry, upstream and downstream, as well as in the electricity sector, created a series of bottlenecks that had direct effects on the availability of natural gas and the price of electricity. Access to abundant and cost-competitive capital and production efficiencies is expected to address these concerns with markets fully opened to private investment in all segments of the power sector, except partially in distribution and retail. Lower costs of energy became the major driver on policy debates—an outcome that could be attainable independently from the power sector reform or long-term diversification strategies—because of historically low gas prices in North America.

One of the fundamental challenges for transitioning to clean power in a liberalized regime is that the cost of ambition will be evident to consumers (Pollitt 2012). This occurs not only because of transparency in operations across industry segments that previously were embedded into the vertical structure, but also because policy instruments under markets are to be transparent, general, and enduring to provide the right incentives to participants (e.g. clean energy certificates and carbon tax). Ultimately, this is precisely the challenge faced by the current administration.

Energy transition under adequate incentives and planning could represent an opportunity to increase energy security and hedge against cost instability that might have economy-wide negative impacts. Yet, under very low prices of gas, the benefits are less clear because of the primacy of delivering on the political promise of low-cost electricity in the very short term. Energy-intensive industries, such as the steel industry, that are not prepared for the regulatory and economic challenge have taken this juncture to advocate for further downscaling of Mexico's commitments towards power sector transformation. These enterprises that benefited from the previous self-supply regime and ready access to natural gas imported from the US will have to share the burden of clean energy transition.

In 2008, when a full power sector reform was politically unfeasible and high gas prices further strengthened the argument for diversification through private investment in renewable energy, the Calderón government effectively coupled the emerging climate change agenda with

renewable energy investment policies. These included the first renewable energy promotion law and clear long-term non-fossil fuel targets in the power matrix. At the same time, a robust climate change institutional framework was set in place, plausibly securing that in years to come climate change, and, in particular, mitigation commitments and national goals, would become a driving force in future energy policy-making and market development.

The incumbent government effectively manoeuvred for full reform and benefited from the political windfall profits of lower gas prices in the region. Although it might seem only natural to continue the hustle to power the country with natural gas, it is precisely in this circumstance that the government should provide certainty of the development of low-carbon technologies, which it has provided to a limited extent because of the compromises undermining some of the potential benefits of new policies (primarily, that of certainty for investors).

Some of these compromises include putting cogeneration and low-carbon technologies such as renewables and nuclear energy into the same category, thus benefiting from similar policy and market instruments, as well as shorter-than-expected contracts for long-term supply of clean energy and the lack of vision to reduce the significant share of subsidies.

There are three key issues to be addressed. First, power system planning and policy should reflect a clear separation between high-efficiency cogeneration and low-carbon technologies, as this would facilitate linking instruments such as clean energy certificate mandates to mitigation results. Second, risk-mitigating instruments such as auctions should not be compromised by decision-making informed only by low gas prices observed in the near past and future, postponing the expansion of clean energy obligations. Finally, the country should adopt a comprehensive approach for adequate pricing, through a more aggressive use of clean energy obligations and reducing subsidies in the power sector, and for scaling up the carbon taxes economy-wide.

These measures can be effectively addressed only if the government is able to assume political commitment to scale up climate ambition, and to fully communicate the economic costs and benefits of rapidly deploying renewable energies in the power sector, at the expense of decelerating the deployment of natural gas-based energy generation.

The coherence of climate and energy policies or the lack thereof will determine the success of Mexico's climate ambition in the 2020s. As discussed, Mexico expects its power sector to reduce a large share of emissions by 2030, whereas specialists expect a zero-emissions power system by the middle of the century. The enactment of the LTE serves to bridge some of the gaps in the energy reform regarding the challenges of efficiency and low-emission technology promotion, allowing for a set of energy sector institutions to work hand-in-hand with climate policy institutions. Developing a solid climate policy framework can have a significant effect in guiding key aspects of power sector restructuring, so that market-guiding instruments are put in place. In Mexico, taking advantage of the existence of a capable independent system operator, clean energy certificates and mandates and long-term auctions could allow for the expansion of renewable energies in a very brief period of time.

The Mexican case offers a valuable example to other economies undergoing or considering power sector restructuring, particularly whenever fossil fuel resources are still more competitive than large-scale deployment of renewable energy. It is possible to observe the political economy trade-offs between the need for a strong climate commitment that provides a stable long-term energy transition pathway and the political and economic short-term benefits derived from low electricity tariffs. It is also possible to observe how these trade-offs are only partially resolved through adequate institutional construction.

Mexico's political elites, interest groups, and society need to recognize and assume that transition will entail additional costs in the short term, but that, in a broader context, these costs could remain below the economic gains of a structural transformation and liberalization of the power sector. More importantly, the lack of coherence between energy policy and climate change policy is unsustainable and will ultimately have an effect on increasing the costs in the power sector owing to late action, with a potential burden to be disproportionately shared by other sectors.

References

Alvarez, J., and F. Valencia (2015). 'Made in Mexico: Energy Reform and Manufacturing Growth'. IMF Working Paper WP/15/45. Washington, DC: International Monetary Fund (IMF) Available at: https://www.imf.org/external/pubs/ft/wp/2015/wp1545.pdf (accessed 26 March 2016).

Auditoría Superior de la Federación (2010). 'Programa Especial de Cambio Climático-Auditoría de Desempeño: 10-0-16100-07-0073' ['Special Programme on Climate Change: Performance Audit: 10-0-16100-07-0073']. Mexico: Grupo Funcional Desarrollo Económico, Secretaría de Medio Ambiente y Recursos Naturales. Available at: http://www.asf.gob.mx/trans/informes/ir2010i/grupos/desarrollo_economico/2010_0073.pdf (accessed 26 March 2016).

Auditoria Superior de la Federación (2014). Importación de Gas Natural Licuado: Auditoría Financiera y de Cumplimiento 13-1-18TOQ-02-0365-DE-174. Informe de Resultados de la Fiscalización Superior de la Cuenta Pública 2013 ['Import of Liquefied Natural Gas: Financial Audit Compliance 13-1-18TOQ-02-0365-DE-174. Report of Supreme Audit Results of Public Accounts 2013']. Mexico: Comisión Federal de Electricidad. Available at: http://www.asf.gob.mx/Trans/Informes/IR2013i/Documentos/Auditorias/2013_0365_a.pdf (accessed 26 March 2016).

Bloomberg New Energy Finance (2015). 'How Ambitious Are the Post-2020 Targets? Assessing the INDCS: Comparing Apples with Oranges'. New York: Bloomberg New Energy Finance, p. 15. Available at: http://about.bnef.com/content/uploads/sites/4/2015/10/2015-10-02-How-ambitious-are-the-post-2020-targets-UPDATE-2-Oct.pdf (accessed 26 March 2016).

Borenstein, S., and J. Bushnell (2015). 'The U.S. Electricity Industry After 20 Years of Restructuring'. NBER Working Paper Series 21113. Washington, DC: National Bureau of Economic Research (NBER).

Cámara de Diputados (2014). 'Dictamen de las Comisiones Unidas de Medio Ambiente y Recursos Naturales, con proyecto de decreto que expide la Ley de Transición Energética' ['Opinion of the Joint Committee on Environment and Natural Resources, with Draft Decree on the Energy Transition Act'], 15 December. *Gaceta Parlamentaria*, XVIII: 4176–11.

CANACERO (2011). 'Desplegado' ['Communique']. 12 December. Mexico: Cámara Nacional del Acero (CANACERO). Available at: http://www.canacero.org.mx/Es/assets/desplegado_leycambioclimatico_dic2011.jpg (accessed 4 April 2016).

CANACERO (2015). Energy Transition Forum at the Senate, 7 October [PowerPoint slides]. Mexico: Cámara Nacional del Acero (CANACERO).

Carreón-Rodríguez, V., A. Jiménez, and J. Rosellón (2006). 'The Mexican Electricity Sector: Economic, Legal and Political Issues'. In D.G. Victor and T.C. Heller (eds), *The Political Economy of Power Sector Reform*. New York: Cambridge University Press, pp. 175–214.

CAT (2015). 'Mexico'. Climate Action Tracker (CAT). Available at: http://climateactiontracker.org/countries/mexico.html (accessed 23 March 2016).

Cavazos, T. (ed) (2015). *Conviviendo con la Naturaleza, El Problema de los Desastres Asociado A Fenómenos Hidrometeorológicos y Climáticos en México* [*Co-existing with Nature: the Problem of Disasters Associated with Hydrometerological Phenomena and Climate in Mexico*]. Mexico: REDESClim/CENAPRED/INECC/CICESE. Available at: http://www2.inecc.gob.mx/publicaciones/download/721.pdf (accessed 26 March 2016).

CEMDA (2012). 'El gobierno de Calderón se va sin actualizar ni cumplir las normas ambientales de calidad del aire' ['Calderón's Government Will Not Update or Enforce Environmental Air Quality Standards']. Press Bulletin Notice, 28 November. Mexico: Centro Mexicano de Derecho Ambiental (CEMDA). Available at: http://www.cemda.org.mx/el-gobierno-de-calderon-se-va-sin-actualizar-ni-cumplir-con-normas-ambientales-de-calidad-del-aire/ (accessed 26 March 2016).

CENACE (2016). 'Primera Subasta de Largo Plazo del Mercado Elèctrio Mayorista' [First Long-Term Auction of the Wholesale Electricity Market'], 30 March. Mexico: Centro Nacional de Control de Energía (CENACE). Available at: http://cenace.gob.mx/Docs/MercadoOperacion/Subastas/32%20Presentaci%C3%B3n%20CENACE%20Conclusi%C3%B3n%201a%20Subasta%20Largo%20Plazo%20v2016%2003%2030.pdf (accessed 10 April 2016).

CENAPRED (2012). *Impacto Socioeconómico de los Principales Desastres Ocurridos en México en el Año 2012* [*Socio-economic Impact of Major Disasters in Mexico in 2012*]. Mexico: Centro Nacional de Prevención de Desastres (CENAPRED). Available at: http://www.cenapred.gob.mx/es/Publicaciones/archivos/279-NO.14-IMPACTOSOCIOECONMICODELOSPRINCIPALESDESASTRESOCURRIDOSENMXICOENELAO2012.PDF (accessed 26 March 2016).

CESPEDES (2013). 'Aportaciones de CESPEDES sobre las oportunidades y retos del Programa Especial de Cambio Climático (PECC), 2013–2018' ['Contributions of CESPEDES to address the opportunities and challenges of the Special Climate Change Programme (PECC), 2013–2018'], November. Mexico: Comisión de Estudios del Sector Privado para el Desarrollo Sustentable (CESPEDES). Available at: http://www.cespedes.org.mx/wp-content/uploads/2015/03/131121-PECC-CESPEDES-CONSULTA-final-7-0.pdf (accessed 26 March 2016).

CESPEDES–PwC. (2015). 'Estudio de las inversiones necesarias para que México cumpla con sus metas de Energías Limpias' ['Study of the Necessary Investments for Mexico's Clean Energy Goals'], October. Mexico: Comisión de Estudios del Sector Privado para el Desarrollo Sustentable (CESPEDES). Available at: http://www.estrategiaweb360.com/clientes/cespedes/PwC_CESPEDES_estudio_energias_limpias.pdf (accessed 26 March 2016).

CFE (n.d.). 'Factores de ajuste mensual a las tarifas de energía eléctrica año 2015' ['Factors of Monthly Adjustments to Electrical Energy Tariffs, 2015']. Available at: http://app.cfe.gob.mx/Aplicaciones/CCFE/Tarifas/factores/factores_industria.asp?tarifa=ICC2012&anio=2015 (accessed 26 March 2016).

Clean Energy Ministerial (2015). '21st Century Power Partnership: Overview and Goals'. Available at: http://www.cleanenergyministerial.org/Our-Work/Initiatives/21st-Century-Power (accessed 23 March 2016).

Davis, S., M. Houdashelt, and N. Helme (2012). 'Case Study: Mexico's Renewable Energy Program. A Step-by-Step Approach for Overcoming Barriers to Renewable Energy

Deployment'. Washington, DC: Center for Clean Air Policy. Available at: http://ccap.org/assets/Case-Study-Mexicos-Renewable-Energy-Program_CCAP_Jan-2012.pdf (accessed 26 March 2016).

Fekete, H., F. Mersmann, and M. Vieweg (2013). 'Climate Change Mitigation in Emerging Economies: From Potentials to Actions'. *Climate Change Series 19/2013*. Dessau-Roßlau, Germany: Umweltbundesamt. Available at: http://www.umweltbundesamt.de/publikationen/climate-change-mitigation-in-emerging-economies (accessed 23 March 2016).

Fuentes, R., and J. Bowler (2014). 'In Search of the Mexican Way: How to Kick Start Competition in the Electricity Sector and Achieve Lower Tariffs'. OIES Oxford Energy Comment Paper, May. Oxford: Oxford Institute for Energy Studies (OIES). Available at: http://www.oxfordenergy.org/2014/05/in-search-of-the-mexican-way-how-to-kick-start-competition-in-the-electricity-sector-and-achieve-lower-tariffs/ (accessed 23 March 2016).

GCF (2015). 'PledgeTracker: Resource Mobilization'. Available at: http://news.gcfund.org/pledges/ (accessed 26 March 2016).

Gobierno de la República (2007). *Plan Nacional de Desarrollo, 2007–2012* [*National Development Plan, 2007–2012*]. Mexico: Federal Government, 324pp. Available at: http://pnd.calderon.presidencia.gob.mx/pdf/PND_2007-2012.pdf (accessed 26 March 2016).

Gobierno de la República (2013). *Reforma Energética* [*Energy Reforms*]. Mexico: Federal Government, 22pp. Available at: http://cdn.reformaenergetica.gob.mx/explicacion.pdf (accessed 26 March 2016).

Gobierno de la República (2015). 'Intended Nationally Determined Contribution'. Mexico: Federal Government, 8pp. Available at: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Mexico/1/MEXICO%20INDC%2003.30.2015.pdf (accessed 26 March 2016).

Guerra Abud, J. (2014). 'La Reforma Energética y el Medio Ambiente' ['The Energy and Environment Reform']. Press Conference, 19 August. Mexico: Federal Government. Available at: http://www.radioformula.com.mx/notas.asp?Idn=434664&idFC=2014#sthash.2XiYqQYy.dpuf (accessed 26 March 2016).

Hernández, C. (2006). *La Reforma Cautiva: Inversión, trabajo y empresa en el sector eléctrico mexicano* [*The Captive Reform: Investment, Labour and Entrepreneurship in Mexico's Electricity Sector*]. Mexico: Centro de Investigación para el Desarrollo, AC. Available at: http://reddecompetencia.cidac.org/es/uploads/1/LaReformaCautiva.pdf (accessed 26 March 2016).

Höhne, N., S. Moltmann, M. Hagemann, H. Fekete, J. Grözinger, and V. Schüler (2012). *Assessment of Mexico's Policies Impacting Its Greenhouse Gas Emissions Profile: Climate Action Tracker Mexico*. Mexico: Ecofys and Climate Analytics. Available at: http://www.ecofys.com/files/files/ecofys_2012_cat_mexico_country_report_en.pdf (accessed 26 March 2016).

IGS-EGADE (2014). *Energías Renovables para la Competitividad en México* [*Renewable Energy Competition in Mexico*]. México: Instituto Global para la Sosteniblidad (IGS)-EGADE Business School. Available at: http://igs.org.mx/sites/default/files/ENERGIAS_RENOVABLES_MAYO23_WEB2.pdf (accessed 26 March 2016).

ICCT (2013). 'Mexico Light-Duty Vehicle CO_2 and Fuel Economy Standards'. ICCT Policy Update, July. Washington, DC: International Council on Clean Transportation (ICCT). Available at: http://www.theicct.org/sites/default/files/publications/ICCTupdate_Mexico_LDVstandards_july2013.pdf (26 March 2016).

IEA (2011). 'Are We Entering a Golden Age of Gas?'. *World Energy Outlook 2011: Special Report*. Paris: OECD/ International Energy Agency (IEA). Available at: http://www.worldenergyoutlook.org/media/weowebsite/2011/WEO2011_GoldenAgeofGasReport.pdf (accessed 26 March 2016).

IEA (2015). *Energy Prices and Taxes 2014: Quarterly Statistics*. Paris: OECD/International Energy Agency (IEA).

IRENA (2015). 'Renewable Energy Prospects: Mexico'. Abu Dhabi: International Renewable Energy Agency (IRENA). Available at: http://www.irena.org/DocumentDownloads/Publications/IRENA_REmap_Mexico_report_2015.pdf (accessed 23 March 2016).

Kessel, G. (2009). 'Speech During the Opening of the Ecological Parks of Mexico Program'. SENER, Juchitán de Zaragoza, Oaxaca, 22 January. Available at: http://portal.energia.gob.mx/webSener/portal/Default.aspx?id=1142 (accessed 10 April 2016).

Kossoy, A., G. Peszko, K. Oppermann, N. Prytz, A. Gilbert, N. Klein, L. Lam, and L. Wong (2015). 'Carbon Pricing Watch 2015: An Advanced Brief from the State and Trends of Carbon Pricing Report 2015'. Washington, DC: World Bank. Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2015/08/26/090224b08309a09a/4_0/Rendered/PDF/Carbon0pricing0e0released0late02015.pdf (accessed 26 March 2016).

Mauleón Medina, C.C., and Y. Saito (2012). 'The New General Law of Climate Change in Mexico: Leading National Action to Transition to a Green Economy'. IDLO Legal Working Brief. Rome: International Development Law Organization (IDLO). Available at: http://www.idlo.org/Publications/MexicoClimateChangeLWB.pdf (accessed 26 March 2016).

Nachmany, M., S. Frankhauser, T. Townshend, M. Collins, T. Landesman, A. Matthews, C. Pavese, K. Rietig, P. Schleifer, and J. Setzer (2014). *The GLOBE Climate Legislation Study A Review of Climate Change Legislation in 66 Countries*, Fourth Edition. United Kingdom: GLOBE International, Global Legislators Organization. Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/03/Globe2014.pdf (accessed 26 March 2016).

OECD (2013). *Environmental Performance Reviews: Mexico 2013*. Paris: OECD Publishing.

OECD (2015a). 'Air and GHG Emissions' (Mexico: Environment Indicator). Paris: OECD Data. Available at: https://data.oecd.org/mexico.htm (accessed 26 March 2016).

OECD (2015b). 'Climate Change' (Country Profiles: Mexico). Paris: OECD Environmental Data. Available at: http://www.oecd.org/site/envind/mexico.htm (accessed 26 March 2016).

Pierre-Marc, R. (2014). 'México debe de aprovechar el gas natural: Semarnat' ['Mexico Must Take Advantage of Natural Gas: SEMARNAT']. *24 Horas*, 7 January. http://www.24-horas.mx/mexico-debe-de-aprovechar-el-gas-natural-semarnat/ (accessed 26 March 2016).

Pollitt, M.G. (2012). 'The Role of Policy in Energy Transition: Lesson from the Energy Liberalization Era'. *Energy Policy*, 50(C): 128–37.

Presidencia de la República (2015). 'México se suma a la iniciativa mundial para reducir las emisiones de bióxido de carbono' ['Mexico Joins Global Effort to Reduce Carbon Dioxide Emissions']. *Blog*, 20 October. Available at: http://www.gob.mx/presidencia/articulos/mexico-se-suma-a-la-iniciativa-mundial-para-reducir-las-emisiones-de-bioxido-de-carbono (accessed 16 April 2016).

PwC (2013). *Busting the Carbon Budget: Low Carbon Economy Index 2013*. United Kingdom: Sustainability and Climate Change, PricewaterhouseCoopers. Available at: http://www.pwc.co.uk/en_UK/uk/assets/pdf/low-carbon-economy-index-2013.pdf (accessed 26 March 2016).

PwC (2014). '*Two Degrees of Separation: Ambition and Reality: Low Carbon Economy Index 2014*. United Kingdom: Sustainability and Climate Change, PricewaterhouseCoopers. Available at: http://www.pwc.co.uk/assets/pdf/low-carbon-economy-index-2014.pdf (accessed 26 March 2016).

PwC (2015). 'Mexico GDP, Intensity and Emissions Trends and Projections'. Available at: http://pwc.blogs.com/.a/6a00d83451623c69e201b8d11839f0970c-pi (accessed 26 March 2016).

SENER (2007). 'Programa sectorial de energía 2007–2012' ['Sectorial Energy Programme, 2007–2012']. Mexico: Secretaría de Energía (SENER), Federal Government, 52pp. Available at: dof.gob.mx/nota_to_doc.php?codnota=5030249 (accessed 26 March 2016).

SENER (2013). 'Programa Especial para el Aprovechamiento de las Energías Renovables 2013–2018' ['Special Programme for the Development of Renewable Energy, 2013–2018']. Mexico: Secretaría de Energía (SENER), Federal Government. Available at: http://www.gob.mx/cms/uploads/attachment/file/249/PEAER-2014.pdf (accessed 26 March 2016).

SENER (2015a). 'Aviso por el que se da a conocer el requisito para la adquisición de Certificados de Energías Limpias en 2018' ['Notification on Requirements for Acquiring Energy Certificates in 2018]. *Diario Oficial de la Federación*, 31 March. Available at: http://www.dof.gob.mx/nota_detalle.php?codigo=5387314&fecha=31/03/2015 (accessed 26 March 2016).

SENER (2015b). 'Programa de Desarrollo del Sistema Eléctrico Nacional (PRODESEN), 2015–2029' ['National Electricity System Development Programme (PRODESEN), 2015–2019']. Mexico: Secretaría de Energía (SENER), Federal Government. Available at: http://www.gob.mx/cms/uploads/attachment/file/54139/PRODESEN_FINAL_INTEGRADO_04_agosto_Indice_OK.pdf (accessed 26 March 2016).

SENER (2015c). 'MIR de Alto Impacto. Expediente de Bases de Mercado' ['High Impact Regulatory Impact Assessment: Record of Market Bases']. Mexico: Secretaría de Energía (SENER), Federal Government. Available at: http://www.cofemersimir.gob.mx/mirs/38520 (accessed 26 March 2016).

SENER (2015d). 'Programa de Desarrollo del Sistema Eléctrico Nacional' ['National Electricity System Development Programme (PRODESEN)']. Available at: http://www.gob.mx/cms/uploads/attachment/file/54139/PRODESEN_FINAL_INTEGRADO_04_agosto_Indice_OK.pdf (accessed 26 March 2016).

SENER (2015e). *Sistema de Información Energética* [*Energy Information System*]. Mexico: Secretaría de Energía (SENER), Federal Government. Available at: http://sie.energia.gob.mx/ (accessed 26 March 2016).

SEMARNAT (2009). *Programa Especial de Cambio Climático, 2009–2012* [*Special Programme for Climate Change, 2009–2012*]. Mexico: Comisión Intersecretarial de Cambio Climático. Available at: http://www.semarnat.gob.mx/archivosanteriores/programas/Documents/PECC_DOF.pdf (accessed 26 March 2016).

SEMARNAT (2012). *México: Quinta Comunicación Nacional ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático* [*Mexico: Fifth National Communication of the United Nations National Framework Convention on Climate Change*]. Mexico: Instituto Nacional de Ecología y Cambio Climático. Available at: http://www2.inecc.gob.mx/publicaciones/download/685.pdf (accessed 26 March 2016).

SEMARNAT (2014). 'Reforma energética aumentará la creación de energías renovables en México' ['Energy Reform Increases the Creation of Renewable Energy in Mexico']. Press Release, 8 September. Available at: http://saladeprensa.semarnat.gob.mx/index.php/noticias/1833-reforma-energetica-aumentara-la-creacion-de-energias-renovables-en-mexico (accessed 26 March 2016).

SEMARNAT, CESPEDES, WRI, and WBCSD (n.d.). 'Factor de Emisión Eléctrico 2013' ['Electric Emission Factor 2013']. Mexico: Secretaría del Medio Ambiente y Rescursos Naturales (SEMARNAT), Comisión de Estudios del Sector Privado para el Desarrollo sustentable (CESPEDES), World Resources Institute (WRI), and World Business Council for Sustainable Development (WBSCD). Available at: http://www.geimexico.org/factor.html (accessed 26 March 2016).

SRE (n.d.). 'La nueva gobernanza internacional: Participación mexicana en el G20' ['The New International Governance: Mexican Participation in the G20']. White Paper. Mexico: Secretaría de Relaciones Exteriores (SRE), 83pp. Available at: https://sre.gob.mx/images/stories/doctransparencia/rdc/1lb20.pdf (accessed 26 March 2016).

Sen, A., and S. Upadhyaya (2014). 'Awaiting the Mexican Wave: Challenges to Energy Reform and Rising Oil Output'. OIES Oxford Energy Comment Paper, June. Oxford: Oxford Institute for Energy Studies (OIES). Available at: http://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/06/Awaiting-the-Mexican-Wave-Challenges-to-energy-reforms-and-raising-oil-output.pdf (26 March 2016).

SGM (2015). 'Seguimiento precio gas natural—Datos' ['Natural Gas Price Data']. Mexico: Servicio Geológico Mexicano (SGM), Secretaría de Economía. Available at: http://portalweb.sgm.gob.mx/economia/es/energeticos/precios/701-seguimiento-precio-gas-natural-datos.html (accessed 26 March 2016).

Torres, B. (2014). 'Mexico and Climate Change: Was the Country a Multilateral Leader?'. *Global Governance: A Review of Multilateralism and International Organizations*, 20(1): 147–62.

World Resources Institute (2015). *CAIT Climate Data Explorer*. Available at: http://cait.wri.org/historical/Country%20GHG%20Emissions?indicator[]=Total%20GHG%20Emissions%20Excluding%20Land-Use%20Change%20and%20Forestry&indicator[]=Total%20GHG%20Emissions%20Including%20Land-Use%20Change%20and%20Forestry&year[]=2012&chartType=geo (accessed 26 March 2016).

WWF (2012). 'New Law Makes Mexico a Climate Leader'. 13 April. Available at: http://wwf.panda.org/homepage.cfm?204246/Mexico-climate-law-passes (accessed 26 March 2016).

WWF, Climate Works, and PwC (2013). *Plan Integral para el desarrollo de las energías renovables en México, 2013–2018: Propuestas de escenarios y acciones necesarias para su desarrollo* [*Integral Plan for Renewable Energy Development in Mexico, 2013–2018: Proposed Scenarios and Actions Necessary for Implementation*]. Mexico: Iniciativa Mexciana de Energías Renovables. Available at: http://awsassets.panda.org/downloads/130222_plan_integral_para_desarrollo_de_energias_renovables.pdf (accessed 26 March 2016).

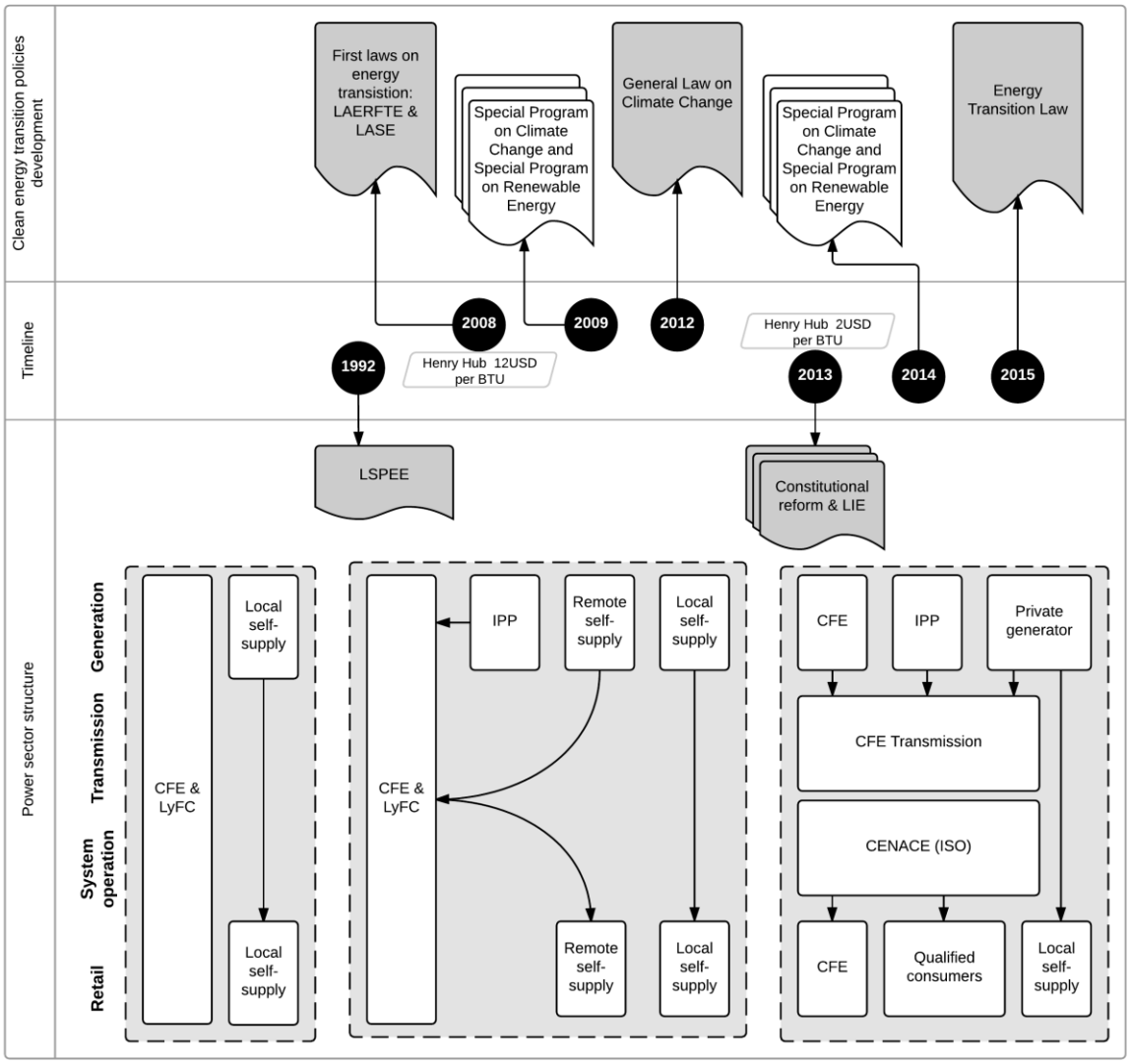
Yale School of Management (2012). 'Walmart de México: Investing in Renewable Energy'. Available at: http://som.yale.edu/our-approach/teaching-method/case-research-and-development/cases-directory/walmart-de-m%C3%A9xico (accessed 26 March 2016).

Veysey, J., C. Octaviano, K. Calvin, S. Herreras Martinez, A. Kitous, J. McFarland, and B. van der Zwaan (2015). 'Pathways to Mexico's Climate Change Mitigation Targets: A Multi-Model Analysis'. *Energy Economics*. doi:10.1016/j.eneco.2015.04.011.

Zinaman, O., M. Miller, A. Adil, D. Arent, J. Cochran, R. Vora, S. Aggarwal, M. Bipath, C. Linvill, A. David, R. Kauffman, M. Futch, E. Villanueva, J.M. Valenzuela, E. Martinot, M. Bazilian, and R.K. Pillai (2015). 'Power Systems of the Future: A 21st Century Power Partnership Thought Leadership '. NREL Technical Report NREL/TP-6A20-62611, February. Golden, CO: National Renewable Energy Laboratory (NREL). Available at: http://www.nrel.gov/docs/fy15osti/62611.pdf (accessed 23 March 2016).

Appendix A

Figure A1: Relevant developments on power sector clean energy transition



Note: The figure synthetizes the institutional evolution in relation to the power sector structure and significant relative maximum and minimum natural gas prices in the reform period.

Source: Authors' compilation.