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The Mexican Emission Trading System and the Electricity Market

Influence of market structures and market regulation on the carbon market

Case study report

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Abstract: The Mexican Emission Trading System and the Electricity Market

This report analyses the interaction of the pilot Emissions Trading System (ETS) and the electricity market in Mexico. It does so along two main questions: a) How do ETS design features affect the environmental effectiveness of the system and the quality of the carbon price signal? b) How do electricity market design features affect the carbon price induced abatement in the power sector? Due to the absence of a carbon price during the pilot phase of the Mexican ETS, the assessment is based on expected effects based on publicly available data and expert interviews.

The Mexican emissions trading scheme (ETS) started operation in 2020. The first three years are designated as a pilot phase with the expressed aim to gather experience in the implementation of an ETS in Mexico. At the time of writing, the first compliance cycle had not yet been finalized and – due to the specific rules for the pilot phase – there was not yet an established CO_2 price. The Mexican electricity market is undergoing a period of great uncertainty, both in terms of the regulation of the electricity market itself but also in term of the ETS. It remains to be seen to which extent the energy reform of 2014 will be rolled back and which level of ambition the future climate policy will have. Together with the special rules during the pilot phase of the Mexican ETS it is unlikely that the trading system will have a noticeable impact in the short term on demand, supply, or investments.

This case study is part of the project *"Influence of market structures and market regulation on the carbon market"* that aims to identify the impact of market structures and regulations on carbon markets and to investigate the interdependencies between carbon and energy markets in Europe, California, China, South Korea, and Mexico.

Kurzbeschreibung: Das Emissionshandelssystem und der Strommarkt in Mexiko

Dieser Bericht analysiert die Wechselwirkungen zwischen dem mexikanischen Emissionshandelssystem und dem Strommarkt entlang zweier Hauptfragen: 1) Wie könnten sich die Designmerkmale des Emissionshandelssystems auf die Qualität des Preissignals für Zertifikate auswirken? Und 2) Wie beeinflussen Marktdesignmerkmale und zusätzliche Regulierungen im mexikanischen Stromsektor die durch den Zertifikatspreis induzierten Emissionsminderungen?

Das mexikanische Emissionshandelssystem (ETS) startete im Jahr 2020. Die ersten drei Jahre sind als Pilotphase vorgesehen. Explizites Ziel dieser Phase ist es, Erfahrungen bei der Implementierung eines ETS in Mexiko zu sammeln. Zum Zeitpunkt der Erstellung dieses Berichts war der erste Compliance-Zyklus noch nicht abgeschlossen und es gab - aufgrund der spezifischen Regeln für die Pilotphase - noch keinen CO_2-Preis. Der mexikanische Strommarkt befindet sich in einer Phase großer Unsicherheit, sowohl in Bezug auf die Regulierung des Strommarktes selbst als auch in Bezug auf das ETS. Es bleibt abzuwarten, inwieweit die Energiereform von 2014 rückgängig gemacht wird und welches Ambitionsniveau die zukünftige Klimapolitik haben wird. Zusammen mit den Sonderregelungen während der Pilotphase des mexikanischen ETS ist es unwahrscheinlich, dass das Handelssystem kurzfristig einen spürbaren Einfluss auf Nachfrage, Angebot oder Investitionen haben wird.

Diese Fallstudie ist Teil des Projekts *"Influence of market structures and market regulation on the carbon market"*, welches zum Ziel hat, die Auswirkungen der Marktstrukturen und Regulierungen auf CO_2-Märkte zu identifizieren und die Abhängigkeiten von CO_2- und Energiemärkten in Europa, Kalifornien, China, Südkorea und Mexiko zu untersuchen.

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CEL	Certificados de Energía Limpia (clean energy certificates)
CENACE	Centro Nacional de Control de Energía (National Energy Control Centre)
CFE	Comisión Federal de Electricidad (Federal Electricity Commission, electricity supplier)
CHP	Combined heat and power
CO_2	Carbon dioxide
CRE	Comisión Reguladora de Energía (Energy Regulatory Commission)
DFT	Derechos Financieros de Transmisión (financial transmission rights)
ETS	Emissions Trading System
GHG	Greenhouse gas
HFO	Heavy Fuel Oil
LMP	Locational marginal price
LSPEE	Ley del Servicio Público de Energía Eléctrica (Law on public electricity supply)
LTE	Ley de Transición Energética (energy transition law)
MAC	Marginal abatement cost
MEM	Mercado Electrico Mayorista (wholesale electricity market)
MRV	Monitoring, reporting and verification
NDC	Nationally Determined Contributions (in Paris-Agreement)
OTC	Over the counter
PEMEX	Petroleos Mexicanos (Mexican Oils, oil company)
PIE	Productor Independiente de Electricidad (independent electricity producer)
PIIRCE	Programa Indicativo para la Instalación y Retiro de Centrales Eléctricas (indicative program for the installation and retirement of power plants)
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales (environment ministry)
SENER	Secretaría de Energía (energy ministry)
TWh	Terawatt hours (measuring units for energy)
UNFCCC	United Nations Framework Convention on Climate Change

Summary

This report analyses the interactions between the Mexican Emissions Trading System (ETS) and the electricity market along two main questions: 1) how could the ETS design features impact the quality of the allowance price signal; and 2) how do market design features and additional regulations in Mexico's electricity sector impact abatement opportunities induced by the allowance price.

Impacts of carbon market design and market regulations on the quality of the price signal

The Mexican emissions trading scheme started operation in 2020. It is one of many measures to achieve Mexico's Nationally Determined Contribution (NDC) under the Paris Agreement. It covers the energy sector as well as large industrial installations. The first three years are designated as a pilot phase with the expressed aim to gather experience in the implementation of an ETS in Mexico. The operational phase is scheduled to begin in 2023. At the time of writing, the first compliance cycle had not yet been finalized and – due to the specific rules for the pilot phase – there was not yet an established CO_2 price.

- **Volatility:** According to the Mexican legislation, there should be no economic impacts of the ETS during the pilot phase. Operators therefore receive enough allowances for free to meet their verified emissions and there is likely no carbon price until the beginning of the operational phase. No trading platform has been established for Mexican ETS allowances. The rules governing the operational phase starting in 2023 are not yet decided. If the current design is continued, auctioning might only play a minor role hampering price finding. So far there is little public information on emissions, allocation and government plans for the operational phase. In addition, the state-owned electricity and oil companies control a large share of the total carbon market in Mexico and might dominate the market. It seems plausible that the initial years of the operational phase will show high volatility. Operators can use credits from offset projects which might help stabilise prices if there is scarcity of allowances. If there is no such scarcity it will put further pressure on carbon prices.
- **Price reflection of marginal abatement cost (MAC):** Like the discussion of volatility this cannot be assessed for the pilot phase due to the absence of a carbon price signal. Looking at the operational phase large private companies operating in Mexico tend to know their abatement options and associated costs. This is especially true for companies that are already participating in other ETS schemes around the world, but is different for smaller entities which often do not have a dedicated unit (or even person) working on issues related to energy efficiency and emission reduction. The large state-owned electricity and oil companies face a different challenge: Investment decisions of these companies need to be approved by the finance ministry; if the federal government does not approve cost-effective measures the allowance price will not reflect the marginal costs in these companies. Due to their large market share and the expectation that the electricity sector will offer some of the cheapest abatement options this could lead to an allowance price above the MAC in the Mexican ETS.
- **Predictability:** There is a clear lack of long-term or even short-term predictability about the carbon price and the general ETS and energy sector framework. The energy reform initiated by the previous administration is partially being reversed by the current administration. The current federal government has shown less public support for domestic emission reductions than previous governments. It is not yet clear how the ETS will continue after the pilot phase and to which extent the federal government will tighten the cap to ensure a scarcity of allowances.

- **Environmental effectiveness:** During the pilot phase the Mexican ETS will only have minimal impacts on emissions. An abundant supply of allowances allocated for free, a generous cap, the possibility to use offset units and the economic downturn due to the COVID-19 pandemic all indicate that any carbon price will be too low to affect decisions. The environmental effectiveness in the operational phase depends strongly on the political willingness to reduce the cap and to provide for scarcity. The cap needs to account for the expected impacts of clean energy policies and the decarbonisation of power generation. A positive feature of the pilot phase is that surplus allowances cannot be banked to the operational phase. This is a crucial provision as the data to determine the cap was of mixed quality. The accounting rules for using offset units prohibit double counting both domestically as well as internationally but it is not yet clear which offset units will be eligible under the Mexican ETS.

Impact of electricity market structure and regulations on the potential for abatement under the ETS

The pilot phase of the Mexican ETS will have a negligible impact on the electricity sector as there is no CO_2 price and the political uncertainty about future developments is high. Free allocation is expected to be at least as high as emissions during the pilot phase.

- **Capacity mix and ownership:** Mexico's power mix is dominated by natural gas which had a share of 44 % of installed capacity in 2017. Heavy fuel oil (HFO) is the second largest fuel with a share of 19 %; coal only contributes with 8 % to the installed capacity. Renewable electricity based capacity has a share of 26 %. In terms of electricity generation, gas-fired power plants dominate other energy sources, accounting for 56 % of total generation in 2017. Variable renewable energy sources – wind and solar - had a share of 4 %. In this context, there is high latent potential for the carbon price to spur renewable energy growth under an appropriate electricity market regulation, but little potential for short-term fuel switching as natural gas is already the cheapest fossil fuel in the merit order.
  The Mexican electricity market is strongly concentrated: in 2017 57 % of the installed capacity belonged to the single public electricity provider (Comisión Federal de Electricidad, CFE); another 17 % of the capacity is owned by private entities but only produces electricity for CFE under long-term contracts with fixed prices. Only 25 % of the capacity is not directly linked to the public provider. CFE is owned and controlled by the federal government and operates differently than a private company would.

- **Age of fleet:** Mexico has a relatively young gas fleet with an average age of 14 years; HFO and coal-based power plants have an average age of 24 and 27 years respectively. Coal plants are subject to emissions standards, fine dust regulations, a phase down plan with earmarked decommissioning and coal-to-gas retrofits, and a lifecycle cap of 30 years. The lifecycle cap, combined with capacity payments, mitigate the economic risk of stranded assets but also limit the role the carbon price may have in incentivising early decommissioning.

- **Companion policies:** The Mexican ETS operates alongside a range of energy policy instruments. The energy reform adopted in 2014 initiated a liberalisation of the electricity market, established a scheme of clean energy certificates to promote renewable electricity generation and set indicative energy efficiency targets. One year prior, the government introduced a carbon tax on all fossil fuels except natural gas. The current administration is partially reversing this energy reform and especially moving away from promoting renewable energies.

- **Pass-through of carbon costs to wholesale electricity prices:** In the absence of a carbon price during the pilot phase of the Mexican ETS no cost pass-through will take place. Once a carbon price is established, the possibility to pass costs through to the wholesale market depends on the type of producer. Private producers and CFE itself should be able to charge the additional carbon costs. Private generators with fixed contracts producing electricity only for CFE will most likely not be able to change the conditions of these contracts and include carbon costs.
- **Potential for fuel switch:** In the Mexican electricity market, power plants are dispatched according to the merit order, in which low carbon technologies already take priority[1]. However, the role of the carbon price in the dispatch may be limited for some contracts concluded prior to the energy reform which are given priority and represent, on average, about 12 % of the dispatch. While the composition of the Mexican fuel mix is diverse the influence of an allowance carbon price to influence the fuel mix is limited as natural gas is already cheaper than the more emission intensive fuels (HFO and coal). In contrast to other regions such as Europe it is not the fuel price difference that limits electricity generation from natural gas, but the fact that there are not enough gas pipelines to import the required quantities. This has forced the operation of older and inefficient plants in Mexico.
- **Impacts on low carbon investments:** Mexico disposes of an only partially liberalized electricity sector in which investments by CFE – which owns 60 % of the generation assets – must be approved by the government. Importantly, such approval is strongly determined by the political preferences of the authority in turn. As an emerging, stable market with great potential for renewable energy, the energy reform highly encouraged private investments, mostly renewable energy projects. This path was strengthened by the low technological costs with one of the world's lowest costs for renewable energies. However, by cancelling auctions for renewable generation, by attempting to modify the regulation for clean energy certificates, by cancelling investments in transmission grids and by attempting to restrict additional entry of renewables into the grid, the current administration has caused a great degree of uncertainty for investors.
- **Pass-through of carbon costs to retail electricity prices:** Electricity prices for households and small consumers are subsidised and unlikely to be affected by a carbon price. Large users that receive their electricity directly from the basic supplier CFE would likely be affected by carbon costs. The most efficient and lest-emitting plants are assigned for providing electricity to the residential sector; the remaining fleet supplying large consumers would be affected more strongly by a carbon price. Large consumers have the option to enter contracts with private qualified suppliers. In this market the carbon costs will also be passed through, but these plants are more efficient and would be affected less by the ETS. Small businesses which do not meet the minimum threshold to switch suppliers and which do not qualify for subsided electricity rates might be affected the most.

The Mexican electricity market is undergoing a period of great uncertainty, both in terms of the regulation of the electricity market itself but also in term of the ETS. It remains to be seen to which extent the energy reform of 2014 will be rolled back and which level of ambition the future climate policy will have. Together with the special rules during the pilot phase of the Mexican ETS it is unlikely that the trading system will have a noticeable impact in the short term on demand, supply, or investments.

[1] The latest reform to the energy industry law changes dispatch order (Cámara de Diputados 2021), but it is contested in court and not yet implemented. See sections 4.1.1 and4.2.2.

Zusammenfassung

Dieser Bericht analysiert die Wechselwirkungen zwischen dem mexikanischen Emissionshandelssystem und dem Strommarkt entlang zweier Hauptfragen: 1) wie könnten sich die Designmerkmale des Emissionshandelssystems auf die Qualität des Preissignals für Zertifikate auswirken; und 2) wie beeinflussen Marktdesignmerkmale und zusätzliche Regulierungen im mexikanischen Stromsektor die durch den Zertifikatspreis induzierten Emissionsminderungen.

Auswirkungen des Kohlenstoffmarktdesigns und der Marktregulierung auf die Qualität des Preissignals

Das mexikanische Emissionshandelssystem (ETS) startete im Jahr 2020. Es ist eine von vielen Maßnahmen, um Mexikos Nationally Determined Contribution (NDC) unter dem Übereinkommen von Paris (Paris Agreement) zu erreichen und umfasst sowohl den Energiesektor als auch große Industrieanlagen. Die ersten drei Jahre sind als Pilotphase vorgesehen. Explizites Ziel dieser Phase ist es, Erfahrungen bei der Implementierung eines ETS in Mexiko zu sammeln. Die operative Phase soll im Jahr 2023 beginnen. Zum Zeitpunkt der Erstellung dieses Berichts war der erste Compliance-Zyklus noch nicht abgeschlossen und es gab - aufgrund der spezifischen Regeln für die Pilotphase - noch keinen CO_2-Preis.

- **Volatilität:** Entsprechend der mexikanischen Gesetzgebung soll während der Pilotphase der ETS keine wirtschaftlichen Auswirkungen auf die Anlagenbetreiber haben. Die Betreiber erhalten daher genügend Zertifikate kostenlos, um ihre verifizierten Emissionen zu decken. Bis zum Beginn der Betriebsphase wird sich wahrscheinlich kein CO_2-Preis etablieren. Bisher wurde keine Handelsplattform für mexikanische ETS-Zertifikate eingerichtet. Die Regeln für die Betriebsphase ab 2023 sind noch nicht festgelegt. Wenn das derzeitige Design beibehalten wird, könnten Versteigerungen nur eine geringe Rolle spielen, was die Preisfindung erschweren würde. Bislang gibt es nur wenige öffentliche Informationen über Emissionen, Zuteilung und Pläne der Regierung für die Betriebsphase. Darüber hinaus kontrollieren die staatlichen Strom- und Ölunternehmen einen großen Anteil des gesamten Kohlenstoffmarktes in Mexiko und könnten den Markt dominieren. Es scheint plausibel, dass die ersten Jahre der Betriebsphase eine hohe Volatilität aufweisen werden. Die Betreiber können Gutschriften aus Kompensationsprojekten verwenden, was zur Stabilisierung der Preise beitragen, aber auch zusätzlichen Druck auf die Preise ausüben könnte.
- **Widerspiegelung der Grenzvermeidungskosten:** Wie bei der Diskussion zur Volatilität kann dies für die Pilotphase nicht bewertet werden, da es kein Kohlenstoffpreissignal gibt. Die Erwartung für große Unternehmen in der die Betriebsphase ist, dass sie ihre Vermeidungsoptionen und die damit verbundenen Kosten kennen. Dies gilt insbesondere für Unternehmen, die bereits an anderen ETS-Systemen auf der Welt teilnehmen. Anders verhält es sich jedoch bei kleineren Unternehmen, die oft keine spezielle Einheit (oder nicht einmal eine spezielle Person) haben, die sich mit Fragen der Energieeffizienz und Emissionsreduktion beschäftigt. Die großen staatlichen Strom- und Ölgesellschaften stehen vor einer anderen Herausforderung: Investitionsentscheidungen dieser Unternehmen müssen vom Finanzministerium genehmigt werden. Sollte die mexikanische Bundesregierung kosteneffiziente Maßnahmen nicht genehmigen, wird der Zertifikatspreis nicht die Grenzkosten in diesen Unternehmen widerspiegeln. Aufgrund ihres großen Marktanteils und der Annahme, dass der Stromsektor einige der günstigsten Vermeidungsoptionen anbietet, könnte dies zu einem Zertifikatspreis oberhalb der Grenzvermeidungskosten im mexikanischen ETS führen.

- **Vorhersagbarkeit:** Es gibt einen klaren Mangel sowohl an langfristiger als auch an kurzfristiger Vorhersagbarkeit des Kohlenstoffpreises und der allgemeinen ETS- und Energiesektor-Rahmenbedingungen. Die von der vorherigen Regierung eingeleitete Reform des Energiesektors wird von der aktuellen Regierung teilweise wieder rückgängig gemacht und die aktuelle Bundesregierung hat bisher wenig öffentliche Unterstützung für inländische Emissionsreduktionen gezeigt. Es ist noch nicht klar, wie das ETS nach der Pilotphase weitergeführt wird und inwieweit die Bundesregierung die Obergrenze verschärfen wird, um eine Verknappung der Zertifikate zu gewährleisten.

- **Umweltwirksamkeit:** Während der Pilotphase wird das mexikanische ETS nur minimale Auswirkungen auf die Emissionen haben. Ein reichliches Angebot an kostenlos zugeteilten Zertifikaten, eine großzügig bemessenes Cap, die Möglichkeit Gutschriften zu nutzen und der wirtschaftliche Abschwung aufgrund der COVID-19 Pandemie deuten darauf hin, dass ein etwaiger Kohlenstoffpreis zu niedrig sein wird, um Entscheidungen zu beeinflussen.
  Die Umweltwirksamkeit in der Betriebsphase hängt stark von der politischen Bereitschaft ab, die Obergrenze für Emissionen zu senken und für Knappheit von Zertifikaten zu sorgen. Die Obergrenze muss dafür die erwarteten Auswirkungen der Politiken für saubere Energien und die Dekarbonisierung der Stromerzeugung berücksichtigen. Ein positives Merkmal der Pilotphase ist, dass überschüssige Zertifikate nicht in die Betriebsphase übertragen werden können. Dies ist eine wesentliche Bestimmung, da die Daten zur Bestimmung der Obergrenze von durchwachsener Qualität waren. Die Anrechnungsregeln für die Verwendung von Offset-Einheiten verbieten eine Doppelzählung sowohl im Inland als auch international, aber es ist noch nicht klar, welche Offset-Einheiten im Rahmen des mexikanischen ETS anrechenbar sein werden.

Auswirkung der Struktur des Elektrizitätsmarktes und der Regulierung auf die durch die CO2-Preise induzierte Emissionsreduktion

Die Pilotphase des mexikanischen ETS wird einen vernachlässigbaren Einfluss auf den Stromsektor haben, da es keinen CO_2-Preis gibt und die politische Unsicherheit über zukünftige Entwicklungen hoch ist. Es wird erwartet, dass während der Pilotphase die kostenlose Zuteilung mindestens so hoch sein wird wie die Emissionen der beteiligten Anlagen.

- **Kapazitätsmix und Eigentumsverhältnisse**: Mexikos Strommix wird von Erdgas dominiert, das 2017 einen Anteil von 44 % an der installierten Kapazität hatte. Schweres Heizöl ist der zweitgrößte Brennstoff mit einem Anteil von 19 %; Kohle trägt nur mit 8 % zur installierten Kapazität bei. Die auf erneuerbarem Strom basierende Kapazität hat einen Anteil von 26 %. Bei der Stromerzeugung dominieren Gaskraftwerke mit einem Anteil von 56 % an der Gesamterzeugung im Jahr 2017. Variable erneuerbare Energiequellen - Wind und Sonne - hatten einen Anteil von 4 %. Vor diesem Hintergrund besteht ein hohes latentes Potenzial für den Kohlenstoffpreis, um das Wachstum der erneuerbaren Energien unter einer geeigneten Strommarktregulierung anzukurbeln. Das Potenzial für einen kurzfristigen Brennstoffwechsel aufgrund des ETS ist gering, da Erdgas bereits der billigste fossile Brennstoff in der Merit-Order ist.
  Der mexikanische Strommarkt ist stark konzentriert: Im Jahr 2017 gehörten 57 % der installierten Kapazität dem einzigen öffentlichen Stromversorger (Comisión Federal de Electricidad, CFE); weitere 17 % der Kapazität befinden sich im Besitz privater Unternehmen, die aber nur im Rahmen langfristiger Verträge mit festen Preisen Strom für CFE produzieren. Nur 25 % der Kapazität sind nicht direkt an den öffentlichen Versorger gebunden. CFE ist im Besitz und unter Kontrolle der Bundesregierung und arbeitet anders als ein privates Unternehmen.

- **Alter der Flotte:** Mexiko hat eine relativ junge Gasflotte mit einem Durchschnittsalter von 14 Jahren. Öl- und kohlebasierte Kraftwerke haben ein Durchschnittsalter von 24 bzw. 27 Jahren. Kohlekraftwerke unterliegen Emissionsstandards, Feinstaubvorschriften, einem Auslaufplan mit Stilllegung und Vorgaben zur Umrüstung von Kohle- auf Gaskraftwerke. Die Obergrenze für das Alter von Kohlekraftwerken ist 30 Jahre. Die maximale Lebensdauer in Kombination mit Kapazitätszahlungen mindert das wirtschaftliche Risiko von Fehlinvestitionen, begrenzt aber auch die Rolle, die der Kohlenstoffpreis als Anreiz für eine frühzeitige Stilllegung haben kann.

- **Begleitende Politikmaßnahmen:** Das mexikanische ETS existiert neben einer Reihe von energiepolitischen Instrumenten. Die 2014 verabschiedete Energiereform leitete eine Liberalisierung des Strommarktes ein, führte ein System von Zertifikaten für saubere Energie ein, um die Stromerzeugung aus erneuerbaren Energien zu fördern, und setzte indikative Ziele für die Energieeffizienz. Ein Jahr zuvor hatte die Regierung eine Kohlenstoffsteuer auf alle fossilen Brennstoffe außer Erdgas eingeführt. Die aktuelle Regierung macht diese Energiereform teilweise wieder rückgängig und rückt insbesondere von der Förderung erneuerbarer Energien ab.

- **Überwälzung der CO_2-Kosten auf die Stromgroßhandelspreise:** In Ermangelung eines Kohlenstoffpreises während der Pilotphase des mexikanischen ETS findet bisher keine Kostenüberwälzung statt. Sobald ein Kohlenstoffpreis etabliert ist, hängt die Möglichkeit der Kostenüberwälzung auf den Großhandelsmarkt von der Art des Erzeugers ab. Private Erzeuger und die CFE selbst sollten in der Lage sein, die zusätzlichen Kohlenstoffkosten in Rechnung zu stellen. Private Erzeuger mit festen Verträgen, die nur für CFE Strom produzieren, werden wahrscheinlich nicht in der Lage sein, die Bedingungen dieser Verträge zu ändern und Kohlenstoffkosten einzubeziehen.

- **Potenzial für Brennstoffwechsel:** Im mexikanischen Strommarkt werden die Kraftwerke nach der Merit-Order eingesetzt, in der kohlenstoffarme Technologien bereits Vorrang haben[2]. Allerdings kann die Rolle des Kohlenstoffpreises beim Dispatch bei den Verträgen, die vor der Energiereform abgeschlossen wurden, begrenzt sein, da diese unabhängig von den Kosten vorrangig behandelt werden und im Durchschnitt etwa 12 % des Dispatch ausmachen. Obwohl Mexiko über einen diversifizierten Brennstoffmix verfügt, ist der Einfluss eines Kohlenstoffpreises zur Beeinflussung des Brennstoffmixes begrenzt, da Erdgas bereits günstiger ist als die emissionsintensiveren Brennstoffe (Öl und Kohle). Im Gegensatz zu anderen Regionen wie z.B. Europa ist es nicht der Brennstoffpreisunterschied, der die Stromerzeugung aus Erdgas begrenzt, sondern die Tatsache, dass es nicht genügend Gaspipelines gibt, um die benötigten Mengen zu importieren. Dies erfordert in Mexiko den Betrieb älterer und ineffizienter Öl- und Kohlekraftwerke.

- **Auswirkungen auf kohlenstoffarme Investitionen:** Mexiko verfügt über einen nur teilweise liberalisierten Stromsektor, in dem Investitionen der CFE - die 60 % der Erzeugungsanlagen besitzt - von der Regierung genehmigt werden müssen. Diese Genehmigung wiederum hängen stark von den politischen Präferenzen der Regierung ab und folgen nicht notwendigerweise Kostenüberlegungen. Als aufstrebender, stabiler Markt mit großem Potenzial für erneuerbare Energien hat die Energiereform private Investitionen, vor allem in Projekte für erneuerbare Energien, stark gefördert. Dieser Weg wurde durch die niedrigen technologischen Kosten mit einem der weltweit niedrigsten Kosten für erneuerbare Energien verstärkt. Durch die Absage von Auktionen für erneuerbare Energien,

[2] Die jüngste Reform des Gesetzes für die Energieindustrie ändert die Merit Order (Cámara de Diputados 2021), aber die Reform ist rechtlich umstritten und noch nicht umgesetzt, s. Abschnitt 4.1.1und 4.2.2.

den Versuch, die Regulierung für Zertifikate für saubere Energie zu ändern, die Absage von Investitionen in Übertragungsnetze und den Versuch, die zusätzliche Einspeisung von erneuerbaren Energien ins Netz zu beschränken, hat die derzeitige Regierung jedoch ein hohes Maß an Unsicherheit für Investoren verursacht.

- **Überwälzung der CO_2-Kosten auf die Strompreise für Endkunden:** Die Strompreise für Haushalte und Kleinverbraucher sind subventioniert und werden wahrscheinlich nicht von einem Kohlenstoffpreis beeinflusst. Großverbraucher, die ihren Strom direkt vom Grundversorger CFE beziehen, würden wahrscheinlich von Kohlenstoffkosten betroffen sein. Die effizientesten und emissionsärmsten Kraftwerke werden für die Versorgung des Haushaltssektors eingesetzt; der übrige Kraftwerkspark, der die Großverbraucher versorgt, wäre von einem Kohlenstoffpreis stärker betroffen. Großverbraucher haben allerdings die Möglichkeit, Verträge mit privaten Anbietern abzuschließen. In diesem Markt werden die Kohlenstoffkosten ebenfalls weitergegeben, aber diese Anlagen sind effizienter und würden weniger vom ETS betroffen sein. Kleine Unternehmen, die die Mindestschwelle für einen Anbieterwechsel nicht erreichen und die sich nicht für subventionierte Stromtarife qualifizieren, könnten am stärksten betroffen sein.

Der mexikanische Strommarkt befindet sich in einer Phase großer Unsicherheit, sowohl in Bezug auf die Regulierung des Strommarktes selbst als auch in Bezug auf das ETS. Es bleibt abzuwarten, inwieweit die Energiereform von 2014 rückgängig gemacht wird und welches Ambitionsniveau die zukünftige Klimapolitik haben wird. Zusammen mit den Sonderregelungen während der Pilotphase des mexikanischen ETS ist es unwahrscheinlich, dass das Handelssystem kurzfristig einen spürbaren Einfluss auf Nachfrage, Angebot oder Investitionen haben wird.

1 Introduction

The Mexican emissions trading scheme (ETS) started operation in 2020. It is one of many measures to achieve Mexico's Nationally Determined Contribution (NDC) under the Paris Agreement. In the NDC Mexico committed itself to reducing greenhouse gas emissions by 22 % compared to the business as usual development in the year 2030. The Mexican ETS covers the energy sector as well as large industrial installations. The first three years are designated as a pilot phase with the expressed aim to gather experience in the implementation of an ETS in Mexico. The operational phase is scheduled to begin in 2023. At the time of writing, the first compliance cycle had not yet been finalized and – due to the specific rules for the pilot phase – there was not yet an established CO_2 price.

The Mexican electricity mix is strongly based on fossil fuels (generation): 56 % on natural gas, 14 % fuel oil and diesel and 11 % on coal. Renewable energies have a share of 16 % and nuclear power of 3 % (SENER 2018). A large share of the Mexican electricity market is centrally regulated. The only public electricity provider Comisión Federal de Electricidad (CFE) belongs to the government which also controls investments and retail prices for non-industrial consumers. Private generation exists but much of it is sold to the state-owned company at fixed prices. Large consumers can enter direct contracts with private energy providers or produce their own electricity.

The aim of this study is to identify the impact of carbon and energy market structures and regulations and to investigate the interdependencies between these two markets in Mexico. It is one of five case studies which are based on a joint theoretical framework. This framework identified major interactions based on a literature study Acworth et al. (2019). In this report, we present the case study for the Mexican Emission Trading System and electricity market. The aim of the case study is (i) to analyse the design of the different markets and regulations, (ii) to understand how these affect the carbon price and (iii)the market interactions in terms of emission reductions. This report addresses the following two questions:

1. How do design features of the Mexican ETS affect the environmental effectiveness of the system and the quality of the carbon price signal?
2. How do electricity market design features in Mexico affect the abatement in the power sector induced by the carbon price?

The report is structured in two parts. First, we describe the Mexican ETS and its most important design features. We assess the expected effects of design features on the effectiveness of the system and the quality of the allowance price along four dimensions:

- Environmental effectiveness: The environmental effectiveness equals the amount of emissions abated.
- Reflection of marginal abatement cost (MAC): Examining the MAC enables to examine whether the price signal is distorted.
- Long-term price predictability: Because investors have a planning horizon of several years, the long-term predictability of the price signal is essential to foster low carbon investments.
- Price volatility: Volatile carbon prices are an indicator that a market is able to react to newly revealed information, e.g., changes in production cost. Yet, excessive volatility makes it difficult for market participants to make abatement and trading decisions.

Second, we describe the Mexican electricity markets in terms of design, supply, and demand. We then assess the interaction of carbon and electricity markets, focusing on the impact of carbon prices on electricity generation, demand, and consequently abatement. We assess this impact along the three main abatement channels:

- Fuel switch: Short-term abatement through change in dispatch.
- Low carbon investment/divestment: Long-term abatement through investment in low carbon technologies or divestment from fossil technologies.
- Demand reduction: Short to long-run abatement due to demand reduction induced by higher electricity prices for consumers in wholesale and retail markets.

All three abatement channels depend on the pass-through of the carbon price signal to bids in the electricity market, and thus wholesale market prices; demand-side abatement also depends on the cost pass-through to end-users. We thus also provide evidence on the cost pass-through.

The framework of this report is based on Acworth et al. (2019). For the analyses, we (i) used literature on carbon and electricity market regulations, research articles, and secondary literature; (ii) analysed electricity and carbon market data from CFE, SENER, SIE, CRE and CENACE; and (iii) conducted semi-structured interviews with different stakeholders from Mexico. Table 1 gives an overview of the interview partners.

Table 1: Interview partners

Group	Interview partners
Companies	4
Researchers and Think Thanks	7
Public officials	2

Source: Own elaboration, Öko-Institut

With our analyses we provide descriptive and narrative evidence on the interactions of carbon and electricity market regulations in Mexico. A thorough quantitative assessment of causal relations is beyond the scope of this project and not yet possible due to the lack of data. Also, it is important to note that the results from expert interviews provide a range of expert opinions but cannot be seen as representative.

This report proceeds as follows: Section 2 describes design and regulation of the Mexican ETS, section 3 assesses their impact on environmental effectiveness and the quality of the price signal, section 4 introduces the electricity markets, and section 5 analyses the impact of electricity market design on carbon price induced abatement in the power sector.

2 Design and regulation of the Mexican ETS

The Mexican ETS started in 2020 and covers around 40 % of the total national greenhouse gas emissions. It covers large installations in the energy sector as well as in many industrial sectors. Together, these sectors are responsible for over 90 % of the emissions reported in the national emissions registry (see section 2.3.3) The first three years of the ETS are a pilot phase, with the last year designated as transitionary phase; the full operational phase will start in 2023. During the pilot phase the ETS shall have no economic effect on operators. Free allocation is based on historic emissions and operators receive as many allowances as needed unless the overall demand exceeds the cap and the reserves. Additionally, there will be no financial penalty in cases of non-compliance; another important aspect is that no banking is allowed from the pilot phase towards the operational phase. Table 2 gives an overview of the most important design features of the Mexican ETS.

Table 2: Overview supply and demand side design features in the Mexican Pilot ETS

Feature	Mexican ETS Design	Comment
Allowance Cap	Absolute	Absolute cap linked to NDC target path for pilot phase (increase of emissions, 271 million allowances in 2020, 273 million in 2021); Three reserves (general, new entrants, auctions) additional to the cap, joint size of reserves is 20 % of cap.
Mid-term Target Long-term Target	National 2030 target adopted National 2050 target adopted	Conditional (36 % below BAU) and unconditional (22 % below BAU) national 2030 target adopted in NDC. Aspirational 2050 target in Climate Law. ETS cap specified for the years 2020 and 2021.
Primary Allocation (in electricity sector)	Grandparenting	From 2021 onwards, possible auctioning of allowances from the auctioning reserve (5 % on top of cap)
Banking Borrowing	Allowed Allowed from year X+1	Within periods, not from pilot phase to operational phase Free allocation corresponding to the year X+1 is issued one week before the compliance deadline for year X
Additional sources of Supply	Offsets No linking	Offsets only from domestic projects (up to 10 % of verified emissions). New projects only for non-CO_2 gases. Rules currently under development.
Market Stability Mechanism	Indirectly	No banking from pilot phase to operational phase.
Voluntary Cancellation	Not allowed	
Coverage	40 % of national emissions	CO_2 only
Market participation	Closed System	Non-regulated entities cannot open accounts and participate in trade

Source: Own elaboration, Öko-Institut

2.1 Allowance supply

This section describes the supply side features of the Mexican pilot ETS.

2.1.1 Allowance cap and long-term targets

The Mexican pilot ETS has an absolute cap. It is based on the historic emissions, the 2030 target set in the Mexican NDC and on sectoral targets. In its NDC, Mexico commits itself to an unconditional reduction of 22 % below baseline emissions by 2030. The NDC emission path shows increasing emissions until 2026 and a steep decline thereafter (México, Gobierno de la República 2015). This is reflected in the cap for the first two years of the ETS: the cap for 2020 is 271.3 Mt CO_2, and for 2021 it increases slightly by 0.7 % to 273.1 Mt CO_2 (SEMARNAT 2019a). So far, the Ministry for the Environment (SEMARNAT) has not yet published the cap for 2022 or later periods. Following the considerations established in Art. 12 of the Agreement on the ETS pilot (SEGOB 2021b)[3] the cap should initially increase in line with the NDC pathway during the operational phase and only decline in the second half of the decade.

Three reserves contain allowances in addition to the ETS cap:

- New entrants reserve (10 % of the cap volume);
- Auction reserve (5 % of the cap volume);
- General reserve (5 % of the cap volume);

The objective of the general reserve is to enable ex-post adjustments for operators where emissions exceed free allocation and to increase the new entrants reserve if necessary (SEMARNAT 2020). If all three reserves were fully used, the effective cap in the year 2020 would be 325.6 Mt CO_2.

In addition to the 2030 target the Climate Law includes a long-term target of reducing total GHG emissions by 50 % below 2000 levels until 2050. Mexico has also joined the Climate Ambition Alliance in 2019 and vowed to achieve net carbon neutrality (UNFCCC secretariat 2021). However, this has not yet been reflected in national interim targets or domestic legislation.

2.1.2 Allowance allocation

Allowances are allocated for free during the pilot phase. Allocation is based on grandparenting, i.e. the historic emissions of each installation (SEMARNAT 2020):

- For 2020, free allocation is equal to the latest verified emission report in the period 2016-18. Until the beginning of the ETS, emission reports by operators were only verified every three years.
- From 2021 onwards, free allocation is based on the latest verified emission report. If necessary, a correction factor will reduce free allocation proportionally to ensure that it remains within the cap.
- New entrants receive their allocation based on their emissions in the first year in which they surpassed the minimum threshold of 100 kt CO_2 emissions out of the new entrants reserve. If the reserve is depleted, it can be resupplied from the general reserve.

[3] The Mexican pilot ETS is based on the "Agreement which established the preliminary rules for the pilot phase of the of the Mexican ETS" (hereafter called *Agreement on the ETS pilot*) The full regulations specifying the rules for the operational phase are not yet adopted.

- In any year of the pilot phase, operators can apply for more allowances from the general reserve if their emissions exceeded free allocation for that year. If the demand for additional allowances exceed the general reserve, allocation is reduced proportionally for all operators applying for additional allowances.[4]

From 2021 onwards and depending on market behaviour, SEMARNAT may auction allowances from the auction reserve. There are several provisions in cases of plant closures. Depending on the date of closures operators just return the previous' year free allocation, surrender all allowances received for free or still participate fully in that year.

2.1.3 Banking and borrowing

Banking is allowed without restrictions within the pilot phase and within the operational phase for operators in compliance with their obligations. Operators which have not surrendered sufficient allowances cannot use banking. Under current rules, allowances issued for the pilot phase will not be valid for the operational phase, i.e. no banking is allowed between the two phases. This rule might change though: SEMANART is tasked with assessing the viability of allowing some banking between phases. In an interview with a person close to the process it was indicated that this will most likely not be allowed.

There are no explicit rules for borrowing. Free allocation for the year X takes places on 24 October of each year. The compliance deadline for the year X-1 is one week later on 1 November. Participants can therefore use allowances issued for the year X to meet their obligations for the year X-1.

2.1.4 Provisions for additional allowances supply

Offsets and early action credits

Operators can use two different types of offsetting projects: new domestic projects and recognition of early action. Both types of projects need to comply either with standards set by SEMARNAT or standards defined in other national and international protocols which have been approved by SEMARNAT. Emission reductions need to be verified and validated by an accredited entity.

During the pilot phase offset units from new projects need to be implemented in Mexico and only reductions of GHG emissions other than CO_2 can be used. Concerning early action, SEMARNAT may approve the usage of credits resulting from such projects. These can address all GHG emissions including CO_2 and be in all sectors. To be eligible, these projects need to have received "compensation credits" before the beginning of the pilot ETS. These projects can continue to create credits even after the pilot-ETS has started.

During the pilot phase it is not possible to use reductions linked to the clean energy certificates (CEL, see section 4.3.4). In total, operators can use credits up to 10 % of their verified emissions during the pilot phase.

For offset projects and credits from early action there are rules to prevent double counting domestically and internationally. Units from eligible early actions projects from approved external protocols can only be used in the pilot ETS if they have been cancelled by the governing entity. In such a case SEMARNAT then issues an equivalent amount of offset credits.

[4] This rule contravenes Art. 6 of the Agreement on the ETS pilot which states that operators receive free allocation to the extent needed independently of the remaining allowances in the reserves. It is unclear what will happen if this situation arises.

Compensation credits that have been used in the ETS will be cancelled by SEMARNAT and cannot be used in other domestic or international offsetting schemes.

As discussed in section 2.1.2 it is unlikely that there will be scarcity of allowances during the pilot phase. The two flexibility mechanisms will therefore most likely only be used for trial purposes but not to increase the supply considerably. The importance of these mechanisms during later phases will depend on the cap, the CO_2 price, the specific rules for offset projects and which national and international protocols will be recognized. SEMARNAT is currently working on the necessary legislative documents to operationalize the offset mechanisms.

Linking

The Mexican ETS is not linked to other schemes and linking is not foreseen in the ETS Agreement.

2.1.5 Market stability mechanisms

The Mexican ETS does not yet include an explicit market stability mechanism. However, it includes a safety mechanism during the transition from pilot to operational phase. The experience in other ETS has shown that the initial cap in a new ETS tends to be too high to ensure scarcity of allowances (Oeko-Institut e.V. 2018). This is partly due to a lack of high-quality emission data in the scope of the ETS prior to its start: in the absence of good data policy makers tend to err on the side of caution and do not want to make their ETS over-ambitious.

In the case of Mexico operators are obliged to report their greenhouse gas emissions by installation since 2014. Despite this, the quality of the data in the national registry RENE is uncertain. Verification is only conducted every three years, not all operators have complied from the beginning, the scope of emissions is different compared to the ETS, and some operators lacked the capacity to calculate their emissions correctly. This is reflected in the ETS Agreement that establishes the Mexican ETS: one of the objectives for the trial phase is to “generate more robust and better quality” information. To ensure that a possible initial oversupply of allowances does not affect the ETS for a prolonged time, banking from the pilot phase to the operational phase is not allowed. This provision might change in the future: the ETS agreement gives SEMARNAT the task to assess the viability of banking between the phases.

2.1.6 Voluntary cancelation of allowances

Voluntary cancelation is not foreseen during the Pilot phase.

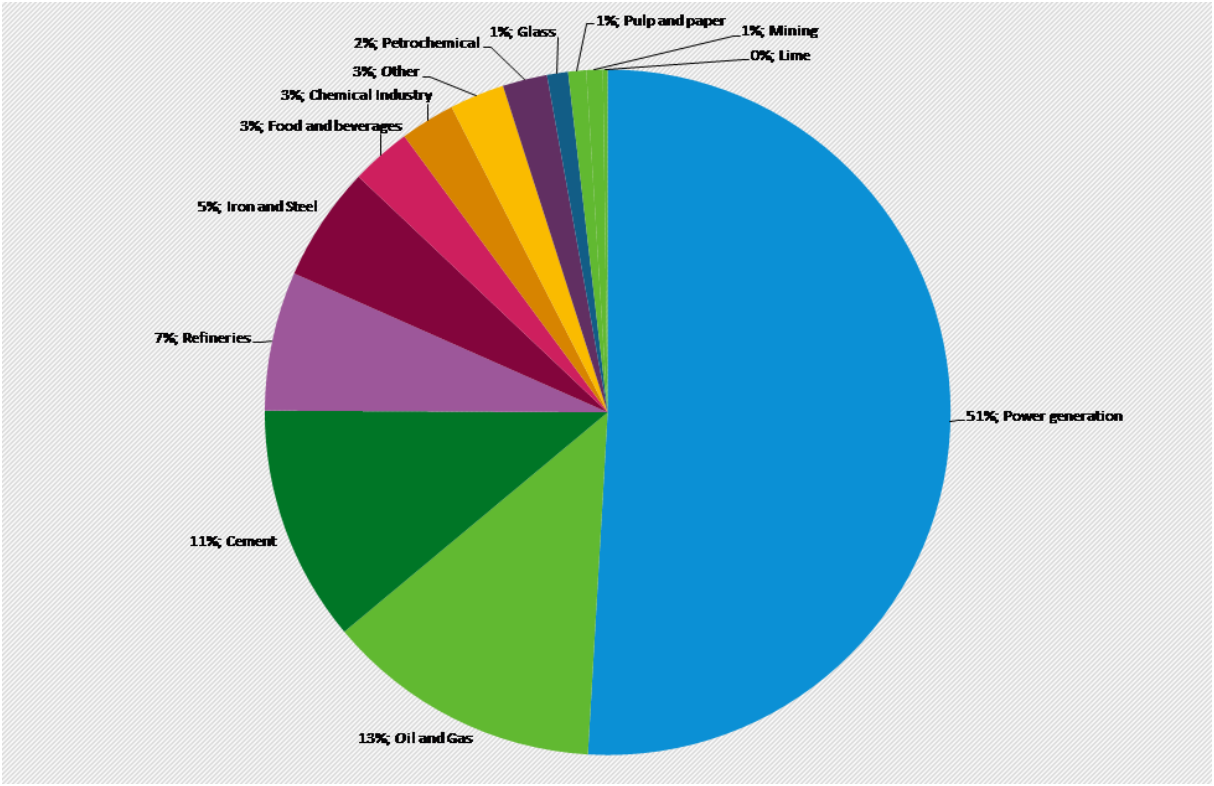
2.2 Demand

This section describes the demand side features of the Mexican ETS.

2.2.1 Coverage

During the pilot phase the trading scheme covers direct CO_2 emissions from stationary sources. Installations which have exceeded the minimum threshold of 100 kt CO_2 in at least one year between 2016 and 2019 need to participate. In the energy sector it covers oil and gas production and distribution and electricity generation. The main industrial subsectors covered are cement, iron & steel, refineries, food & beverages and the chemical industry (Figure 1). Data on emissions is not yet available (see section 2.3.3), but it is estimated that in total the ETS covers around 40 % of the total national greenhouse gas emissions.

Figure 1: Free Allocation by sector in 2020



Source: Own depiction, Öko-Institut, based on SEMARNAT (2019b).

2.2.2 Market participation

The Mexican Pilot ETS is a closed system, which means that only regulated entities can hold and transfer allowances.

2.3 Transaction and market oversight rules

Table 3 summarizes transaction and market oversight rules. They are described in the following.

Table 3: Overview transaction and market oversight rules

Feature	Mexico Pilot ETS Design
Legal nature	Administrative instrument
Fiscal nature	Under development
Market Places	OTC and possibly auctions.
Transparency	Yearly reporting

Source: Own elaboration, Öko-Institut

2.3.1 Legal and fiscal nature of allowances

Allowances are defined as “administrative instruments”. Their exact legal nature and their fiscal treatment are still under development.

2.3.2 Market places

So far there is no public marketplace to trade ETS allowances in Mexico. All trading is expected to take place over the counter (OTC) for the time being. Auctioning will start in 2021 but it is unsure whether there will be any demand for allowances initially: during the pilot phase operators receive all allowances for free with a special reserve dedicated to supplement any shortfalls. Surplus units from the trial phase cannot be used in the operational phase. It is unclear which role auctioning will play in the operational phase.

2.3.3 Transparency regulation and compliance

Art. 30 of the regulations for the pilot phase stipulate that the number of allowances allocated for free, verified emissions and submitted allowances will be published. The National Emissions Registry RENE is the central platform where operators need to submit their verified emission reports. RENE was established by the General Climate Change Law in 2012 with first reports being submitted for the year 2014. Initially, not all companies were willing or able to comply with the reporting obligations, but completeness and quality of data has improved over the years. With the start of the ETS, covered entities have a strong incentive to ensure adequate MRV procedures. So far, the RENE has not yet published emission data by operators but the first emission reports under the ETS are only due in June 2021. One interviewee close to the process was sceptical whether installation level data will be published at all as it is seen as commercially sensitive data.

Under the ETS covered entities need to develop, submit and periodically review a monitoring plan. The plan includes the name, location and description of the installation and stationary points sources, the monitored parameters and their characteristics (e.g. sampling frequency, calibration process, data processing and storage) and an evaluation process.

From January to June each year operators need to prepare their emission report and have it verified by an independent and accredited entity. The emission report together with the verification report and a positive verification statement need to be submitted to RENE by the end of June of each year. By 1 November at the latest, operators need to hand in allowances for the previous year in accordance with their verified emissions. If an operator is in non-compliance no transfers of allowances out of the account are possible and remaining allowances cannot be banked. In addition, any deficit accrued during the pilot phase will be deducted twice from the free allocation during the operational phase. There will be no monetary penalties for non-compliance during the pilot phase.

3 Assessing the ETS design and the quality of the allowance price

The pilot phase is designed to pose "no economic impact" on regulated entities (Art. 6). In practice this means that operators not only receive 100 % free allocation based on historic emissions, but also that an ex-post adjustment is made if entities' emissions exceed their initial allocation. As described in section 2.1.2 above, the volume available for ex-post adjustments is limited in theory, but in practice – especially in light of the economic downturn brought about by the Covid-19 crisis – such reserves are very likely to cover all possible demand. This, coupled with the fact that there will be no banking between the pilot and the operational phase and that additional compliance units will be available in the form of offsets, means that there will likely be no scarcity in the market during the pilot years. During these years there will also be no monetary penalties for non-compliance. As a result, prices are expected to hover around zero, possibly with a few "test transactions" by regulated entities during the pilot years.

The political uncertainty about the future of the ETS is also very high. The current administration and the current Mexican president have not prioritized climate action as strongly as previous administrations which laid the ground for the ETS. The uncertainty is also apparent in the current policies to strengthen the state-owned (and fossil-fuel based) energy suppliers and roll back the liberalization of the energy market (see chapter 4 below). This represents a crucial challenge for the future of the Mexican ETS, since regulations for the 'transitional' and 'operational' phases are yet to be drafted and some elements relevant for the first two pilot years are still under development. Nearly all interviewed experts raised the political uncertainty about the future of the ETS as posing a major obstacle to its effectiveness. None of the interviewees expected a strong CO_2 price signal for the first operational phase. To achieve such a signal, the cap would need to provide for scarcity and to account for the expected decarbonisation of power generation instead of allowing emissions to rise up to the year 2026 in line with the current NDC.

The assessment of the following sections aims to identify elements in the current design of the ETS which would impact the different issues. Unless stated otherwise, **the analysis below assumes that the ETS will be strengthened in the next phase at least by creating scarcity and therefore creating a price signal**. All other design features are assumed to stay unchanged. As such, the aim of the sections below is to conduct an analysis of current regulations while isolating the current key challenge of lack of scarcity. It should be highlighted that the analysis is purely theoretical, since at the time of writing no allowance trades have taken place.

3.1 Volatility

Carbon price volatility describes the fluctuations of the price signal. A very volatile price, i.e. large price changes in short timeframes, can hinder market participants in making abatement and trading decisions (Acworth et al. 2019). At the same time, a price needs to be volatile enough to be able to react to changing market conditions, e.g. changes in fuel prices or costs for new generation capacities. A key element to decrease volatility is transparency, both on emissions as well as price finding. Long-term expectations help reduce volatility due to short-term effects and a liquid market ensures that changing conditions can be reflected in the carbon price.

Out of the elements identified in Acworth et al. (2019) several aspects of the Mexican pilot ETS can be identified that decrease volatility: Mexico has an aspirational long-term target established

in the Climate Law and the NDC of reducing emissions by 50 % by 2050 compared to 2000. The ETS-cap is explicitly linked to the NDC and, assuming the ETS continues into its operational phase, it seems likely that the cap would stay in line with the national target path during the operational phase. This provides for (some) long-term anchoring of the ETS and its possible trajectory over time.[5] The ETS covers around 40 % of the Mexican total greenhouse gas emissions and has a broad sectoral coverage. Operators can bank allowances and it will be possible to use offsets from domestic projects.

At the same time, there are several aspects which are likely to increase volatility. Allowances are likely to be allocated primarily through grandparenting with low shares of auctioning, which means that the market, once sufficiently scarce to provide for a price signal, may be volatile and it may take time for participants to discover the correct price. The pilot phase has no explicit market stability mechanism (although one may be introduced in the operational phase). Current transparency rules may also hinder market stability: so far, RENE does not publish quantified information on emissions. The Agreement on the pilot ETS requires publication of verified emissions, free allocation and surrendered allowances but it is unclear whether this will be published by installation or in an aggregate form only. Interviewees also mentioned deficient communication channels from the ETS governance structure towards market participants, making it hard for participants to understand what to expect and to take informed decisions; should this situation continue, this could contribute to higher levels of volatility.

The organization of the carbon market is another element not yet established. It remains to be seen if and how many carbon trading platforms will be established; for the initial years it seems likely that trade will be primarily based on confidential bilateral agreements (OTC), which again hinders price discovery and enhances the risk of volatility; in contrast, exchange based trade provides a public price. The market is, at least under current regulations, closed to market-makers such as financial entities and trading firms. Interviewees do expect such organizations to be granted access to the market in an operational phase.

Moreover, we estimate that the Federal Electricity Commission, the state-owned electricity provider, and Mexican Oils (Petroleos Mexicanos, PEMEX), the state-owned oil company, together receive more than 50 % of all allowances currently allocated for free.[6] The behaviour of these two actors will thus have a strong impact on liquidity, trade volumes and price volatility. According to the interviews, for example, CFE currently intends to do all trading for all power plants through one central unit, which would therefore control a large share of the total supply and demand. It remains to be seen how liquid the Mexican carbon market will be.

3.2 Reflection of MAC

A high quality or undistorted allowance price is one that equals the marginal abatement cost (MAC) of all market participants. As mapped out in detail in Acworth et al. (2019), certain design elements and market structures of the ETS can impact the ETS price signal such that the allowance price deviates from the system's MAC. Key elements include the existence and credibility of long-term targets, non-distorting allowance allocation methods such as auctioning, provisions for intertemporal flexibility such as banking, a wide scope of coverage, the existence

[5] Analysis by Climate Action Tracker, however, indicates that Mexico's unconditional NDC lies within its post-Covid emission projections based on current policies - which do not assume emission reductions by the ETS. This means that an ETS cap that follows the NDC trajectory may not provide sufficient scarcity for adequate market functioning (Climate Analytics and NewClimate (2020)).

[6] This is a rough estimate based on own calculations. Under current rules, the allowance allocation to power, refineries, oil & gas amounts to 70 % of total allocation. While there are some private electricity generators, all refineries and most of oil & gas belongs to PEMEX.

of liquid market places, as well as publicly available information on emissions and allocation that decrease uncertainty about allowance supply and demand.

Again, assuming a market with scarcity, the current Mexico ETS rules provide for a wide scope of coverage, but other elements are less favourable. The political uncertainty around the future of the ETS can encourage market participants to heavily discount future allowance prices and in doing so distort current prices (Fuss et al. 2018; Koch et al. 2016; Brunner et al. 2012). Free allocation (e.g. through grandparenting) can distance the ETS price signal from the MAC: if participants receive allowances for free, they may not recognize the opportunity cost of allowances and may consequently trade less (Burtraw and McCormack 2016). The lack of transparent market information described in section 3.1 above may also present a challenge to Mexican participants.

Another important element particular to the nascent Mexican ETS pertains to the knowledge of market participants of their own MACs, and their ability to act on that information. In other trading systems such as the EU ETS the electricity sector is deemed to have the lowest MAC (Abrell et al. 2020) and it seems likely that this also applies for Mexico: replacing old thermal power plants using heavy fuel oil by renewable energies is likely among the most cost-effective options for decarbonisation across the covered sectors. If this is the case and considering that the electricity sector is responsible for 50 % of the ETS emissions, CFE will play a central role in price finding.

In theory, CFE would reduce emissions if the CO_2 price increases beyond a certain level ensuring that the price reflects the marginal abatement costs. For fuel switching this might be possible: dispatch is based on marginal operating costs and most interviewees agreed that it would be feasible to include the cost of carbon in the calculation of the operating costs. Abatement potential linked to retrofitting existing installations or new installations might be more challenging: CFE is not only state-owned but also state-controlled. It depends strongly on the federal government and congress for its access to finance, either directly from the federal budget or to guarantee credits (see section 4.3.1). The same applies for PEMEX which, as the second biggest market actor, is likely to play a central role in price finding as well. Decisions to fund projects not only depend on their cost-effectiveness but also on the state of the public finances, political priorities, regional development plans and other factors (see section 4.1.1). If funding for cost-effective projects in these two companies is not approved, the allowance price will not reflect the MAC. Another obstacle are the fixed electricity prices and subsidies for the general public (see section 4.4); in such a system carbon costs can only be passed through partially if at all. The impact of the carbon price on decisions about abatement options might be reduced as a result. The situation is different for electricity generation by private companies either for auto-consumption of when sold to CFE for distribution. For these companies the long-term predictability of the ETS and the overall political framework for the energy sector are likely to be the relevant factors when assessing long-term investments which would reduce emissions below the allowance price (see below).

For the industry sectors, interviewees stated that large companies are aware of their abatement potentials and associated costs. Especially international companies that are also operating in the EU or California have already gathered practical ETS experience. The situation, however, was seen as bleaker for smaller companies: most interviewees believe that there is little knowledge about MAC and many of these companies do not have a person/unit dedicated to energy efficiency and reducing greenhouse gas emissions.

3.3 Long-term predictability

The long-term predictability is a key price characteristic informing investment decisions. Electricity generation facilities have long lifetimes from at least 20 years for solar panels; the oldest hydroelectric plant in Mexico is over 100 years old (see section 4.1). For a carbon price to be able to impact investment choices it needs to send a long-term signal with high predictability. A stable political framework and long-term emission targets are key features to increase predictability.

There is a clear lack of long-term or even short-term predictability about the carbon price and the general ETS and energy sector framework. The energy reform initiated by the previous administration is partially being reversed by the current administration (see chapter 4 below). The effect of some of the policies and measures adopted by the current federal government has been a strengthening of the state-owned oil and electricity monopolists. The lack of a clear regulatory framework was seen as a major obstacle to investments in renewable energy by private entities in the interviews.

It is not yet clear how the ETS will continue after the pilot phase and to which extent the federal government will tighten the cap to ensure a scarcity of allowances. The Climate Law which established the ETS was supported broadly by all parties in congress so there could be a willingness to enhance the system in the future. At the same time, several of the experts interviewed highlighted the lack of resources and personnel at the Climate Change Division in the Ministry for the Environment. This constrains the ability of SEMARNAT to operationalize the pilot phase and lead the work on the revision of regulations for the operational phase; at the time of writing there were only two people working in the ministry whose tasks included the administration and development of the ETS. In addition, there is little open support by the federal government for action on climate change and especially for domestic action. Against this background all interviewees said that the lack of long-term predictability is one of the main obstacles the ETS is facing.

3.4 Environmental effectiveness of the Mexican ETS

The environmental effectiveness of an ETS describes its ability to drive GHG emission reductions. The carbon price can influence dispatch (i.e. increased generation from less emitting sources), change investment decisions and reduce electricity consumption. Environmental effectiveness depends on a meaningful price signal and the ability of stakeholders to take action based on the price.

The expressed purpose of the pilot phase of the Mexican ETS is to give actors the possibility to learn the functioning of an ETS such as the MRV cycle, trading of allowances, and accounting of allowances. This is to ensure that operators are fully prepared for the operational phase. The pilot phase will likely have no impact on actual emissions: an abundant supply of allowances allocated for free, the possibility to use offset units and the economic downturn due to the COVID19 pandemic all indicate that any carbon price will be too low to affect decisions. Without clear long-term expectations stakeholders are also unlikely to base any current investment decisions on a potential future carbon price.

It is not possible to assess the environmental effectiveness of the operational phase at the moment. A positive feature of the pilot phase is that surplus allowances cannot be banked to the operational phase - there is no danger that a potentially inflated cap has long-term implications on supply and demand. This is a crucial provision as the data to determine the cap was of mixed quality and the experience in other countries has shown that the cap of the first phase of carbon trading schemes tend to be too high (Oeko-Institut e.V. 2018).

The effectiveness in the operational phase depends strongly on the political willingness to reduce the cap and to ensure scarcity in the market. To assess the environmental effectiveness, it would also be necessary to know the specific rules for offsets which operators will be able to use. The experience with JI and CDM has shown, that many projects were not additional despite strong regulation (Kollmuss et al. 2015). If a stringent cap is introduced and the rules for offsetting are sufficient enough, the Mexican ETS could lead to real and credible emission reductions in the future.

4 Introduction to the Mexican electricity market

4.1 Market design and structure

4.1.1 Market Design

The electricity sector in Mexico has undergone several attempts towards liberalization, without having succeeded until 2014. For the past 60 years, the electricity sector in Mexico was controlled by the federal government under a vertically integrated monopoly, the CFE. According to the law on public electricity supply (Ley del Servicio Público de Energía Eléctrica, LSPEE), it was the exclusive right of the state to generate, transform, distribute and supply electricity; leaving the provision of all these services to the CFE (Cámara de Diputados 1992). Electricity was produced under a non-competitive scheme where electricity tariffs were not determined by market criteria (Gastelum Rivera et al. 2015). According to the interviews, being an oil-rich country, Mexico favoured the development of electricity-generation facilities based on fuel oil, where PEMEX sold the fuel oil to CFE far below the opportunity cost.

The LSPEE also stipulated that the Ministry of Finance should determine retail tariffs that allow for the recovery of electricity supply costs. However, energy subsidies to protect consumers from constant price increases due to inflation (Komives et al. 2009) have been in place since 1973, and remain so until today - representing approximately 1 % of GDP each year (Sánchez et al. 2018) The subsidies led to net losses for the government and consequently to shallow investment levels within CFE (whose investments were centrally planned and approved by the government); this increased production costs over time and thus, in turn, the subsidies themselves.

In 1992, amendments were made to the law and the private sector was allowed to participate in the electricity industry. Its participation was exclusively allowed[7] in the generation segment, under different modalities: self-consumption, cogeneration, exports and imports, small production and independent production of electricity (the latter with generation exclusively for sale to CFE). The scheme of independent producers of energy (Productor Independiente de Electricidad - PIE), was the most successful. These projects were financed by the private sector in two modalities: (a) selling the energy to CFE, with a prior 30-year purchase contract; or (b) built and operated by the private sector entity until CFE became the owner after completely paying the investments through agreed energy rates. However, the public sector debt grew exponentially as interest rates went up from 37 % in 1992 to 70 % in 2002 (Cámara de Diputados 2002). Moreover, formulas for tariff calculation include uncertainty over time concerning the peso exchange rate against the dollar and the behavior of fuel – also affecting prices over time.

Even though the PIE scheme allowed the introduction of more efficient combined-cycle power plants[8], the lack of gas pipeline networks to satisfy total demand caused greater use of more expensive fuels, such as fuel oil, diesel or liquefied natural gas (PwC 2019). In addition to this, subsidies, electricity theft, and significant labor liabilities contributed to high production costs

[7] The negotiation of the North American Free Trade Agreement was the opportunity to initiate deregulation and liberalization in this industry. Among the agreements reached, it was established that American and Canadian companies could participate in the generation segment. This coincided with the experiences of deregulation and privatization of the electricity sector that was being carried out worldwide.

[8] However, the interviewees mentioned that currently, these rates are much higher than those experienced in the wholesale electricity market, primarily because of the long-term auctions.

and inadequate finances for the public sector. However, attempts to pass an energy reform that could address these issues failed in 1999, 2002, and 2006 (Valenzuela and Studer 2016).

Table 4: Participants of the market structure

Market participant	Description
Generation	• 'CFE Generation' power plants[9] • Private generators, who are directly involved in the market; and pre-reform private participants ('PIEs' and self-supply) participating through pre-established contracts. • Exempted Generator: power plants with a capacity of less than 0.5 MW that do not require a generation permit. They sell electricity to basic service suppliers at regulated rates.
Independent operator	An independent system operator manages the dispatch, CENACE. The operator must dispatch the electricity-based on marginal costs.
Suppliers	The supply segment is categorized into: • Qualified supplier ('suministrador calificado'): purchases electricity in the wholesale market (i.e. the 'MEM') to provide electricity to qualified consumers. • Basic supplier ('*suministro básico'*): provides electricity to users that cannot participate in the MEM (basic consumer). • Last resource supplier.
Transmission & Distribution	The State maintains exclusivity in planning and control of transmission and distribution. Investments in transmission are possible through public-private partnerships.
Consumers	• Basic consumer (small and medium consumers): end-user with a demand less than 1 MW; has to buy its electricity from the basic supplier at regulated or subsidized rates. • Qualified consumer (medium industry): is an end-user with a demand greater than 1 MW and less than 5 MW. They can participate in the MEM through a qualified supplier. • Qualified consumer participating in the MEM: is an end-user with a demand greater than 5 MW and higher annual consumption or equal to 20 GWh. They can participate in the MEM directly or through a qualified supplier.

Source: Own elaboration, Adelphi, based on Hernandez (2017)

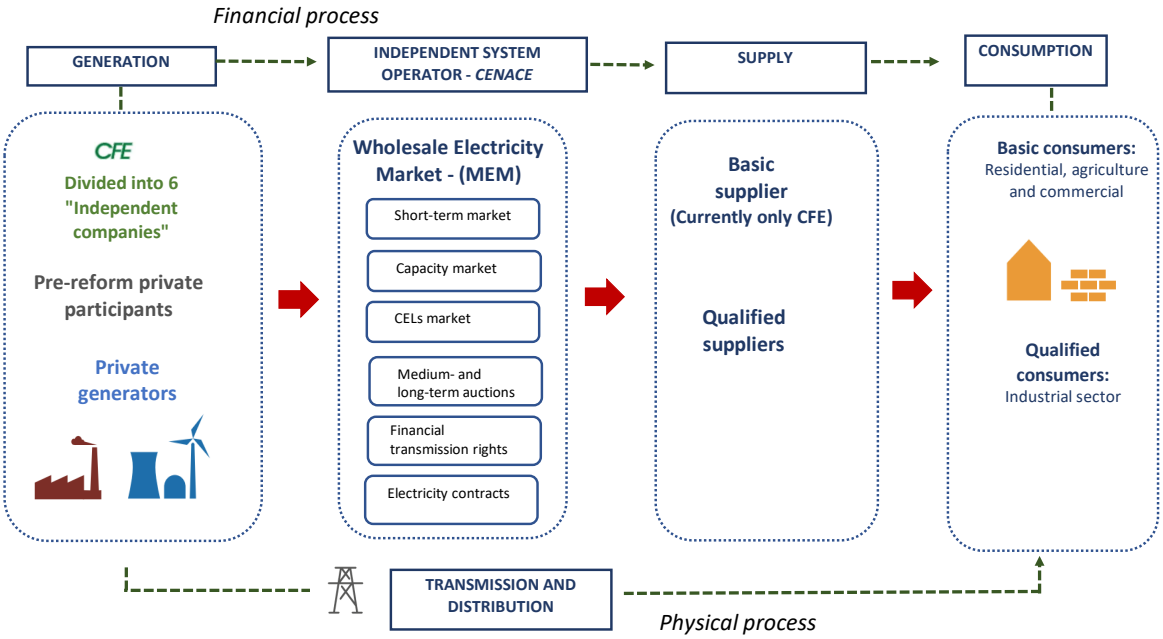
In 2014 an energy reform was enacted by Congress, enabling a comprehensive restructuring of the sector. The generation and retail segments were opened to competition from the private sector; CFE activities were unbundled into generation companies and retail companies, while maintaining the monopoly of transmission and distribution. The National Energy Control Centre (Centro Nacional de Control de Energía - CENACE)[10] was created as a decentralized public agency to exercise operational control of the electricity system and of the wholesale electricity market, and to guarantee access to the transmission and distribution networks. The statutes of CENACE as well as those of the Energy Regulatory Commission (Comisión Reguladora de Energía – CRE), establish them as independent entities that must guarantee competition in the

[9] According to the legal framework of the energy reform, CFE had to be divided into six "independent generation companies" with legal personality and technical, operational, and management autonomy. However, in 2019, an agreement that repealed this separation was published.

[10] Prior to the reform, CENACE directed the operation and supervision of the electricity infrastructure owned by CFE.

market. The reform also created a wholesale electricity market[11] (Mercado Electrico Mayorista – MEM), aimed to lower the production costs through competitive tariffs (Hernandez 2017). Table 4 describes the market participants, and Figure 2 shows the new market structure.

Figure 2: Electricity market structure



Source: Own elaboration, Adelphi, based on Hernandez (2017)

However, Mexico had a change of government in 2018. The new administration has exposed its disagreement with the rules of the energy reform, under the argument that it was achieved through corruption, and that CFE does not hold a level playing field favouring foreign private companies (Cámara de Diputados 2021). For this reason, the President has sent an initiative to Congress to amend the Electricity Industry Law, proposing fundamental changes to the current regulations. This situation has generated a point of contention between the government, the private sector, and civil society.

The government's central debate relies upon three main aspects (Cámara de Diputados 2021): The dispatch based on marginal costs hides fixed costs and privileges the privately-owned renewables at the expense of CFE fossil-based plants. The new initiative proposes to move away from marginal-costs dispatch. Second, pre-reform contracts enjoy high subsidies from CFE:[12] the PIEs received increasing rates in generation contracts, and the self-supply generation model does not pay for transmission costs fully.[13] The government proposes to modify these contracts. The third argument is that CFE heavily subsidizes privately-owned renewable plants by buying clean energy certificates (Certificados de Energía Limpia - CELs) and paying increasing

[11] The reform also opened the oil and gas sector, as another of its main objectives was to boost oil exploration and extraction. While Mexico is the 10th biggest crude oil producer worldwide, its oil production has shown a decreasing tendency as 80 % comes from mature fields already declining (Secretaria de Energia 2014). This sector is out of the scope of this study.

[12] These contracts were not part of the energy reform, but obtained generation permits under original (pre-reform) conditions under the general principle of non-retroactivity of a law.

[13] In 2009, the Energy Regulatory Commission designed a tariff model for the self-supply modality to incentivize renewables. Under this model, a private company could use the transmission grid with a preferential porting fee. It generated growth in renewables but it was not recognized in the CFE budget, impacting CFE's transmission finances.

transmission costs and backup for intermittency.[14] The initiative proposes grant CELs to power plants installed before the law was enacted.

The changes proposed by the government to amend the law have been declared unconstitutional and suspended by the legal system. However, the government will seek to amend the constitution to redeem the unconstitutionality. In the meantime, the government has initiated secondary modifications to the market rules that largely harm the promotion of renewable energies. The first modification was to cancel the long-term auctions[15], which had encouraged additional renewable energy capacity and two tenders for building public-private transmission lines in two high renewable potential areas. Moreover, the Ministry of Energy, issued an agreement[16] which imposed limitations on the approval process of new renewable energy projects. This Agreement also requested the system operator to give preference to "stable" power plants, arguing that renewables endanger the system's reliability in times of the COVID-19 pandemic (SEGOB 2020a).These modifications are seen by many to run contrary to the rules stated in law, and often have the effect of weakening existing institutions.

The sections that follow present the current status of the energy market regulations, as per the 2014 energy reform. The degree of restructuring with ongoing and future regulatory changes is uncertain.

4.1.2 Market Structure and Dynamics

Capacity mix, investments and age of power plant fleet

The capacity mix is diverse in terms of the technologies and energy sources used. In 2017, the installed capacity was 75 685 MW – 72 % of which corresponding to conventional power plants based on fossil fuels, 26 % to renewables (including hydro) and 2 % to nuclear. The installed capacity grew 44 % in 2007-2017. During this period, the installed capacity of combined cycle power plants (representing 45 % of total capacity) and coal plants (representing 7 %) doubled, and HFO plants slightly decreased. A pronounced growth of renewable energies, mainly due to the installation of new wind and solar power plants, started in 2014 (SENER 2018).

The Ministry of Energy is in charge of planning future installed capacity. This planning is published through the Indicative Program for the Installation and Retirement of Power Plants (Programa Indicativo para la Instalación y Retiro de Centrales Eléctricas, PIIRCE). On an indicative basis, it establishes the public and private investments planned in the next 15 years.[17] The publication also includes the decommissioning of assets. Generation capacity is expected to double by 2030 compared to 2017, mainly driven by the anticipated increase in demand and the need to modernize the fleet. This plan foresees that combined cycle power plants will continue to prevail, representing at least 50 % of total installed capacity, replacing three-quarters of HFO plants along the way. On the other hand, renewables will almost triple their capacity by 2030, led by wind and solar (Figure 3).

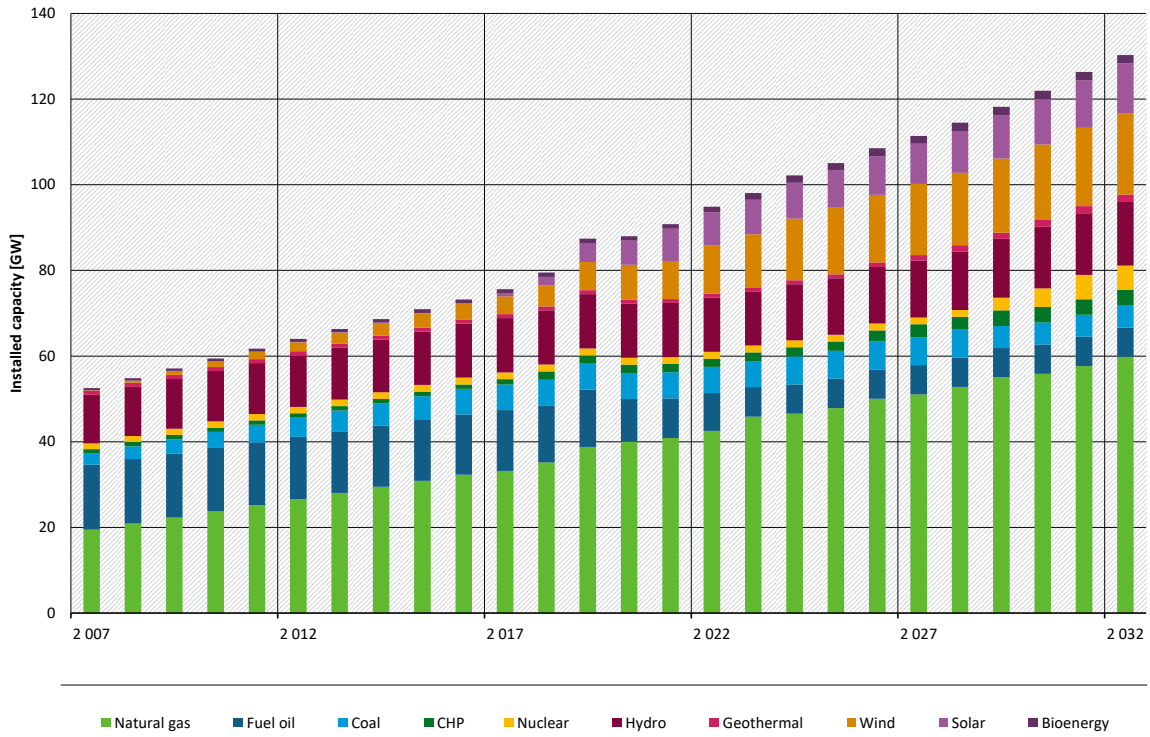
[14] Both, private and public participants must purchase CELs to comply with the clean energy standard mandated by law. It is also worth noting, that the law states that transmission fees and backup costs (through ancillary services) are included in the supply tariffs, not in the generation tariffs.

[15] Long-term electricity auctions had the purpose of allocating contracts to purchase capacity, electricity, and Clean Energy Certificates.

[16] Agreement of the Reliability, Safety, Continuity and Quality Policy for the National Electricity System

[17] Within this planning, the first three years correspond to projects that, for the most part, already have an installation permit.

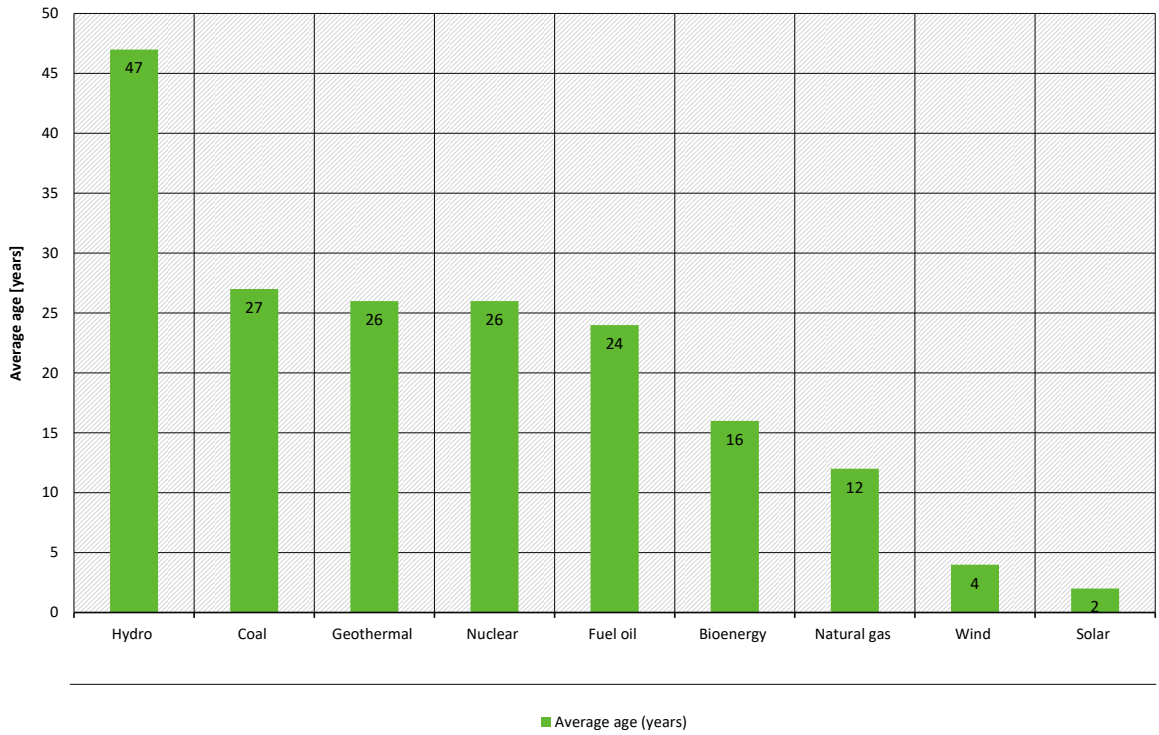
Figure 3: Installed capacity by fuel for 2002 -2017 and expected installed capacity for 2018-2032



Source: Own elaboration, Adelphi, based on SENER (2018)

The fleet's age is 17 years on average: the oldest installation is a hydropower plant (112 years old), followed by a conventional thermoelectric plant (54 years old). Of these, coal plants have the highest average age at 27 years; however, they are younger than those in Germany (29 years) and Poland (48 years) but older than plants in China (14 years) (Acworth et al. 2021). HFO plants are 24 years old on average and are the most inefficient and expensive to run in the electricity system. Renewable power plants (wind and solar) are the youngest generation facilities on average (Figure 4).

Figure 4: Average age of the fleet

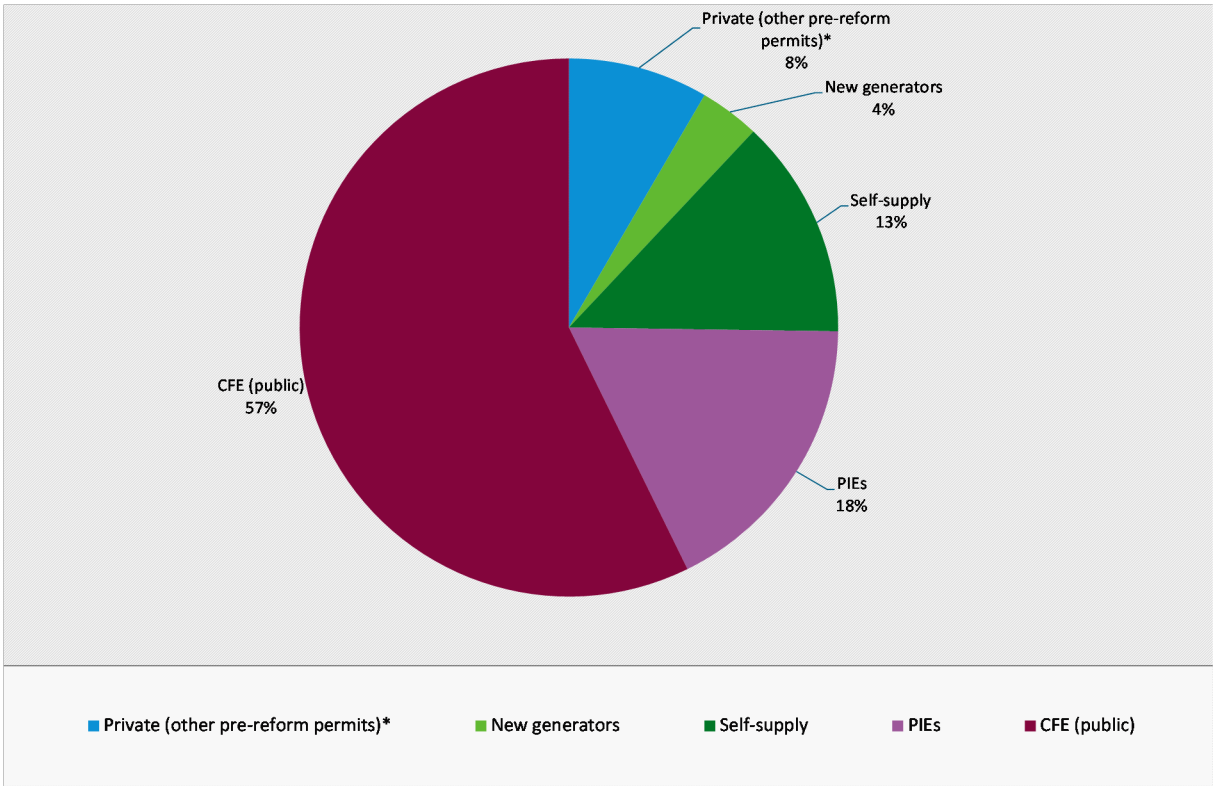


Source: Own elaboration, Adelphi, based on SENER (2018)

Ownership and Market Concentration

In 2017, 57.2 % of the total installed capacity corresponded to power plants owned by the public sector (i.e. by CFE), and 42.8 % to the private sector (Figure 5). The private sector generation capacity is divided between (a) PIEs, which were established before the energy reform and supply exclusively to CFE; (b) systems of self-supply, cogeneration, export, and distributed generation established before the reform; and (c) liberalized private generation put in place after the energy reform. From the private sector, 17.5 % of the generation capacity belonged to PIEs, 3.5 % to new private generators, and the remaining 21.7 % fell under the pre-reform modalities of self-supply, cogeneration, export, and distributed generation (SENER 2018).

Figure 5: Share of capacity by ownership



Note: * Other pre-reform generation permits includes small production, CHP, exports, own uses and distributed generation (not connected to the grid)

Source: Own elaboration, Adelphi, based on SENER (2018)

Even after the introduction of market reforms, there are essential differences between CFE and private companies owing to the utility's broader mandate to support state finances and socioeconomic policy (Cámara de Diputados 2014a). From its earnings, CFE must make an annual payment (additional to taxes) to the federal government, determined by the Ministry of Finance. Secondly, it must prioritize energy access. And thirdly, at the time of writing, CFE was the only basic supplier in the market, so it must supply electricity to the basic consumers (residential, commercial, and agriculture). Low retail tariffs in the residential and agriculture sectors have become a political promise, becoming an obstacle to eliminating energy subsidies for this segment.

In terms of technologies, the public sector's assets are more carbon-intensive, older, and less efficient than the private ones, as the latter have recently installed more efficient and competitive combined cycle and renewable power plants (SENER 2018). According to the interviews, in face of a carbon price, CFE thus stands at a comparative disadvantage.

To promote competitiveness, the 2014 energy law mandated that CFE be divided into six different subsidiaries with an equal amount of generation assets, technology shares and geographical distribution (Cámara de Diputados 2014b). The objective was to foster competition in the market, while CFE focused on strengthening transmission and distribution. However, changes by the current Federal administration have put into question the CFE restructuring process, as there have been attempts to re-integrate the subsidiaries into a single company[18]. In

[18] See, e.g. "Agreement amending the Terms for the strict legal separation of the Federal Electricity Commission, published on January 11, 2016", https://www.dof.gob.mx/nota_detalle.php?codigo=5555005&fecha=25/03/2019.

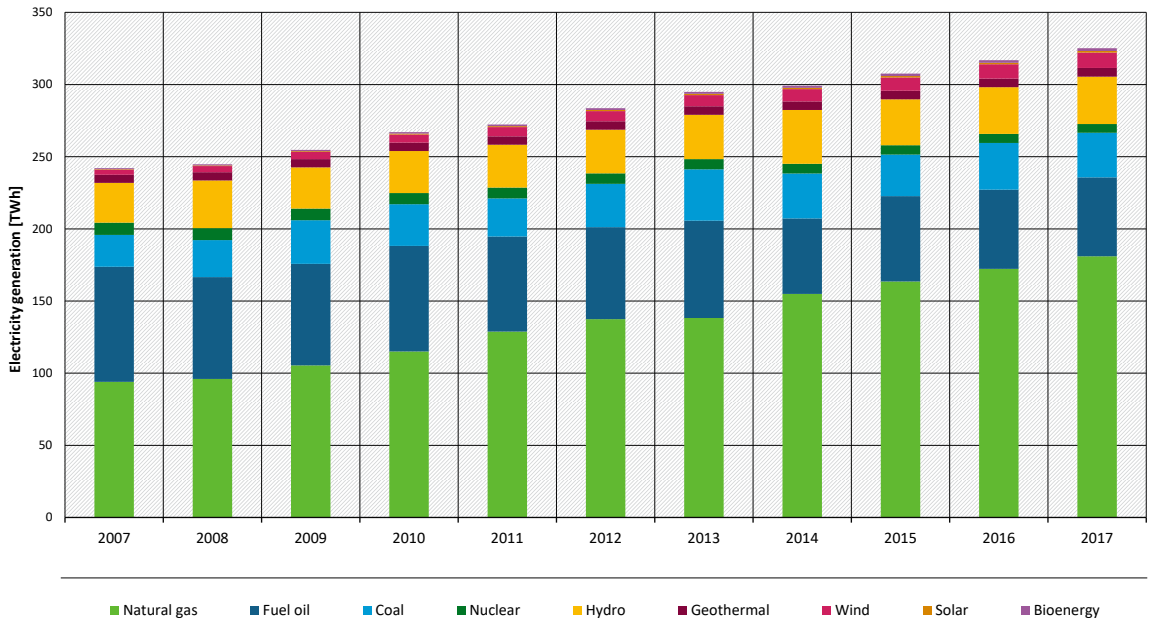
a presidential address, the current administration stated its intention for CFE to maintain a 55 % market share (Nava 11 Oct 2019).

Electricity generation and demand

Much in line with the characteristics of the capacity mix, electricity generation is based 80 % on fossil fuels: 56 % on natural gas, 14 % fuel oil and diesel, and 11 % on coal; 3 % nuclear, 10 % hydro[19] and the remaining 6 % on other renewable energy (wind, solar and bioenergy) (Figure 6). Recent years have seen a substitution of fuel oil with natural gas, mainly because of the generation costs of $200 US/MWh versus $40 US/MWh, respectively. These costs are due to (a) differential fuel prices ($7.94 US/MMBtu for fuel oil versus $ 2.53 US/MMBtu for gas in 2019) (ESTA 2020)[20]; and (b) efficiency[21].

Under the prior administration and before the clean energy long-term auctions were cancelled, the drop in technological costs facilitated increases in renewable energy generation at an average price of USD 20.5/MWh in 2017 (where one of the winning bids offered the solar MWh at USD 17.7, one of the lowest prices reached worldwide) (CENACE 2017).

Figure 6: Electricity generation by fuel for the period 2007-2017



Source: Own elaboration, Adelphi, based on SENER (2018)

In terms of consumption, electricity is the second-largest energy source in Mexico, representing 18 % of total national energy consumption (INECC 2018). Demand has been increasing at an average annual growth rate of 2 % over the past decade. In 2018, industry represented 60 % of total consumption, followed by residential and commercial buildings with 35 %, agriculture with 4.5 %, and transport with 0.5 % (Figure 7).

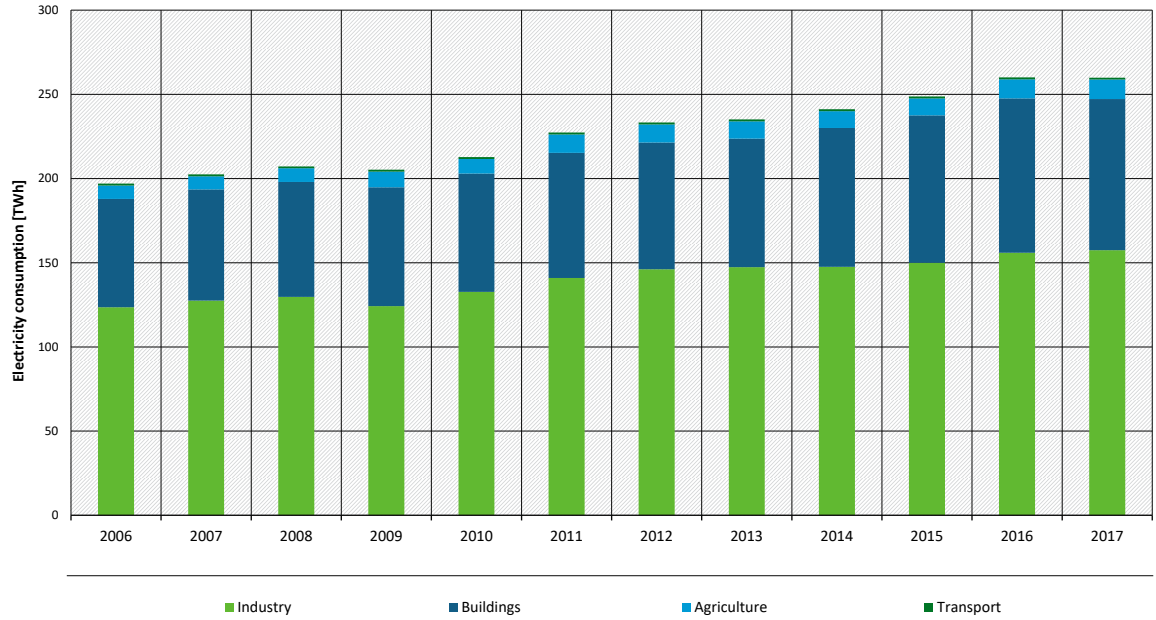
The electricity sector is the second-largest contributor to GHG emissions, representing 18 % of total national emissions (INECC 2018).The transport sector is the highest emitting sector, accounting for 24.5 % of national GHG emissions.

[19] Recent droughts have reduced the generation capacity of hydro power plants.

[20] Assuming an average 2019 exchange rate of 19.25 Mexican pesos/US dollar.

[21] A combined cycle power plant is 1.4 times more efficient than internal combustion or conventional thermo.

Figure 7: Electricity consumption by sector



Source: Own elaboration, Adelphi, based on SENER (2018)

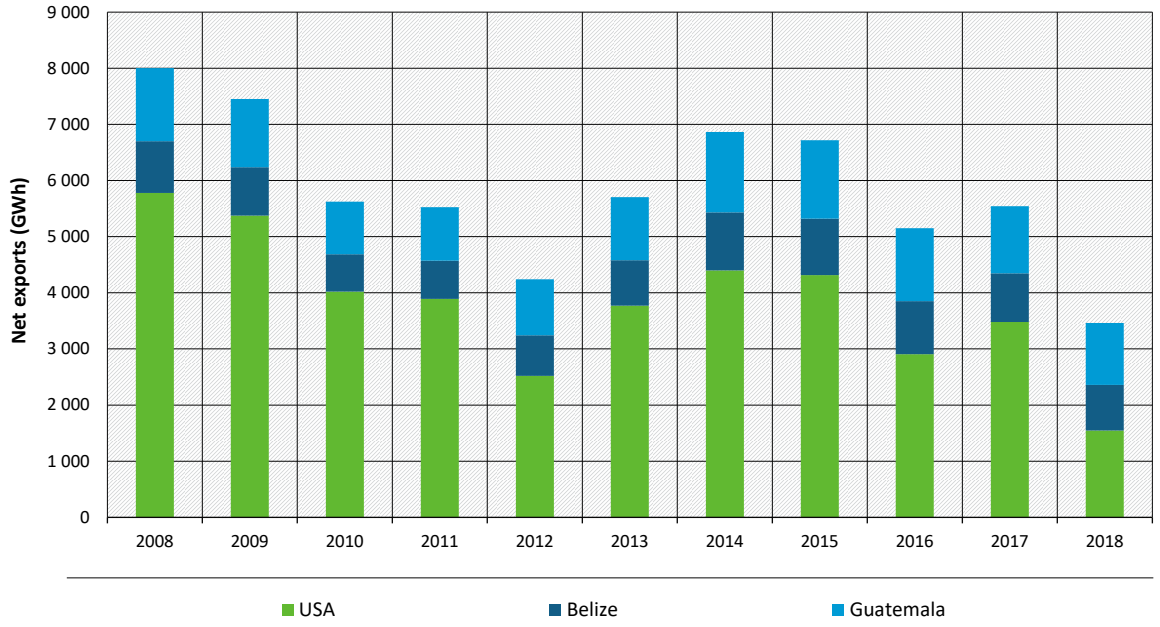
Cross-border electricity trade

There are 13 interconnections in Mexico with North and Central America, out of which 11 are on the border with the United States, one with Belize and one with Guatemala. Mexico has been a net exporter of electricity in the past decade, although with high annual fluctuations. Most trade is with the United States, where net-exports represented around 70 percent of the total in 2017, followed by 15 percent to Guatemala and the rest to Belize. In 2017 total net exports were 3 463 GWh, amounting to 1.24 % of Mexico's total electricity demand (SENER 2020b).

The liberalization of the energy market opened the door to new energy integration opportunities between Mexico and the United States. In particular, the possibility of private investments in transmission[22] could increase trade, reduce prices, provide greater electricity systems stability, and ensure the adequacy of electricity supply between both countries (Energía a Debate 2017).

[22] Even though the State maintains exclusivity in planning and control of transmission and distribution, investments in information are possible through public-private partnerships, such as a build-operate-transfer (BOT) contracts.

Figure 8: Cross-border electricity trade



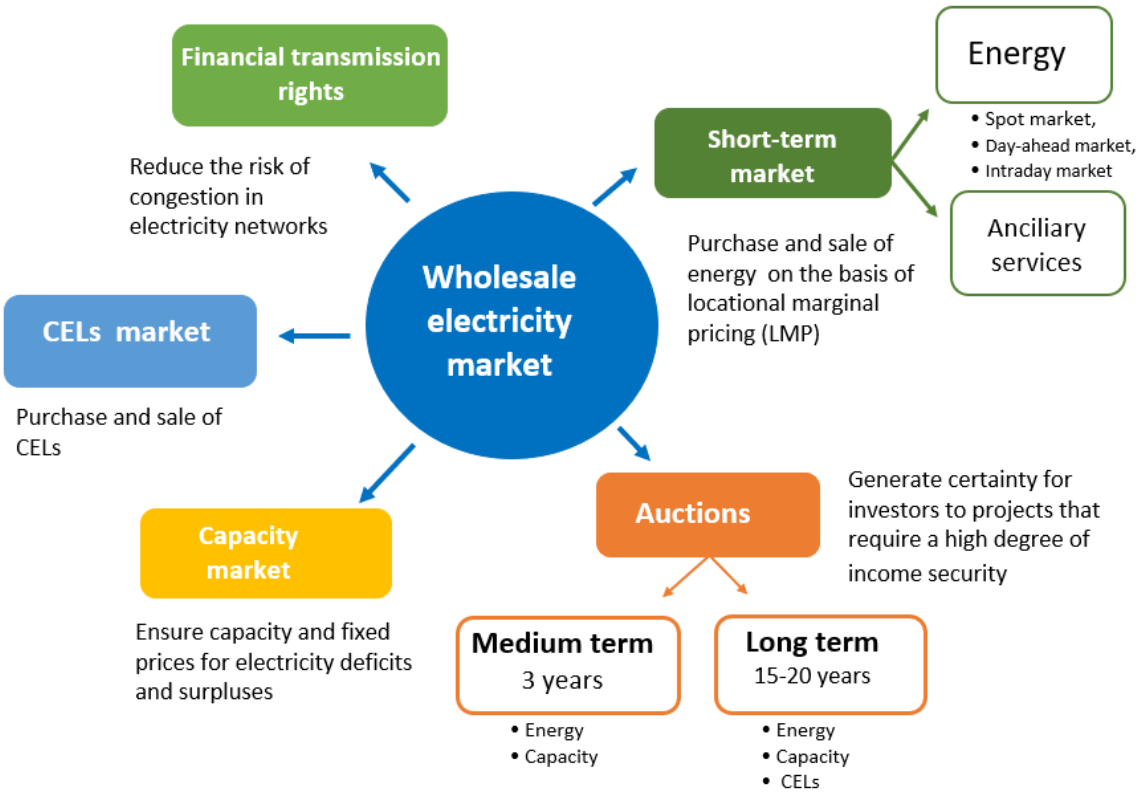
Note: Data for 2018 is preliminary

Source: Own elaboration, Adelphi, based on SENER (2020c)

4.2 Wholesale markets and dispatch

The wholesale electricity market (MEM) started operating in 2016 and its liberalization is still ongoing, albeit with an uncertain future. In the MEM, transactions are conducted for the purchase and sale of different products: electricity, related services, capacity, financial transmission rights (Derechos Financieros de Transmisión, DFT) and clean energy certificates (CELs), through the mechanisms described in Figure 9.

Figure 9: The wholesale electricity market



Source: Own elaboration, Adelphi, based on PCME (2020)

With the MEM's operationalization in 2016, generators that were already in operation before the reform were able to choose between participating in the MEM (as market participants), or continue under previous arrangements to transition to the market once these contracts have expired.[23] Generators that decide to retain prior arrangements then operate under their pre-reform contracts. Particularities vary depending on the type of the generation permit:

- CFE power plants: applicable to power plants either in operation before 2014 or already planned in the federal budget. These generators have the right, but not the obligation, to enter into contracts with the basic supplier. They can also migrate to the MEM
- Independent Power Producers (PIEs): will be represented by CFE in the MEM and will keep their initial contract conditions. When these contracts expire, they have to migrate to the MEM. Self-supply and other pre-reform permits: 20-year contracts between private companies that also have to migrate to the MEM when the contracts expire.

4.2.1 Wholesale prices

From these mechanisms in the MEM, energy is bought and sold under the short-term energy market. The MEM aims to send price signals through criteria of economic efficiency and security of dispatch (ESTA and Instituto Politécnico Nacional 2017). In this market, the **locational marginal price (LMP)** indicates the market price by hour and by node (N), which allows costs

[23] According to interviewees and CFE sources, most of these contracts will expire around 2030.

to be related to demand and its geographical location. The LMP is made up of three components (ESTA and Instituto Politécnico Nacional 2017):

LMP_N: $Energy_N$ + $Congestion_N$ + $Losses_N$

Fuel prices are the main component of the marginal costs of generating electricity. Additionally, the price also captures the levels of the network´s saturation and transmission losses. The short-term market design contemplated a gradual implementation in two stages, the first one starting in 2016, comprising the day-ahead and real-time market operation. The second stage was planned to start at the beginning of 2020 and would operate an hour-ahead market (Favio Perales 2018), but as of early 2021 the actual starting date of this stage remains uncertain. Table 5 shows the description of the transactions in the short-term market (ESTA and Instituto Politécnico Nacional 2017).

Table 5: Short term energy market mechanisms

Market	Description
First stage	
Day-ahead market (Mercado en día de Adelanto - MDA),	Sale and purchase offers for next day use (24 prices presented - equivalent to 24 hours/day)
Real-time market (Mercado en tiempo real, MTR)	Offers energy for immediate purchase, for the same day. This market is used to cover the costs of an imbalance in the MDA.
Second stage	
Hour-ahead market (Mercado de una hora en adelanto, MHA)	Supply and demand are updated with just one hour in advance, but which is not yet in operation as it corresponds to the Second Stage of MEM operation and whose starting date is still uncertain.

Source: Own elaboration, Adelphi, based on ESTA and Instituto Politécnico Nacional (2017)

Under this market, prices are a function of supply and demand. However, the system operator makes an evaluation of the prices offered. It evaluates the energy offers by comparing them with its own reference prices. These reference prices are estimated using the start-up cost, the energy supply (includes variable costs of generation, transmission rate, operator fee, among others), and the costs for related services. If generators submit an offer that exceeds these parameters, they must justify the differences. Otherwise, their offers will be rejected (ESTA and Instituto Politécnico Nacional 2017).

According to the pre-reform contracts, if not migrated to the MEM, electricity prices are agreed between the parties. CFE's assets are regulated and governed under the 'cost of service regulation'. Where the electricity price charged by CFE is defined using historical consumption data (2014-2018), the LMP observed in the previous year, and, most importantly, the operational costs (including depreciation). On the other hand, the PIEs are not exposed to the wholesale market since they have contracts with CFE. This exclusion can have a distorting effect as the PIEs represent about 25 % of the total generation (SENER, 2019).

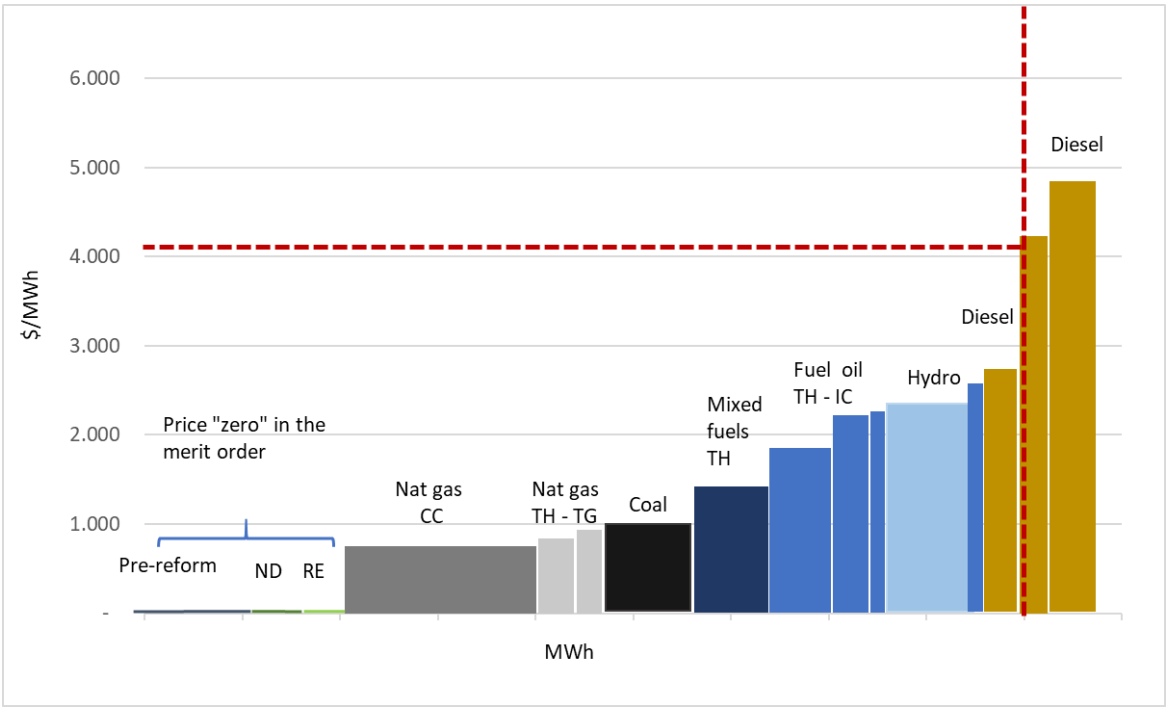
4.2.2 Dispatch

Under the energy reform, the allocation of power plants to operate is set to be under merit order, allowing first entry to the lower marginal cost power plants. Figure 10 shows the dispatch using the average price per MWh (USD/MWh) by type of technology and fuel used in the day-

ahead market in 2018. Priority dispatch applies to three groups irrespective of price: (a) non-dispatchable intermittent sources (renewable energy such as solar and wind), (b) non-dispatchable firm sources (nuclear, hydro, geothermal, and some combined cycle) and (c) the plants belonging to the pre-reform contracts, which are in their great majority gas power plants. The latest reform to the energy industry law changes dispatch order (Cámara de Diputados 2021) but it is contested in court and not yet implemented.

In the dispatch curve, natural gas is already cheaper to run than any other fuel technology. In 2018, however, there was an increase in the LMP as thermal plants that use diesel and fuel oil had to be used more frequently especially in periods of high demand due to gas shortages and congestion (ESTA 2018). Under this scenario, the potential to trigger a fuel switch with a carbon price is minimal, and the opportunity lies in increasing renewable energy capacity. A high carbon price could turn fossil plants' costs unbearable, providing incentives for alleviating congestion and investing in proper infrastructure in the long term. Moreover, the power plants under pre-reform contracts will not be influenced by the carbon price.

Figure 10: Dispatch



Notes: The width of the generation bars and their prices represent the merit order of 2018 average electricity sales bids in the day-ahead market. ND: non-dispatchable non-renewable sources, RE: renewables, CC: Combined cycle, TH: thermoelectric, TG: Turbogas, IC: Internal combustion. Mixed fuels include natural gas, diesel, and fuel oil. Hydro is divided into two: with or without the restriction of available energy. Hydro without restrictions is listed as non-dispatchable along with other renewables, whereas hydro with restriction in available energy is placed in the merit order according to the opportunity cost[24]

Source: Own elaboration, Adelphi, based on ESTA (2018)

[24] The opportunity cost is determined by the sum of the variable costs and the shadow price related to the limitation in the consumption of their energy resource. In this case, it is not optimal to dispatch them based on their production costs since, being so low, the energy resource could be depleted during the first periods (SEGOB (2017a)).

4.3 (Dis)investment and interacting policies

4.3.1 Regulation of generation investments

Opening the energy market has attracted private sector investment. The main elements inducing investments are the low natural gas prices from North America (eia 2021), enabling higher margins for gas plants owners, and the clean energy certificates, encouraging wind and solar energy to increase at a fast pace. By 2030, 43 % of the total electricity generation is supposed to come from renewables and CHP (SENER 2018).

Moreover, one of the most successful schemes to incentivize investments were the long-term auctions for electricity and CELs, the vast majority of which were won by wind and solar projects. However, the auctions have been cancelled, and a new mechanism has not yet been announced. Most interviewees highlighted that this decision had brought significant uncertainty to the investment framework, especially for the private sector.

Likewise, CFE aims to triple the total national nuclear capacity by 2028, going from 800 MW to 2 400 MW, to represent 6 % of the total generation (see Figure 3). These plans have been in place for at least eight years. The original plan from 2012 was for construction to begin in 2021, but due to financial barriers it has been postponed year by year (SENER 2013; 2018). Interviewees also mentioned that following other countries' experiences, the expansion in nuclear will not be economically feasible.

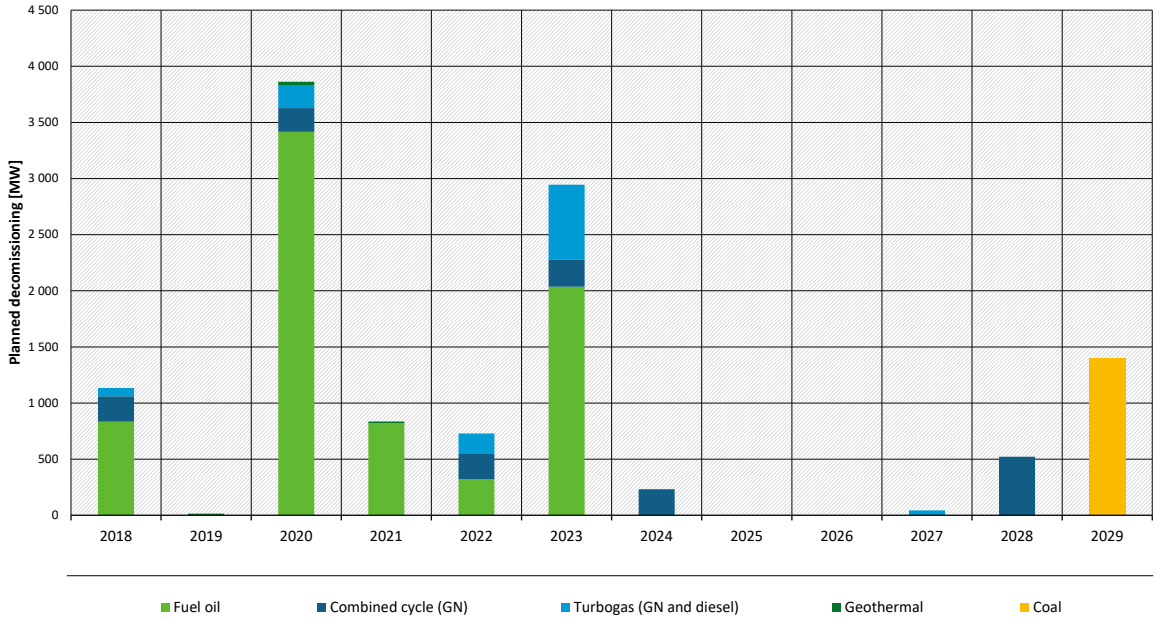
In terms of governance, the investment process for CFE faces important constraints. After the energy reform, CFE is supposed to have budgetary autonomy; however, it still faces strong regulation. For example, for significant investments, such as building new power plants, CFE has to generate debt through the Ministry of Finance. The Ministry of Finance, which maintains the right to adjust CFE's plans depending on public finance availability, sends it to Congress for approval. According to interviewees, CFE has not had sufficient resources over to renew its assets for several years, investing only in retrofits.

4.3.2 Decommissioning (closures)

The PIIRCE[25], published annually by the Ministry of Energy, includes a timeline for the decommissioning of assets. The main factor for decommission is whether the asset has been used for its full economic life (between 25 and 60 years, depending on the technology) (SENER 2018). Overall, generators are required to notify the system operator of decommissioning plans one year in advance, so that the system operator can evaluate whether the unit is necessary to guarantee the system's reliability. If the unit is deemed to be necessary for system reliability, then the generator must provide an alternative source to replace the same amount of power. The 2017 energy prospective stated that during the 2018-2032 period 53 % of the fuel oil, 23 % of the coal, and 9 % of the natural gas-based assets need to be retired or require substantial retrofit as they are close to become obsolete (Figure 11).

[25] Indicative Program for the Installation and Removal of Power Plants

Figure 11: Plants foreseen for retirement or substantial retrofit by technology as of 2018



Source: Own elaboration, Adelphi, based on SENER (2018)

However, the new administration announced that not all decommissioning will occur, in line with an objective to strengthen CFE´s role in the electricity market (SENER 2019b). Instead, the administration aims to retrofit these plants (SENER 2019b). According to the interviews, however, these plants are inefficient and expensive to run and interviewees doubt that they can be kept in circulation.

4.3.3 Capacity markets

The objective of the Mexican capacity market is to promote sufficient installed capacity to guarantee the reliable operation of the electricity system. Under this market, generators commit to maintaining during a given period a certain level of capacity which can be offered to the short-term market (SENER 2015).

On the other side, suppliers and qualified consumers who participate directly in the MEM are obliged to acquire an amount of capacity that is determined by the Energy Regulatory Commission (Comisión Reguladora de Energia, CRE). The CRE establishes these requirements as a function of the demand, taking into account the area and the probability of unsupplied energy into the system between other variables.

The capacity obligations can be obtained through:

- Medium-term and long-term auctions: both auctions will be held annually. Medium-term contracts will be for the following three years and the long-term will have a duration of fifteen years (the delivery of these products will begin three years after the auction is held).
- The capacity balancing market: this market operates annually. It offers the opportunity to the qualified consumer and the suppliers to obtain capacity when their electricity hedging contracts were insufficient to comply with the regulation requirements. They will carry out transactions with entities with surpluses related to their installed capacity commitments that are not covered or committed through any agreement.
- Bilateral contracts: the contract agreed between the two parties.

4.3.4 Companion policies and drivers of investment

4.3.4.1 Renewable Energy Promotion

The Energy Transition Law[26] (Ley de Transición Energética, LTE), sets targets for clean energy generation: 25 % of the electricity must be generated by clean sources in 2018, 30 % in 2021, and 35 % in 2024 (Cámara de Diputados 2015b). A particularity is that the definition of clean energy in the law includes renewable energy (including big hydro), as well as nuclear, efficient co-generation, and fossil fuel-facilities with carbon capture and storage (Cámara de Diputados 2015b). To meet the targets and provide certainty in clean investments, the government created a market for clean energy certificates (CELs). The participants in the CELs market are:

a) Participants that receive CELs: any clean energy project which entered operation after 2014.

b) Participants who must submit CELs: the suppliers (i.e. the basic supplier, qualified suppliers and last resource suppliers), qualified consumers who participate directly in the MEM, and the holders of pre-reform contracts (self-supply).

Under this mechanism, the Ministry of Energy established the CELs requirements as a proportion of the total electricity consumed (Figure 12).

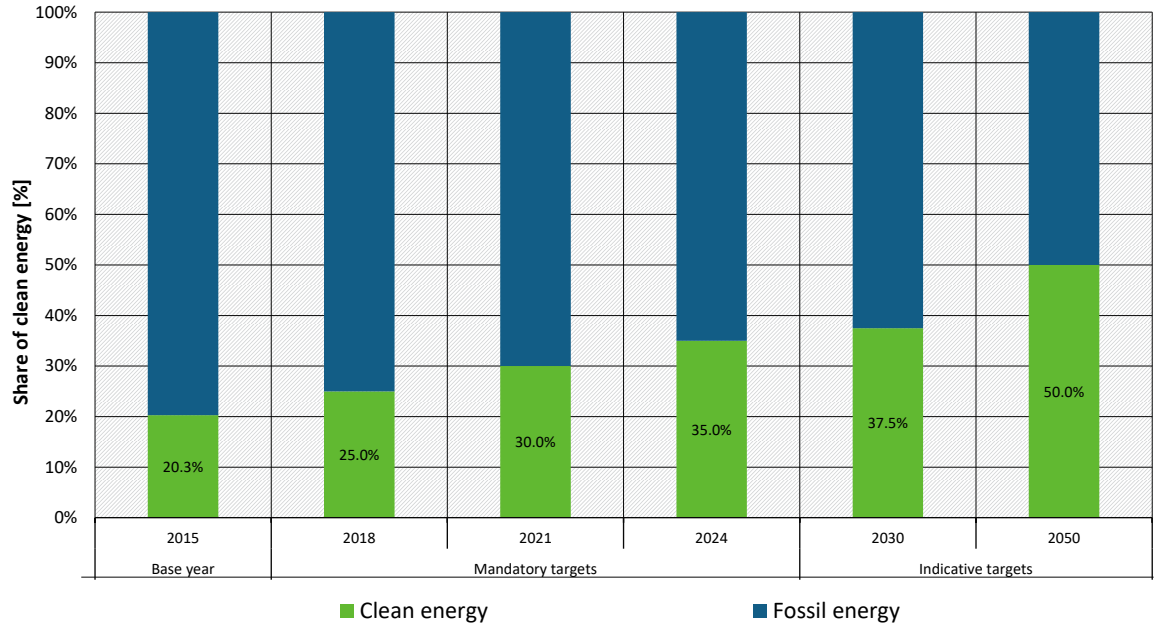
Figure 12: CELs requirements

Source: Own elaboration, Adelphi, based on SEGOB (2017b)

The future of the CELs policy is currently unclear. In the longer term, the Strategy to Promote the Use of Cleaner Technologies and Fuels (Energy Strategy, SENER 2020a), which is Mexico's long-term national energy policy planning instrument, established indicative and non-mandatory clean energy targets for 2030 and 2050, although the NDC does set a 43 % of clean energy target for 2030 (Figure 13) (SENER 2020a). In the short-term and perhaps more importantly, the current administration is looking to reform the CELs system, notably by allowing old renewable energy facilities and especially old hydro energy plants to generate CELs. Under the current law, this is not possible, as only facilities established as of 2014 can participate as a means of incentivizing new capacity. The government has also cancelled clean energy auctions which were meant to bring new capacity and CELs into the system. These proposed changes have been challenged by market participants.

[26] In 2008, in an attempt to pass an energy reform, the government published the Law for the Use of Renewable Energies and the Financing of the Energy Transition (Ley para el Aprovechamiento de las Energías Renovables y el Financiamiento de la Transición Energética, LAERFTE). The law set that electricity generation must have a maximum of 65% of fossil fuels in the mix in 2024 and 50 % in 2050. The LTE replaced the LAERFTE and eliminated the 2050 target.

Figure 13: Clean energy targets



Source: Own elaboration, Adelphi, based on SENER (2020a)

4.3.4.2 Energy efficiency

The 2014 energy reform also set an indicative national energy efficiency target which promotes a 1.9 % annual reduction rate of the final energy consumption of the economy (PJ/GDP) for the period 2016-2030 and a 3.7 % annual reduction rate for the period 2031-2050 (Cámara de Diputados 2015a).

This target, set in PJ/GDP, is not comparable to sectoral goals set in absolute reductions. According to the experts interviewed, it is not clear whether these targets were taken into account in the mitigation target contained in Mexico's NDC, or in the design of the ETS pilot phase. The potential for reducing emissions through Mexico's energy efficiency target is not yet clear, and its sectoral targets in reducing emissions have not been calculated officially.

4.3.4.3 Carbon Tax

In 2013, as part of its fiscal reform, Mexico introduced a carbon tax which is applied to the producers or importers of fossil fuels. Under this tax, each fuel has a different rate according to the amount of CO_2 it contains. The average rate is MXN 43.77/t CO_2 (USD 2.31/t CO_2) as of 2018, adjusted annually by inflation (Sánchez et al. 2018). Natural gas and aviation fuel are exempted, and coal has been taxed at a reduced rate (Table 6). In the years 2014/2015 the tax revenue has been mostly from gasoline (48 %), diesel (28 %), and LPG (10 %), followed by fuel oil (9 %) and coal (4 %) (MéxiCO2 2017).

Table 6: Tax per unit and by type of fuel as of 2021

Fossil Fuels	Tax per unit of measurement (Mexican Pesos)	Implied carbon tax (USD/t CO2)a
1. Propane	7.72 cents/litre	2.32
2. Butane	10.00 cents/litre	3.01
3. Gasoline and aviation gas	13.55 cents/litre	2.98
4. Kerosene	16.19 cents/litre	3.06
5. Diesel	16.45 cents/litre	2.92
6. Fuel oil	17.55 cents/litre	2.87
7. Petroleum coke	20.37 pesos/ ton	1.01
8. Coal coke	47.76 pesos/ton	2.36
9. Coal	35.96 pesos/ton	1.78
10. Other fossil fuels	51.99 pesos/t CO_2 contained in the fuel.	2.57
11. Natural gas and aviation fuel	Exempt -	

[a] Exchange rate 1 USD: 20.20 Mexican pesos with date 03 May 2021.

Source: own elaboration based on SEGOB (2020b), SEMARNAT (2015) and SENER (2019a)

4.4 Retail market and consumer price regulation

There is great dispersion in retail tariffs by sector and by level of consumption. The system has maintained high subsidies for the residential and agriculture sectors (Sánchez et al. 2018). Meanwhile, the commercial and industrial sectors have one of the highest electricity tariffs among OECD countries, mainly because they reflect the real costs of electricity production based on a cross-subsidy form (Valenzuela and Studer 2016). In 2016, subsidies for electricity tariffs reached MXN 130 billion (USD 6.8 billion), where households received 78 %, followed by agriculture with 11.3 %, industry with 10 %[27], and services with 0.7 % (Sánchez et al. 2018). Several electricity rates are set at a value above the corresponding level of cost recovery, although the surplus covered only 9.5 % of the total subsidy in 2016 (Sánchez et al. 2018).

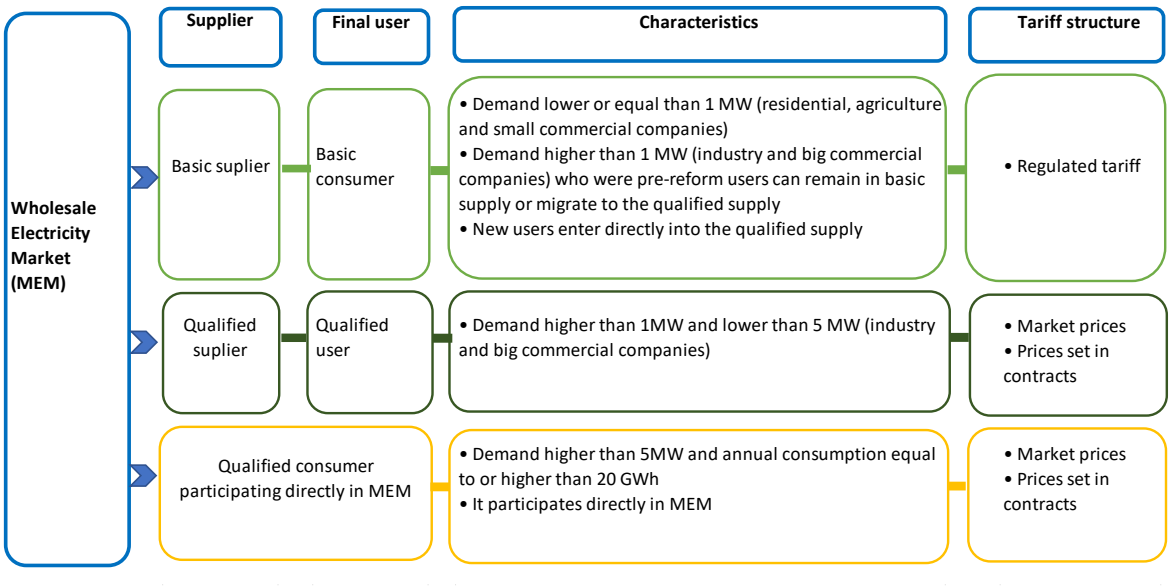
In the retail market, consumers are divided into two main groups: *basic supply* ('suministro básico') and *qualified supply* ('suministro calificado') (see section 4.1.1 for further details). This division is based on an average demand threshold of 1 MW. The basic supplier provides electricity to basic consumers (i.e. those that consume less than 1 MW). CFE is the only basic supplier currently in the market[28]. Consumers with consumption levels above 1 MW with a contract set before the energy reform can choose to stay with the basic supplier or migrate to the qualified segment. New users with consumption greater than 1 MW must set contracts with a qualified supplier. Large consumers with consumption above 5 MW have the additional option to participate directly in the wholesale market. The type and level of the tariff depend on the

27 Rates for industry and services vary over time and, in some years, lower prices have been set, making them subsidized in those specific years.

28 In principle, the reform allows the entry of several basic suppliers, and CRE authorized three permits in 2018. At the moment, however there is no regulation that establishes how to incorporate these other suppliers into the market. This has not yet been resolved (Arzate, 2019) and these suppliers are not yet active in the market.

consumption segment. Figure 14 provides a summary and the following subsections detail the tariff structures for different consumers.

Figure 14: Suppliers and final consumers structure[29]



Source: Own elaboration, Adelphi, based on interviews and PCME (2020)

4.4.1 Retail tariffs for basic consumers

In 2018, to build a more competitive and transparent sector, the market regulator (i.e., CRE) designed a new tariff methodology, allowing cost recovery (CRE 2018a). Costs elements included: generation, transmission, and distribution, the operation of the system, and related services. Generation costs are calculated based on the pre-reform contracts and from the electricity bought in the wholesale market.

In the basic segment, electricity tariffs are divided into 17 regions and 12 sector categories, grouped according to their sector, demand level, and voltage). The tariffs are regulated and are reviewed and published by the regulator on a monthly basis (CRE 2018a). Table 7 shows the division by sectors and the type of tariff.

[29] In the supply segment, two other categories exist: the non-supplier retailer, which does not represent any participant but is allowed to purchase and sale of electricity and other services; and the last resource supplier, which provides electricity under price caps, for a limited time, when a qualified supplier fails to supply.

Table 7: Composition of the tariff from the basic supplier

Type of consumer	Type of tariff	Energy	Capacity
Low-electricity consumers (residential, commercial, services and agriculture)	Multi-part tariff (subsidized)	Fixed price per kWh per blocks of consumption	Assigned in the consumption (kWh) at a fixed rate.
Medium consumers (high-medium voltage on commercial and agriculture)	Multi-part tariff	Fixed price per kWh	According to maximum demand levels (kW)
High consumers (high voltage on medium and large industry)	Multi-part with time of use tariff	Price per kWh with an hourly price (base, intermediate, peak) by season and weekday	According to maximum demand levels (kW) with hourly peak periods

Source: Own elaboration, Adelphi, based on CRE (2018a)

Of the total electricity consumed under the basic segment, 95 % of the demand is covered by pre-reform contracts, and the remaining 5 % is covered through purchases in the wholesale market through long-term energy auctions (electricity purchased by CFE basic supplier). As pre-reform contracts reach their expiration dates, their share it's expected to fall to 20 % in 2030, where the basic supplier will have to buy more electricity from the MEM (CRE 2018a).

Noting that the liberalization of the electricity market would represent a significant increase in residential and agriculture rates as compared to the pre-reform tariffs for this segment, the Ministry of Finance decided that these segments would keep the subsidies, and that it would absorb the costs (Sánchez, et al., 2018). The tariffs in these sectors are set per block of consumption, where the unit price per kWh increases with higher consumption (John Scott Andretta 2011). Only the high consumption rate (tarifa de alto consumo -DAC) pays the real cost. This rate is based on a consumption threshold, which is high enough to be applied only to 1 % of Mexican households (Sánchez et al. 2018). Although budgetary consequences are important, removing these subsidies has been impossible due to a historical political aversion towards electricity price increases.

On the other hand, the commercial and industrial sector face the highest electricity tariffs. As discussed previously, CFE´s generation costs have been increasing. This has incentivized companies with a consumption threshold greater than 1 MW to look for different suppliers– although options for small and medium-sized companies are still limited. Large consumers (> 1 MW) that remain with the basic supplier have a multi-part time of use tariff according to base load, intermediate load, and peak load by season and weekday.

4.4.2 Retail tariffs for qualified consumers

To date, qualified suppliers have become the most competitive segment in terms of prices, and the most significant incentive for large consumers to switch suppliers with the possibility of reducing tariffs. A number of companies have already migrated, of which 70 % belong to the manufacturing sector. However, there are still some challenges such as the understanding of the new tariff scheme (PwC 2019). As for 2018, only 1 % of the electricity demand is fulfilled through qualified suppliers.

Different qualified suppliers have different pricing structures. As with the basic tariffs for large consumers, qualified suppliers follow a multi-part time of use tariff for distribution, transmission, and other services. Still, each supplier can offer different generation costs. Capacity is also charged according to maximum demand levels and peak periods.

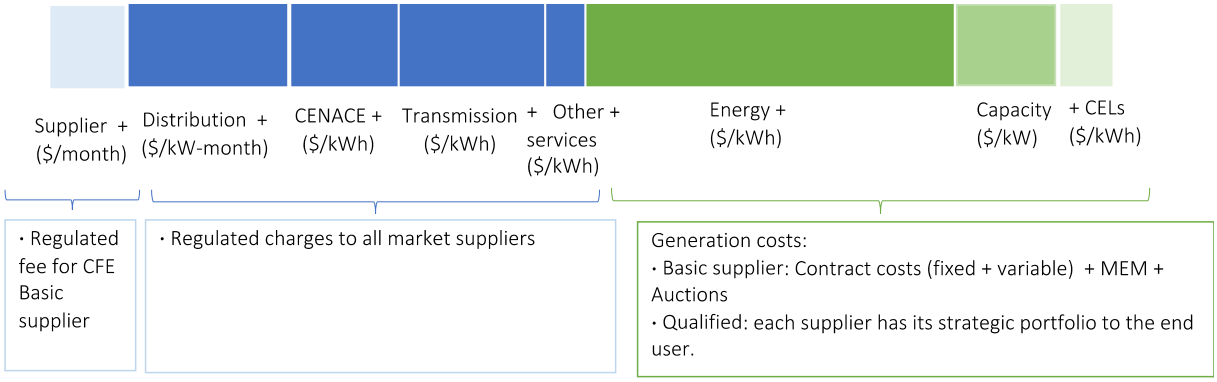
In general, the pricing structure for qualified consumers can be divided into two categories (PwC 2019):

a) The costs plus a margin (Cost-Plus), which integrates the costs incurred by the supplier as well as a fixed profit.

b) The NetBack structures, which generally offer fixed prices that represent savings compared to the reference rate.

Figure 15 illustrates the components of the tariffs for basic and qualified consumers, depending on the type of supply.

Figure 15: Composition of the retail tariffs from basic and qualified suppliers



Source: Own elaboration, Adelphi, based on the interviews, PwC (2019) and SEGOB (2021a)

5 Assessing electricity markets and the ETS' (possible) impact on abatement

In Mexico, the regulation of the electricity market is still in turmoil and the ETS is not yet in full operation: regulated entities, for example, are yet to receive their first allocation and no price signal exists.

In the pilot phase, allowances will be allocated for free on the basis of historical and verified emissions in the compliance year; participants are expected to receive 100 % (or more) of their compliance needs each year. The Mexican ETS is expected to begin its first full implementation phase in 2023, although rules for this phase are yet to be developed and it is unclear whether that phase will reach scarcity in the supply of allowances. Therefore, we do not expect the ETS to drive electricity sector abatement in the next two years, which means a likely negligible impact on consumers as no or very low additional costs are expected to be incurred in the short term as a result of the ETS.

A theoretical possibility of windfall profits exists, although windfall profits during the pilot phase would require a price signal. Moreover, current rules stipulate that allowances cannot be banked from the pilot into the first phase, thereby limiting the possibility of windfall profits in the full implementation phase due to excessive allocation in the pilot years. Scarcity in the pilot phase could be generated (and therefore a small price signal may emerge) if some type of correction factor reduces allowance allocation, and/or if there is an indication of scarcity in the full implementation phase and allowance banking into that phase is allowed. Be it as it may, the price signal during the pilot phase is expected to be very low. While the ETS pilot is likely to serve the purpose of helping participants become acquainted to the ETS and its compliance cycle, it is very unlikely to drive new investment or affect decisions on plant closures. In interviews, no market participant expected an impact from the ETS on abatement during the pilot phase.

The sections below present an analysis of a hypothetical situation where a price signal does exist, be it during the pilot phase or during the full implementation one, on the basis of electricity sector regulations valid in July 2020.

5.1 Carbon cost pass-through in the wholesale electricity market

How electricity producers respond to an ETS depends partly on how allowances are allocated and to a large degree if generators can pass the carbon price to wholesale electricity prices. This cost pass-through is the pre-condition that retail prices reflect carbon cost and, thus, are able to incentivize carbon abatement at the demand side. In the case of Mexico, the cost pass-through will depend, at least in the short and medium term, on the type of generator:

- CFE generators: it seems very plausible that the carbon cost can be passed through in the tariffs charged by CFE generators in the wholesale market: in theory, the regulation of wholesale prices (through the locational marginal price) allows for cost recovery. Pre-reform contracts by CFE in the wholesale market are also meant to cover operational costs, although it is not clear whether they could be amended in light of new costs such as those arising from the ETS.

- PIEs: PIEs are currently not fully exposed to the wholesale market as they hold contracts with CFE, who represents them in the MEM. According to the interviews, the cost pass-through between the PIEs and CFE is not possible, as existing contracts could not be amended to incorporate additional costs. The PIEs, as the regulated entities, would therefore

have to absorb all costs related to ETS compliance. However, it is expected that these contracts will gradually expire and that PIEs be incorporated into the MEM. Interviewees mentioned that even though it has not yet been officially defined, it seems likely that the PIEs would receive free allocation until the end of their contracts with CFE.

- Private generators: similarly to the case of CFE generators, it seems very plausible that private generators be able to pass on the costs in the short-term energy market through the LMP, under the energy component. In the case of medium and long-term bilateral contracts, rates may be agreed between the parties. Therefore, for new contracts it is also very feasible that they will pass on the cost. For existing contracts it is not clear whether they could be amended in light of new costs such as those arising from the ETS.

In general, the system operator must recognize cost increases as it monitors the price offers of generators. Further research is needed from the regulatory authorities, such as analysing how to deal with the costs of the allowances and how this could impact the decarbonization of the electricity sector (Boute 2016). According to the interviews, to date there is little awareness of this issue in Mexico.

5.2 Fuel switch: Impact of carbon price on dispatch

In the Mexican electricity market, power plants are dispatched according to the merit order, in which low carbon technologies already take priority (see section 4.2.2). Under this approach, it is expected that the carbon price is internalized in the marginal cost making the carbon-intensive plants more expensive, causing them to be displaced in the dispatch curve. However, the role of the carbon price in the dispatch may be limited for the pre-reform contracts, which have price "zero" in the merit order and which represented, on average, about 12 % of the dispatch; at least 80 % of this capacity comes from fossil fuels[30].

Moreover, the composition of the Mexican fuel mix is diverse, however there is no (significant) potential for fuel switching as an abatement option because natural gas is already cheaper than the more emission intensive fuels such as coal, diesel, and fuel oil – which are also often burned in old generation units. Despite higher generation costs, these plants could not be displaced completely. One of the main reasons is that there are not enough gas pipelines to import the required volumes to satisfy the natural gas demand, which has forced the operation of older inefficient plants. In addition, a combination of building a new refinery that increases fuel oil residues on the one hand, and the implementation of the new International Maritime Organization (IMO) rules[31] prohibiting ships from using fuel with a sulphur content greater than 0.5 % on the other, will drastically increase the domestic fuel oil supply. Lacking the alternative of exporting heavy fuel oil for marine use, interviewees expect that the alternative will be its burning in the CFE thermoelectric power plants. A carbon price would make these plants even less economic and could help to phase out HFO for electricity generation.

Moreover, the electricity mix is already composed by nearly 50 % of natural gas. The economic lifetime of such plants could lock Mexico in a high-carbon trajectory with stranded assets, making it difficult for the country to comply with targets in line with the Paris Agreement (Ramones Fernández et al. 2019).

In addition, renewable energy uptake can be limited if the grid infrastructure faces congestion due to a lack of network infrastructure (Acworth et al. 2019). This is the case of Mexico, in which

[30] Plants under these contracts can reach up to 18 % when they are at full capacity.

[31] Starting from January 1, 2020

congestion has been identified as the principal cause of emergency and alert states of the grid (CRE 2018b). According to the interviewees, in the absence of infrastructure and due to high congestion, local diesel plants have had to be dispatched, as renewable energy sources in other interconnected regions cannot be transmitted. The two cancelled tenders to carry out the construction of two transmission lines are necessary to expand renewable energy transit and avoid high congestion.

Altogether, these conditions in electricity generation would likely present a strong obstacle that would hamper an ETS signal towards fuel switch. However, once political conditions and infrastructure constraints have improved, the underlying energy economics of low-emissions technologies and renewables should displace coal, diesel and fuel oil, even irrespective of a carbon price. The pre-reform contracts are also an important issue impeding the ETS role, but this barrier will cease once these contracts have expired.

5.3 Impact of carbon price on low carbon investment/disinvestment

Mexico disposes of an only partially liberalized electricity sector in which investments by CFE – which owns 60 % of the generation assets – must be approved by the government (CFE 2015). Importantly, such approval is strongly determined by the political preferences of the authority in turn (Solís 2019). If the authority regulates investments, the role of the ETS in directing investment decisions will be limited (Boute 2016).

Moreover, the ETS abatement incentives may be nullified under the pre-reform contracts in the short term. If the cost pass-through is possible in their tariffs and the dispatch is guaranteed (without competing with other power plants that do not fall under this segment), it is likely that the generators do not have an incentive to invest in cleaner technologies. Besides, this method of cost-recovery will allow them to recover the carbon costs. If the cost pass-through is not possible (as may be the case for PIEs), their profits will decline over time (see discussion under 5.1).

In the long-term, and once the market is fully liberalized and pre-reform contracts for legacy assets have phased out/expired, economic dispatch across the generation segment will enhance the financial viability of low carbon investments. A sufficiently high carbon price may also encourage the decommissioning of older and inefficient power plants.

However, there are many limitations in the infrastructure that inhibit the generation of renewable energies, especially due to the lack of investment in transmission infrastructure. Transmission will represent a crucial role in combining new technologies and more active consumers while maintaining the grid´s reliability (World Energy Council 2020). Unfortunately, the government cancelled the current transmission investment projects, and, as highlighted above, has expressed a strong desire to maintain old assets in operation as they are held by CFE.

As an emerging, stable market with great potential for renewable energy, the energy reform highly encouraged private investments, mostly renewable energy projects, through the long-term auctions and CELs requirements. This path was strengthened by the low technological costs, presenting a price per MWh of one of the world's lowest for renewable energies. However, by cancelling the auctions, by attempting to modify the regulation of CELs, by cancelling the investments in transmission systems and by attempting to restrict additional entry of renewables into the grid, the current administration has caused a great degree of uncertainty for investors. It has also put multiple future investments at risk.

In combination with a solid policy for renewables, through the CELs, and investments in transmission, the ETS could strengthen a signal towards a low carbon transition. With the

current policy changes, a stronger price signal for the ETS is required to encourage clean investments. At the same time, the ETS must provide long term certainty in order to regain lost confidence in investors.

Capacity market

Under the capacity markets and the arrangement of public tenders where the installed capacity of fossil fuel plants for the next 3 to 15 years is guaranteed, the role of the ETS in driving low carbon investments is reduced. In addition, it would limit the ETS role by delaying the decommissioning of carbon-intensive assets. The requirement wherein the retirement of a power plant unit with existing obligations under the capacity market is not permitted unless it establishes an alternative source to replace such capacity further weakens the disinvestment signal.

The Baja California area presents a case in point. In Mexico, the Baja California area is not interconnected with the national electricity system (due to infrastructure constraints as lacking natural gas pipelines and transmission lines). This zone has been relying on expensive diesel turbines for years. In this case, the capacity market is incentivizing the permanence of these technologies as a means of ensuring security and reliability on the grid. For an ETS to impact the reference technology for the capacity market in Baja California, the CO_2 price would need to be high enough to make an investment in in renewable energy combined with sufficient storage capacity for providing security of supply, a natural gas pipeline or transmission lines economically feasible.[32]

Renewable Energy Promotion

There are no clear, mandatory, clean energy targets in the medium to long term beyond 2024 and the ETS currently only has the pilot phase's goals until 2022. The cap for the operational phase should account for the clean energy associated reductions. For example, a recent study showed that compliance with the clean energy certificates up to 2021 could reduce total electricity emissions by 12 % compared to its business-as-usual scenario in the same year (CRS 2018). A stable path of how both mechanisms will contribute to NDC compliance is required. According to the interviews, this is currently unknown.

There is also the possibility of a positive interaction of the ETS with renewable energy generation: with the uncertain future of the CEL-scheme and the low carbon tax, a carbon price might be the strongest incentive for the uptake of renewable energies in the future. However, under the scenario that the clean energy targets are updated beyond 2024, the ETS cap must be set to guarantee that a reasonable degree of scarcity remains after emissions reductions from companion policies (IEA 2020). Market Stability Mechanisms can improve the ETS operation and help ensure the additionality of policies when overlapping takes place. However, the Mexican regulation has not established any explicit mechanisms for this, either for the pilot or the operational phase.

Carbon Tax

As previously mentioned (section 4.3.5), the carbon tax is differentiated for each fuel and not necessarily based on its carbon content. Natural gas, the most commonly used fossil fuel in the electricity sector, is exempt. Although the revenue collection has been significant for the Ministry of Finance, the rate is still too low to incentivize emissions reductions. In the interviews, the impact on consumers was deemed negligible. In terms of an implicit interaction with the ETS, the carbon tax strengthens fuel switching for cleaner options given that coal, diesel

[32] According to interviewees, many studies demonstrate this area's vast renewable potential with economic and technical sense. However, there is still a great fear in Mexico about its intermittent nature.

and fuel oil would be facing double costs (from both the ETS and the tax). At the moment, an explicit interaction between the ETS and the carbon tax is not expected.

For example, in the electricity sector, CFE contributes the most to the payment of the tax. For the private sector, the impact has been almost imperceptible because natural gas is not taxed. In 2018, the total income collected over five years amounted to $ 35.2 billion pesos (1.6 billion USD[33]), of which it is considered that the electricity sector contributed 22.5 % (SENER 2020b).

5.4 Demand-side response and carbon cost pass-through in retail electricity

Whether and to what extent electricity consumers decrease their demand due to an increase in the electricity prices depends on (i) the pass-through of carbon cost to end consumer prices; and (ii) on how sensitive consumers are to price changes (elasticity of demand). We focus on the former. In the case of Mexico, the allowance price would influence consumers differently, depending if they are (a) basic consumers under subsidized tariffs, (b) basic consumers under regulated tariffs, (c) qualified consumers or (d) qualified consumers participating in the MEM.

Basic consumers

The cost pass-through in the residential and agriculture sectors is not possible due to existing subsidies - assuming that the consumer price would not change (see section 4.4). These subsidies distort electricity prices for these consumers and thus any potential impact from the ETS price signal; there is little incentive for consumers to reduce their consumption or change their behaviour.[34] The only consumers that could receive the cost are high-consumption residential users, which represent 1 % of all households. According to the interviews, if there is a sudden increase in electricity prices due to the ETS, the Ministry of Finance will likely absorb the costs for basic consumers. However, interviewees noted that the government may likely not allow for an increase in costs due to the ETS - e.g. by ensuring ample supply of free allowances.

Users with consumption greater than 1 MW who continue with the basic supplier would receive a price increase due to the ETS. In addition to the fact that they are not subsidized, the regulator assigned the most efficient plants to the residential sector, leaving the less efficient generators to supply commercial and industrial sectors. These sectors' dynamic pricing will better reflect the changes in the marginal cost of electricity, including the allowance price (Acworth et al. 2019). The cost pass-through would encourage a reduction in consumption and the migration towards suppliers with cleaner energy portfolios. It will be essential to measure the impact on small businesses that are not subsidized and cannot move into the qualified supplier segment, where electricity costs have a notable proportion of their operating costs.

Qualified consumers

There is a greater opportunity to pass on the allowance cost to users who enter into contracts with qualified suppliers. These qualified suppliers will also receive the cost-pass through from the short-term market or through new medium and long-term contracts. This would make suppliers offering clean energy portfolios more competitive in the market. Likewise, large consumers who already participate directly in the MEM will be exposed to the carbon price signal through the short-term market. Interview respondents also concluded that the most feasible alternative to passing the carbon price will be through qualified supply.

[33] Exchange rate of 1 peso= 0.046 USD on 22 September 2020.

[34] Generally, where allowance costs are reflected in final electricity bills, these are likely to be diluted due to transmission and distribution costs, levies and taxes. Moreover, price elasticity is limited. Price responsiveness will likely be limited unless cost factors are separated and smart metering is installed, and consumers are free to switch to low-carbon energy suppliers.

6 List of references

Abrell, J.; Betz, R.; Kosch, M. (2020): The European Emissions Trading System and the German and Polish Electricity Market: Influence of market structures and market regulation on the carbon market: Case study report, Influence of market structures and market regulation on the carbon market (Climate Change, 48/2020). Umweltbundesamt (ed.), 2020. Online available at https://www.umweltbundesamt.de/publikationen/european-emissions-trading-system-and-german-and-polish-electricity-market, last accessed on 22 Jun 2021.

Acworth, W.; Kuneman, E.; Boute, A.; Betz, R. (2021): Emissions trading in pursuit of electricity decarbonisation - market structures and regulations matter, Synthesis report (Climate Change, 38/2021). Umweltbundesamt (ed.), 2021. Online available at https://www.umweltbundesamt.de/publikationen/emissions-trading-in-pursuit-of-electricity, last accessed on 22 Jun 2021.

Acworth, W.; Kuneman, E.; La Hoz Theuer, S.; Abrell, J.; Baer, J.; Betz, R.; Kosch, M.; Müller, T.; Cludius, J.; Healy, S.; Graichen, J.; Boute, A.; Zhang, H. et al. (2019): Influence of market structures and market regulation on the carbon market, Interim report. Deutsche Emissionshandelsstelle (ed.), December 2019. Online available at https://www.dehst.de/SharedDocs/downloads/EN/publications/report_influence-of-market-structures-and-market-regulation.pdf?__blob=publicationFile&v=3, last accessed on 27 Jan 2021.

Boute, A. (2016): The Impossible Transplant of the EU Emissions Trading Scheme: The Challenge of Energy Market Regulation. The Chinese University of Hong Kong (ed.), 2016.

Brunner, S.; Flachsland, C.; Marschinski, R. (2012): Credible commitment in carbon policy. In: *Climate Policy* (12), pp. 255–271.

Burtraw, D.; McCormack, K. (2016): Consignment Auctions of Free Emissions Allowances under EPA's Clean Power Plan (Discussion Paper, 16-20). Resources for the Future (ed.). Washington, 2016. Online available at https://www.rff.org/publications/working-papers/consignment-auctions-of-free-emissions-allowances-under-epas-clean-power-plan/, last accessed on 21 Jun 2021.

Cámara de Diputados (1992): Ley del servicio público de energía eléctrica, 1992. Online available at https://www.senado.gob.mx/comisiones/energia/docs/marco_LSPEE.pdf, last accessed on 1 Mar 2021.

Cámara de Diputados (2002): La participación privada en la industria eléctrica nacional y la Propuesta de Modernización del La participación privada en la industria eléctrica nacional y la Propuesta de Modernización del Sector Eléctrico en los mercados de grandes consumidores, Cámara de Diputados. Online available at http://www.diputados.gob.mx/sedia/sia/se/SIA-DEC-38-2002.pdf, last accessed on 25 Feb 2021.

Cámara de Diputados (2014a): Ley de la Comisión Federal de Electricidad, 2014. Online available at http://www.diputados.gob.mx/LeyesBiblio/pdf/LCFE_110814.pdf, last accessed on 25 Feb 2021.

Cámara de Diputados (2014b): Ley de la Industria Eléctrica. In: *Cámara de Diputados*, 2014. Online available at http://www.diputados.gob.mx/LeyesBiblio/pdf/LIElec_061120.pdf, last accessed on 25 Feb 2021.

Cámara de Diputados (2015a): Ley de Transición Energética, 2015.

Cámara de Diputados (2015b): Ley de Transición Energética, Nueva Ley publicada en el Diario Oficial de la Federación el 24 de diciembre de 2015 (Diaro Oficial de la Federación (DOF)), 24 Dec 2015. Online available at https://www.gob.mx/cms/uploads/attachment/file/112838/Ley_de_Transicion_Energetica.pdf, last accessed on 26 Feb 2021.

Cámara de Diputados (2021): Parlamento abierto con relación a la iniciativa de decreto por el que se reforma la Ley de la industria eléctrica- Emitido en directo el 11 feb 2021, Cámara de Diputados. Online available at https://comunicacionnoticias.diputados.gob.mx/comunicacion/index.php/boletines/inicia-en-parlamento-abierto-analisis-de-la-iniciativa-preferente-que-reforma-la-ley-de-la-industria-electrica#gsc.tab=0, last accessed on 25 Feb 2021.

CENACE - Centro Nacional de Control de Energía (2017): Resultados preliminares de la Tercera Subasta de Largo Plazo.

CFE - Comisión Federal de Electricidad (ed.) (2015): Programa de Obras e Inversiones del Sector Eléctrico, 2015. Online available at http://b-dig.iie.org.mx/BibDig2/V12-0028/V12-0028.pdf, last accessed on 1 Mar 2021.

Climate Analytics; NewClimate - NewClimate Institute (2020): Climate Action Tracker - Mexico, Current policy projections. Online available at https://climateactiontracker.org/countries/mexico/current-policy-projections/, last updated on 22 Sep 2020, last accessed on 27 Jan 2021.

CRE - Comisión Reguladora de Energía (2018a): Tarifas Finales del Suministro Básico. Ciudad de México, 31 Oct 2018. Online available at https://www.gob.mx/cms/uploads/attachment/file/469061/Tarifas_Finales_del_Suministro_B_sico.pdf, last accessed on 26 Feb 2021.

CRE - Comisión Reguladora de Energía (ed.) (2018b): Reporte de Confiabilidad del Sistema Eléctrico Nacional 2016 - 2017, 2018. Online available at https://www.gob.mx/cms/uploads/attachment/file/317909/Reporte_de_confiabilidad_de_Electricidad_.pdf, last accessed on 26 Feb 2021.

CRS - Center for Resource Solutions (2018): Clean Energy Certificates and Emissions Trading in Mexico: Reciprocal Effects and Interactions, 2018. Online available at https://resource-solutions.org/wp-content/uploads/2019/01/Clean_Energy_Certificates_and_Emissions_Trading.pdf, last accessed on 22 Jun 2021.

eia - U.S. Energy Information Administration (2021): Natural Gas Prices, U.S. Energy Information Administration. Online available at https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm, last accessed on 25 Feb 2021.

Energía a Debate (2017): Integración eléctrica entre México y Estados Unidos. Energía a Debate (ed.). Online available at https://www.energiaadebate.com/blog/2723/, last updated on 2017, last accessed on 25 Feb 2021.

ESTA - ESTA International LLC, S.A. de C.V. (2018): Reporte Anual del Mercado Eléctrico Mayorista 2018, Monitor independiente der Mercado Eléctrico - México, 2018. Online available at https://www.gob.mx/cms/uploads/attachment/file/497897/Reporte_Anual_2018_del_Monitor_Independiente_del_Mercado_compressed.pdf, last accessed on 25 Feb 2021.

ESTA - ESTA International LLC, S.A. de C.V. (2020): Reporte Anual del Mercado Eléctrico Mayorista 2019, Monitor independiente der Mercado Eléctrico - México,. Mexico, 15 May 2020. Online available at https://www.gob.mx/cms/uploads/attachment/file/553784/Reporte_Anual_2019_del_Monitor_Independiente_del_Mercado.pdf, last accessed on 29 Jun 2021.

ESTA - ESTA International LLC, S.A. de C.V.; Instituto Politécnico Nacional (2017): Reporte Anualdel Mercado Eléctrico Mayorista 2016, Monitor Independiente del Mercado. Centro Nacional de Control de Energía (ed.), 2017. Online available at https://www.cenace.gob.mx/Docs/MercadoOperacion/ReporteAnual/2017/Reporte%20Anual%20del%20MEM%202016%20-%20Monitor%20Independiente%20del%20Mercado.pdf, last accessed on 25 Feb 2021.

Favio Perales (2018): Estado Actual y Etapas Futuras de Implementación del Mercado Eléctrico Mayorista, Taller de las Prioridades Nacionales de Investigación, Desarrollo Tecnológico y Formación de Recursos Humanos: Redes y Microrredes Eléctricas Inteligentes. Centro Nacional de Control de Energía. Cuernavaca, Mexico, 18 Sep 2018. Online available at https://www2.ineel.mx/taller_redes/documentos/pdf/mercado_el/2_estado_actual_y_etapas_futuras_de_implementacion_mem.pdf, last accessed on 26 Feb 2021.

Fuss, S.; Flachsland, C.; Koch, N.; Kornek, U.; Knopf, B.; Edenhofer, O. (2018): A Framework for Assessing the Performance of Cap-and-Trade Systems – Insights from the European Union Emissions Trading System. In: *Review of Environmental Economics and Policy* (12(2)), pp. 220–241.

Gastelum Rivera, D.; Gutiérrez García, J.; Hernández Amezcua, T.; Inclán Acevedo, C.; Islas Cortés, I.; Landa, G.; Reynès, F. (2015): Transitioning towards a low-carbon economy in Mexico, an application of the ThreeME model. AFD (ed.), 2015. Online available at https://spire.sciencespo.fr/hdl:/2441/192fcun0f09bg94v6tftmhhbdl/resources/2015-03-etudes-afd-transition-rivera.pdf, last accessed on 1 Mar 2021.

Hernandez, C. (2017): El Nuevo Sector Electrico Mexicano. In: *Presentacion en evento Alianza Pacífico*, 2017.

IEA - International Energy Agency (2020): Managing interactions between carbon pricing and existing energy policies, Guidance for Policymakers. International Emissions Trading Association (ed.), 2020. Online available at https://www.iea.org/reports/implementing-effective-emissions-trading-systems/policy-interactions, last accessed on 1 Mar 2021.

INECC - Instituto Nacional de Ecología y Cambio Climático (2018): Inventario Nacional de Emisiones de Gases y Compuestos de Efecto Invernadero, 2018. Online available at https://www.gob.mx/inecc/acciones-y-programas/inventario-nacional-de-emisiones-de-gases-y-compuestos-de-efecto-invernadero, last accessed on 1 Mar 2021.

John Scott Andretta (2011): ¿Quién se beneficia de los subsidios energéticos en México?. CIDE, 2011. Online available at http://repositorio-digital.cide.edu/bitstream/handle/11651/141/Subsidios_energeticos_J_Scott.pdf?sequence=, last accessed on 1 Mar 2021.

Koch, N.; Grosjean, G.; Fuss, S.; Edenhofer, O. (2016): Politics matters – Regulatory events as catalysts for price formation under cap-and-trade. In: *Journal of Environmental Economics and Management* (78), pp. 121–139.

Kollmuss, A.; Schneider, L.; Zhezherin, V. (2015): Has Joint Implementation reduced GHG emissions? Lessons learned for the design of carbon market mechanisms. Stockholm

Environment Institute, 2015. Online available at https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2015-07-JI-lessons-for-carbon-mechs.pdf, last accessed on 31 Aug 2020.

Komives, K.; Johnson, T.; Halpern, J.; Aburto, J.; Scott, J. (2009): Residential Electricity Subsidies in Mexico Exploring Options for Reform and for Enhancing the Impact on the Poor (Working Paper, 160). World Bank (ed.), 2009. Online available at https://openknowledge.worldbank.org/handle/10986/5959, last accessed on 25 Feb 2021.

México, Gobierno de la República (2015): INTENDED NATIONALLY DETERMINED CONTRIBUTION Mexico, 2015. Online available at https://www.gob.mx/cms/uploads/attachment/file/162973/2015_indc_ing.pdf, last accessed on 20 Jan 2021.

MéxiCO2 (2017): Impuesto al Carbono en México, Nota Técnica, 2017. Online available at http://www.mexico2.com.mx/uploadsmexico/file/artimpuestofinal.pdf, last accessed on 26 Feb 2021.

Nava, D. (11 Oct 2019): CFE debe mantener 55% del mercado eléctrico, el resto puede ser de privados: Bartlett. In: *El Financiero*, 11 Oct 2019. Online available at https://www.elfinanciero.com.mx/economia/cfe-debe-mantener-55-del-mercado-el-resto-puede-ser-de-privados-bartlett-a-diputados, last accessed on 25 Feb 2021.

Oeko-Institut e.V. (2018): Designing an Emissions Trading System in Mexico: Options for Setting an Emissions Cap. Oeko-Institute. Gesellschaft für internationale Zusammenarbeit (ed.), 2018. Online available at https://www.gob.mx/cms/uploads/attachment/file/401981/Options_for_Setting_an_Emissions_Cap.pdf, last accessed on 22 Oct 2018.

PCME (2020): El mercado eléctrico: Plataforma de Clima y Energía.

PwC - PricewaterhouseCoopers (2019): El suministro eléctrico en México, 2019. Online available at https://www.pwc.com/mx/es/industrias/energia/suministro-electrico-en-mexico.html, last accessed on 25 Feb 2021.

Ramones Fernández, F.; Sierra Brozon, L.; Chacón, D.; Palacios, R. (2019): Presupuestos de carbono: una oportunidad para ampliar la ambicion climatica del sector electrico. GIZ, ICM, 2019. Online available at https://iki-alliance.mx/wp-content/uploads/CONECC_PresupuestoCarbono_Nov19.pdf, last accessed on 1 Mar 2021.

Sánchez, L.; Echeverría, D.; Wooders, P.; Kuehne, K.; Lean, T.; Beaton, C.; Shama, S.; Oharenko, Y. (2018): Mejorando y refocalizando los subsidios a la electricidad: Opciones para su optimización en México. Convergencia de la Política Energética y de Cambio Climático (CONECC) y la Alianza Energética entre México y Alemania. (ed.), 2018. Online available at https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/SubsidiosElectricos-MEX.pdf, last accessed on 25 Feb 2021.

SEGOB - Secretaría de Gobernación (2017a): ACUERDO por el que se emite el Manual de Costos de Oportunidad (Diaro Oficial de la Federación (DOF)). Mexico, 16 Oct 2017. Online available at http://www.dof.gob.mx/nota_detalle.php?codigo=5501341&fecha=16/10/2017, last accessed on 29 Jun 2021.

SEGOB - Secretaría de Gobernación (2017b): AVISO por el que se da a conocer los requisitos para la adquisición de Certificados de Energías Limpias en 2020, 2021 y 2022 establecidos por la Secretaría de Energía (Diaro Oficial de la Federación (DOF)), 31 Mar 2017. Online

available at http://dof.gob.mx/nota_detalle.php?codigo=5478190&fecha=31/03/2017, last accessed on 29 Jun 2021.

SEGOB - Secretaría de Gobernación (2020a): ACUERDO por el que se emite la Política de Confiabilidad, Seguridad, Continuidad y Calidad en el Sistema Eléctrico Nacional.: Diario Oficial de la Federación. Online available at https://dof.gob.mx/nota_detalle.php?codigo=5593425&fecha=15/05/2020, last accessed on 25 Feb 2021.

SEGOB - Secretaría de Gobernación (2021a): ACUERDO Núm. A/046/2020 por el que la Comisión Reguladora de Energía autoriza el cálculo y ajuste de las tarifas finales que aplicarán de manera individual a la empresa productiva subsidiaria CFE Suministrador de Servicios Básicos del 1 de enero al 31 de diciembre de 2021 (Diaro Oficial de la Federación (DOF)), 9 Feb 2021. Online available at http://www.dof.gob.mx/nota_detalle.php?codigo=5611102&fecha=09/02/2021, last accessed on 29 Jun 2021.

SEGOB - Secretaría de Gobernación (2021b): ACUERDO por el que se establecen las bases preliminares del Programa de Prueba del Sistema de Comercio de Emisiones (Diaro Oficial de la Federación (DOF)), 27 Jan 2021. Online available at https://www.dof.gob.mx/nota_detalle.php?codigo=5573934&fecha=01/10/2019, last accessed on 27 Jan 2021.

SEGOB - Secretaría de Gobernación (ed.) (2020b): ACUERDO por el que se actualizan las cuotas que se especifican en materia del impuesto especial sobre producción y servicios., Acuerdo 138/2020 (Diaro Oficial de la Federación (DOF)), 24 Dec 2020. Online available at https://www.dof.gob.mx/nota_detalle.php?codigo=5608674&fecha=24/12/2020, last accessed on 25 Feb 2021.

SEMARNAT - Secretaría de Medio Ambiente y Recursos Naturales (2015): ACUERDO que establece las particularidades técnicas y las fórmulas para la aplicación de metodologías para el cálculo de emisiones de gases o compuestos de efecto invernadero (Diaro Oficial de la Federación (DOF)), 3 Sep 2015. Online available at http://dof.gob.mx/nota_detalle_popup.php?codigo=5406149, last accessed on 29 Jun 2021.

SEMARNAT - Secretaría de Medio Ambiente y Recursos Naturales (2019a): Aviso sobre el tope de emisiones del programa de prueba del Sistema de Comercio de Emisiones, AVISO para el Programa de Prueba del Sistema de Comercio de Emisiones, 27 Nov 2019. Online available at https://www.gob.mx/cms/uploads/attachment/file/513702/Aviso_Tope.pdf.

SEMARNAT - Secretaría de Medio Ambiente y Recursos Naturales (2019b): Aviso sobre la asignación sectorial del programa de prueba del Sistema de Comercio de Emisiones, AVISO para el Programa de Prueba del Sistema de Comercio de Emisiones, 27 Nov 2019. Online available at https://www.gob.mx/cms/uploads/attachment/file/513701/Aviso_Asignacion_Sectorial.pdf , last accessed on 27 Jan 2021.

SEMARNAT - Secretaría de Medio Ambiente y Recursos Naturales (2020): Aviso sobre las reglas y criterios de asignación de derechos de emisión, AVISO para el Programa de Prueba del Sistema de Comercio de Emisiones, 16 Dec 2020. Online available at https://www.gob.mx/cms/uploads/attachment/file/600718/Aviso-Reglas-Criterios-de-Asignacion-SCE.pdf, last accessed on 27 Jan 2021.

SENER - Secretaría de Energía (2013): Prospectiva del Sector Eléctrico 2013-2027. Online available at https://www.gob.mx/cms/uploads/attachment/file/62949/Prospectiva_del_Sector_El_ctrico_2013-2027.pdf, last accessed on 25 Feb 2021.

SENER - Secretaría de Energía (2015): ACUERDO por el que la Secretaría de Energía emite las Bases del Mercado Eléctrico. (Diaro Oficial de la Federación (DOF)), 2015. Online available at https://www.cenace.gob.mx/Docs/14_REGLAS/Bases/Bases%20del%20Mercado%20El%C3%A9ctrico%20%5bDOF%2008-09-15%5d%20.pdf, last accessed on 26 Feb 2021.

SENER - Secretaría de Energía (2018): Programa de Desarrollo del Sistema Eléctrico Nacional. Secretaría de Energía, 2018. Online available at https://base.energia.gob.mx/prodesen/PRODESEN2018/PRODESEN18.pdf, last accessed on 25 Feb 2021.

SENER - Secretaría de Energía (2019a): Balance Nacional de Energía 2018. Mexico, 2019. Online available at https://www.gob.mx/cms/uploads/attachment/file/528054/Balance_Nacional_de_Energ_a_2018.pdf, last accessed on 29 Jun 2021.

SENER - Secretaría de Energía (2019b): PRODESEN 2019 - 2033. Online available at https://www.gob.mx/sener/articulos/prodesen-2019-2033-221654, last accessed on 25 Feb 2021.

SENER - Secretaría de Energía (2020a): ACUERDO por el que la Secretaría de Energía aprueba y publica la actualización de la Estrategia de Transición para Promover el Uso de Tecnologías y Combustibles más Limpios, en términos de la Ley de Transición Energética. Online available at https://www.dof.gob.mx/nota_detalle.php?codigo=5585823&fecha=07/02/2020, last accessed on 26 Feb 2021.

SENER - Secretaría de Energía (2020b): Sistema de Información Energética, 2020. Online available at http://sie.energia.gob.mx/, last accessed on 25 Feb 2021.

SENER - Secretaría de Energía (ed.) (2020c): Comercio exterior importación y exportación de energía eléctrica: Datos y Recursos, 2020. Online available at https://datos.gob.mx/busca/dataset/comercio-exterior-importacion-y-exportacion-de-energia-electrica, last accessed on 28 May 2021.

Solís, A. (2019): CFE generará más electricidad con combustóleo si Pemex se lo vende barato. In: *Forbes Mexico*, 2019. Online available at https://www.forbes.com.mx/cfe-generara-mas-electricidad-con-combustoleo-si-pemex-se-lo-vende-barato/, last accessed on 1 Mar 2021.

UNFCCC secretariat (2021): Climate Ambition Alliance: Net Zero 2050. UNFCCC secretariat (ed.). Online available at https://climateaction.unfccc.int/views/cooperative-initiative-details.html?id=94, last updated on 15 Apr 2021, last accessed on 22 Jun 2021.

Valenzuela, J. M.; Studer, I. (2016): Climate change policy and power sector reform in Mexico under the 'golden age of gas'. In: *WIDER Working Papers, World Institute for Development Economics Research (UNU-WIDER), United Nations University*, 2016. Online available at https://www.wider.unu.edu/publication/climate-change-policy-and-power-sector-reform-mexico-under-%E2%80%98golden-age-gas%E2%80%99, last accessed on 25 Feb 2021.

World Energy Council (2020): Performing while transforming: The role of transmission companies in the energy transition, 2020. Online available at https://www.worldenergy.org/publications/entry/innovation-insights-brief-the-role-of-transmission-companies-in-the-energy-transition.