Achieving the Mexican Mitigation Targets: Options for an Effective Carbon Pricing Policy Mix

SEMARNAT
SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

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Abbreviations

AF: Assistance Factor

BAU: Business as Usual

CDM: Clean Development Mechanism

CER: Certified Emissions Reduction

CICC: *Comisión Intersecretarial de Cambio Climático*

ENCC: *Estrategia Nacional de Cambio Climático*

ETS: Emissions Trading System

EU: European Union

EU ETS: European Union Emissions Trading System

GDP: Gross Domestic Product

GHG: Greenhouse Gas

GS: Gold Standard

IEA: International Energy Agency

IMF: International Monetary Fund

INDC: Intended Nationally Determined Contribution

IPCC: Intergovernmental Panel on Climate Change

LGCC: *Ley General de Cambio Climático*

LIEPS: *Ley del Impuesto Especial sobre Producción y Servicios*

Mt: Million metric tons

NAFTA: North American Free Trade Agreement

OECD: Organisation for Economic Co-operation and Development

OTA: Office of Technology Assessment

PECC: *Programa Especial de Cambio Climático*

SEMARNAT: *Secretaría de Medio Ambiente y Recursos Naturales*

t: Metric ton

UNCED: United Nations Conference on Environment and Development

UNFCCC: United Nations Framework Convention on Climate Change

UNPD: United Nations Population Division

VCS: Verified Carbon Standard

WEF: World Economic Forum

Key messages

- As climate policy tools, neither a price set through a carbon tax nor quantity rationing through an emissions trading system is clearly superior to their alternative under all circumstances; considering economic advantages under uncertainty and political economy constraints, real tradeoffs can be mitigated by hybrid approaches.
- A combination of emissions trading and a carbon tax can leverage synergies if properly aligned. Importantly, the coverage of a tax should be equal to or exceed that of a concurrent trading system to avoid leakage between both instruments.
- Aside from uncoordinated coexistence, different coordinated combinations are possible based on the degree of synchronicity and the symmetry of application, allowing it to serve as a flexibility option, a transition mechanism, or a price-management mechanism.
- International experience has shown that the increased flexibility offered by a carbon pricing mix is welcomed by compliance entities. Likewise, the use of a carbon pricing mix to manage price extremes and excessive volatility in the carbon market can help avoid adverse effects, such as bounded rationality in investment decisions and carbon lock-in.
- Mexico's emissions are currently on a pathway to nearly achieve its unconditional 2030 contribution, equal to a 22% reduction in GHGs relative to business as usual. Achieving Mexico's unconditional target with an emissions trading system may result in a carbon price of MXN 74/tCO_2e (USD 3/tCO_2e) in 2030. Reducing emissions further, to 26% below projected business as usual emissions, may result in a carbon price of MXN 495/tCO_2e (USD 23/tCO_2e) in 2030.
- Mexico can implement an emissions trading system while maintaining a stable inflow of carbon pricing revenue by including a carbon price floor. Depending on the level, revenue could then remain consistent with current carbon tax proceeds, even if some allowances are allocated free of cost.
- The uncertainty analysis presented in this paper suggests approximately a one-in-four chance that an emissions trading system would result in a carbon price of MXN 21/tCO_2e (USD 1/tCO_2e) or less in 2030. A hybrid approach with a carbon price floor would mitigate the risk of adverse effects and avoid a decline in government revenue.

1

Introduction

1. Introduction

Mexico is the world's 13th largest emitter of greenhouse gases (GHGs), yet at the same time a pioneer among emerging economies in its transition towards a competitive, low-carbon economy. At present, Mexico's policy framework for energy and climate change is undergoing a comprehensive reform towards greater sustainability, competitiveness and security of supply. But Mexico also shares many of the challenges faced by other emerging economies, with a political and social context favoring policies that promote economic growth and development. Consequently, Mexico's legal framework sets a clear obligation to give priority to the least costly mitigation actions while promoting and sustaining the competitiveness of the vital sectors of the economy (INDC, 2015). Economic instruments that afford flexibility in the location and timing of abatement measures have proven – in both economic theory and international practice – to offer such a least costly approach to correcting the various market failures underlying climate change (see Section 2.1 below).

Mexico's General Law on Climate Change (LGCC) reflects this by including an entire chapter on economic instruments (Chapter IX) and requiring the Federal Government, the States, and the Federal District, within their respective authority, to "design, develop, and apply economic instruments that provide incentives for meeting the objectives of national climate change policy" (LGCC, 2012: Art. 91). Exercising this mandate, Mexico introduced a carbon tax on certain fossil fuels starting in 2014 (see Section 4.2.2 below), and is now considering the option of establishing an of an emissions trading system (ETS) for one or more emitting sectors. Although an ETS would be in line with Mexico's strategy of pursuing economically efficient climate policies, and is indeed expressly mentioned in the LGCC (LGCC, 2012: Art. 94; see also Section 4.2.3 below), it remains unclear how these two approaches to carbon pricing – one based on fixed prices, the other on specified quantities – will operate alongside each other. What this analysis therefore sets out to explore are alternative pathways towards an instrument mix that combines both the carbon tax and a potential future ETS, including the economic and environmental implications of different combinations.

2

Definitions and Theoretical Considerations

2. Definitions and Theoretical Considerations

2.1. Carbon Pricing: Rationale and Alternative Approaches

Concern about the cost of environmental policy, coupled with a broader trend towards deregulation and market liberalization, has contributed to the diffusion of concepts from economic theory into environmental policy (Kneese et al., 1975; Pearce et al., 1989; Stavins, 1988). Economic theory commonly ascribes environmental challenges to different market failures, such as positive or negative externalities (Buchanan et al., 1962; Meade, 1952), the bounded rationality of economic actors, or information asymmetries. For economists, such market failures denote an inefficient allocation of goods and services by the market (Bator, 1958. One school of thought calls for public policy intervention to correct such market failures, for instance to internalize the social cost of pollution in the private cost of underlying economic activity (Baumol et al., 1988: 155; going back to Pigou, 1920). An alternative approach focuses on the role of institutions in allowing markets to correct themselves: because rational individuals may fail to take collective action in the common interest (Olson, 1968: 2; Hardin, 1968), properly defined institutions – including property rights – are necessary for the market to achieve an efficient outcome (Coase, 1960; Ostrom, 1990: 15)[(1)].

Although different policy instruments are available to address the market failures underlying environmental pollution (e.g. OTA, 1995: 81–89), economic instruments are widely considered to achieve effective outcomes at the lowest economic cost (Opschoor et al., 1989). Economic instruments are defined as "instruments that affect costs and benefits of alternative actions, open to economic agents, with the effect of influencing behaviour in a way which is intended to be favorable to the environment" (OECD, 1991: 117).

A subset of these economic instruments includes those that introduce an explicit price on environmental harm, be it through a corrective price set in the form of taxes, charges, and other levies (Baumol, 1972, drawing on Pigou, 1920), or through quantity controls based on a market for tradable permits (Crocker, 1966; Dales, 1968; Montgomery, 1972; drawing on Coase, 1960). By increasing the economic cost of harmful behavior, these instruments create a continuous incentive to reduce environmental harm: polluters will abate whenever they can do so at a cost below the price of pollution, but pay the applicable price when abatement is costlier, in line with the principle that "the polluter should pay" (UNCED, 1992: Principle 16). Abatement decisions are thus decentralized, helping overcome the information asymmetry between policy makers and polluters, and thereby reducing efficiency losses through rent seeking and regulatory capture (Helm, 2005: 215; on the underlying concepts, see Buchanan et al., 1975; Krueger, 1974). Ultimately, both instruments should result in an equilibrium where marginal abatement costs are equalized across all regulated entities, and abatement occurs where it yields the largest net benefit to society (Baumol et al., 1988: 177).

Policies that generate an explicit price on pollution are considered particularly useful to address climate change (Aldy et al., 2012; Bowen, 2011: 5-6; Krupnick et al., 2012: 1; OECD, 2013b: 14-15; Rydge, 2015), which has been described as "the greatest market failure the world has ever seen" (Stern, 2006: viii). The unique nature of climate change calls for policies that are flexible, scalable, and cost-effective. GHGs are not in themselves toxic, and the damage function of their accumulation in the atmosphere is likely to be shallow in the short run (Helm, 2005: 223), both of which allow for a more flexible policy approach[(2)]. Scale thus becomes critical to any viable policy solution, because the causes of climate change originate in diffuse, widely heterogeneous and virtually ubiquitous activities, with the boundless geographic scope of emissions matched only by the long time horizons of their accumulation in the atmosphere. So does the economic cost of a policy response: although

(1) In the presence of enforced property rights and sufficiently low transaction costs, the 'Coase Theorem' postulates that bargaining will lead to an efficient outcome when trade in externalities is allowed (Coase, 1960). For common-pool resources and public goods (Samuelson, 1954), where property rights are typically not defined, this will require creation of institutions such as common property protocols (Ostrom, 1990) or formation of clubs (Buchanan, 1965).

(2) Note, however, that the emission of GHGs is often accompanied by other pollutant emissions, notably air pollutants discharged during the combustion of fossil fuels. High concentrations of such pollutants may set limits to the flexibility afforded to GHG emitters under any form of policy constraint.

the avoided impacts of climate change – such as extreme weather events, flooding, crop losses, vector-borne diseases, and biodiversity loss (IPCC, 2014; World Bank: 2014) – and the co-benefits of mitigation, such as energy savings, reduced health impacts, or improved energy security (IPCC, 2015: 1152), suggest that a carefully designed mitigation strategy will generate benefits that outweigh costs in the long term (Stern, 2006), abatement actions divert resources and capital away from the production of conventional goods and services, and can thus have a detrimental effect on economic growth in the short term. Aside from scale, therefore, cost effectiveness becomes an overriding concern when addressing climate change.

For these reasons, introduction of a price on GHGs – commonly described as "carbon pricing" – has been referred to as the "logical foundation of any policy regime for clean energy" (WEF, 2009: 39). Unlike policies targeting specific solutions, carbon pricing is able to harness all available potential mitigation opportunities, providing scalability and avoiding potentially costly path dependencies in technological innovation (Anadon et al., 2016). By equalizing marginal abatement cost across all covered entities, it also minimizes the negative welfare impacts of mitigation. As the economic cost of climate action rises over time – with cheap abatement options being, by design, exhausted first (Stern, 2006: 63, 191) – the cost-effectiveness of carbon pricing will become increasingly critical to sustain any policy regime in the long run.

Another advantage of carbon pricing is its ability to generate public revenue to address distributional effects, reduce other distortionary taxes, or invest in research, development and deployment where the price signal alone is insufficient to alter behavior and channel finance to sustainable technologies and infrastructure. But although elegant in its conceptual simplicity, carbon pricing can be challenging to implement in practice, especially as part of an instrument mix alongside other policy instruments, where interactions can have multiple and unintended effects. Such interactions are the focus of the next section.

Definition: Carbon Pricing through Prices and Quantities

Policy makers seeking to address the causes and effects of climate change can take recourse to a portfolio of policy instruments, including corrective pricing and quantity rationing, performance standards, subsidies, agreements, and informational instruments (IPCC, 2015: 1155; OECD, 2008: 18-22). As mentioned earlier, both pricing and quantity controls deliver an explicit price signal on GHG emissions, better known as a "carbon price" (Aldy et al., 2012). Other policy instruments will also incur a cost of compliance and abatement, and therefore can be said to have an implicit, "effective", or "shadow" carbon price (OECD, 2013a; see generally Posner, 1971); but although this price can be estimated, it will vary widely among compliance entities, and – not being revealed like an explicit carbon price – will fail to send a price signal to the economy.

A pricing approach is implemented by way of fiscal instruments, commonly through what is called a "carbon tax". At a general level, taxes are compulsory, unrequited payments to a government where public benefits provided to taxpayers are not normally in proportion to their payment (OECD, 2001: 15). Other fiscal instruments, such as charges and fees, are payments in return for services received, limiting their suitability for climate policy. Functionally, a carbon tax can pursue various objectives individually or simultaneously, and focus on influencing behavior, financing specific expenditures, or generating public revenue. As for the taxable object and the point of regulation, the tax can be levied upstream on products and natural resources, based on their embedded carbon content, or on GHG emissions discharged in connection with certain activities along all stages of the value chain.

A *quantity rationing approach* involving a market, by contrast, is based on units conferring the right to discharge a specified quantity of GHGs for a specified duration of time, and includes both emissions trading systems based on a technological baseline or an emissions ceiling, and crediting systems based on mitigation efforts at project, sectoral or economy-wide level.

All these approaches – collectively referred to as "carbon markets" – have in common that they are based on a quantity limitation which generates demand for carbon units, and that they enable parties to purchase or sell carbon units at the respective market price, signaling the opportunity costs of pollution as determined by the forces of demand and supply. Following the initial issuance of units, thus, their distribution is left to market forces. As prices for units rise in response to growing scarcity, the demand for them will gradually decrease, along with the associated emissions (Tietenberg, 2006). Like a carbon tax, emissions trading can be implemented at different stages of the value chain, upstream, mid- or downstream.

2.2. Carbon Pricing in the Climate Policy Mix

As Mexico transitions to a sustainable economy, it will have to consider the policy instruments it chooses as part of a balanced and coordinated mitigation strategy. In practice, climate policy instruments are applied alone or in varying combinations to different sectors, such as electricity generation, industry, transport, buildings, and land use (Krupnick et al., 2010: 8-9)[(3)]. With this diversity of policy options comes a need for reliable criteria to guide and justify selection processes between contending instruments. While no universal framework serves to evaluate policy instruments across all settings, a number of criteria have been proposed in academic literature that focus on the environmental effectiveness, the cost effectiveness, and the distributional impacts of alternative policy approaches (Goulder et al., 2008; IPCC, 2015: 1156; Keohane et al., 1998).

A first subsection below discusses the application of these criteria to price controls and quantity rationing in climate policy, illustrating the limitations of a purely theoretical approach to instrument choice. Experience also suggests that carbon pricing will rarely, if ever, be introduced into a policy void, emerging instead alongside existing and evolving policy frameworks dedicated to climate change mitigation and adaptation, environmental protection more generally, and other social and economic concerns. Because the inevitable interactions with other policies can undermine both the environmental and the cost effectiveness of mitigation efforts, the following subsection introduces the concept of an instrument mix, and the current state of knowledge about successful policy alignment. Finally, a third subsection focuses specifically on alternative ways in which a carbon tax and an ETS can exist alongside each other, distinguishing a range of options based on the symmetry and synchronicity of application.

2.2.1. Prices vs. Quantities: Theory and Practice

Much theoretical debate has focused on the relative merits of pricing and quantity controls, focusing largely on a key difference between both approaches: the manner in which prices are determined. Under a carbon tax, it is set exogenously by administrative fiat, whereas in a carbon market, the price is discovered in the market at the meeting point of demand and supply, the latter being determined by the regulator (Goulder et al., 2014). Under idealized conditions of perfect information, both pricing and quantity rationing should equalize marginal abatement cost at a level that reflects the marginal environmental damage of pollution and therefore yields identical welfare outcomes (Baumol et al., 1988). When the marginal costs and benefits of policy intervention are uncertain, however, this assumed identity no longer holds true, and the welfare implications become contingent on whether the marginal costs or the marginal benefits of abatement rise faster with growing policy ambition ('Weitzman Theorem', after Weitzman, 1974). Climate change is driven by aggregate GHG concentrations in the atmosphere, prompting some commentators to argue that anthropogenic emissions will only result in a marginal increase in the overall "carbon stock", whereas the abatement costs – although also uncertain – are likely to grow more steeply; in other words, the global climate might be less sensitive to short-term changes in emissions than abatement costs (Hoel et al., 2002; Newell et al., 2003; Tol, 2014: 56).

(3) In most sectors, GHG mitigation will be achieved by improving the efficiency with which energy is used or by reducing its carbon intensity (OECD, 2008: 11), but in agriculture, forestry, and certain chemical and industrial processes where emissions are not related to energy use, other actions – such as input substitution, process changes, and stabilization or expansion of carbon sinks – will be necessary.

Applying the foregoing theorem, the flat damages from climate change would suggest favoring a carbon tax because a quantity set at the wrong level will result in greater deadweight loss than a wrong price (Weitzman, 2015). Empirical research on the accuracy of emission forecasts and its impact on policy design seems to underscore this conclusion (Wara, 2015). Importantly, however, uncertainty about the damages function of climate change over longer timeframes – and especially the possibility of climatic discontinuities and catastrophic outcomes (Pindyck, 2013; Weitzman 2014, 2011, and 2009) – can shift the preference towards quantity controls and the emissions certainty they offer (IPCC, 2015: 1167; Hepburn, 2006: 238; Pizer, 2002: 415; Pollitt, 2015: 8).

Indeed, as an influential commentator has suggested, the theoretical debate about prices and quantities might thus be one of "second-order importance" (Tirole, 2012: 124), prompting instead a focus on considerations of political economy. And in effect, experience to date suggests that political economy dynamics may favor emissions trading over taxes (Goulder, 2013: 99; Keohane et al., 1998: 315; Mehling; 2012: 278; IPCC, 2015: 1167). Different factors have been suggested to explain this observation, from the deliberation focused on a science-based target rather than a politicized price, the emergence of net beneficiaries under an ETS – including the financial services sector – as supportive constituencies (Paterson, 2012), and a proactive role of invested business coalitions (Meckling, 2011), to greater flexibility in distributing the economic burden of mitigation efforts through free allocation of units (Tirole, 2012: 124; Helm, 2005: 216; Hood, 2010: 12)[4].

Still, reasoned disagreement exists on the political economy of various aspects of instrument design and implementation. In terms of the administrative capacities required for carbon taxes and emissions trading, both approaches will require mechanisms to determine carbon emissions or content, and to monitor and enforce compliance at the point of regulation; but only an ETS will also require the establishment of a registry to track issuance, possession and transfers of units, and market infrastructure to allow for trading (Goulder, 2013: 99; Goulder et al., 2013: 11). Some commentators additionally cite the ability to use existing tax levying structures in defense of a pricing approach, reducing the overall administrative burden (Cramton et al., 2015; Helm, 2005; IPCC, 2014; Wara, 2014). Others, meanwhile, point to the greater transparency of outcomes in an ETS relative to domestic fiscal flows as an advantage of quantity rationing (Gollier, 2015; Tirole, 2012). As for revenue generation, empirical research shows that a larger share of revenue from ETS auctions has been allocated to environmental expenditures, whereas carbon tax revenue more commonly accrues to the general budget or is refunded to taxpayers, some authors would suggest reduced flexibility for policy makers under a pricing approach (Carl et al., 2016). Both instruments also interact differently with complementary policies in an instrument portfolio, affecting cost and, in some cases, environmental outcomes (see below, Section 2.2.2).

Once introduced, carbon taxes and emissions trading may also differ in their resilience against political change. Revenue generated by a carbon tax should incentivize governments to protect or even strengthen tax rates over time (Weitzman, 2015), although recent experience has also shown how the countercyclical tendency of carbon prices to fall during an economic downturn lessens the compliance burden in an ETS (Goulder, 2013: 95), increasing its resilience precisely at a time when pressure to weaken climate policies makes taxes more vulnerable (Doda, 2016; Pollitt, 2015). An argument can also be made about the opportunities each approach offers for international cooperation. While some commentators have argued in favor of international carbon tax harmonization (Cramton et al., 2015; Weitzman, 2015), science-based quantity targets have proven far easier to negotiate in international arrangements (Helm, 2005: 212). To date, emissions trading has also resulted in greater harmonization and linkage across jurisdictions (Mehling, 2016), however, it has been argued that the accompanying cross-border financial transfers may contribute to political vulnerability (Weitzman, 2015: 39).

(4) Unlike tax revenue returned to a compliance entity, which affects the net incentive to reduce emissions, free allocation of units under an ETS does not alter the overall quantity, or 'cap', and therefore the environmental outcome. It does, however, have distributional impacts and limit the ability to use auctioning revenue to reduce other distortionary taxes, which would increase aggregate welfare (Goulder et al., 2010; Parry et al., 2010), and some forms of free allocation – notably grandfathering – can significantly favor incumbents, creating a barrier against new entrants (Helm, 2005: 216).

Perhaps the most important difference relates to the consistency of the price signal under each instrument, where a carbon tax, by default, will be more stable and predictable than the price discovered by market forces within an ETS. Some observers have countered that tax rates will usually require frequent adjustment, whereas quantity targets can be set for the medium and long term, providing a longer policy horizon (Tirole, 124; Gollier et al., 2015: 20). Still, experience has shown price volatility to be considerable in markets for tradable carbon units, with potential ramifications for the achievement of intended policy objectives.

While this may not have implications for static cost effectiveness, it can affect the dynamic efficiency of carbon pricing over time (Görlach, 2014: 735). Volatility may prompt risk averse firms to engage in fewer transactions under an ETS (Baldursson et al., 2004), reduce incentives to innovate (Cramton, 2015; Hepburn, 2006; Johnstone et al., 2010), and increase financing cost for low-carbon investments (see below, Section 3.4.2). Under extreme volatility or extended periods of very low prices, market participants are more likely to focus on available mitigation options and hold off on innovation, which may promote unsustainable path dependencies and risk locking in carbon emissions (Bertram et al., 2015a; Seto, 2016; Unruh, 2000). Still, while carbon taxes avoid such volatility by offering price certainty, the rates set in most jurisdictions – as well as prices revealed in most carbon markets – are far from approaching even the low end of estimates of the social cost of carbon (OECD, 2016). A price in line with such estimates would be necessary for optimal outcomes, but may be precluded by binding political constraints (Jenkins et al., 2016).

Pursuit of an optimal outcome may be unrealistic in situations of incomplete information, limited resources, and various contending objectives (Simon, 1955). What that may instead justify is a pragmatic focus on reasonable, second-best solutions, with greater attention afforded to policy design rather than a futile pursuit of theoretical optimality (Labandeira et al., 2012). One important design option available to harness the relative advantages of pricing and quantity rationing while limiting their shortcomings is the introduction of a hybrid carbon price (see text box below), obviating much of the debate about the theoretical merits of pure pricing or quantity rationing.

Carbon Pricing Hybrids

Price uncertainty and volatility in an ETS can be reduced by combining its emissions certainty with some degree of price predictability through market interventions, resulting in a hybrid between pure pricing and quantity rationing. One way to manage prices is the introduction of a price floor, price ceiling, or both, by either setting prices directly or by manipulating unit supplies. A price ceiling, for instance, can be created by injecting additional units into the markets whenever the price reaches or exceeds a designated threshold, or by allowing compliance entities to pay a fixed tax in lieu of compliance. A price floor, by contrast, can be implemented by setting a minimum price for the initial sale of units (e.g. an 'auction reserve price'), by removing units from circulation whenever prices fall below a specified threshold, or by introducing a minimum tax that compliance entities must pay whenever the price of units drops below the tax (Goulder, 2013: 95; Wood et al., 2011). More complex mechanisms that intervene in the supply of units pursuant to sophisticated rules, such as market stability and cost containment reserves, have been established in several ETS (Golub et al., 2012; Murray et al., 2009). Such hybrid approaches have been thoroughly researched (Goulder et al., 2013; Grüll et al., 2011; Hepburn, 2006; Pizer, 1997 and 2002; going back to Weitzman, 1978), offer a viable means to secure predictable price signals for investors (Brauneis et al., 2013), and are also increasingly established features of carbon pricing systems currently in operation (Holt et al., 2015; Kollenberg et al., 2015). At the same time, they come with a tradeoff, as the presence of a price ceiling removes the constraint on overall emissions and thus compromises certainty about the environmental outcome. Some authors have suggested alternative ways to compensate for emission increases, for instance by using revenues from ceiling price sales or taxes to purchase offsets (e.g. Stavins, 2008).

2.2.2. Aligning Prices and Quantities in the Policy Mix

Different market failures contribute to anthropogenic climate change, from the negative externality of GHG emissions and the positive externality of innovation spillovers, to information asymmetries, bounded rationality, and principal-agent problems. Accordingly, policies adopted to correct these market failures can pursue objectives other than GHG emissions abatement, such as promoting innovation, inducing structural transformation, or increasing energy security (Helm, 2005: 214; Knudson, 2009: 308). A widely accepted precept, the 'Tinbergen Rule', states that each policy target requires at least one policy instrument for all policy goals to be achieved (Tinbergen, 1952; Johansen, 1965: 12), thereby providing the theoretical justification for climate strategy harnessing a variety of policy instruments in an instrument portfolio.

In keeping with this rationale, and despite the theoretical benefits of carbon pricing outlined earlier (see Section 2.1), there is growing recognition that a price on carbon by itself will prove insufficient to address climate change (IPCC, 2014: 1173; ITD, 2015; Stern, 2006: 308). So far, political constraints have mostly prevented the adoption or emergence of a carbon price sufficient to compensate the negative externality of GHG emissions (Jenkins et al., 2016; OECD, 2016). In such cases, additional policy measures will be indicated to correct the market failure, as reliance on the carbon price alone may delay necessary action and significantly increase welfare costs (Açemoglu et al., 2016).

Even where the carbon price reaches or exceeds median estimates of the social cost of carbon, additional barriers and distortions justify introduction of complementary policy instruments. In particular, policies that foster research, development, demonstration, and market deployment of low-carbon technologies are considered vital to drive innovation and bring forward the range of technology options needed to make deep emissions cuts (Açemoglu et al., 2012; Bertram et al., 2015b; IPCC, 2014: 1174; Stern, 2006: 308). Additionally, barriers to behavioral change – such as information failures, bounded rationality, and lacking availability of finance – can require targeted policies (Labandeira et al., 2011). Over time, the innovation and efficiency improvements spurred by such policies may even foster a more favorable political context for strengthened carbon pricing efforts (Wagner et al., 2015).

Transitioning to a low-carbon economy – a trajectory Mexico has committed to – will therefore likely require a balanced and coordinated strategy that leverages a combination of policy approaches. But in practice, concurrent policy objectives and instruments are not always clearly defined or easily distinguishable (Tinbergen, 1952: 37). Moreover, the positive theory of government suggests that political and institutional dynamics result in policy accretion (Helm, 2005: 213-214), where some policy instruments are introduced for purely symbolic reasons or concealed motivations. Negative policy impacts, for instance on low-income households or vulnerable industries, may require additional policy interventions, further increasing the number of instruments in the mix. In the end result, policy portfolios are not necessarily the result of a rationally conceived and fully coordinated process (Görlach, 2014: 735).

With simultaneous operation of different policy instruments, however, comes an increased likelihood of interactions (OECD, 2007: 27), especially where instruments pursue more than one objective or undermine other policy objectives and therefore necessitate tradeoffs (Knudson, 2009: 309-311). Depending on the instrument type, objectives, and context, such interactions can be positive or negative. They are more likely to be beneficial when each of the affected instruments addresses a different market failure with sufficient specificity, whereas adverse interactions are more likely when multiple policies seek to correct the same market failure (IPCC, 2014: 1181).

When combined with other policy instruments, carbon pricing will also interact along the same logic. Synergies can arise from the simultaneous operation of a carbon price, which aims to compensate the negative externality of emissions, and policies targeting a different market failure. Examples include financial incentives to internalize the positive knowledge spillover of innovation in renewable energy technology, where the combination with carbon pricing has been shown to allow emissions mitigation at lower cost than either policy would achieve alone (Fischer et al., 2004; Oikonomou et al., 2010; Schneider et al., 1997), or policies to overcome behavioral barriers, such as bounded rationality or information failures (Goulder et al., 2008; Gillingham et al., 2009).

Given its economic rationale of promoting mitigation at least cost, however, carbon pricing is also vulnerable to adverse interactions and even outright redundancies when implemented alongside other instruments that address the same market failure. Performance standards targeting particular technologies, for instance, will interfere with the ability of carbon pricing to equalize abatement cost across the economy and identify the most cost-effective abatement options. If the carbon price is higher than the marginal abatement cost under such complementary policies, it becomes redundant (IPCC, 2014: 1182); if the carbon price is lower, however, the simultaneous application of directed technology mandates will curtail the compliance flexibility of emitters and increase the cost of achieving the same environmental outcome. With a pricing approach, such as a carbon tax, the interaction should not compromise the environmental effectiveness (de Jonghe et al., 2009; Goulder et al., 2011); but with a quantity rationing approach that involves tradeable units, such as an ETS, the introduction of complementary policies can result in undesirable emissions leakage, as described in the text box below.

Quantity Rationing and the 'Waterbed Effect'

In the presence of an ETS, introducing additional instruments such as a performance standard might yield no further reductions in overall emissions. Because the overall emissions level is determined by the number of units in circulation, emissions reductions achieved under the complementary policy will displace units that can be used to offset emissions elsewhere under the ETS, effectively only shifting the location and timing of emissions under the determined limit (Burtraw et al., 2009; Fankhauser et al., 2010; Goulder and Stavins, 2011; Goulder, 2013). Additionally, the increase in unit supply will, ceteres paribus, exert downward pressure on unit prices until all units in circulation are again demanded (Goulder et al., 2013: 16), thereby weakening the price signal in the market. Although observers have countered that such an effect will not occur whenever unit supply exceeds emissions (Whitmore, 2016), an imbalance observed in most existing ETS, it still has an important bearing on the design of climate policy portfolios.

Occasionally described as the 'waterbed effect' because of how pressure in one location leads to expansion in another, the foregoing phenomenon will occur when the coverage of an ETS overlaps with that of a complementary policy at the same jurisdictional level, or when a policy introduced at a lower jurisdictional level is integrated within an ETS implemented at a higher jurisdictional level (IPCC, 2014: 1180, 1182; see also the Case Study on the United Kingdom, below). With relevance for a carbon pricing policy mix, such interactions can also arise when a carbon tax is introduced in the presence of an ETS (Böhringer et al., 2008; Fischer and Preonas, 2010), provided the fixed price is introduced only for a subsection of entities participating in emissions trading; whenever coverage of both instruments is identical, however, the tax will assume the role of a price floor (see below, Section 3.4).

For climate policy makers exploring the adoption of multiple climate policy instruments – including carbon pricing – as part of an instrument portfolio, the foregoing observations translate into a number of important recommendations. A starting point can be derived from the Tinbergen Rule: just as each target requires its own policy (Tinbergen, 1952), each policy should seek to address a different market failure, and do so with the greatest level of specificity possible. Policies adopted to promote climate mitigation should avoid the simultaneous pursuit of other policy objectives, such as labor or industrial policy goals (Görlach, 2014: 736). Because political economy considerations may nonetheless require that individual instruments invoke concurrent policy priorities, limiting the overall number of instruments may also be indicated (Knudsen, 2009: 309). Level of governance and sectoral coverage of complementary policies both have an important bearing on interactions, which, in the case of carbon pricing, suggests a preference for either full or no policy overlap: to avoid the "waterbed effect" described above, concurrent pricing through a carbon tax and quantity rationing with an emissions trading system requires that both instruments have identical coverage, or that the carbon tax have broader coverage, including all sectors and activities covered by the ETS. In the next section, these guiding principles are assessed in greater detail, with a view to specific case studies drawn from international experience.

3

Options and International Experiences

3. Options and International Experiences

3.1. Options for a Carbon Pricing Mix

A carbon tax and an ETS can exist alongside each other without any degree of coordination, or can form part of a coordinated instrument mix. Concurrent application without coordination will result in an aggregate effective price signal for sectors and activities covered by both instruments, but not offer the opportunity to leverage their coexistence for specific design purposes. Additionally, lack of coordination risks incurring leakage of emissions between policies described as the "waterbed effect" above.

A coordinated carbon pricing mix, by contrast, can help avoid unintended interactions and offers additional options for policy makers to introduce specific design features. Each of the following subsections outlines a conceptual option for the inclusion of pricing and quantity rationing in a coordinated carbon pricing mix, and provides case studies drawn from international practice. Alternative approaches to a carbon pricing mix are distinguished by the scope and timing of their application, described in terms of the 'symmetry' and 'synchronicity' of coverage.

Where a carbon tax and an ETS are fully symmetrical in coverage, they will apply to all the same activities and sectors; where they are partially symmetrical, there will be some, but not full overlap; and where they are asymmetrical in coverage, they will apply to entirely different sectors. Likewise, a carbon tax and an ETS will be synchronous if they apply at the same time, and asynchronous if one applies first, and phases out or transitions into the other. Depending on the degree of symmetry and synchronicity, a portfolio of options emerges to combine pricing and quantity rationing, as described in the following table.

Table 1: Variations in a Carbon Pricing Mix

<table>
<tr><th>Timing
Coverage</th><th colspan="2">Synchronous</th><th>Asynchronous</th></tr>
<tr><td rowspan="2">Symmetrical</td><td colspan="2">Price Floor and/or Ceiling</td><td rowspan="2">Transition/Phase-In</td></tr>
<tr><td rowspan="2">Compliance Alternative</td><td rowspan="2">No Overlap</td></tr>
<tr><td rowspan="2">Asymmetrical</td><td rowspan="2">No Overlap</td></tr>
<tr><td colspan="2">No Overlap</td></tr>
</table>

Each of these possible combinations will be described in greater detail below, with reference to international experiences in the form of case studies where available. It bears noting, however, that the boundaries between some options – such as the compliance alternative and the possibility to opt into an ETS – are blurry, and different options can also be combined. For instance, the case studies on Switzerland and the United Kingdom describe both an opt-in scenario as well as a transition from voluntary to mandatory participation in the respective ETS. Conceptually, moreover, using a floor or ceiling price to manage volatility and price extremes in an ETS is, in some ways, a mirror image of using offset credits as a compliance alternative in a carbon tax regime. Rather than offer precise definitions and sharp conceptual boundaries, therefore, the following sections are meant as a heuristic approach to categorizing different combinations of pricing and quantity rationing in a carbon pricing mix.

3.2. Carbon Pricing Mix as a Transition Mechanism

One option for lawmakers is to implement price-based and quantity-based carbon pricing sequentially. An example of this approach would be to put a price on carbon emissions that is initially fixed, but eventually allowed to float through an ETS. Australia offers an example of how such a transition can work (see text box below).

The advantage of starting carbon pricing with a fixed-price period is that it provides stakeholders with relative certainty over policy costs. Such certainty can ease the lawmaking process. The history of lawmaking in the environmental and health arenas shows that policy costs have been far more often overestimated than underestimated (Harrington et al., 1999; Goodstein and Hodges, 1997). We conjecture that it is more likely for stakeholders to overestimate the costs of a quantity-based instrument than to overestimate the costs of an equivalent price-based instrument. This is because it is impossible to predict what carbon price will emerge from the former, which leaves greater room for error in analyses that seek to estimate policy costs. Since errors tend to be on the side of overestimation, we think that the greater cost uncertainty associated with quantity-based instruments may result in greater exaggeration of these costs. Indeed, our experience with constructing long-term ETS carbon price forecasts has shown us that it has been more common to overestimate than to underestimate future carbon prices. For these reasons, fixed-price instruments are likely to lead to cost expectations that are closer to actual costs than those resulting from quantity-based instruments. Thus, fixed-price instruments can mitigate the potential for cost exaggeration and help lawmakers secure the support of the companies that are to be regulated.

A disadvantage of this approach is that a fixed carbon pricing instrument focuses the political debate on a specific price (rather than an emissions target), which may reduce its political appeal and burden the instrument with the political economy context of other fiscal measures. In Australia, a sustained, and eventually effective, opposition to the nation's carbon pricing system was founded on the notion that the carbon price was a tax (see text box below).

It is also worth recalling that a fixed-price instrument does not allow for a cap on emissions. Given that the primary objective of carbon pricing is to cost-effectively reduce greenhouse gas emissions, policy makers may therefore have a rationale to eventually transition from a fixed price period to an ETS that can ensure that emission reduction targets are met.

Case Study: Australia's Carbon Pricing Mechanism

Australia implemented carbon pricing when it enacted the Clean Energy Act of 2011. The act introduced the Carbon Pricing Mechanism, which became operational in the fiscal year 2012-2013. The mechanism operated until 1 July 2014, when it was repealed by the newly elected government formed by the center-right Liberal party under Prime Minister Tony Abbot. Despite its short existence, Australia's Carbon Pricing Mechanism holds lessons for policy makers due to its unique integration of price-based and quantity-based instruments. The mechanism required that liable emitters surrender a permit for each ton of CO_2 emitted.

It covered emissions from power, industry, waste management, and fugitive sources, capturing around 60% of Australia's emissions. A unique feature of the mechanism was that it introduced carbon pricing in a sequential manner.

For the first three years of the program, emitters could purchase permits from the government at a fixed price. The mechanism stipulated that the price level would start at AUD 23/t CO_2e for the 2012-2013 fiscal year, and gradually rise to about AUD 25/t CO_2e in 2014-2015.

The design of the fixed price period allowed a broad coverage of sectors, while mitigating competitiveness concerns. The program covered politically sensitive sectors such as energy-intensive industries, but gave them permits for free to protect them from any adverse effects of the carbon price. Companies could sell free permits back to the government, which provided them with an incentive to reduce emissions.

The Carbon Pricing Mechanism stipulated that an ETS would come into force in 2015-2016. Though the carbon price was to be determined by the market, the government decided to maintain some level of price management by including provisions for a price floor and a price ceiling. The transition was to be facilitated by virtue of that fact that some of the prerequisites for emissions trading had already been put in place for the fixed-price period, such as systems for the monitoring, reporting and verification of emissions.

However, the ETS never entered into operation. Politically, the fixed-price period incurred significant challenges for the government. Opponents to the carbon price, led by the Liberal Party, assailed it as an economically harmful carbon tax, implying that Prime Minister Julia Gillard had reneged on an earlier campaign promise not to implement any new taxes. The ensuing controversy caused damage to Gillard's approval ratings and played a part in the Liberal Party's victory in the 2013 elections, ultimately resulting in the repeal of the Carbon Pricing Mechanism.

3.3. Carbon Pricing Mix as a Flexibility Option

Pricing and quantity rationing can be implemented alongside each other to offer compliance entities increased flexibility in meeting their obligations. Two alternative approaches have been deployed in practice, allowing entities liable under a carbon tax the option to voluntarily become participants in an ETS, or affording them the opportunity to comply with the tax obligation through use of emission offset credits. Both approaches are described through case studies below.

3.3.1. Voluntary Opt-in

Being able to voluntarily opt into an ETS offers entities flexibility in their compliance with climate policy objectives and related carbon constraints. Typically, the decision to opt into the ETS is voluntary, but once it has been exercised, participation becomes mandatory, with affected entities either subject to an aggregate cap or individual mitigation targets. Different motivations may underlie such a choice, including reputational benefits or a desire to participate in the carbon market for speculative or other purposes, but most commonly the driver will be a desire to avoid having to comply with costlier policy alternatives.

In Switzerland and the United Kingdom, for instance, the default policy at one point in time was a carbon tax, but taxable entities were given the option to adopt a mitigation target and participate in an ETS in lieu of servicing their tax liability. Both cases saw significant uptake of the opportunity to opt into the ETS, reflecting the cost-savings expected from participation in the market and from having access to offset credits. In both cases, however, participation in the ETS eventually became mandatory for entities exceeding certain emission or capacity thresholds. While the advantages of a voluntary opt-in are readily apparent for compliance entities, the uncertainty it introduces also curtails the ability of policy makers to predict and control emissions outcomes, possibly explaining why this option has often remained a temporary one.

Case Study: Switzerland

In 1999, Switzerland adopted an Act on the Reduction of Carbon Dioxide (CO_2) Emissions (Federal Council, 1999) to help achieve the quantified emission reduction commitment entered under the Kyoto Protocol to the UNFCCC. Included in the 1999 CO_2 Act was a mandate to adopt a CO_2 levy if alternative instruments proved insufficient to achieve the Swiss climate commitment. This mandate also specified the earliest launch date, the scope, and the maximum rates for such a levy. Starting in 2008, Switzerland exercised this mandate by imposing a levy on all fossil thermal fuels, such as heating oil, natural gas, coal, petroleum, and coke, used to produce heat, to generate light, in thermal installations for the production of electricity or for the operation of heat-power cogeneration plants. Rates under the levy have gradually risen from CHF 12/tCO_2 (USD 11.9/tCO_2) in 2008 to CHF 84/tCO_2 (USD 82/tCO_2) in 2016 (Federal Council, 2007: Art. 3; Federal Council, 2012: Art. 94).

Up until 2012, energy intensive and trade exposed entities had the option to seek an exemption from the tax, provided they voluntarily adopted an absolute GHG emissions target and subjected themselves to specified transparency obligations (Federal Council, 1999: Art. 9). Exempted entities were assigned allowances at no cost and could sell surplus allowances to other compliance entities, or cover a shortfall in their compliance obligation by purchasing allowances or international offset credits. In essence, thus, the CO_2 levy functioned as a de facto price ceiling for covered entities, and the option to participate in the ETS afforded entities flexibility to potentially comply at a lower rate than the levy (Dahan et al., 2015c).

Approximately 1,900 companies were affected by the levy or participated in the ETS during this period (Dahan et al., 2015c: 3). Starting in 2013, participation for approximately 50 installations with emissions exceeding specified thresholds became mandatory (FOEN, 2014: 13). Large emitters set out in an Annex to the Ordinance on the Reduction of CO_2 Emissions (Federal Council, 2012) are subject to an aggregate emissions cap, which started at 5.63 Mt CO_2 in 2013 and declines 1.74% annually thereafter. Small and mid-sized emitters not included in the Annex may continue to opt-in voluntarily in order to avoid payment of the CO_2 levy (Dahan et al., 2015c).

Case Study: United Kingdom (2002-2004)

In 2000, the United Kingdom adopted a Climate Change Programme outlining ways to achieve its quantified emission reduction obligation under the Kyoto Protocol to the UNFCCC, as well as a stringent unilateral objective of reducing GHG emissions 20% below 1990 levels by 2010. With this Programme, it introduced various flexible instruments, including a new tax on industrial energy use, the Climate Change Levy (CCL); negotiated arrangements with large emitters, so-called Climate Change Agreements (CCAs); and a voluntary ETS, which became the first comprehensive trading system for GHG emission allowances upon its launch in 2001 (Dahan et al., 2015d; Smith et al., 2007). 34 entities became direct participants in this ETS, allowing them to bid for support from an incentive fund in return for committed emissions reductions.

Moreover, entities that had voluntarily entered CCAs with the government in order to obtain an 80% discount on their CCL payment obligation were able to use allowances from the ETS for compliance. Entities in over 40 energy-intensive sectors took on such quantitative energy efficiency targets in exchange for discounts on their CCL liability.

According to a study of the UK ETS, it incentivized substantial abatement in its first two years, achieving emission reductions of 4.62 million tCO_2e against the target reductions of only 0.79 million tCO_2e in 2002 (Smith et al., 2007).

When the mandatory EU ETS was introduced in 2005, most participants in the UK ETS became subject to the larger system by virtue of their inclusion in the annex listing covered activities and coverage thresholds. The UK ETS ended in December 2006, with the final reconciliation completed in March 2007 (Dahan et al., 2015d).

3.3.2. Compliance Alternative

Conceptually similar to the opt-in approach described in the previous section, a quantity rationing approach can also provide a compliance alternative for affected entities. Instead of opting to participate in an ETS, however, this option is characterized by the original compliance obligation remaining in place, but offering compliance entities an additional means to satisfy their obligation. It is particularly suited for carbon tax regimes, affording taxable entities the option to meet their tax liability by surrendering allowances or offset credits in lieu of payment. For affected entities, this will normally be attractive only when allowances or offset credits can be obtained at lower cost than the equivalent tax liability. To determine whether that is the case, however, the mechanism to calculate equivalence first has to be determined. One option applied in the case of South Africa, described in greater detail below, is to base equivalence on the amount of GHGs represented by an allowance or offset credit – typically one metric ton of CO_2e – and accepting these units in lieu of payment of the tax for the equivalent amount of GHGs. An alternative option would be to base equivalence on the nominal or market value of allowances and offset credits, in which case, however, the economic rationale of choosing compliance by way of such emission units is less clear.

Case Study: South Africa

Following its submission of a climate pledge under the Copenhagen Accord, South Africa began exploring policy options to achieve its mitigation objectives. An analysis of a carbon tax presented by the South African National Treasury in 2010 surveyed the advantages and disadvantages of a carbon tax versus an ETS. In an updated version of May 2013, the National Treasury ultimately supported the implementation of a carbon tax (National Treasury, 2013). In November 2015, it released a draft Carbon Tax Bill for comments (National Treasury, 2015), which envisioned introduction of a carbon tax on 1 January 2017 covering fossil fuel combustion emissions, industrial processes and product use emissions, and fugitive emissions. Nominally set at ZAR 120 (USD$ 8.77) per tCO_2e, the tax would be phased in over time and allow for a number of exemptions and tax-free thresholds to avoid impacts on vulnerable industries and households.

Additionally, it would establish a carbon offsets tax-free allowance of 5 to 10 per cent of the tax liability. Offset credits from mitigation projects in South Africa would be eligible for use up to this limit, with the expectation that this flexibility will enable mitigation at a lower cost and therefore lower the tax liability of affected entities, while also incentivizing abatement measures in sectors that are not directly covered by the tax (Dahan et al., 2015b).

More specific details about the offset mechanism and its design, including eligible offset crediting standards, project types and methodologies, have yet to be published; in the meantime, a number of international verification standards, including the CDM, Verified Carbon Standard (VCS), and CDM Gold Standard (GS), should be eligible (Dahan et al., 2015b).

3.4. Carbon Pricing Mix as a Price Management Option

Lawmakers can also use price-based and quantity-based policies in conjunction to create a hybrid carbon pricing instrument. Such an approach policy uses taxes or fees as tools to manage the floating carbon price generated by an ETS. Countries have used such approaches to incorporate both price floors (see the UK Case Study, text box below) and price ceilings (see New Zealand Case Study, text box below) into their carbon markets.

The reason lawmakers may want to consider carbon price management is the instability of carbon prices generated by an ETS, as introduced in Section 2.2.1. Historical experience has shown that ETS policies that lack meaningful price controls have produced carbon prices that are highly variable. Carbon prices in the European Emissions Trading System (EU ETS), for instance, have fallen precipitously from their initial levels. In 2013, the EU carbon price hovered around an annual average value of 4.5 EUR/t CO_2e (4.8 USD/t CO_2e), 80% lower than its average value in 2008.

Another common concern for lawmakers has been a tendency for ETS policies to result in carbon prices lower than what they had initially expected. The reason behind this phenomenon is that, across all ETSs, emitters have needed fewer permits than lawmakers have allocated (Ferdinand and Dimantchev, 2015). Such permit surpluses have stemmed from overestimations of future emissions and unanticipated emission reductions caused by complementary policies such as renewable energy mandates and incentives. Against this background, price management provisions can help lawmakers mitigate the risk of low carbon prices. In the following subsections, we discuss the specific ways in which price management has been shown by historical experience to improve carbon pricing.

3.4.1. Improving Cost-effectiveness

Theory and practice suggest that stable carbon prices deliver long term emission reductions at a lower cost than variable ones. In ETSs with no price management in place, carbon prices largely follow short-term changes in the supply and demand for permits. This occurs because market participants generally pursue a short-term orientation and because they apply higher than socially optimal discount rates, leading them to either ignore or heavily discount information about the long-term supply and demand for permits. As a result, carbon prices may not reflect the costs of meeting long-term climate targets and send misleading signals to the private sector. In such cases, businesses can overinvest in high-carbon assets, causing “carbon lock-in” that makes emission reductions costlier (Seto et al., 2016). Carbon-intensive facilities may later become “stranded assets” and be forced to close prematurely so that climate targets can be met (Bertram et al., 2015a; on the concept of carbon lock-in, see Unruh, 2000).

A testimony to these dynamics is the history of the EU ETS. The sharp decline of the European carbon price after 2009 hurt the profitability of low carbon investments which the EU needed to achieve its long-term target to reduce emissions by 80% from 1990 levels by 2050 (COM(2014)20, 2014). While the European Commission estimated that the long-term target would require a 2050 carbon price between 100 EUR/t CO_2e and 370 EUR/t CO_2e (in real 2008 euros), the carbon price hovered around 6 EUR/t CO_2e (7.9 USD/t CO_2e) in 2014. Out of concern for high-carbon lock-in, the European Commission proposed a measure to increase and stabilize the carbon price, called the “Market Stability Reserve”, which was eventually adopted in 2015 (Decision (EU) 2015/1814, 2015).

As discussed in Section 2.2.1, the academic literature also suggests that – all things being equal – a fixed carbon price may be more cost-effective than a variable one in the short-term, unless the risk of climate change discontinuities and non-linear impacts is significant. Likewise, studies have shown that a mix of climate policies that includes a carbon tax is more cost-effective than a mix that includes emissions trading without price management; the main reason is that complementary climate policies induce price variability in emissions trading systems (see the text box on the "Waterbed Effect" in Section 2.2.2), which in turn can lead to suboptimal investments and a carbon lock-in effect (Bertram et al., 2015b). As discussed earlier (see Section 2.2.1), political economy constraints may nonetheless favor emissions trading as the more viable instrument. But policy makers can still capture the foregoing advantages of a carbon tax while retaining the benefits of emissions trading by implementing an ETS with a price floor (Grubb, 2012; Burtraw et al., 2013; see also text box on carbon pricing hybrids in Section 2.2.1).

3.4.2. Driving Low-carbon Investments

A number of studies have found that uncertainty with regard to the future CO_2 price decreases the ability of carbon pricing to induce low-carbon investments (Yang et al., 2008; Fuss et al., 2009; Oda and Akimoto, 2011). Investors in capital-intensive and long-lived assets such as low-carbon technologies require a relatively large degree of certainty over their future profitability. Carbon prices that swing from one year to the next make investing in low-carbon technologies a riskier venture. Uncertainty leads to higher financing costs, which can be particularly challenging for renewable technologies, which require most funding upfront. Consequently, some authors argue that the variable European carbon price proved to be ineffective as a driver of investments in renewables (Grubb, 2012).

One solution for investors in capital-intensive assets that has been applied in electricity markets is hedging risk through long-term contracts. However, willingness to engage in long-term contracts is likely to be insufficient in carbon markets characterized by significant variability in price. Indeed, such lack of interest is demonstrated by the low liquidity of futures contracts for EU carbon allowances for delivery in the long-term on their most liquid trading platform (Intercontinental Exchange, 2017).

An additional challenge is the fact that low-carbon investments are often irreversible, which generally leads investors to adopt a "wait and see" approach in the presence of uncertainty (Dixit and Pindyck, 1994). Such delays to low-carbon investments make decarbonization more expensive overall (Altamirano et al., 2016).

Therefore, a cost-effective transition to a low-carbon economy requires carbon prices that are predictable (Stern, 2006; Global Commission on the Economy and Climate, 2014). A carbon price floor will likely accelerate investments in low-carbon technologies (Brauneis et al., 2013, Wood et al., 2011). This rationale led the UK to implement such a tax in 2013 (see UK Case Study below).

3.4.3. Revenue Certainty

Variability in carbon prices can also diminish the predictability of the associated government revenues generated from the sale of carbon permits under an ETS. A lack of revenue certainty complicates budget planning for governments. Inability to rely on variable revenues interferes with the ability of governments to reliably plan expenditures funded through emissions trading revenues. For example, Germany set up a special fund that channels revenues from allowance sales toward climate related initiatives, but it raised less revenue than expected when the price of carbon in the EU ETS fell substantially, forcing the government to seek alternative financing to fill resulting gaps in already committed expenditures (Esch, 2013).

Where revenues are directed toward specific programs such as energy efficiency, their effectiveness is limited if funding is volatile. Such programs are most effective when they can provide a consistent stream of financing that incentivizes businesses to invest in research and development (R&D), develop supply chains, and provide labor force training. In the UK, inconsistent funding for energy efficiency prior to the implementation of the price floor hindered the ability of the energy efficiency sector to maintain a skilled workforce (Vaze, 2014).

A carbon price floor in the form of a top-up tax within the ETS alleviates this problem. It makes revenue from emissions trading more reliable, and allows regulators to plan how to spend it most effectively.

3.4.4. Curtailing Regulatory Uncertainty

Carbon price floors and ceilings can in some cases reduce regulatory uncertainty for market participants. In their absence, there may be times when carbon prices deviate too much from expected or desired levels, leading regulators to take discretionary actions to adjust them. In 2014, for instance, the EU responded to the crash in the European carbon price with an intervention to adjust the projected supply of CO_2 permits (an initiative known as "backloading"). The legislative debate leading up to this decision led to periods of excessive volatility in the market and uncertainty among traders about the possibility of such discretionary actions (on the adverse effects of such volatility, see above, Section 2.2.1). To reassure market participants, the EU stipulated in its backloading decision that it would never pursue such interventions again. Carbon price floors and ceilings would largely obviate the need for such regulatory interventions.

3.4.5. Enhancing Co-benefits

Price management can also enhance certain co-benefits of emissions trading. For example, in the absence of a price floor, an economic downturn may substantially reduce the carbon price in an ETS, thus making coal more competitive relative to alternative generating technologies, which in turn will increase concentrations of dangerous air pollutants such as PM 2.5 (see UK Case Study below).

Another co-benefit that can be compromised by carbon price variability is energy security. As noted above, variable carbon prices generally fail to drive investments in renewable generation. This can make it more difficult for regulators to increase or diversify domestic energy production capacities (HM Treasury, 2010).

Case Study: United Kingdom (Since 2013)

The UK has implemented a carbon pricing policy that combines emissions trading and a carbon tax. The country participates in the European ETS (the EU ETS), which applies to emissions from power, industry and aviation. In addition, the UK charges a domestic top-up carbon tax on fossil fuels used in electricity generation (called "Carbon Price Support"). The tax is referred to as a top-up because companies only have to pay it when the EU ETS price is below a certain target price level defined by the government. The amount of tax they pay is equal to the difference between the EU ETS price and the target price. Hence, the target price acts as a floor for the price of carbon.

The rationale for the price floor was to provide businesses with a stable incentive to invest in low-carbon power generation. The government argued it was necessary because the carbon price produced by the EU ETS was too variable and unpredictable to drive low-carbon investments (HM Treasury, 2010). The UK chose a price floor trajectory that started at GBP 16/t CO_2e (USD 25/t CO_2e) in 2013 and was initially set to rise to GBP 30/t CO_2e (USD 46/t CO_2e) in 2020 and GBP 70/t CO_2e (USD 110/t CO_2e) in 2030, a trajectory that was eventually revised (see below). Under the original policy framework, the government was mandated with determining the annual top-up tax rate twelve months before the start of each fiscal year. This system would provide UK businesses upfront certainty about the amount of the top-up tax.

However, it still left companies with some uncertainty about their overall carbon price obligation, because the calculation of the top-up tax used a one-year historical average of the EU ETS price. When the EU ETS price later declined from this level, the final carbon price was slightly lower than the government's target price.

The government estimated that the tax would increase low-carbon generation capacity by 7 GW, mainly from nuclear and carbon capture and sequestration (CCS), by 2030. Its analysis also calculated co-benefits in air pollution abatement valued at 400 million pounds. Ex-post analyses of the carbon price floor have shown that a short-term effect has been a switch in power generation from coal to gas (Carbonbrief, 2016). Meanwhile, ex-post evaluations of the expected long-term effects have yet to be performed.

A prominent issue that surrounds the UK's carbon price floor is the burden it imposes on British energy-intensive industry (HM Treasury, 2011). Some businesses expressed concern that the UK's carbon price floor would harm their competitiveness compared to rivals in mainland Europe which only have to comply with the lower carbon price generated by the EU ETS. The UK managed to minimize such risks by limiting the scope to power generation. Since electricity costs are a relatively minor component of costs for energy-intensive industry, the price floor is unlikely to harm their competitiveness (Grover et al., 2016). The government further assuaged such concerns by introducing the tax in conjunction with other tax reforms that lowered taxes on capital and income (HM Treasury, 2011). In 2014, the UK government decided to cap the top-up tax at a maximum GBP 18/t CO_2e (USD 29/t CO_2e) until 2020 (HM Treasury 2014). This was partly a reaction to the fact that the EU ETS carbon price continued to decline, expanding the gap between the carbon prices paid by UK producers and mainland ones.

UK's policy experience provides a proof of concept of how top-up carbon taxes can be used to provide a price floor in emissions trading systems, improving predictability for investors. Britain's experience of combining its tax with the EU ETS also demonstrates that such a top-up carbon tax does not categorically prevent countries from participating in linked carbon markets, retaining the opportunity to meet domestic policy goals while cooperating with others on carbon pricing.

Politically, the willingness to embrace greater climate policy ambition through a carbon floor price might even signal leadership and incite other jurisdictions to adjust their carbon pricing regimes.

But at the same time, given its integration in the larger EU ETS, the UK carbon floor price has also given rise to criticism for merely shifting emissions to other EU Member States, where allowances displaced by the higher carbon price in the UK will be used to offset an emissions increase and also exert downward pressure on EU carbon prices (Fankhauser et al., 2010; Sartor et al., 2011; Goulder, 2013).

Although this "Waterbed Effect" (see also text box in Section 2.2.2) is greatly dampened by the current allowance surplus in the EU ETS, making for a flatter supply curve and thus lowered demand (and price) sensitivity (Whitmore, 2016), the UK carbon floor price will nonetheless alter the equilibrium of demand and supply across Europe, exacerbating the current imbalance.

4

Carbon Pricing in Mexico

4. Carbon Pricing in Mexico

4.1. Socioeconomic Parameters

4.1.1. Macroeconomic Context

In the design of climate policy, one of the most important considerations is its impact on the economic system. The economic literature suggests that mitigating climate change does not have to come at the expense of economic prosperity, and that carbon pricing plays a role in cost-effective climate policy (Global Commission on the Economy and Climate, 2014). As Mexico prepares to expand carbon pricing, two issues will likely be particularly prominent in the national conversation: industrial competitiveness and government revenues.

Mexico derives as much as 34 percent of its Gross Domestic Product (GDP) from industry (compared to an OECD average of 24%). This includes both energy-intensive industries, which may feel the impact of a carbon price, and industries that are not energy-intensive, which will very likely suffer no impacts. Mexico is also a relatively open economy, with trade as a percent of GDP at 73% (compared to an OECD average of 56%). The economy derives competitive advantage from relatively low labor costs and its proximity to the United States. In that context, lawmakers designing a carbon pricing system will have to consider how such a policy may influence Mexico's international competitiveness.

A price on carbon can both help and hinder international competitiveness, depending on how it is designed. Carbon pricing can strengthen competitiveness by giving Mexico a head start in the development of the technologies and capabilities that will be increasingly demanded in a future low-carbon global economy, spurring a structural shift towards higher value-added industries and sectors. At the same time, it can also raise manufacturing costs for carbon-intensive Mexican firms, which can harm their competitiveness if other nations do not implement comparable climate policies. International experience has shown that carbon pricing can be designed in a way that minimizes this risk by including exemptions or favorable allocation provisions for sectors deemed particularly vulnerable due to their energy intensity and exposure to international trade (Bolscher et al., 2013).

Carbon pricing also has important implications for the national budget. Mexico has recently seen growing levels of debt as a percentage of GDP, due in part to the slump in oil prices. Public budges are coming under additional strain from the rising costs of extreme weather events associated with climate change (PECC, 2014). An ETS that incorporates auctioning of allowances can generate revenues for the state, as we discuss below (see Section 5, "Quantitative Analysis").

4.1.2. Emissions and Emission Trends, by Sector

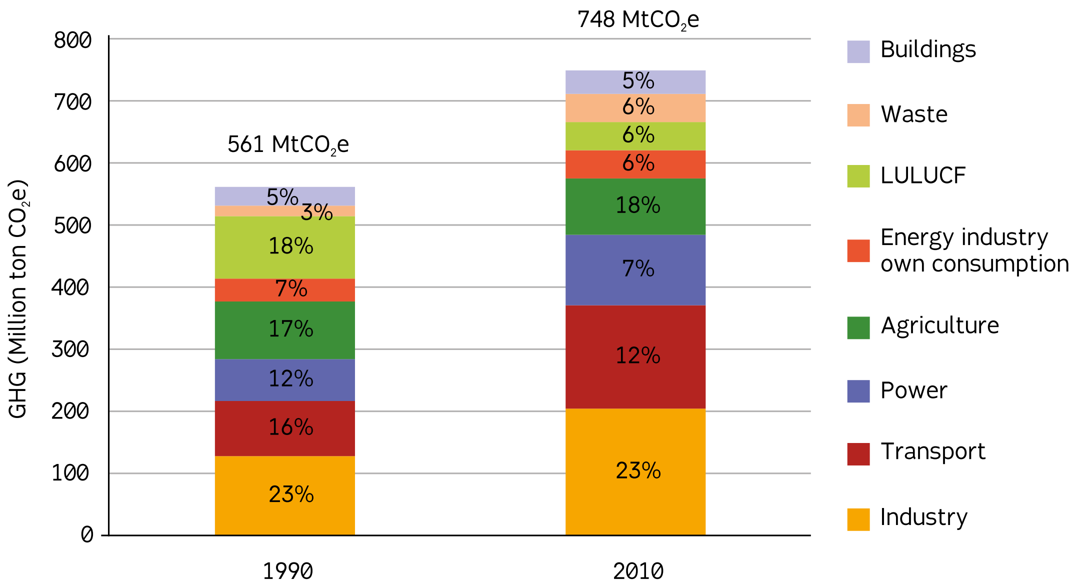
Analyzing the sources of greenhouse gas emissions can help regulators determine the scope of a carbon pricing policy. The potential of carbon pricing will be maximized if it is targeted toward high-emitting sectors. As shown in Figure 1, Mexican greenhouse gas emissions are concentrated in three sectors: industry (27% in 2010), transport (22%), and power (15%). Based on Mexico's more recent emissions inventory of 2013, which uses an updated methodology, these sectors contribute 29%, 26%, and 19% to overall Mexican greenhouse-gas emissions. Though Figure 1 displays data calculated based on an older methodology, it provides a look into how sectoral emissions have changed over time. The industry, transport and power sectors have seen growth in emissions since 1990 as a result of rising energy demand, which is itself a result of economic growth and a relatively small change in energy intensity per unit of GDP (IEA, 2016). They have also come to represent higher shares of Mexico's overall emissions, as emissions in other major sectors have decreased significantly (LULUCF), or stayed relatively unchanged (agriculture). Emissions in these sectors will likely continue to rise with economic growth and continued increase in energy demand (IEA, 2016), making them a prime target for carbon pricing policy.

Carbon pricing will be most cost-effective when it covers sectors with a relatively small number of large emitters. Such sectors include industry and power. In contrast, policy costs may be higher for sectors with many small, diffuse and remote emission sources (such as forestry, agriculture, and waste), where administrative costs per entity are higher and emissions measurement potentially more uncertain. A solution to the problem of diffuse emission sources is the implementation of an upstream carbon price on fossil fuel producers or importers. California's ETS has demonstrated that such a policy can effectively capture the transport sector, a large but highly diffuse source of emissions. An upstream carbon price on fossil fuels can also cover the combustion of fossil fuels in smaller sectors such as the residential and commercial buildings sector. Burning of fossil fuels in this sector led to the emissions of 24 Mt of CO_2e in 2013.

A comprehensive coverage of Mexican emissions would likely require a combination of upstream and downstream carbon pricing, with an upstream point of regulation particularly suited to capture carbon emissions from fossil fuel combustion by diffuse sources, such as households and transport, and downstream regulation a more direct way to target emissions from large point sources in the power sector and in industry. An important consideration is the significant amount of non-fossil fuel emissions in the industry sector. Emissions from industry arise not only from fossil fuel combustion, but also from industrial process emissions. Fossil fuel combustion, and processes, respectively contributed 57% (66 Mt CO_2e in 2013), and 43% (49 Mt CO_2e) to the sector's emissions. This split indicates that a carbon price imposed solely on fossil fuels will exempt significant emissions from industrial processes. Another consideration is that downstream carbon pricing applied on emitters is theoretically likely to be more salient to company managers, and may therefore have a higher potential of effecting a change in behavior (PMR and ICAP, 2016). Interviews with companies liable under the EU ETS show a shared belief that the market raised environmental awareness among company managers and employees (European Commission, 2015), which may be due to the fact that the EU ETS applies to downstream emissions at the point of combustion.

The overarching takeaway is that carbon pricing can apply to a broad share of Mexico's emissions, the extent of which regulators can adjust through various design parameters. The optimal sectoral coverage of carbon pricing in Mexico is beyond the scope of this section and will depend on a number of additional factors such as the ability of various points along the supply chain to pass through carbon costs, measure emissions, and comply with regulations.

Figure 1: GHG Emissions by Sector, 1990 and 2010



Source: Inventario Nacional de Emisiones de Gases de Efecto Invernadero 1990-2010

4.1.3. Emissions Abatement Cost, by Sector

There are two categories of abatement costs: societal and private. The first category represents the monetary costs that accrue to society when it reduces a certain amount of emissions. The latter measures the costs that firms and individuals bear when they reduce their emissions. Both have important implications for designers of carbon pricing policy. In this section, we provide a broad review of societal abatement costs and compile estimates of the private marginal abatement costs, which we will use later in our economic analysis in section 5.1.

4.1.3.1. Societal Abatement Costs

Regulators can use societal abatement costs to determine the overall costs of climate policy at varying levels of stringency, and to decide what level of stringency is desired.

Studies have found that Mexico can achieve substantial emission reductions at a net negative cost (an economic gain). This is because many of the ways Mexico can reduce emissions – such as industrial efficiency standards, vehicle fuel economy standards, gas flaring abatement, waste recycling – yield savings that over time exceed their initial costs. McKinsey & Co., an international consultancy, estimate that Mexico will benefit financially if it meets its target to reduce emissions by 30% below Business-as-Usual (BAU) levels by 2020 (McKinsey, 2013). Earlier calculations by McKinsey & Co found that Mexico can reduce 2030 emissions from BAU levels by over 500 Mt CO_2e at a net economic gain (McKinsey, 2009). These results suggest that Mexico can exceed both its conditional and unconditional commitments to the Paris Agreement in a profitable manner (Section 4.2 explains these targets in detail). Similarly, an analysis authored by the World Resources Institute found that Mexico can meet its unconditional and conditional targets while accruing net economic savings of 500 and 200 billion pesos respectively by 2030 (Altamirano et al., 2016).

Three caveats are worth noting. First, these analyses do not account for the opportunity costs of abatement. They do not compare the profitability of abatement compared to other investments. Economic analyses using general equilibrium models find that a climate mitigation scenario lowers GDP compared to a BAU scenario (Veysey et al., 2016). Yet, such models likely overestimate climate policy costs because they make the unrealistic assumption that all resources are used efficiently in their BAU scenarios.

Second, the quoted marginal abatement costs do not factor in the substantial co-benefits that accompany climate change mitigation, such as air pollution mitigation (Altamirano et al., 2016) and energy security. Despite these first two caveats, the evidence on abatement costs does demonstrate the fact that Mexico has ample cost-effective opportunities to reduce emissions.

A third caveat regarding the above estimates is that they do not reflect the costs that individual firms bear when they implement a given abatement option. The analyses use relatively low discount rates of around 3%-4% to calculate the present value of future costs and savings. Private decision makers typically use higher discount rates, one reason being that businesses face a higher cost of capital. The values above also take no account of non-financial barriers, which in practice prevent private firms from implementing otherwise profitable abatement options such as energy efficiency improvements.

4.1.3.2. Private Abatement Costs

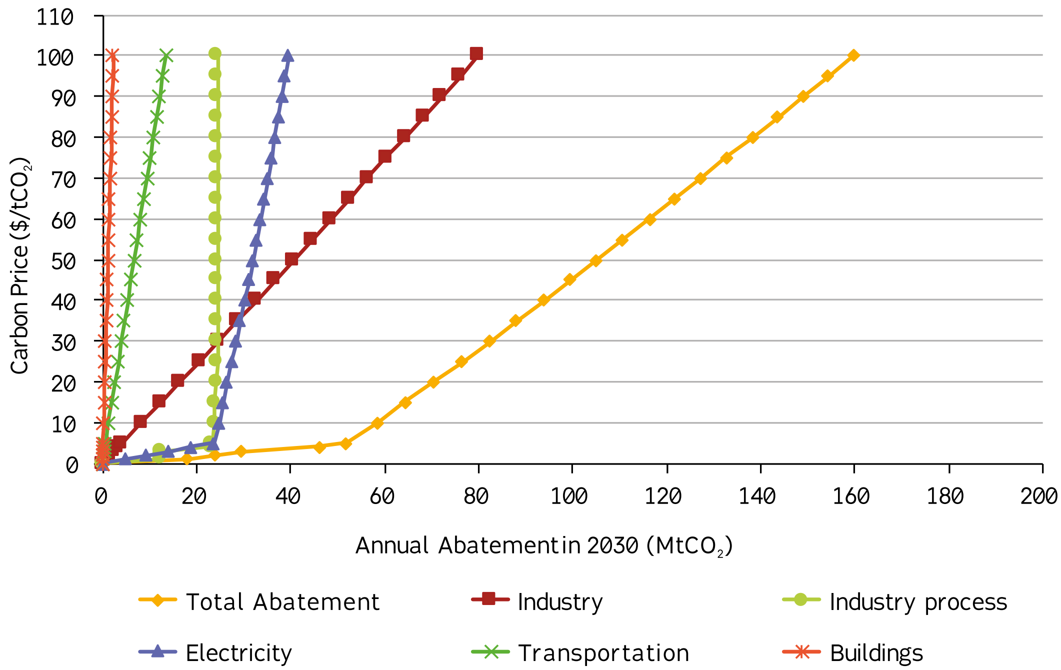
Private abatement costs can help regulators answer two questions: under a given carbon price, how many emissions will be abated; and for a given abatement requirement, what will the carbon price be? Figure 2 displays the total private marginal abatement costs curve for Mexico and the respective curves for each sector, based on data from the Energy Policy Simulator for Mexico.

These abatement curves include the costs of reducing emissions by changing production levels or material usage, changing the efficiency of newly purchased equipment (in buildings, transport) and the efficiency of newly built power plants, and early retirement of power plants. Additionally, we constructed the marginal abatement curve for industrial process emissions by combining data from the Energy Policy Simulator model for the costs of clinker substitution in the cement sector as well as for the costs of abatement through worker training for better equipment maintenance (Altamirano et al., 2016), and data from the EPA for the costs of abatement of non-CO_2 process related emissions (EPA 2013), which includes abatement cost data for methane capture in the oil and gas sector and abatement in nitric and adipic acid production.

The curves presented here are used below in our economic analysis (see section 5.1). When interpreting results, it is important to keep in mind several simplifying assumptions. A key assumption is that these abatement curves represent the implementation of carbon pricing without any other change in climate policy relative to the BAU, which includes Mexican policies enacted as of 2014. Thus, the numbers presuppose that regulators do not take any additional steps to eliminate barriers to abatement. In reality, additional policies may eliminate such barriers. For example, an increase in transmission relative to BAU will allow the carbon price to deliver additional emission reductions. Another important assumption is that these curves exclude several major abatement options including industrial energy efficiency improvements. Therefore, they underestimate the emission reductions associated with a given carbon price, particularly in the industry sector. Similarly, these simplifying assumptions likely lead to a certain overestimation of the carbon price for a given level of abatement.

Figure 2 suggests that, under these assumptions, an emissions trading policy will have the most potential to reduce emissions in the power and industry sectors. The transportation and building sectors show modest abatement potential under a carbon price of USD 100/t tCO_2e, which reflects the fact that there are various non-financial barriers that make reductions difficult.

Figure 2: Marginal Abatement Curves for 2030 by Sector



Source: Energy Innovation LLC. We derived this data from the Energy Policy Simulator for Mexico, an open-source system dynamics model developed by Energy Innovation LLC. The tool allows users to model the impacts of a given 2030 carbon tax on GHG emissions. Carbon prices are assumed by the model to rise linearly from 0 in 2016 to the specified value in 2030. We generated the curves above by iteratively increasing the 2030 carbon price from 0 to 100 in $5/tCO_2$ increments. Process related emissions were derived from EPA data (EPA, 2013) and Energy Innovation LLC data (Altamirano et al., 2016).

4.2. Regulatory Framework of Carbon Pricing

In 2012, Mexico became the first developing country to adopt comprehensive climate change legislation when its Congress unanimously passed the General Law on Climate Change (LGCC, 2012), which mandates the Federal Government with strengthening institutions and exploring suitable instruments to reduce GHG emissions. A landmark act of legislation, the LGCC is complemented and operationalized by a number of ancillary laws and policies, such as the National Strategy on Climate Change of 2013, which sets the vision for the next 10, 20 and 40 years (ENCC, 2013), as well as the second Special Program on Climate Change for 2014-2018 (PECC, 2014) and further legislative and regulatory measures implementing the reform of the Mexican energy system.

Importantly, the LGCC requires giving priority to the least costly mitigation actions which also promote and sustain the competitiveness of the vital sectors of the economy, including an entire chapter on economic instruments (Chapter IX). Already, exercising a mandate under the LGCC, Mexico has implemented a National Emissions Registry (RENE), which requires all entities emitting in excess of 25,000 tCO_2e/year to submit annual reports on their emissions of seven categories of GHGs[5] and black carbon, subject to verification every three years. Extending to direct and indirect emissions from stationary and mobile sources, RENE covers all major sectors including energy, transport, agriculture, services, industry, construction, tourism and government, and thereby provides a critical basis of information for carbon pricing.

(5) Covered gases are: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), sulphur hexafluoride (SF6), perfluorocarbons (PFCs), hydrochlorofluorocarbons (HCFCs), and nitrogen trifluoride (NF3).

4.2.1. Economy-wide Mitigation Targets

Mexico was the first major developing country to submit an Intended Nationally Determined Contribution (INDC) in March 2015, committing itself to unconditional GHG emission reductions of 22 percent, and a reduction of soot emissions – a Short-Lived Climate Pollutant – of 51 percent by 2030, each relative to expected business-as-usual (BAU) emission levels. BAU has not been explicitly defined. On the one hand, a graph illustrating the path of a constant economic growth and constant carbon intensity of GDP is presented, although in the text the objective of reducing the carbon intensity of GDP is highlighted. According to a series of interviews, the interpretation of the BAU seems to be more along the lines of the latter, while the graph appears to be used to provide a tangible set amount of tons to reduce for the argumentation of the efforts to be carried out.

Subject to a number of conditions, Mexico intends to strive for even more ambitious emission mitigation efforts of 36% GHG and 70% soot emission reductions by 2030, again relative to BAU. These contributions build on previous targets set out in the LGCC, mandating emissions reductions of 30% below BAU by 2020 and 50% relative to a 2000 baseline by 2050, and to source 25% of electricity from clean energy sources by 2018, rising to 35% by 2024, conditional on international technical and financial support.

4.2.2. Carbon Tax: Sectoral Coverage and Rates

In 2013, Mexico introduced a carbon tax on selected fossil fuels as part of a broader fiscal reform, implementing it by way of an amendment of the Excise Tax Law (LIEPS, 1980). From 2014 onwards, fossil fuels – with the exception of natural gas – are subject to a carbon tax set at MXN$ 39.80 (US$ 3.50) per tCO_2e released during combustion, translated into volumetric or mass-based rates for individual fuels (see Table 2 below).

Tax rates were modified from the original initiative to implicitly cap them at 3% of the sales price of fuel that year, and the tax is expected to yield revenue of approximately US$ 1 billion a year (Dahan et al., 2015a). Pending adoption of further implementing rules, taxable entities will have the option of complying with Certified Emission Reduction (CER) based on the market value of these credits at the time the tax liability is paid, and provided the credits have been issued under the Kyoto Protocol to the UNFCCC for offset projects implemented in Mexico (LIEPS, 1980: Art. 5 Para. 8). Interestingly, this alternative compliance option would create a hybrid carbon pricing regime combining elements of price setting and quantity rationing, allowing greater compliance flexibility. A voluntary carbon exchange, MexiCO_2, was established in 2013 to facilitate trading of credits, including CERs (Dahan et al., 2015a).

Table 2: Mexico Carbon Tax Rates in 2016 (MXN$)

Timing Coverage	Synchronous
Natural gas	0
Propane	6.29 ¢/l
Butane	8.15 ¢/l
Gas (Regular & Premium)	11.05 ¢/l
Jet Fuel	11.05 ¢/l
Turbosine & other Kerosene	13.20 ¢/l
Diesel	13.40 ¢/l
Fuel Oil (Heavy & Regular 15)	14.31 ¢/l
Petroleum Coke	$16.60/ton
Coal Coke	$38.93/ton
Mineral Coal	$29.31/ton
Other fossil fuels	$42.37/ton of carbon content

Source: LIEPS, Art. 20 lit. h)

4.2.3. Emissions Trading System: State of Discussion

Under the LGCC, the Ministry of the Environment (SEMARNAT), involving the Inter-Ministerial Commission on Climate Change (CICC) and the Council on Climate Change, is authorized to explore and implement an ETS “with the objective of promoting emissions reductions that can be achieved at the least possible cost and in a measurable, reportable, and verifiable form” (LGCC, 2012: Art. 94). The relevant provisions read as follows:

> *Article 94:* The Secretary, with the participation of the Commission and the Council, will be able to establish a voluntary system of emissions trading with the objective of promoting emissions reductions that can be accomplished at the lowest cost possible, in a measurable, reportable and verifiable way.

> *Article 95:* Those interested in participating in a voluntary manner in emissions trading will be able to carry out operations and transactions that link the emissions trading in other countries or that can be utilized in international carbon markets under the terms provided by applicable legal provisions.

Although exploratory work is underway, no substantive arrangements or draft legislation have been adopted as of now under this mandate. Important aspects, including the timing, scope, stringency, and legal nature of a future ETS, still need to be determined, rendering it difficult to evaluate alternative carbon pricing scenarios combining the existing or an amended carbon tax with the future ETS. In the following section, therefore, the quantitiative analysis will be based on a set of hypothetical outcomes, based on the likelihood of implementation and the usefulness to illustrate possible interactions between carbon pricing regimes.

5

Quantitative Analysis

5. Quantitative Analysis

In this section, we quantify the potential economic impacts of alternative carbon pricing mixes for Mexico. First, we outline the general framework of the analysis and several of the main assumptions. Specifically, our analysis evaluates four options for a carbon pricing mix, incorporating a subset of the combinations outlined in Section 3 above based on early indications of likely policy trajectories, the political viability of the scenarios, and the demonstration value of their quantitative assessment:

1. “Limited ETS”: The current carbon tax continues to apply and an ETS is introduced to cover process emissions in the industrial sectors. Limited ETS represents a possible instrument mix, in which Mexico uses both a carbon tax and an ETS, which cover different sectors. This approach combines synchronous and asymmetrical application of a carbon tax and ETS.
2. “ETS Only”: An ETS is introduced to cover all GHG emissions from energy-related and process-related activities in the power, steel, chemical, oil & gas, cement, lime, glass, and ground transportation sectors, as well as emissions from “other combustion” as defined in Mexico’s 2013 inventory, which includes sectors such as pulp and paper, car manufacturing, plastics, metals, and others. The carbon tax is discontinued. This approach reflects an asynchronous and partially symmetrical application of a carbon tax and ETS, and would incorporate elements of the transition scenario described above in Section 3.2.
3. “Overlapping Tax & ETS”: The current carbon tax continues to apply and an ETS is introduced with the same coverage as in the “ETS Only” scenario. This approach combines synchronous and partially symmetrical application of a carbon tax and ETS, but does not represent a price management mechanism as outlined above in Section 3.4 because the fixed carbon price component does not apply to all sectors included in the ETS.
4. “Hybrid ETS”: Finally, an ETS is introduced together with a carbon tax in the form of a “top-up” carbon price floor. This hybrid instrument is assumed to apply to the same sectors as the above two scenarios. The carbon tax is discontinued. The top-up price floor is set at the current carbon tax level of $3.5/t (75 MXN/t). This approach represents a synchronous and symmetrical application of a carbon tax and ETS, and therefore constitutes a genuine price management mechanism as described above in Section 3.4.

All policy changes implied by these scenarios are assumed to take place in 2017 for the purposes of this analysis. While this may not be practical, the results presented here are also applicable to policy changes introduced at a later point.

The impacts of an ETS depend to a large extent on the stringency of the emissions cap. All four ETS policies are assumed to have a cap on emissions stringent enough to allow Mexico to meet a given emission reduction target for 2030. The targets being analyzed cover only GHG emissions (Mexico’s targets for black carbon are excluded from the analysis). For this purpose, we first make a Reference Case projection for total Mexican emissions out to 2030 in the absence of an ETS and compare this to a given 2030 emission target. This way, we derive an estimate for the emission abatement necessary for the achievement of the target. Next, for each ETS being analyzed, we calculate a cap on emissions by subtracting the required emission abatement effort from the 2030 Reference Case emissions. Thus, the analysis assumes that all of the reductions necessary for Mexico to close the gap between its Reference Case emissions and its target will be met by the ETS-participating sectors.

Below, we present results for Mexico's unconditional target of 22% reduction from Mexico's BAU projection for 2030. Second, to allow additional comparison between the four different instrument mixes, we show results for a more ambitious ETS cap, which is set at such a level that allows Mexico to meet a target equal to a 26% reduction from BAU in 2030. This "26% reduction" case was selected for the simple fact that it represents a reduction in emissions that is twice as large as that required to achieve the unconditional target (see Section 5.1 below on Emission Projections). This case allows us to quantify the sensitivity of our results to the level of cap stringency.

An important purpose of carbon pricing can be the generation of government revenue. For each scenario, we calculate revenue under two different policy design options that refer to the balance between free allocation and auctioning of permits. We model a system of full free allocation to sectors that participate in international markets (industry) and auctioning in sectors less exposed to international competition (power and ground transportation), and a system with full auctioning of permits. The former scenario reflects the approach to distribution of allowances used in many ETSs currently in operation, including the EU ETS and the Californian ETS. The latter presents a case in which the government has opted to maximize the revenue potential of the ETS.

5.1. Emission Projections

In order to measure the impacts of new carbon pricing policy, we construct a Reference Case projection for future greenhouse-gas emissions (see below, Section 5.1.1). In this scenario, emissions are only influenced by Mexico's current policies.

It is important to note that this scenario is only one way that future emissions may evolve. There are many other pathways that emissions may follow. And if emissions do turn out to be substantially different from the Reference Case projection, the impacts of any new policy will also differ from what the Reference Case suggests. Policy makers that are aware of possible alternative developments can plan ahead and design better policies, which can better accommodate the uncertainties of the future. That is why, in Section 5.1.2, we lay out a range of possible future emission pathways. We discuss probabilities of various emissions outcomes and their implications for policy makers.

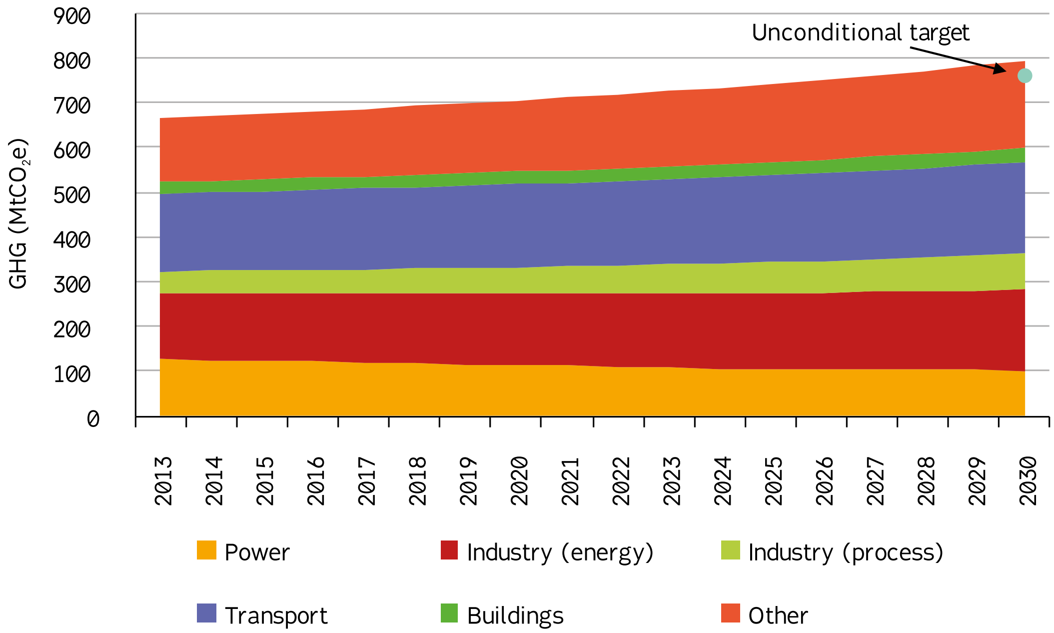
5.1.1. The Reference Case

In the Reference Case, we estimate that Mexico's GHG emissions grow from 665 Mt in 2013 to 793 Mt in 2030. Emissions thus grow at an average of 1 percent per year. Figure 3 presents the resulting emission projections by sector.

To derive this estimate, we combine historical 2013 emissions data per sector with projections for emissions calculated by previous modeling exercises. Specifically, we assume that emission growth rates in sectors with energy-related CO_2 emissions (power, industry, transport, and buildings) equal the growth rates projected by the International Energy Agency (IEA) in its Current Policy Scenario as featured in the Mexico Energy Outlook (IEA, 2016). IEA's Current Policies Scenario is an appropriate representation of the Reference Case, as it accounts for Mexico's current climate mitigation efforts, including the two major CO_2 reducing policies: the Special Program on Climate Change (PECC, 2014) and the clean energy targets inscribed in the LGCC. For process emissions in the industry sector and for emissions in the "other" sectors, which include waste, agriculture and forestry, we use the emission growth rates from the BAU scenario constructed by the World Resources Institute and Energy Innovation LLC (Altamirano et al., 2016).

These results suggest that Mexico's emissions in 2030 may not be far from the illustration for the unconditional target laid out in Mexico's INDC to the Paris agreement. Mexico's unconditional target of 759 Mt is 34 Mt, or 4 percent, lower than the 793 Mt emitted in the Reference Case. For the purposes of comparing instrument mixes in the analysis below, we also analyze a 2030 target of 26 percent below BAU, equal to 725 Mt. Meeting this target would require an emission reduction of 69 Mt, representing a doubling of policy ambition.

Figure 3: Reference Case Emission Projections by Sector



Source: Baseline 2013 emissions numbers are derived from Mexico's 2013 emissions inventory (INECC, 2013).

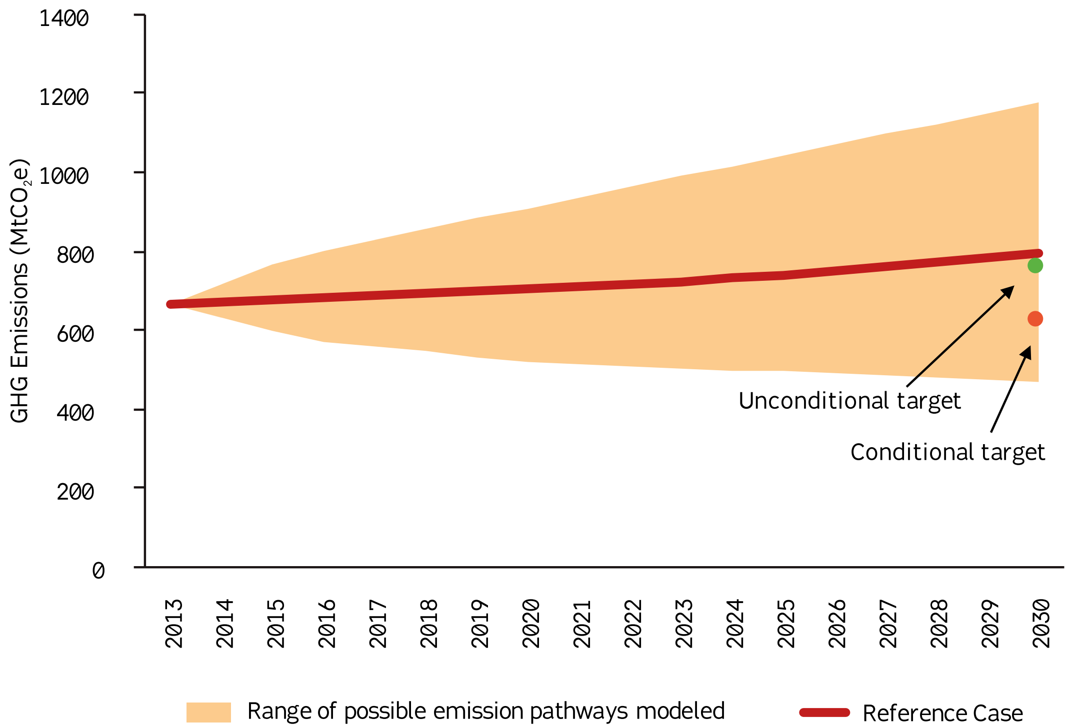
5.1.2. How Likely Is the Reference Case?

The difficulty of accurately projecting future emissions makes it advisable for policy makers to consider the uncertainty involved in such projections. To quantify the uncertainty related to future emissions, we constructed a Monte Carlo model. This statistical method allows us to use information about the historical variation of Mexico's emissions to project how future emissions may vary around the expected trajectory of the Reference Case (see Text Box "Monte Carlo Model for Mexico's Emissions" below for details). Using this model, we ran a large number of simulations of future emissions, where each simulation represents a possible pathway for future emissions, to represent the full range of possible future trajectories. The range, for which we ran 20,000 simulations, is displayed in Figure 4. It is important to note that, due to a number of simplifying assumptions (see Text Box), the range shown is not necessarily an all-inclusive representation of all possible future scenarios, but an approximation thereof.

As displayed, this analysis shows that future emissions are highly uncertain. Mexico's emissions in 2030 could be as low as 470 Mt or as high as 1,177 Mt. The emission level in 2030 has a standard deviation of 87 Mt (the mean 2030 emissions among our simulations equal 790 Mt). Based on our model, we estimate that there is about a 68 percent probability that Mexico's emissions will be between 706 Mt and 880 Mt in 2030 (68 percent of the simulations of our model fell in this range). And there is a 95 percent likelihood that emissions fall between 627 and 960 Mt.

It is noteworthy that Mexico's unconditional target of 759 Mt in 2030 lies well within the 68 percent probability range. This suggests that there is a considerable chance that Mexico meets its target without an additional carbon pricing policy. According to our model, this may occur with a 36 percent likelihood. Similarly, there is a considerable chance that emissions turn out higher than in the Reference Case, and thus necessitate more emission reductions.

Figure 4: Range of Reference Case Emissions



Source: Own calculations

Such significant variation in future emissions means that the performance of a future Mexican ETS is vulnerable to uncertainty, a challenge faced by all ETS designers. Wide fluctuations in future emissions could result in substantial variation in the level of the carbon price, with important implications for policy predictability, government revenues, and policy efficiency. How well such risks are managed is critically dependent on policy design. The following analysis will discuss the implications of this uncertainty for Mexico as it considers alternative policies and instrument mixes (see Section 5.5).

Monte Carlo Model for Mexico's Emissions

The Monte Carlo method employed here estimates the distribution of future emissions based on the assumed distribution of the relevant inputs. The inputs in our emission projections are the annual growth rates in emissions since 2013 (as well as the amount of emissions in 2013) as discussed in Section 4.1.1. For a given sector, the emission projection can be described by the following equation:

〚*Emissions*〛_2030=〚*Emissions*〛_2013×*g*_2014×*g*_2015×*g*_2016⋯ ×*g*_2030

Where: g_i denotes growth in emissions for year *i*.

Our Monte Carlo model repeats the above equation over a very large number of simulations. For each simulation, the model selects different emission growth rates, with each growth rate picked randomly from the distribution of possible growth rates. We assume that growth rates are normally distributed around the expected growth rate value (the average growth rate of the Reference Case equal to 1 percent per year). The model uses a standard deviation of 2.8 percent, which we derived from historical Mexican emission growth rates for the period for which data was available: 1991-2010.

A key assumption is that the standard deviation of historical emissions is a good representation of the variation of future emissions. Another important methodological input is the choice of distribution type. Our choice of the normal distribution may somewhat overestimate the chances of emissions being higher than the Reference Case and underestimate the chances of emissions being lower. The normal distribution passed common goodness-of-fit tests such as the Kolmogorov-Smirnov and Chi-squared tests, but other distributions did so as well. In particular, it is possible that emission growth rates follow a skewed distribution, whereby deviations from the expected value tend to be rather on the low side than the high side. Indeed, the historical data was to an extent skewed toward the low side. However, it is unclear whether we can assume that this will continue to be the case, given that the historical record consisting of 20 data points may not be an accurate representation of the future. Consequently, we opted for the normal distribution. This assumption is conservative as it likely underestimates the possibility of emissions being lower than the Reference Case, and therefore underestimates the possibility of policy costs being lower than implied by the Reference Case.

5.2. Carbon Price

We estimate carbon prices in each policy scenario by comparing supply and demand for emission reductions. The supply curve for emission reductions is equivalent to the marginal abatement cost curve. The demand for emissions is represented by the emission reduction effort necessary for emissions in the ETS-covered sectors to equal the emissions cap (as explained above, this is equivalent to the difference in emissions between the Reference Case emissions in 2030 and a given climate target, such as Mexico's unconditional INDC target).

As we estimated above, for Mexico to meet its unconditional target, the demand for emission abatement would equal 34 Mt in 2030. The supply, represented by the marginal abatement cost curve, depends on the scope of the ETS. In the "Limited ETS" scenario, abatement potential is constrained by the emission reductions options that exist in the industrial process sector. As suggested by the industrial process abatement curve we presented in Figure 2, an abatement of 34 Mt would require a 2030 carbon price in excess of MXN 2,148/t (USD 100/t). This suggests that in the "Limited ETS" scenario, the carbon price may be greater than USD 100/t, a level that may pose considerable political challenges, and, therefore, is likely to be infeasible. For the remainder of the analysis, we exclude this scenario.

For the remaining scenarios, we use a marginal abatement cost curve derived from abatement options in the power, industry, industrial processes, and ground transport sectors, as presented above in Section 4.1.3.2. As explained above, these abatement curves reflect the carbon price level required in 2030 for a given amount of abatement to take place (given the simplifying assumptions explained in Section 4.1.3.2). The curves further assume that the carbon price would rise linearly from 0 in 2016 to the respective level by 2030. Given these assumptions, we can construct projections for carbon prices under the different ETS scenarios (Table 3). The carbon price levels for 2030 are uncertain and should be seen as our best-guess approximations for what the carbon price will be in each scenario, based on the available data and resources. We note that the price trajectories between 2017 and 2029 are even more uncertain. In reality, carbon prices will fluctuate based on variation in emissions and the availability of abatement options over time. These temporal effects have not been taken into account. Thus, the presented set of projections is mainly a tool to compare different policy options.

Table 3: ETS Carbon Price Projections by Scenario (Units in Constant MXN/t)

	2030 Cap = Unconditional target			2030 Cap = 26% below BAU		
	ETS Only	Overlapping Tax & ETS	Hybrid ETS	ETS Only	Overlapping Tax & ETS	Hybrid ETS
2017	5	5	75	35	33	75
2018	11	10	75	71	65	75
2019	16	15	75	106	98	106
2020	21	20	75	141	131	141
2021	26	25	75	177	163	177
2022	32	31	75	212	196	212
2023	37	36	75	247	228	247
2024	42	41	75	283	261	283
2025	47	46	75	318	294	318
2026	53	51	75	353	326	353
2027	58	56	75	389	359	389
2028	63	61	75	424	392	424
2029	68	66	75	459	424	459
2030	74	71	75	495	457	495

Source: Own calculations

This analysis suggests that the "ETS Only" scenario with a cap based on the unconditional target will result in a 2030 carbon price of MXN 74/t (USD 3/t). This carbon price is a reflection of the fact that demand for abatement is relatively low, and that enough relatively cheap abatement options exist, mainly in the power sector and in industrial processes, to achieve the necessary emission reductions.

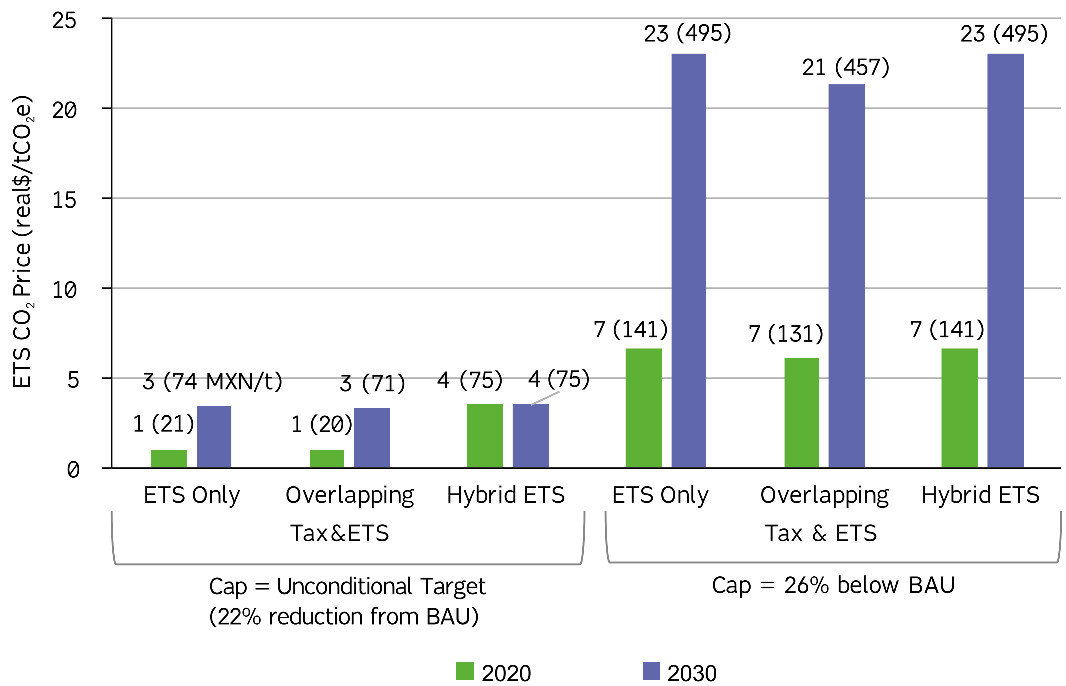
The "Overlapping Tax & ETS" scenario results in a similar, but slightly lower price, according to this analysis, at MXN 71/t (USD 3/t) in 2030. The lower price is a result of the fact that the existence of the carbon tax reduces emissions, creating less demand for ETS permits. We assumed that Mexico's carbon tax reduces 1.8 Mt per year based on previous work (Muñoz-Piña, 2016). For the "ETS Only" and the "Hybrid ETS" scenarios, where the carbon tax is discontinued, we assumed that the emission reduction driven by the ETS would have to be 1.8 Mt higher, which creates additional demand for ETS permits and leads prices to be slightly higher in these scenarios.

Comparing the "ETS Only" scenario with the "Hybrid ETS" scenario reveals the effect of the top-up price floor. The two scenarios are identical with one exception: the "Hybrid ETS" contains a top-up carbon tax that acts as a price floor in the carbon market. While low-cost abatement options lead to a low ETS price in the "ETS Only" scenario, the price floor of the "Hybrid ETS" scenario prevents the price from falling below MXN 75/t (USD 3.5/t).

A stricter cap would result in higher prices, as shown in Table 3 and Figure 5. An ETS cap in 2030 consistent with a 26% emission reduction from Mexico's 2030 BAU results in a carbon price of MXN 495/t (USD 23/t) in the "ETS Only" and "Hybrid ETS" scenarios, according to our model, and in a price of MXN 457/t (USD 21/t) in the "Overlapping Tax & ETS" scenario. The reason for the extent of the difference in the carbon prices projected here compared to those projected under the unconditional target is that a 26% reduction would require twice as much emissions abatement. Such an amount of abatement would exhaust the relatively low-cost abatement options featured in our marginal abatement cost curves and require the most costly reductions.

As displayed in Table 3, even such a more ambitious policy may result in a carbon price lower than the current carbon tax in the "ETS Only" scenario during the first years of implementation (2017-2018). Meanwhile, the top-up price floor featured in the "Hybrid ETS" scenario maintains a carbon price at the current carbon tax level at all times. As long as the ETS carbon price is above the price floor, the Hybrid ETS generates the same carbon prices as the "ETS Only" design.

Figure 5: ETS Carbon Prices by Scenario

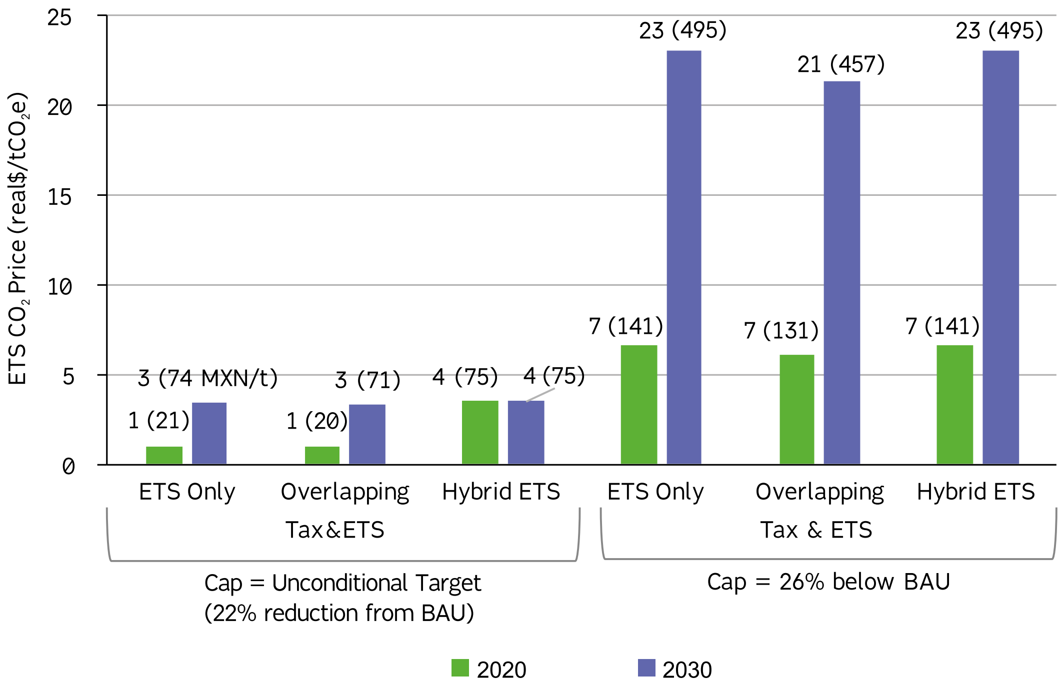


Source: Own calculations

5.3. Government Revenues

Figure 6 presents a comparison of the total government revenues generation from 2017 to 2030 by scenario. Table 4 and Table 5 below present the annual results. We show results for two different options available to policy makers when it comes to distributing ETS permits. A system of full auctioning generates the maximum possible revenue by selling all permits to participating companies. The other policy design we have modeled is a system whereby some of the ETS allowances are given for free to industrial companies to cover their energy- and process-related emissions, while the remaining permits are sold to the other ETS participants, namely, the power and ground transport sectors.

Figure 6: Total Government Revenues, 2017-2030, by Scenario



Source: Own calculations. Revenues are based on the projected carbon prices and sector-level emissions in each scenario. Sector emissions in each scenario were estimated based on the projected carbon price and the respective marginal abatement cost curve.

The "Overlapping Tax & ETS" scenario generates the most revenue, as companies pay both the ETS carbon price and the carbon tax. The tax is assumed to generate MXN 21 billion (USD 1 billion) in 2016, which we scaled up every year until 2030 based on projected emissions growth. A noteworthy result is that the "Hybrid ETS" generates revenues that are not far from the "Overlapping Tax & ETS" scenario in the case of full auctioning, with the cap equal to the unconditional target. This result stands out at first glance because companies participating in the "Hybrid ETS" pay only one carbon price, while those in the "Overlapping Tax & ETS" scenario pay two different carbon prices (the carbon tax and the ETS-generated price). However, government proceeds are similar because revenues from the ETS featured in the "Overlapping Tax & ETS" scenario are lower than those generated by the "Hybrid ETS" scenario, due to the lower ETS carbon price, which is caused by the lack of a price floor. In addition, the "Hybrid ETS" scenario covers a greater amount of emissions than the carbon tax included in the "Overlapping Tax & ETS" scenario, resulting in additional revenues.

Table 4: Revenues per Year, Full Auctioning (Units in Constant Billion MXN)

	2030 Cap = Unconditional target			2030 Cap = 26% below BAU		
	ETS Only	Overlapping Tax & ETS	Hybrid ETS	ETS Only	Overlapping Tax & ETS	Hybrid ETS
2017	3	24	36	17	37	36
2018	5	27	36	34	53	36
2019	8	29	36	50	68	50
2020	10	32	36	67	84	67
2021	13	34	36	83	99	83
2022	15	37	36	99	114	99
2023	18	40	36	116	129	116
2024	20	42	37	132	144	132
2025	23	45	37	148	159	148
2026	26	48	37	164	175	164
2027	28	50	37	180	190	180
2028	31	53	37	196	204	196
2029	34	56	37	212	219	212
2030	37	59	37	227	234	227

Source: Own calculations.

These results also show that free allocation of ETS permits comes at a cost of foregone revenue. Yet, this policy design is frequently employed in ETSs around the world as a way to assuage concerns about any adverse impacts a carbon price might have on industrial competitiveness, and, thus, to secure political support. Our results show that even when permits are allocated for free to industrial participants, an ETS can still generate significant government revenue. The "Hybrid ETS" scenario with a cap at the unconditional INDC target generates revenues in line with the current carbon tax revenues of roughly MXN 21 billion (USD 1 billion) per year (Table 5).

The "ETS Only" scenario shows that replacing the current tax with an ETS without a price floor may lower government revenues. Especially in the case of freely allocating allowances to industry, revenues generated by the "ETS Only" scenario are lower than current carbon tax revenues when the ETS cap equals the unconditional target (Table 6). However, even the ETS Only scenario can generate substantial revenues if the ETS cap is made more stringent.

As shown in the last three columns of Table 4 and Table 5, a cap that achieves a 2030 reduction of 26% from Mexico's BAU is estimated to more than double the current carbon tax revenues (of MXN 21 billion per year) by 2020, and to increase them by more than six-fold by 2030, across all three ETS scenarios. These results reflect the significance of the level of the ETS cap.

Table 5: Revenues per Year, Free Allocation to Industry (Units in Billion MXN)

	2030 Cap = Unconditional target			2030 Cap = 26% below BAU		
	ETS Only	Overlapping Tax & ETS	Hybrid ETS	ETS Only	Overlapping Tax & ETS	Hybrid ETS
2017	2	23	22	10	31	22
2018	3	25	22	20	40	21
2019	5	26	22	30	50	30
2020	6	28	21	40	59	40
2021	7	29	21	50	68	50
2022	9	31	21	59	77	59
2023	10	32	21	69	86	69
2024	12	34	21	78	94	78
2025	13	35	21	87	103	87
2026	15	37	21	96	111	96
2027	16	38	21	105	120	105
2028	18	40	21	114	128	114
2029	19	42	21	122	136	122
2030	20	43	21	131	144	131

Source: Own calculations.

5.4. Policy Costs

We estimate policy costs by using the quoted marginal abatement cost curves and approximating the area under the curve for a given carbon price level. Table 6 displays estimated policy costs in 2030. We estimated costs conservatively by assuming linear marginal abatement cost curves. Rather than as forecasts of future impacts, the costs are best seen as a way to compare impacts across scenarios and sectors.

Costs are concentrated in the power and industrial process sectors in the cases where the ETS cap equals Mexico's unconditional target. This results from the fact that most abatement occurs in these sectors. Particular industrial process sub-sectors that deliver significant emission reductions are the oil and gas sector, where methane capture is a relatively low-cost abatement option; and the cement sector, where clinker substitution supplies sizable reductions.

A higher policy ambition, represented by the 26% reduction case, result in higher costs, as well as a higher proportion of costs being born by industrial energy-related activities. This occurs as a growing share of emission reductions come from these sectors.

Turning to instrument mix options, we observe that the "Hybrid ETS" scenario results in slightly higher costs than the "ETS Only" case, due to the 2030 carbon price being slightly higher as it is bolstered by the price floor. In the "Overlapping Tax & ETS" scenario, the costs of the ETS are lower because of the slightly lower carbon price and because fewer emission reductions take place in the ETS. It is worth making clear that these costs refer to ETS costs only and do not include costs related to the carbon tax. Nor do these numbers include the expenses companies will bear when they purchase ETS permits. The costs of purchasing permits are equivalent to the revenues that accrue to the government, which we discussed above.

Table 6: ETS Policy Costs in 2030 by Sector (Units in Million Pesos)

	2030 Cap = Unconditional target				2030 Cap = 26% below BAU			
	Power	Industry (energy)	Industry (process)	Transport	Power	Industry (energy)	Industry (process)	Transport
ETS Only	598 (0.2%)	106 (0.003%)	628 (0.02%)	15 (0.002%)	6691 (2%)	4722 (0.1%)	6043 (0.2%)	773 (0.1%)
Overlapping Tax & ETS	560 (0.2%)	99 (0.003%)	565 (0.01%)	14 (0.001%)	6106 (2%)	4031 (0.1%)	5572 (0.1%)	658 (0.1%)
Hybrid ETS	624 (0.2%)	111 (0.003%)	670 (0.02%)	16 (0.002%)	6691 (2%)	4722 (0.1%)	6043 (0.2%)	773 (0.1%)

Source: Numbers in the parentheses denote costs as a percent of value added of the relevant sector. Value added is for 2013 and was derived from Producto interno bruto trimestral por sector – Inegi. Sector 22 (power generation and transmission) was used for the power sector; A sum of sectors 23 and 31-33 (construction and industrial manufacturing) was used to calculate percentages for both industrial energy and process costs; and sector 48-49 (transport) was used for the transport sector (Inegi, 2013).

5.5. Implications of Future Uncertainty for Policy Choice

The results presented here are based on a number of simplifying assumptions and projections about the future, which may not materialize as described in this analysis. As the future is inherently uncertain, there is a limit to the ability of any modeling exercise to accurately estimate future policy impacts. Climate policy is particularly uncertain because it lies at the intersection of many complex systems, including the economy and energy markets, two areas in which accurate predictions are especially rare. Climate policy designers have experienced substantial surprises, as exemplified by virtually all operating ETS becoming "oversupplied" with permits (Ferdinand and Dimantchev, 2016). An oversupply of permits can harm the long-term efficiency of emissions trading, a risk that prompted the European Commission to take action to reduce the permit surplus in the EU ETS (COM(2014)20, 2014).

Our Monte Carlo model allows us to explore probabilities of various potential outcomes based on the uncertainty of one of the main inputs to our analysis: namely, projected future emissions. Given the assumptions made for that projection, we estimate that the "ETS Only" scenario with a cap equivalent to the unconditional INDC target has about a one-in-four chance of resulting in a carbon price at or less than MXN 21/t (USD 1/t) in 2030, and about a one-in-six chance of resulting in a 2030 carbon price of MXN/USD 0/t. This would mean that there is a one-in-four chance that the government raises 84 billion pesos or less for the whole period 2017-2030 (assuming full auctioning), or roughly a third of what we projected above; and a one-in-six chance of no revenues at all. The "ETS Only" scenario underscores the sensitivity of an ETS to uncertainty. As we discussed above, such unpredictability of future policy makes it difficult for compliance entities to plan strategically, and dulls any incentives for low-carbon investment. These risks are mitigated in the "Hybrid ETS" scenario, where the top-up carbon tax acts as a price floor and thus provides greater predictability.

Similarly, a consideration of contingent possibilities reveals a risk that emissions turn out higher than initially expected, leading to higher carbon prices and policy costs than initially foreseen. This can be an important consideration for lawmakers, depending on the range of policy costs that they may implicitly or explicitly consider feasible. Based on our Monte Carlo model, we estimate that there is about an 8 percent chance that the "ETS Only" scenario results in a carbon price of MXN 2,148/t (USD 100/t) or more. As we mentioned in the earlier Text Box describing the model, we have made conservative assumptions that likely overestimate the chances of emissions being higher rather than lower. Nevertheless, there is a possibility that policy costs are higher than expected. This may provide an argument for a carbon price ceiling in addition to a carbon price floor to mitigate such risks. However, it is worth noting that a price ceiling can undermine the environmental purpose of an ETS if it results in the emissions cap being breached.

In addition to bolstering arguments for price management through price floors and, potentially ceilings, future uncertainty suggests that policy makers will benefit from an adaptive management approach. Mexico's carbon pricing should be structured around a system of periodic reviews. Such procedures for periodic assessment have been built into many carbon pricing policies, one example being the EU ETS (COM(2014)20). ETS policies are typically organized according to temporal phases, with each phase offering an opportunity for a change in regulations. Such phases, combined with a periodic assessment of the effectiveness of policy, can lead to more effective policy making in the face of uncertainty. The case of the United Kingdom's climate policy serves as an example. As our Case Study explained (see above, Section 3.4), the government, as part of its annual budget assessments, proposed to implement a carbon price floor after its assessment reached the conclusion that the variability of its carbon price was hampering investment in clean energy (HM Treasury, 2010).

6

Conclusions and Recommendations

6. Conclusions and Recommendations

6.1. Qualitative Analysis

Due to its ability to equalize marginal abatement cost across covered emitters, carbon pricing offers a highly cost-effective policy instrument to internalize the social cost of GHG emissions, and thereby correct one of the principal market failures contributing to climate change (see Section 2.1). This feature, combined with its scalability, flexibility, and ability to generate revenue, make carbon pricing a favorable policy option for a rapidly growing economy with ambitious climate targets such as Mexico.

Carbon pricing can be implemented through a price set by the government, usually by way of a carbon tax, or through quantity rationing with subsequent trading of emission allowances (see Text Box "Definition: Carbon Pricing through Prices and Quantities" in Section 2.1). Neither approach is clearly superior, with certain theoretical advantages of each approach offset by political economy constraints and uncertainties about the sensitivity of the climate system and the scale and cost of climate impacts (see Section 2.2.1). Moreover, hybrid approaches combining pricing and quantity rationing can help harness the advantages of a carbon tax and an ETS by combining the price certainty of a price-based approach with the certainty of mitigation outcome under a quantity-rationing approach.

Political economy considerations and administrative constraints will typically outweigh theoretical considerations of instrument choice, with an ETS offering greater flexibility to accommodate stakeholder concerns and secure political support (see Section 2.2.1). International experience, including in the cases of Australia and the United Kingdom surveyed in this report (see Sections 3.2 and 3.4), suggest that fixed-price approaches to carbon pricing may be more politically vulnerable in certain contexts. This observation may also prove important in Mexico, where a high share of manufacturing industries will likely spur debate about the competitiveness impacts of climate policy, and where the general public has proven highly sensitive to increases in energy cost.

Mexico has already introduced a carbon tax on certain fossil fuels (see Section 4.2.2). A combination of the existing carbon tax with a future ETS can leverage synergies if both instruments are properly aligned. Economic theory, however, suggests that each policy instrument should address a different market failure; uncoordinated coexistence of carbon pricing instruments can result in adverse effects and significantly undermine both the cost-effectiveness and environmental benefits of carbon pricing. In particular, the sectoral and geographic coverage of a carbon tax should be equal to or exceed that of a concurrent ETS to avoid emissions leakage between the two instruments (see Section 2.2.2).

A carbon tax and an ETS can be combined in different ways, based on the degree of synchronicity and the symmetry of application (see Section 3.1). Without claiming an exhaustive list, the coordinated operation of a carbon tax and ETS alongside each other or in sequence can serve important design functions, allowing the introduction of greater compliance flexibility, facilitating a temporal transition, or serving to manage price extremes and volatility (see Section 3). Each of these approaches to a coordinated carbon pricing mix has been introduced in practice, with varying results.

Where jurisdictions, such as Switzerland or the United Kingdom, have offered the option of participating in an ETS as an alternative to paying a carbon tax, experience has shown that affected entities will exercise this opportunity (see Section 3.3.1), reflecting a likely preference among compliance entities for the perceived advantages of emissions trading. Similarly, the ability to use offset credits to comply with a carbon tax liability, as will be the case in South Africa, has been generally welcomed due to the increased flexibility it offers (see Section 0).

Use of a carbon pricing mix to introduce a carbon floor price in an ETS – as applied, for instance, in the United Kingdom (see Section 3.4) – has also proven to offer distinct benefits. By providing a more predictable carbon price, a price floor helps avoid inefficiencies in investment decisions and the resulting risk of carbon lock-in (see Section 3.4.2), while also guaranteeing a steadier revenue flow (see Section 3.4.3). In rapidly growing economies such as that of Mexico, where significant additional energy, transport and other infrastructure will likely be added in coming decades, this price predictability may prove of particular importance. To avoid emissions leakage between sectors, however, the scope of the carbon tax should be at least equal or larger than that of the ETS (see Section 2.2.2).

Likewise, a carbon pricing mix can be used to introduce a price ceiling. In a political economy context of high sensitivity to increases in energy cost and other production factors, which is the case in Mexico, a price ceiling may be helpful to secure political passage of an ETS. As the case of New Zealand has shown, a fixed payment obligation in lieu of surrendering the requisite number of allowances can be a practical solution (see Section 3.4), although it comes at the expense of certainty of mitigation outcome. Use of revenue for investment in mitigation can reinsert a degree of control over the emissions outcome.

6.2. Quantitative Analysis

A central conclusion from the quantitative analysis is that Mexico's emissions are currently on a pathway that nearly achieves the unconditional climate target of reducing emissions by 22 percent below the government's "Business-as-Usual" scenario. Emissions in our Reference Case, which uses inputs from highly regarded modeling exercises, reach 793 Mt in 2030. This is only 34 Mt short of the unconditional 759 Mt target, as stipulated in Mexico's INDC to the Paris Agreement.

This analysis shows how an ETS can help close this gap. Based on a number of conservative assumptions taken, we find that an ETS could lead Mexico to achieve its unconditional target at a carbon price of MXN 74/t (USD 3/t) in 2030, a relatively modest carbon price compared to that of California, a major trading partner for Mexico, where carbon allowances are around MXN 258/t (USD 12/t), and likely to rise further in the future. The relatively low carbon price projected for Mexico is a result of the fact that our projection for business as usual emissions (our Reference Case) estimates 2030 emissions to be very close to the unconditional target, thus requiring relatively modest reductions to meet the target. The other reason for the relatively low carbon price projection is the availability of relatively low-cost abatement options, mainly in the power sector and in industrial processes. Thus, an important assumption of this analysis is that both combustion and process emissions would be included in the ETS (see Section 5 for details on coverage).

Yet the design of a future ETS matters. As our analysis of the "Limited ETS" scenario shows, an ETS that is constrained in scope to industrial process emissions, but still stringent enough to meet Mexico's unconditional target, will result in a very high carbon price of above MXN 2,148 MXN/t ($100/t) in 2030. An ETS that is confined to sectors outside of the scope of Mexico's carbon tax will come at a relatively high cost.

Due to the inherent uncertainty of future projections, any given policy pathway may not result in impacts that had been expected or desired. Mexico can increase the effectiveness of its carbon pricing policy by implementing a price management system, such as a carbon price floor. As our uncertainty analysis shows, in the absence of a price floor – represented, for instance, in the "ETS Only" scenario – there is a considerable chance that lower than expected emissions will cause a crash in the carbon price and, in turn, government revenue. The possibility of such an outcome will be a risk to low-carbon investors that may preclude investments consistent with cost-effective mitigation from taking place. In contrast, an ETS with a price floor – as in the "Hybrid ETS" scenario – will provide a more stable and predictable carbon price and government revenues. Uncertainty about policy costs may also seem to make the case for carbon price ceilings, but such instruments can undermine the ability of an ETS to meet its original environmental purpose of emission reductions if they compromise the cap on emissions.

As we show above, an "Overlapping Tax & ETS" instrument mix can help generate stable government revenue and meet environmental outcomes. However, it comes at the expense of imposing two carbon prices at the same time, leading to a regulatory regime that may be seen as redundant and overly complex.

Out of the scenarios considered, a hybrid ETS with a carbon price floor in the form of a top-up tax emerges as a suitable carbon pricing mix for Mexico. This policy option allows for the continuation of carbon pricing revenues, and for the introduction of an ETS that introduces higher certainty of achieving climate mitigation goals.

Due to the limited ability of any modeling exercises to predict the future, Mexico can enhance the effectiveness of a future ETS if it implements a system for periodic reviews. Such an adaptive management approach would include a process for monitoring policy effects and potentially amending policy parameters in the face of changing circumstances.

7

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