Chapter 4
Feasibility Analysis of a Cap-and-Trade System in Mexico and Implications to Circular Economy

José-Luis Cruz-Pastrana and María-Laura Franco-García

Abstract Market-based instruments, such as the cap-and-trade, have been widely used to address the increase of greenhouse gases (GHG). In line with other geographic regions, Mexico has seen the need to expand the options of market instruments to mitigate the effects of climate change. Simultaneously, there are important reasons to move towards a circular economy model. In this context, this research seeks to answer if it's feasible to implement a cap-and-trade system in Mexico as part of its climate policy. That said, firstly, it analyses and assesses the cap-and-trade system in Mexico based upon its contextual environment, its potential of implementation and its economic and environmental benefits and costs. Secondly, it highlights the implications of considering circular economy models into a cap-and-trade instrument. Through the use of marginal abatement cost curves (MACC), it was found that the percentage of measures to reduce GHG with negative cost agglomerates 57% of all the measures, which could translate into a benefit for the economy as a whole by almost 1% of GDP by 2020. As part of the conclusions, we argued that MACC results prove partially that the cap-and-trade system is a feasible option to apply in Mexico. In addition, a cap-and-trade mechanism should show a strong carbon price signal felt by end users and therefore motivates the application of circular economy principles, which are related to the introduction of innovations to enable the closing of current materials and energy loops along the supply production chain.

Keywords Cap-and-trade · Marginal abatement cost curves · Circular economy · Climate change · Climate policy

J.-L. Cruz-Pastrana (✉)
Instituto Tecnológico de Estudios Superiores Monterrey,
Cd López Mateos, Estado de México, Mexico

M.-L. Franco-García
University of Twente, Enschede, The Netherlands
e-mail: m.l.francogarcia@utwente.nl

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4.1 Introduction

In recent years, climate change has positioned as the greatest environmental thread that not only the human kind faces but the different ecosystems that inhabit the planet. The impact of climate hazards is no longer denied, and different global actions have emerged to curb greenhouse gases (GHG).

Market-based instruments have been the most penetrating approach to tackle this issue. The cap-and-trade system is based on the market to internalise the external costs of fossil energy use. This scheme has been adopted by some countries and economic blocs (such as the European Union) as a key policy in mitigating GHG emissions. While it is argued that the implementation only belongs to Annex I countries for its international commitments, proposals and pilot schemes in countries outside Annex I are beginning to emerge, such as the recent approval of the Chinese national cap-and-trade in September 2015. Mexico has been no exception, and it's currently building the institutional and legal framework conditions necessary to establish the instruments to mitigate and adapt to the effects of climate change and move towards a sustainable economy.

The content of this paper starts with a conceptual and theoretical framework of the cap-and-trade system as a market-based instrument to mitigate GHG emissions where the objectives and its operation are addressed. Later on, the design principles that should be considered when developing the scheme as a public policy are presented. After that, the feasibility of the instrument in Mexico is analysed, and the results obtained from the assessment of Mexico's marginal abatement cost curve are presented. Finally, some of the convergences, divergences and implications among market-based instruments and circular economy thinking are discussed.

4.2 Overview of the Cap-and-Trade System

Due to the lack of defined property rights over common goods, a pure market approach is practically impossible to implement in the context of climate change (Wagner 2013). That said, the cap-and-trade system was created to be a practical alternative that combines the interaction between governments (which represent society) and pollutants through a market.

In recent years, the cap-and-trade system has become not only the backbone of the climate policy in some countries but also has been the mitigation instrument that has received the biggest boost in international agendas. Betsill and Hoffmann (2011) consider that the reason of such boost relies on the fact that currently most of the discussions have moved from the design phase to a pilot or deployment programme. Quoting Simmons and Elkins (2004, 173 p.):

As growing numbers of important actors articulate theories and implement practises that reflect a normative consensus, the legitimacy of these ideas gathers steam.

Lascoumes and Le Gales (2007) note that from the point of view of economists, cap-and-trade is interpreted as a general equilibrium model in which the feasibility of the scheme is given by their economic and environmental effectiveness. However, this "functionalist orientation", as they denote, ignores the social, political and ethical standards, which are critical for a sound market development. Moreover, recent events have shown how fragile the cap-and-trade system actually is. This occurs primarily in the context of financial crisis, increase of the scepticism about climate science and an increasingly polarised decision-making in key countries like the USA, Canada and Australia.

In a cap-and-trade system, the authorities set a priori the acceptable level of emissions; this amount is called cap and attempts to replicate the optimal level of contamination, between the social damage and the abatement cost for the polluters. Usually, the level of pollution will be given by the GHG emissions generated by the agents subject to this system.

Once the cap is set, the next step is to generate certificates, which represent the right to emit 1 tonne of GHG. Emission certificates are allocated to pollutants either free of charge (grandfathering) or through a compensation system (sale, auction, etcetera).

When the certificates are allocated and the system starts to work, pollutants are free to negotiate their certificates as in the "pure market". Participants act according to their strategies and interests while reducing and meeting the objectives of GHG reductions. Whenever the unit price of a certificate is greater than the cost of reducing pollution by the same unit, the company will reduce polluting emissions, and it would seek to sell the rights to a company with higher costs, in order to make some profit. This will gradually reduce the price of the certificate issuance. By contrast, a polluting company, whose abatement costs are higher than the price of allowances, will seek to buy certificates in the market, pushing the price to a higher value (Wagner 2013).

Finally, at the end of each period, companies are asked to report their total emissions, and the performance of this instrument is simply assessed by comparing the emissions each company has against the certificates that they hold. If the company exceeds their allowances, an additional compensation (fine) per tonne is claimed.

Wagner (2013) summarises that an environmental policy on climate change based on a cap-and-trade system should have the next three objectives:

1. To limit GHG emissions and to achieve the same reduction to prevent dangerous effects of global warming as the best available scientific sources indicate.
2. To minimise the costs of reducing GHG as a whole through the markets.
3. To encourage investment in eco-efficient, clean and low-emission processes and technologies: ultimately, the price signal of certificates would be one of the references to stimulate such investments.

4.3 Principles for Designing a Cap-and-Trade System

In an analysis regarding the experience with various cap-and-trade systems in the world, Betsill and Hoffmann (2011) contextualise the design of the instrument and point out that those systems that have proven to perform well have certain characteristics in common. While the design principles vary depending on the regulatory framework, they generally tend to be flexible and have different options to achieve the objectives outlined before.

For this analysis, the EU ETS was primarily used to establish the main design principles that a possible cap-and-trade system in Mexico should consider.

The scope of regulation was the first principle identified. In the context of the policy, the scope must have two parameters: (i) the magnitude of GHG reductions and (ii) the number of emission sources, which would be subject of regulation. Both parameters are dependent: the decision on the size of the reductions has an impact on the number of sources that should be regulated and vice versa. The choice of these parameters is also linked to the economy of the region, for instance, the greater the emission reductions and the shorter the time to achieve them, the greater the economic cost. Therefore, the choice of both parameters is a complex act of political and economic balance (Burtraw et al. 2010). Furthermore, Bressers and Huitema (1999) stress the role of institutions and interest groups in the policy-making process rather than just take into account the cost-effectiveness assumption of market-based instruments.

The second principle focuses on the characteristics of the cap in every phase of operation. Wagner (2013) and other authors state that a cap on emissions that decreases over the time is a key element in the design, since knowing the path of the cap in advance allows companies to plan their investment decisions. That said, the cap should not only be based on climate science but also on the fairness of the amount each sector needs to reduce. Once again weighing the level of what can be considered fair is far from easy since priority-setting in policy-making is a multi-actor interaction process (Bressers and Huitema 1999).

The third principle is based on how permits are initially allocated. Tietenberg (2003) proposed that the allocation can be carried out through an auction or based on the historical emissions over the past years for free (this process is known in the economic jargon as grandfathering). From there, each sector can buy and sell permits depending on their own ability to reduce emissions. If emission certificates are issued free of charge to the pollutants, then they obtained the right to pollute to a negative cost; however, if they are auctioned by the government, polluters pay for the right to emit one tonne (Betsill and Hoffmann 2011). This principle has been proven to be the most controversial one since cases of overallocation, like in the EU ETS, have affected the price signal of the certificates, pushing it to lower levels.

The fourth principle identified was the point of regulation, that is, who is subject to participate in the system. The main options include an upstream approach, which would require regulation in the fuel and energy production and the downstream approach, which imply that users of fossil fuels and energy would participate. The first approach would naturally include fewer entities to regulate and the second a larger amount of covered entities (Hargrave 2000). There are sectors in which selecting the point of regulation is such a challenge in terms of implementation. For instance, in the transport sector, a downstream approach involves an enormous amount of emission sources, and on the other side in an upstream approach, the number of sources is limited or simply belongs to another jurisdiction or country (Burtraw et al. 2010).

Flexibility is the fifth principle of design, and this can be presented in different measures. For instance, the scheme "save and borrow" allows the certificate prices to be more stable.[1] Another scheme that can help to moderate the price volatility of certificates at strategic moments is the "allowance reserve", which consists of a portfolio of allowances that is not distributed to the companies immediately. The "offsets" are another possible mechanism for flexibility, in which it is allowed to compensate the value of the certificates through another instrument such as the Clean Development Mechanisms (CDM) or the joint implementation (JI) credits. Flexibility is key in controlling costs (Wagner 2013).

Finally, the sixth design principle recommends an adequate supervision. It is desirable that the authorities try to avoid monopolistic practices in the market for emissions or showing other forms of anticompetitive or abusive behaviour. This is clearly not unique to the cap-and-trade system, which is similar to the regulatory oversight of any market. It's also important to ensure that all the participants subject to the cap-and-trade system are responsible for fulfilling their obligations to reduce emissions and face severe penalties in case they don't meet the regulation.

Table 4.1 compiles the six design principles presented throughout this section and the main practices and approaches that have been considered in various systems in the world.

4.4 Feasibility Analysis of a Cap-and-Trade System in Mexico: Contextual Analysis

In this section, the authors look at the relevant factors playing a role of the cap-and-trade system, such as the (Sect. 4.1) potential sectors eligible for the cap-and-trade implementation and (Sect. 4.2) the Mexican context comparing with other market-based instruments.

[1] The "savings" refer to the possibility that companies can save unused permits for future periods, while the "borrowings" represent the possibility of asking permission to use future allocations in the current period.

Table 4.1 Design principles of a *cap-and-trade* system (Own contribution)

Design principle	Approaches
Scope of regulation	Magnitude of GHG reductions
	Number of emission sources which are subject to regulation
	Situation of the sectors in the region (barriers)
Cap characteristics	It should decrease over time
	It should be predictable in its path
	It should be calculated in terms of climate science
	It should be consistent
Allocation	Auction
	Grandfathering
	Hybrid
Point of regulation	Upstream
	Downstream
	Hybrid
Flexibility	"Save" and "borrow" schemes
	Additional offsets like CDM and JI
	Binding schemes with other cap-and-trade systems
	No leakage schemes
Supervision	Anticompetitive practices
	Dishonest practices

4.4.1 Potential Role of a Cap-and-Trade System in the Climate Change Policy in Mexico and Potential Sectors for Implementation

Although Mexico is not among the members of Annex I countries of the Kyoto Protocol (KP), the climate change policy of the country has made notable progress in recent years to outline a legal framework to address the problem of global warming. The most outstanding result came in June 2012 when the General Law on Climate Change was published.

Particularly, the use of an emissions trading system such as the cap-and-trade was introduced for the first time as a possible action plan to lead part of the climate change policies. One motivation for this paper arises from the articles 94° and 95° from Title V, Chapter IX of that law which state:

> Article 94. "The Secretariat, with the participation of the Commission and the Council may establish a voluntary emissions trading system in order to promote emission reductions that can be carried out with the least possible cost, measurable, reportable and verifiable". (Ley General de Cambio Climático 2012, p. 37)
>
> Article 95. "Those interested in participating voluntarily in emissions trading may carry out operations and transactions linked to trading systems from other countries, or may be used in international carbon markets under the terms provided by the legal provisions that are applicable". (Ley General de Cambio Climático 2012, p. 37)

Although this law establishes the legal feasibility of developing a national system of emission trading as an economic mitigation instrument, it is important to underline that its operation does not arise mandatory, in line with Mexico's place in international agreements on climate issues. This law provides as well very explicit (but not binding) emissions reduction targets in the medium and long term: a 30% reduction compared to a business-as-usual scenario in 2020 (960 $MtCO_{2\text{-}e}$) and a 50% from 2000 levels by 2050 (Ley General de Cambio Climático 2012).

A final national framework that raises the feasibility of developing a market for emission certificates is given in the National Climate Change Strategy, which describes the strategic priorities and lines of action to follow from a federal level to a municipal level. Through pillar number two of the strategy (points P2.1 and P2.15), it promotes including economic, fiscal and financial markets in climate change policies to encourage mitigation and adaptation, citing, for example, the voluntary carbon markets (Secretaria de Medio Ambiente y Recursos Naturales 2013).

While the above references provide support and legal feasibility of implementing a system such as the cap-and-trade, there are other factors that could oppose such implementation.

Regarding the potential sectors for implementation, according to the report of the International Energy Agency (2013), Mexico contributed in 2011 to 1.4% of global emissions of CO_2, ranking 12th with the highest emissions. This contribution does not seem to be significant when compared with the large emitters; however, considering that Mexico is a country with high growth perspectives for the coming years coupled with the fact that the demand for energy from conventional sources will still grow, then mitigation of GHG should be a commitment that Mexico could tackle according to their possibilities and realities.

According to the National Institute of Ecology and Climate Change (INECC) in 2010, there were emitted 748 $MtCO_{2\text{-}e}$ to the atmosphere, which represented an increase of 33% compared to the emissions of 1990. As shown in Fig. 4.1, CO_2 emissions in 2010 are still the largest source of GHG. Therefore, designing a

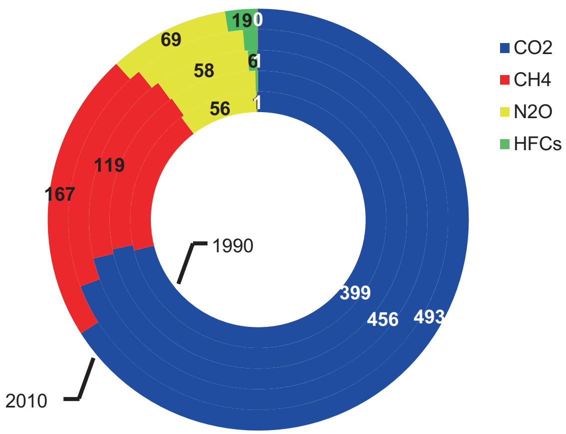


Fig. 4.1 Distribution of GHG emissions in Mexico in 1990, 1995, 2000, 2005 and 2010 (million $CO_{2\text{-}e}$ tonnes; Adapted from INECC 2013)

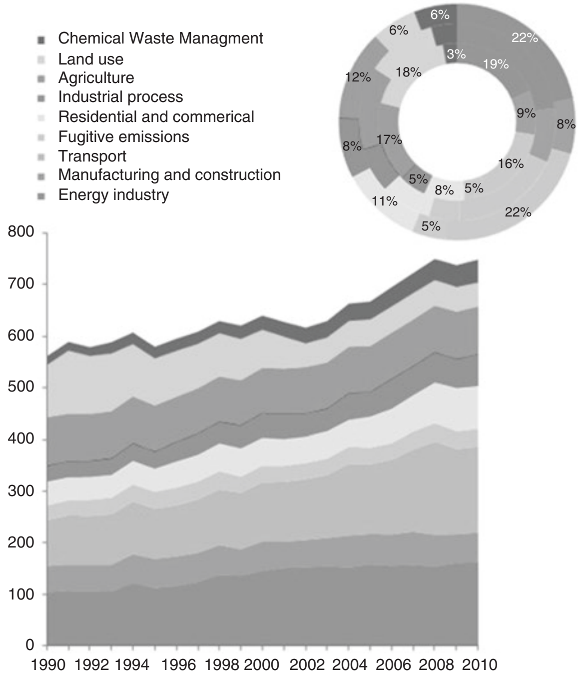


Fig. 4.2 Evolution of GHG emissions by sector (million $CO_{2\text{-e}}$ tonnes; Adapted from INECC 2013) and distribution by sector in 2000, 2005 and 2010 (the inner circle is the oldest year)

cap-and-trade system whose scope of regulation should focus on CO_2 covers a wide range. In comparison, the EU ETS operates only for CO_2 emissions because of the percentage represented by this gas and also because more accurate estimations can be done for monitoring (Fig. 4.2).

With this first evidence, the energy industry in general and the industrial processes would be likely areas to implement a system of emissions trading.

In the currently operating cap-and-trade systems in other countries, the sectors mentioned above are covered by the scheme due to similar reasons. For the EU ETS, the following industries are considered subject of regulation: combustion plants, oil refineries, steel plants, cement, glass, brick, lime, ceramics, pulp, paper and since 2013 airlines (European Commission 2013). EU ETS initially operated only for electricity generation facilities, and during the second phase of implementation, other sectors were incorporated to cover more than 11,500 installations throughout the continent. In Mexico, a similar case could be applied, since the electricity industry represents almost a quarter of total emissions.

It is noteworthy that back in 2012 one of the amendments of the General Law on Climate Change urged the government (federal, state and municipal) to develop GHG inventories, and since August 2015, companies that exceed 25,000 $tCO_{2\text{-e}}$ are required to submit their annual emissions report through the National Registry of Emissions (RENE). Due to the recent application of this tool, which undoubtfully will help to create a more certain national inventory, for the purposes of this paper, the analysis was only limited to the information on the Registry of Emissions and

Table 4.2 CO_2 emissions and number of facilities from nonmobile sources in 2012

	Emissions ($MtCO_2$)	Facilities reported
Energy	**226,6**	**1547**
Power generation	122,2	115
Power facilities from CFE	*52,3*	*68*
Others	*69,9*	*47*
Oil and petrochemical	37,2	266
Pemex	*34,7*	*219*
Others	*2,5*	*47*
Metal and steel industry	29,9	347
Chemical	29,5	514
Car industry	3,1	203
Pulp and paper	2,5	78
Glass	2,1	24
Industrial process	**28,5**	**124**
Cement and lime	25,5	69
Chemical waste management	1,1	35
Others	1,7	20
Others not classified	**2,9**	**223**

Adapted from INECC (2013)

Transfer (RETC). In Table 4.2, CO_2 emissions from different sectors are summarised by the number of facilities.

In 2012, 1894 facilities emitted around 258 $MtCO_2$ into the atmosphere, and only 5% of them (100 facilities) accounted for almost 81% of the total reported. Among those 100 facilities, 53 belong to the electricity generation sector and 15 to the oil sector. In Fig. 4.3, it can be seen that the contribution of CO_2 emissions depends on the number of registered facilities. This figure likewise emphasises that a relatively small number of facilities have the highest concentration of emissions.

The measure mentioned in the preceding paragraph allows establishing a threshold in which the largest number of emission sources is considered without compromising those whose activities are very low. For the case of the EU ETS, all facilities are included; in other words there is no threshold, but in other systems, for example, in California, USA, a threshold of 100,000 metric tonnes is established, or in the case of the regions of Canada, the threshold is 25,000 metric tonnes.

As it can be seen in Fig. 4.3, a large number of facilities in Mexico do not even represent 5% of total emissions. This could represent both an opportunity and a barrier to implement a cap-and-trade system, opportunity in the sense of fewer regulated facilities and the lower costs for verification and monitoring and a barrier since having few participants could reduce market liquidity for the emission certificates.

Parallel, different reports and articles like Morris (2009), Burtraw et al. (2010), IETA (2013) and the European Commission (2010) indicated that Mexico has a great potential for reducing emissions in the sectors of electricity generation, fuel refining, cement and metals.

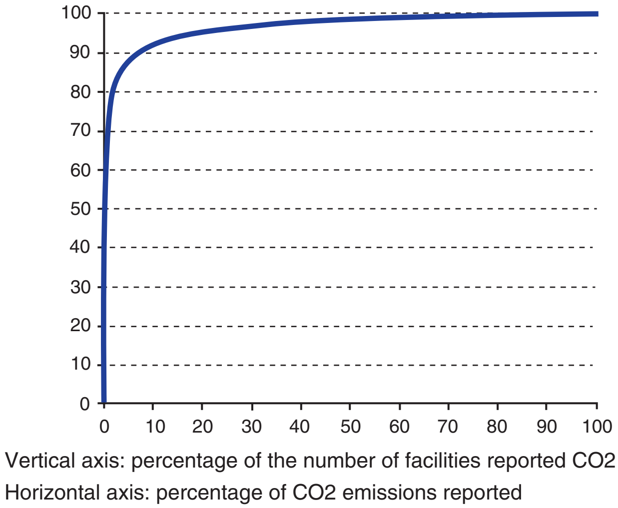


Fig. 4.3 Scatter of the number of facilities regarding their CO_2 emissions. (Adapted from INECC 2013)

4.4.2 Mexico's Context with Other Market-Based Instruments

Mexico has positioned itself as one of the favourite countries to host several CDM projects. According to official figures at the end of 2013, it had accumulated 207 projects, ranking fifth issuing just over 22 million reduction certificates (CERs).

In several reports, including a study by Centro Mario Molina (2008), it is concluded that Mexico still has not yet exploited the full potential of investment in CDM projects. These studies indicated that the country could had reached up to 100 million tonnes of reduced $CO_{2\text{-e}}$ per year only in the energy sector, of which power generation and the oil sector could represent at least 50%.

Kleper (2011) concluded that under the current scheme, the willingness of developing countries to agree with a cap on their emissions would be limited since their efforts to reduce would be accounted for industrialised countries and not for them due to the fact that most of the financial resources come from them. Using CDM as an offset in post-Kioto agreements would require industrialised countries to make more robust reduction commitments.

In parallel, a continuous slump in the demand of these mechanisms has been observed since 2013, especially in the third phase of the EU ETS where CERs from Mexico were no longer allowed (European Commission 2013). That is why Kepler (2011) and some other authors suggest that a scenario is more likely wherein CDMs completely disappear or are totally transformed.

That said, introducing a domestic cap-and-trade in Mexico would not cause any conflict with the current situation of CDM in the world and more precisely in the country.

On the other side, on December 2013, the incorporation of an "environmental tax" in Mexico's tax system was approved which can be addressed by cash or by carbon credits obtained for projects in energy efficiency developed in Mexico and endorsed by United Nations (UN) (Presidencia de la República 2013). The carbon tax was set at a "low" level of 5.70 USD/tonne of $CO_{2\text{-}e}$ in order not to create negative effects on the economy in the short term. However, it will increase gradually each year to generate more resources for mitigation and adaptation to climate change (according to UN figures, the costs for mitigating climate change vary from 20 to 25 USD/tonne of $CO_{2\text{-}e}$).

Moreover, Mexico declared its preference over carbon tax by stating that it was the most straightforward market-based instrument to apply in the country since there was a great concern about the impact of operating costs, supervision, monitoring and the entire institutional infrastructure that for an emission trading system would need to be implemented.[2]

In this context, using a carbon tax as a market-based instrument does not exclude the possibility of a joint implementation with another mechanism such as the cap-and-trade. For instance, in Europe, a number of countries including Sweden, Norway, Denmark and the UK have introduced carbon taxes besides the current EU ETS in operation. In addition, many members of this system (especially Germany and Spain) provide other policies such as subsidies for electricity generation from renewable sources. Or even more, in the UK, there is an additional cap-and-trade system for the service and public sectors (Fankhauser et al. 2011).

Fankhauser et al. (2011) also argue that a hybrid policy, such as putting a tax as a ceiling price on a cap-and-trade scheme, has major economic and environmental benefits rather than applying them separately. In such system, it would require companies to either pay prespecified taxes or simply meet the required permissions but not both.

Therefore, it is concluded that in the Mexican case, within a context of recent incorporation of carbon taxes and because the level is now considered "low", it is also possible that both instruments can interact together since it could send a stronger price signal and could give more certainty to the level of emissions reduction.

Additionally, the Energy Transition Law, which was published in December 2015, will establish different mechanisms to achieve the use of "clean energies" in at least 35% of Mexico's energy mix. Among these mechanisms, Clean Energy Certificates will be generated by 2018–2019, which could potentially be linked to a cap-and-trade national system.

[2] For more information regarding the differences between carbon taxes and emission trading systems, refer to Bristow et al. (2010), Xiangsheng et al. (2013), Balderas (2012), Chesney et al. (2013) and Aghion et al. (2009).

4.5 Feasibility Analysis of a Cap-and-Trade System in Mexico: MACC Assessment

Governments in their quest to reduce CO_2 emissions profitably and cost-effectively have different tools available for making decisions, and one of them is the use of the marginal abatement cost curves (MACC).

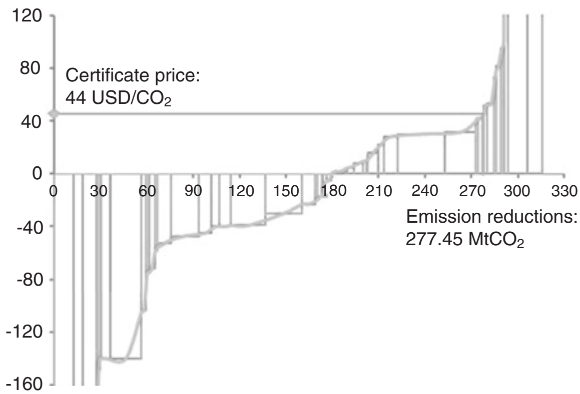
The MACC are used by different actors for different purposes. Regulators, for instance, use them to identify where interventions can be effective in certain public policies (e.g. establish a green tax or cap-and-trade system) and at what cost. Companies can use them to guide their long-term investment decisions to reduce emissions and improve competitiveness, while traders generally use them to derivate the function that provides the price of emission certificates.

Kesicki and Strachan (2011) point out that it is noteworthy that the MACC have been used worldwide as a standard tool to illustrate the economics of climate change mitigation. As an example of this, we have the case of the UK, who has based some of his policy decisions using MACC.

A MACC can, in a simple way, give a price approximation of the certificates associated with a reduction percentage and the potential of applying certain policies such as the cap-and-trade. This is based on the logic that any polluting mitigation option that is below such price would be implemented because they are economically appropriate (Kesicki 2011).

In Mexico, the Mario Molina Centre in cooperation with McKinsey Co. (2008) built the first MACC with horizon to 2030, which served to establish some of the specific objectives of the Strategic Plan for Climate change (CICC 2009). Five years later, the US Agency for International Development (USAID) presented an updated version of the MACC and concluded that Mexico has a potential for reducing its GHG emissions by 33% with respect to the levels of a business-as-usual scenario for 2020 (USAID 2013). It also shows that 87% of the reduction potential is concentrated in five sectors, the most important transportation, power generation, oil and gas and forestry. This particular curve is taken as reference to assess the need for a cap-and-trade system in this paper. Figures 4.4 and 4.5 show how to read the curve and which sections are more suitable for certain policies.

Fig. 4.4 Setting the price of the emission certificates in a *cap-and-trade* system



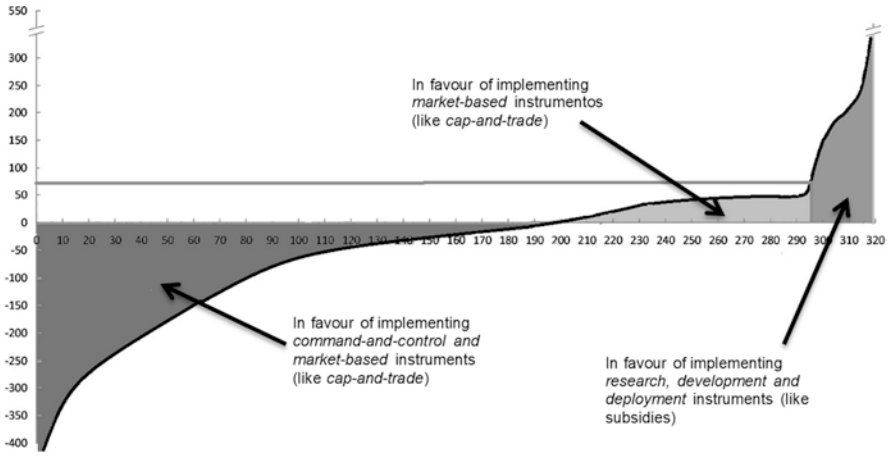


Fig. 4.5 Need for a cap-and-trade system through the reading of a MACC

In the following paragraphs, the results obtained from the assessment of Mexico's MACC are going to be presented. Data for calculating the potential of introducing a cap-and-trade system as well as the costs associated with it were obtained from the latest update of USAID's report entitled "Updated analysis on Mexico's GHG baseline, marginal abatement cost curve and project portfolio". A total of 67 mitigation options from an universe of 126 were obtained. Those that were not reported were not included in this study (lack of data). However, these 67 mitigation options accounted for 91% of the total potential.

The sectors included were agriculture, forestry, cement, chemical, metallurgical and steel, oil and gas, power generation, transportation and waste management. The costs for implementing the various mitigation options were calculated using McKinsey Co. methodology.[3] Since there are some interactions between the mitigation options, the order in which these options are carried out may affect the total reduction potential.

According to the processed information, the reduction potentials are concentrated in four sectors: forestry, transportation, power generation and oil and gas. In Table 4.3, the most important results are condensed.

The percentage of measures with negative cost almost accumulates 57% of all measures; in other words, more than a half of the mitigation options not only achieve a significant reduction in GHG emissions but also save money in the long run. The average cost of all options results in a financial gain of 30.2 USD/tCO_2, which could translate into a benefit for the economy as a whole by almost 1% of GDP by 2020.

[3] The social discount rate used in this method was 4%, and the following costs were not included: transaction costs, information or communication costs, subsidies for taxes and costs of monitoring implementation. For further information on McKinsey Co. methodology for cost estimations, refer to USAID (June 2013).

Table 4.3 Results from all mitigation options

Sector	Abatement potential ($MtCO_{2\text{-}e}$)	Abatement potential (% BAU scenario)	Average cost mitigation options (USD/tCO_2)	Total cost-benefit (million USD)	Total benefit cost (as GDP %)	Negative cost mitigation options (% of total potential)
Agriculture	18.9	−13	−17.7	−335.3	−0.033	50
Forestry	73.0	−145	31.0	2266.3	0.221	0
Cement	1.4	−8	−139.1	−194.7	−0.019	100
Chemical	5.3		−4.5	−23.6	−0.002	14
Metallurgical and steel	4.9		−36.9	−180.7	−0.018	88
Other industries	7.4		−40.0	−296.0	−0.029	100
Oil and gas	47.0	−45	−116.6	−5481.8	−0.534	91
Power generation	55.0	−36	−44.0	−2421.5	−0.236	64
Transportation	55.0	−20	−84.2	−4632.5	−0.451	85
Waste management	44.0	−61	11.1	489.0	0.048	70
Total	**311.9**	**−32**	**−30.2**	**−9530.8**	**−0.93**	**57**

Adapted from USAID (2013)

This also indicates that there are sectors, which find more profitable (but not easy) to reduce their emissions because it also represents savings in costs.

The forestry sector has the biggest potential, which represents 23% of the total. Implementing all mitigation options could even turn it into a net sink. However, it also represents the sector with the greatest impact in terms of costs, because 100% of the options have positive cost, implying that they are mostly absorbed by society. The estimated average cost of this sector is at 31 USD/tCO_2, almost 9 times higher than the current carbon tax and marginally below the maximum value observed in the carbon market in the EU.

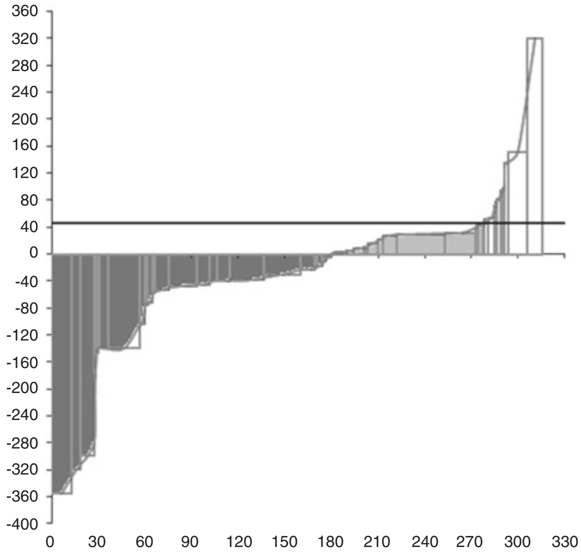
Transportation is the second largest potential sector (18%). Eighty-five percent of all the options have a negative cost; therefore, the average cost results in a financial gain of around 84 USD/tCO_2 or in terms of GDP 45 basis points.

The electricity generation sector shares the same position as transportation, accounting also 18% of the total. Sixty-four percent of the options have negative cost, bringing the average cost to a financial benefit of 44 USD/tCO_2. In terms of GDP, the benefit translates into 0.2%.

For the oil and gas sector, a potential reduction of 55 $MtCO_2$ was obtained, representing 15% of the total. This particular sector has the highest proportion of negative cost options, 91% of the total, as well as in terms of financial gain, which account over 0.53% of GDP by 2020. The average profit per tonne of CO_2 is around USD 116.

Finally, to determine the need for a cap-and-trade system in Mexico, two references or scenarios were used:

Fig. 4.6 Potential use of a *cap-and-trade* system in Mexico throughout the economy. (Adapted from INECC 2013)



1. The maximum price of EUAs (EU ETS certificates): 45.69 USD/MtCO_2 (the exchange rate considered was 1.3846 EUR/USD).
2. The tax value of the fuel most used in Mexico's energy mix: 3.53 USD/MtCO_2 (the exchange rate considered was 13.00 MXN/USD).

As a first step, a cap-and-trade for the economy as a whole was addressed. In the first scenario, if the equilibrium price was at 45.69 USD/tCO_2, the potential supply of certificates could reach 280 million by 2020, and the percentage of potential options which would be appropriate with a cap-and-trade instrument accounts for 89%: 57% with negative costs and 32% with positive costs. That said, a cap-and-trade system throughout the economy has a high potential for implementation; however, the percentage of options that represent negative net costs (or a win-win in the economy) is almost as twice as the percentage of positive costs. In that sense, introducing a cap-and-trade system could generate more supply than demand, which is good in a sense of reductions, but counterproductive in the price of emission certificates in the long term. Figure 4.6 shows, firstly, the level of reduction that could be achieved, given an equilibrium price of 45.69 USD/tCO_2 (denoted by the black line), and, secondly, the regions of the options which are appropriate for a cap-and-trade system (options with positive cost are marked in light gray and options with negative cost are marked dark gray).

Although the potential of those options is appropriate to a cap-and-trade scheme, the next step is to determine if there is predominance in a few sectors. To do this, all mitigation options that belong to the 89% previously calculated were analysed. Table 4.4 shows the potential of implementing a cap-and-trade system for each sector. They are prioritised according to the potential supply of certificates.

Table 4.4 Summary of the potential of introducing a *cap-and-trade* system in various sectors under an equilibrium price of 45.69 USD/tCO_2

Sector	Potential supply of certificates (million)	Potential options of being considered in a *cap-and-trade* (%)	Potential options with positive cost in a *cap-and-trade* (%)
Power generation	52.5	95	88
Gas and oil	44.5	95	33
Transportation	47	85	0
Waste management	32	73	8
Agriculture	18.1	96	91
Forestry	15.5	21	21
Other industries	7.4	100	100
Metallurgical and steel	4.3	88	0
Chemical	4.2	81	86
Cement	1.4	100	0
Total	**280**	**89**	**77**

Adapted from INECC (2013)

Table 4.4 shows that the power generation sector, the oil and gas industry as well as transportation are the sectors in which the implementation of a cap-and-trade with initial price of 45.69 USD/tCO_2 not only has the greater chance of implementation but also the greatest reduction potential.

To complete the analysis, the potential for implementation was also assessed considering the current level of Mexico's carbon tax (3.53 USD/tCO_2). The potential supply of certificates could reach 189 million units by 2020, which is 48% lower compared to the maximum price of certificates in the EU ETS. The percentage of potential options that would be appropriate with a cap-and-trade system decreases to 60%: 57% with negative cost and only 3% with positive cost. That said, a cap-and-trade system across the economy would have a considerable potential for implementation; however, the percentage of options that represent negative cost account for almost the entire potential.

As for the comparison by sector, implementation rates are basically the same for oil and gas industries and transportation. For the electricity generation, the potential decreased almost 20% but still remains at a high rate of implementation. All this would suggest that these three sectors, even considering an initial lower equilibrium price, might be technically feasible to implement a cap-and-trade system.

4.6 Implications of Circular Economy into Cap-and-Trade Systems

In contrast to cap-and-trade instruments, circular economy thinking establishes a more holistic approach since methodologies like life cycle assessment lead not only to emission reductions but also to awareness of the raw materials used and the effects of products' disposal. Even though this thinking has influenced a considerable amount of policies in the EU, there has been no explicit integration into climate mitigation policies.

Niederberger et al. (2013) explore the convergences and divergences that market-based policies and circular economy thinking have and through a series of case studies present interesting implications of how market-based mechanisms can be designed to drive, instead of hindering, the transition to a low-carbon economy. The authors, firstly, indicate that the paradigm of market-based instruments focuses on the flexibility in fulfilling GHG mitigation through the least cost options, while the paradigm of circular economy (CE) shifts from waste management to resource management, leading to the most productive use of resources. Secondly, they expect that the outcomes for market-based instruments are directly linked to emission reductions that address environmental issues like global warming, ozone depletion and human toxicity. In the case of CE, because it applies the life cycle approach, the expected outcomes are the substitution of material inputs by recovered, reused, recycled resources at any stage of the supply chain.

Finally, Niederberger et al. mention that the boundary considerations of market-based policies may vary from country, region and scope of regulation, while CE thinking does not have geographical constrains and considers all life stages of a material/product in any sector.

Since life cycle assessments generally evaluate "potential" impacts and market-based instruments try to represent "real and verifiable" emissions reductions, there is a notable inconsistency between these two thinkings. Even further, from Niederberger et al. (2013), it was shown that there are some deficiencies in market-based instruments when they attempt to stimulate the transition to efficiency in the use of resources. It was argued that the carbon price signal, which is the main direction for participants in a cap-and-trade system, has only marginally changed the use of efficient technologies. In Germany, for instance, there is no evidence that the cost increment in electricity due to EU ETS has translated into a strong signal for households to purchase efficient appliances.

Niederberger et al. (2013) also addressed that market-based instruments until now have failed to stimulate the adoption of cradle-to-cradle practices. For example, it was found that most manufacturers have not managed to generate revenues from offset activities related to cap-and-trade flexibility mechanisms. That said, manufacturers do not really see the economic benefit of product innovation through this system.

Finally, recycling and reusing are key principles for circular economy, and therefore a sound market-based policy should take into consideration these basic processes. However, carbon markets do not directly reward pure recyclers, because the service they provide results in avoidance of upstream GHG emissions reductions associated with raw materials needed to manufacture final products downstream, activities that are beyond the control of the recycling company. There is also no carbon market mechanism that makes manufacturers responsible for carbon embedded in the raw materials they use (Niederberger et al. 2013).

4.7 Conclusions

Mexico has positioned itself as a leader in the emergent economies to address climate change. Through the General Law of Climate Change and the National Strategy of Climate Change, it has endorsed this commitment.

This paper sought to answer if it is feasible to implement a cap-and-trade system in Mexico as part of its climate policy. This scheme aims to limit and reduce GHG emissions in the country and has certain advantages compared with other policies. Even in certain regions, such as the European Union, the cap-and-trade system is considered the backbone of the climate policy. However, recent events and certain elements in its design have shown how fragile any market instrument can actually be, mainly in a context of financial crisis and increasingly polarised negotiations on the international agenda.

As part of the analytical framework to test the research hypothesis, the marginal abatement cost curves (MACC), whose results proved partially that a cap-and-trade system is a feasible option in Mexico, were used. This is because the potential for implementation and associated costs to reduce emissions makes it suitable for the development of a market for emission certificates. However, there are certain barriers and contextual elements that could undermine the effectiveness and thus minimise the fundamental objectives of the scheme.

Firstly, the evidence displayed regarding Mexico's context with other market-based instruments points out that a scenario where CDMs are redesigned is more likely to occur since other ETS (like the third phase of the EU ETS) are no longer allowing CERs from specific countries like Mexico. Therefore, it was concluded that the CDM does not represent a potential barrier to the introduction of a cap-and-trade. In the case of the recent implementation of a carbon tax in Mexico, it is possible that the cap-and-trade system and this tax can interact together. This is mainly because the current level of tax is eight times less than the maximum that has been reported in European markets, as well as the evidence of joint policies in other countries. Therefore, it was concluded that the carbon tax is not a potential barrier for the cap-and-trade system. Furthermore, it could create a hybrid instrument that sends a stronger price signal, giving more certainty on the level of emissions that could be reduced.

It was also found that the percentage of measures to reduce GHG with negative cost agglomerates 89%, of which 57% of the options have negative cost. It could not only mean a significant reduction in Mexico's emissions but also could translate into a benefit for the economy as a whole by almost 1% of GDP by 2020. It was also identified that the sectors of power generation and the oil and gas industry are the sectors in which the implementation of a cap-and-trade would have the greatest chance of implementation.

Finally, it is worth mentioning that since Mexico is characterised to be a manufacturing economy, a possible cap-and-trade system in the country should be designed rewarding more the most productive use of resources, rather than any marginal emission reduction. This would align carbon markets signals to promote better material management throughout its life cycle.

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