Mexico's Climate Change Mid-Century Strategy

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Climate Change Mid-Century Strategy

Prologue

This is a pivotal moment in our history. The Paris Agreement is the foundation for a new paradigm of global action on climate change. We are in the middle of a transformative era of technology, demographics, and human behavior. And we face energy, economic, and environmental challenges that are greater than those that we have conquered in the past.

The twin goals of limiting temperature rise to well below 2ºC in this century and increasing global efforts to limit the temperature increase to 1.5ºC, pose an unprecedented opportunity to transform our economies. To reach the Paris goal, we must plan ahead. Instead of reinventing our past, we can create our future where growth is uninhibited by fossil fuel constraints or health impacts; a future where growth does not come at the cost of future generations.

Mexico assumes its responsibility as a global player. Our Mid-century Climate Change Strategy will guide our actions as a nation for the next 40 years. Built upon sound science, it poses feasible goals that go beyond reducing greenhouse gas emissions. It sets out a long-term vision and a roadmap to incorporate climate change in our development plans, thus impacting key strategic decision-making. At the core of our strategy is the well being of our people, and the peoples of the world. We aim to ensure their right to access clean energy, good health, and safe environments. The goal is for people to reach their full potential without impacting the planet.

Our strategy is the product of a democratic exercise of society as a whole. Our actions have legal foundations, both on the climate and energy fronts. The *General Law on Climate Change* provides the mandate to craft comprehensive long-term climate policy. The *Energy Transition Law* aims to fully revolutionize our energy sector for the adoption of new clean energy technologies and innovation. We have launched consultation processes for both our *National Climate Change Strategy* and the *Energy Transition Strategy*. Our Mid-Century Strategy builds on these processes and thus represents the will of the Mexican people.

In addition to our domestic efforts, Mexico has positioned itself as an international leader. In particular, I want to highlight our common efforts with the United States and Canada. With them, we have committed to an ambitious and enduring *North American Climate, Clean Energy, and Environment Partnership* that sets us firmly on the path to a more sustainable future. It is with them that we present today our Mid Century Strategy, based on the moral imperative to show strong regional leadership in the implementation of the Paris Agreement.

I want to be clear that global efforts must be strengthened. The totality of emissions reductions which have been pledged, as of today, are insufficient to meet the goal of limiting warming to 2ºC. We must find ways to unlock finance, to build capacity in all regions of the world, and to accelerate technology deployment. We present our Strategy and willingness to work with all Parties to find common solutions to raise global ambition.

Climate change is the great unifier. It brings countries together, and calls for us to do more with less. It pulls together planning and investment that was otherwise separate and, at times, working at cross-purposes. There may be disagreement about how to do it, but what is clear is that we must achieve multiple goals in more effective ways than if we stayed in our narrow boxes. We must overcome the way we divide up issue areas and fail to interweave common goals.

We are Mexicans, and our Mid-Century Strategy outlines the roadmap for our future. It is rooted firmly on past lessons, on a vision based on science, and on the unwavering confidence in our ability to grasp and shape our destiny for the benefit of our children – and their children. While the challenge ahead is enormous, I am confident that together we have the creativity, ingenuity and political will to deliver on the promise of a safe climate future.

Enrique Peña Nieto

President of the United Mexican States

Executive Summary

Pursuant to Article 4 paragraph 19 of the Paris Agreement, Mexico submits its Mid-Century Strategy to the UNFCCC. Mexico's mid-century climate change strategy provides the vision, principles, goals, and main lines of action to build a climate resilient society transition towards a low emissions development. This is in line with the global goal of holding the increase in the global average temperature to well below 2ºC, with additional efforts for the more ambitious 1.5ºC goal. This work also responds to a joint effort by the countries of the North American region, which committed to a *North American Climate, Clean Energy, and Environment Partnership*.

First, in the Introduction we discuss our views about the importance of the MCS instrument of the Paris agreement. Together with the USA and Canada, we present strategies that call for deep greenhouse gas emissions reductions across the economy by 2050, emphasizing the importance of early, ambitious, and sustained action. Mexico encourages other Parties to develop their strategies, and welcomes cooperation in this area.

Second, the Context chapter discusses the science, international and national conditions that drive our action. First, we present a brief review of climate science regarding current GHGs concentrations and emissions reductions required to reach the temperature stabilization goal of the Paris Agreement. Then, we briefly discuss international and national actions. Regarding domestic action, key elements of Mexico's General Law on Climate Change are presented, including the institutional arrangements and instruments. Mexico's Law already mandates the elaboration of a long-term climate change strategy, thus Mexico issued in 2013 the National Strategy for Climate Change 10-20-40, the basis of this document.

Third, we present the Objective of our strategy. This document is a guiding instrument of the national climate change policy, both in the medium and long-term. As the guiding instrument, it describes the strategic lines of action guiding policy at national and subnational levels. It also aims to encourage social participation and co-responsibility. The MCS does not intend to define concrete short-term actions. Mexico has other planning instruments that define short-term policies every six-year term (the Special Climate Change Program and State and Municipal Climate Change Programs.)

Forth, we present Mexico's long-term vision. This exercise aims to define milestones for the next 10, 20 and 40 years regarding seven important areas that drive emissions and preparedness for the climate issue: society and population, ecosystems, energy, emissions, productive systems, private sector, and mobility.

Fifth, we present the strategy for climate change adaptation. Based on a vulnerability assessment, we present temperature and precipitation expected changes in Mexico in a RCP8.5 scenario. With this scenario, we identify the most vulnerable municipalities of Mexico. We briefly discuss actions taken to reduce vulnerability in the short-term horizon, and then the lines of action guiding the adaptation work in the long-term. We consider three main action areas: social, ecosystems and productive systems.

Sixth, we present the strategy for climate mitigation. Our GHG emissions reduction goal is to reduce 50% of national GHGs by 2050 below our emissions in 2000. We present results from a modeling exercise using the *Massachusetts Institute of Technology Economic Projection and Policy Analysis (EPPA) Model* that was calibrated using Mexico's information to evaluate two policy scenarios. The first scenario refers to Mexico's current unconditioned NDC emissions reduction goal of 22% reductions from baseline by 2030, with the goal of 50% reduction by 2050. The second scenario, explores a more ambitious policy of 36% reduction by 2030, with additional policies agreed at the regional level with the USA and Canada. We quantified the additional emissions reduction by comparing scenarios. We also discuss indicative technology pathways coming out from the modeling exercise. We included in the analysis the analysis of all GHGs and also black carbon. Also, to support our analysis, we also present results from a detailed electricity sector model (the Balmorel model) and from a land-use model (Carbon Budget Model CBM-CFS3).

The policies direct action in five important areas: the clean energy transition, energy efficiency and sustainable consumption, sustainable cities, reduction of short-lived climate pollutants and sustainable agriculture and protection of natural carbon sinks. Mexico's strategy identifies critical crosscutting issues for long-term climate policy, including: the need for market-based instruments to price carbon, increased innovation, more research and development of new technologies, and the need to build a climate culture with mechanisms for social and private sector participation.

Finally, we describe the evaluation and update process of the MCS strategy. Mexico's General Law on Climate Change requires updating at least once every ten years the mitigation and every six years the adaptation policies. We commit to update our strategy according with the provisions agreed under the UNFCCC. Our Strategy states that under no circumstances will the reviews lessen our goals and objectives.

Introduction

In Paris, countries agree to take action with a long-term perspective. In particular, the Paris Agreement included in Article 4 the provision that countries should:

"strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances"

And in accordance with Article 4, all Parties are invited to:

"communicate, by 2020, to the secretariat mid-century, long-term low greenhouse gas emission development strategies in accordance with Article 4, paragraph 19, of the Agreement, and requests the secretariat to publish on the UNFCCC website Parties' low greenhouse gas emission development strategies as communicated"

Pursuant to Article 4 and paragraph 19 of the Paris Agreement, Mexico submits its Mid-Century Strategy (MCS) to the UNFCCC. Our goal is to underscore the importance of this particular component of the Paris Agreement. We believe that the MCS could provide important guidance to our future work, by aligning our short and medium term actions with the ultimate long-term objectives to protect our planet from dangerous climate change.

As recognized in the Paris agreement, in order to reach the long-term temperature goal, global emissions must peak as soon as possible and rapid reductions must be undertaken thereafter. As of today, the aggregate effect of the intended nationally determined contributions is insufficient to reach our climate goals (UNFCCC, 2016a). Thus, we must provide more ambition, and communicate our future plans to encourage more adaptation and mitigation action. We believe that the submissions of MCS could assist our common goals, by helping us foresee the unfolding low-carbon world. We aim to generate confidence and transparency in the work ahead of us.

In this spirit, we have worked with the US and Canada to submit our strategies during COP22. We have identified areas of collaboration, including policies to accelerate clean energy deployment, efficient transportation and appliances, and to combat other GHG emissions such as methane. Our countries have identified the eminent need for innovation and more technology development. While more work is required to better integrate policies and efforts, our submissions today demonstrate our joint collaboration. We encourage other parties to develop their strategies, and welcome cooperation in this area.

Context

Science-based approach

Earth warming is unequivocal. The average global surface temperature of the planet has increased since the industrial revolution, more notably in the past 50 years. Scientific evidence reviewed by the Intergovernmental Panel on Climate Change (IPCC) shows, with a high level of confidence, that the observed changes in the climate system are significant and very likely driven by human activities, particularly the burning of fossil fuels and deforestation (IPCC, 2014). As shown in Figure 1, observed changes already suggest alarming climate anomalies around the globe. Certain regions of the planet, specially the poles, surpassed 2ºC over their historical average.

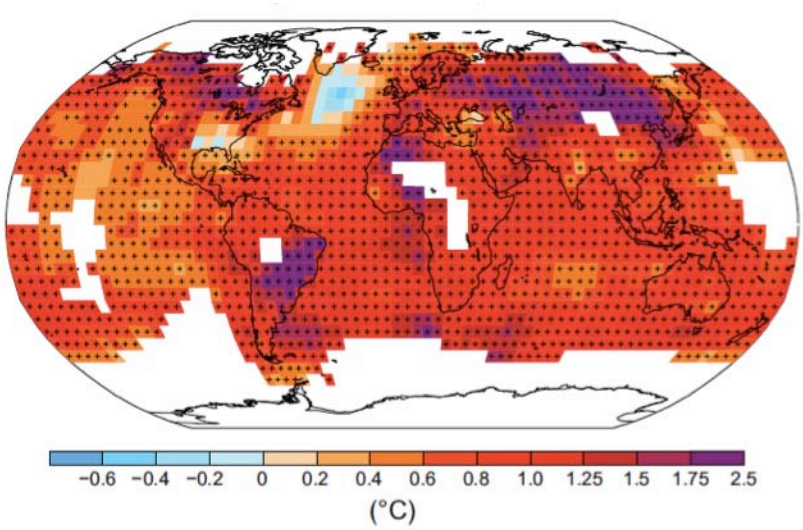

Figure 1 Observed change in surface temperature 1901-2012
Source: (IPCC, 2013)

The climate system depends on the balance of several internal and external factors. Among the external factors, solar radiation and orbit cycles stand out, while some of the internal factors are the atmosphere's chemical composition and the water and carbon cycles. In particular, the concentration of greenhouse gases (GHG) since July 2016, have registered measurements of over 400 parts per million of CO_2 for three consecutive months (Earth

System Research Laboratory, 2016) a threshold that scientists around the world consider already could lead to dangerous climate change (IPCC, 2013; Rockstrom et al., 2009). The state of our knowledge urges global action; we must immediately take measures both to minimize impacts of climate change and to mitigate emissions.

Climate risks of a temperature increase of 2ºC or 3ºC above pre industrial levels include more frequent extreme events, such as droughts and heat waves. Also, temperature increases above these levels could lead to changes in oceanic patterns. Scientists believe that current climate change trends could trigger a situation similar to the one occurred in the early Pliocene (between 3 to 5 million years ago), when the surface of the sea experienced high cyclonic activity (Fedorov, 2010). As shown in Figure 2, current cyclone paths are limited to some tropical and subtropical zones of the Atlantic, Indian, and Pacific oceans. Climate change could increase cyclone-prone areas through the oceans east to west. Furthermore, the cyclones might increase not only in number, but also in intensity. This would be similar to experiencing a constant El Niño effect, with important physical and human consequences.

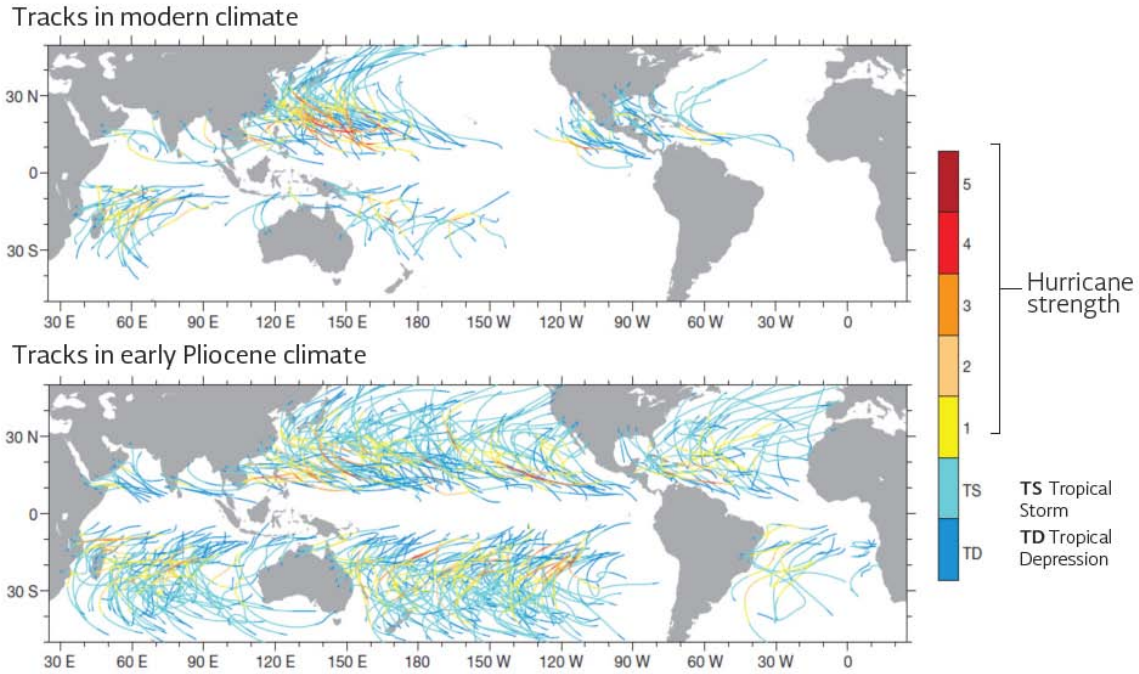

Figure 2 Cyclone Track Comparison in Current Times and the Early Pliocene
Source: (Fedorov, 2010)

An unprecedented example of the potential of extreme weather events was experienced by Mexico in 2015. Hurricane Patricia made history when it became the strongest storm recorded in the western Hemisphere; it was also one of the fastest strengthening storms ever recorded. Such rapid intensification could be explained by particular environmental conditions; namely a stable atmosphere, not dry air intruding into the storm and a particularly warm ocean layer.[1] The water temperature anomaly could be one of the early signals of the global warming effect directly threatening the Mexican west coast.

Figure 3 NASA astronaut Scott Kelly captured Hurricane Patricia from the International Space Station on Oct. 15, 2015
Source: (Scott, 2016)

Thus, there is enough scientific evidence that not only is the planet warming, but also the impacts of temperature rise could represent important risks for our population. Acknowledging Mexico's vulnerability to a changing climate, we are committed to act strongly and fast.

Science also helps us to inform our global decision making on the size of the effort require to prevent dangerous anthropogenic climate change. While uncertainty exists, there is agreement that the CO_2 concentration in the atmosphere most be stabilized in the range of

[1] El Niño warm water layer and "the Blob", a water mass with a significant water temperature positive anomaly, have been recorded for a couple of years now on the north east coast of the Pacific Ocean.

430-480 pmm to hold the temperature below 2ºC.[2] Based on this information, and on available information regarding consistent emissions pathways, the Paris Agreement included two critical components for the global mitigation efforts. Countries agreed that "global emissions must peak as soon as possible" and that "rapid reductions must be undertaken thereafter."

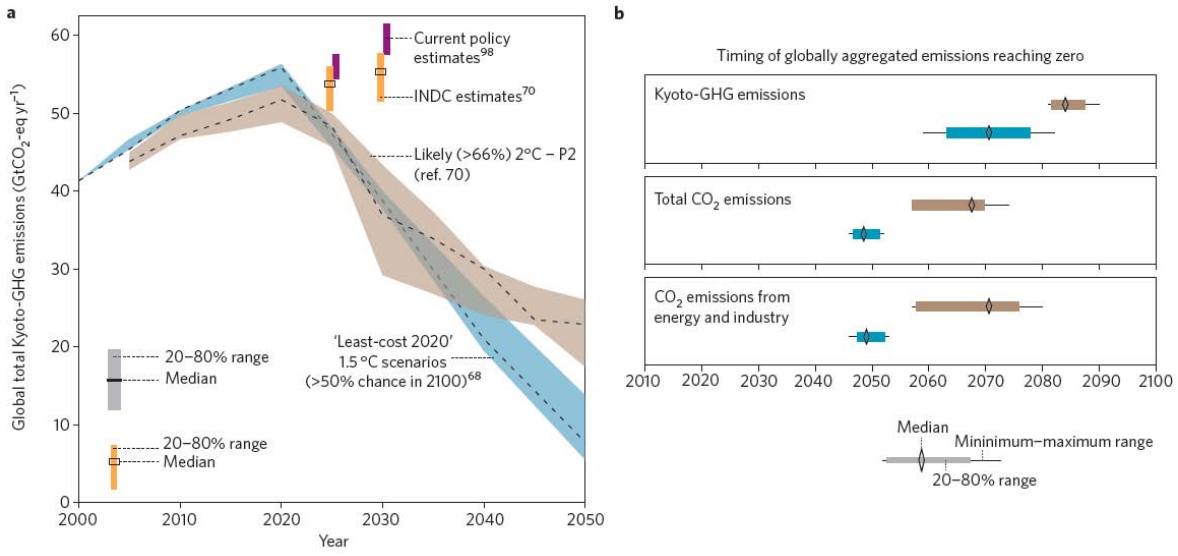

Figure 4 Characteristics of below 2 °C and 1.5 °C pathways
Source: (Schleussner et al., 2016)

As Schleusneer et al discuss, there are both science and policy implications of the Paris Agreement temperature goal. Figure 4 shows emissions pathways, resulting from integrated assessment modeling exercises, which could be consistent with a 2ºC and a 1.5ºC temperature target by 2100 (with 50% probability) (Schleussner et al., 2016). Their comparison of the 2ºC and 1.5ºC goals is illustrative of policy implications regarding timing for global emissions peak and also for the speed at which emissions should fall afterwards (See Figure 4a). Also, CO_2 emissions must be zero by 2050 for a 1.5ºC, and between 2050 and 2070 for a 2ºC target (See Figure 4b.)

To reach the aggressive level of emission reductions required, all mitigation options must be on the table. Mexico's climate strategy includes measures to reduce Short-lived Climate Pollutants (SLCPs), including: black carbon (BC), methane (CH4), tropospheric ozone (O_3),

[2] The IPCC considers that a range of 430-480 ppm would *likely* hold temperature rise below 2ºC; while ranges between 480-530 ppm could *more likely than not* achieve this goal if there is no overshoot over 530, and *about as likely as not* if there is an overshoot.

and some hydrofluorocarbons (HFC). Figure 5 illustrates the important role that SLCPs could have for climate mitigation. While contributing to reduce local air pollution, control strategies for SLCP could assist holding climate forcing in the short-term.

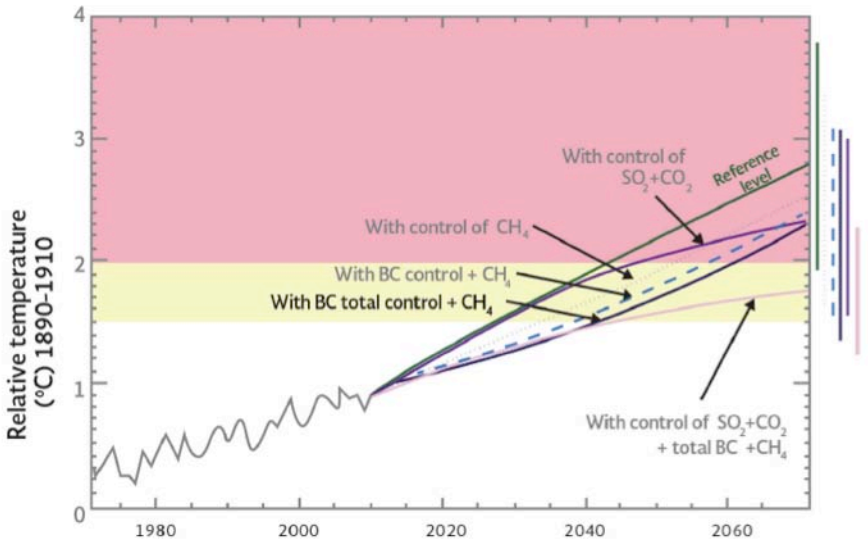

Figure 5 Mitigation strategies in the short and long-term
Source: (Shindell D. et al., 2012)

International Context

After the Paris agreement the international setting for climate policy has now turn gears to full implementation and scaling-up action. All Parties of the UNFCCC are now working to plan and look for adequate financing resources for their INDC. As we focus in our short and medium term strategies to deliver on the NDC pledges, it is important that we align these actions to our overarching goals to protect the planet. In this context, the MCS are a useful tool to signal to all interested communities (other Parties, social and private sectors, and the research community) what are long-term goals and strategic vision. In this context, is that we present together with Canada and the US our MCS. Following, we present a brief overview of each of the North American countries MCS. Areas of commonality can clearly be identified, and are an essential part of the North American Climate and Clean Energy Partnership, to mention clean energy deployment, energy efficiency, methane and short-lived climate pollutants reduction, and protecting our forests and sensitive ecosystems.

Canada

Canada's mid-century low greenhouse gas emissions strategy outlines key principles and pathways consistent with Canada achieving net greenhouse gas emissions reductions in 2050 that respect the 1.5-2°C global temperature goal. A few key factors are identified as paramount to low GHG outcomes in Canada: non-emitting electricity generation; the electrification of certain end-use applications; low-carbon fuels; energy efficiency; and the importance of sequestration from forests. The necessity of reducing non-carbon dioxide emissions is also highlighted. The strategy includes the key message that significant emissions reductions are possible with today's technology, while innovation and research and development will ease and accelerate the deployment of clean technologies and clean energy options – where the role of carbon pricing is paramount in this respect. Canada's strategy also links long term low greenhouse gas objectives to infrastructure and investment planning.

Mexico

Mexico's mid-century climate change strategy provides the vision, principles, goals, and main lines of action to build a climate resilient society and to achieve low emissions development. This is in line with the global goal of holding the increase in the global average temperature to well below 2ºC, with additional efforts for the more ambitious 1.5ºC goal. The climate adaptation strategy, based on Mexico's vulnerability assessment, identifies three main areas of action: reducing vulnerability factors and building social resilience, ecosystems-based adaptation, and measures to protect strategic infrastructure and production systems. Climate mitigation goals are aggressive, and direct action in five important areas: the clean energy transition, energy efficiency and sustainable consumption, sustainable cities, reduction of short-lived climate pollutants and sustainable agriculture and protection of natural carbon sinks. Mexico's strategy identifies critical crosscutting issues for long-term climate policy, including: the need for market-based approaches to price carbon, increased innovation, more research and development of new technologies, and the need to build a climate culture with mechanisms for social and private sector participation. More broadly, Mexico's long-term climate strategy aims to catalyze a profound transformation of our economy. This transformation will address the climate issue as well as national priorities of sustainable and more inclusive development, thereby contributing to building the Mexico we envision; that of a prosperous society that embraces the stewardship of nature.

USA

The U.S. mid-century low greenhouse gas emissions strategy lays out multiple pathways for achieving ambitious reductions of domestic net greenhouse gas emissions by 2050, consistent with holding global average temperature increases to well below 2 °C. The U.S. strategy envisions actions across three categories: (1) the transformation to a low carbon energy system, including a near-complete decarbonization of the electricity grid and deep emissions reductions across the transportation, buildings and industrial sectors; (2) storing carbon and reducing emissions through U.S. lands and agriculture; and (3) reducing non-CO_2 emissions such as methane, nitrous oxide and fluorinated gases, despite large increases in key drivers of these emissions (e.g. agricultural production). To achieve a low GHG pathway, the U.S. strategy envisions an aggressive and cost-effective suite of public policies that include market incentives to reduce emissions and public support for research, development, demonstration & deployment (RDD&D).

National context

Mexico is highly vulnerable to the impacts of climate change. Socioeconomic and ecological trends, including the urbanization phenomena and pressures on natural resources due to economic and population growth, suggest that under a business as usual scenario the climate risk will compound other social and economic problems in the country. Therefore, climate change adaptation is essential for Mexico, and can also constitute an opportunity to reduce inequalities (Nations, 2016).

Mexico is also an important player in terms of GHG emissions. In 2013, Mexico emitted 665 million tons of CO_{2e}, ranking 12th in terms of countries contributing to global emissions (INECC and SEMARNAT, 2015). While this corresponds only to 1.7% of emissions under the Paris Agreement covered emissions (UNFCCC, 2016b), the role of Mexico in climate mitigation is key as a developing country that has set aggressive targets and committed to enhance global mitigation efforts.

Legal and Institutional Framework

General Law on Climate Change

Mexico's General Climate Change Law (GLCC), issued in 2012, is the main climate policy instrument in the country.[3] The GLCC defines planning and policy instruments,

[3] Mexico was the second country to have a national climate change law, after the UK.

institutional arrangements, and provides general guidance for the implementation of climate policy. It also incorporates a long-term, systematic, decentralized, participatory and integrated approach into adaptation and mitigation actions. Under the GLCC, the Federal Government is mandated to formulate and guide national climate change policy. Subnational governments role is also clearly specified, including the elaboration of State level inventories and climate programs. The GLCC establishes the National Climate Change System and provides policy principles that should be followed for climate policy design.

National System for Climate Change

Coordination among government levels is managed through the National Climate Change System. At the federal level two important bodies were created to design and implement climate policy: a) the Inter-ministerial Commission on Climate Change (CICC), b) the National Institute for Ecology and Climate Change (INECC). To coordinate action at the subnational level, the Federal Congress is part of the NCCS, as well as the States and national associations of municipal officials. Finally, to advise the government, the Climate Change Council (C3) was created. (See Figure 6)

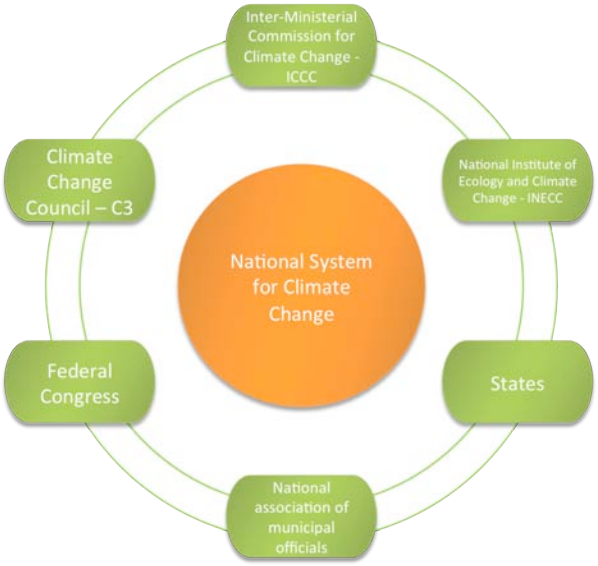

Figure 6 National System for Climate Change

The **CICC** is a body of 13 Federal Ministries: Ministry of Environment and Natural Resources, Ministry of Foreign Affairs, Ministry of Energy, Ministry of Finance and Public Credit, Ministry of Social Development, Ministry of the Interior, Ministry of the Navy, Ministry of Economy, Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food, Ministry of Communications and Transportation, Ministry of Public Education, Ministry of Health, and Ministry of Tourism.[4]

[4] Acronyms in Spanish as follows: SEMARNAT, SRE, SENER, SHCP, SEDESOL, SEGOB, SEMAR, SE, SAGARPA, SCT, SEP, SSA & SECTUR.

The CICC mandate includes: 1) to formulate and implement national policies on climate change mitigation and adaptation, by mainstreaming climate action in sector level programs and actions; 2) to develop criteria for the cross-cutting public climate change policies; 3) to approve the National Climate Change Strategy; and 4) to participate in the elaboration and implementation of the Special Climate Change Program (SCCP).

The **INECC** is the research institute created by the GLCC to coordinate scientific and technology research and projects on climate change, with the assistance of public or private academic and research institutions, both national and foreign. It is the institution in charge of making prospective sector analysis and collaborating in the elaboration of strategies, plans, programs, and instruments related to climate change. Its work includes the estimation of future costs and benefits associated with the climate issue. Importantly, INECC has the mandate to design policies that can help build capacity in the country for climate change adaptation and mitigation. Another important role of INECC is to coordinate the evaluation of climate policy. The evaluation involves the participation of civil society advisors, and may be conducted through one or several independent organizations.

The **C3** is the permanent consultative body of the IMCC that is integrated by members from the social, academic, and private sectors, with renowned merit and experience in climate change. Some of its responsibilities include: 1) to advise the IMCC and provide them with recommendations to conduct studies, policies, actions, and goals to combat climate change, and 2) to promote social participation, through public consultation processes.

Federal Congress, comprised by the Senate and the Chamber of Deputies, has different responsibilities to propose, discuss, and approve laws or amendments to existing legislation that lead to a reduction of greenhouse gases emissions, climate change mitigation, and adaptation strategies. In the Senate, this work is done by the Special Commission on Climate Change and by the Commission on the Environment and Natural Resources. In the Chamber of Deputies the Climate Change Commission does this work.

The functions of the **States** include:

a) Develop, conduct, and evaluate the state-level climate change policy. This can mean implementing climate change mitigation and adaptation actions in the following areas: preservation, restoration, management, and sustainable use of ecosystems and water resources within their own jurisdictions; food security; agriculture, cattle ranching, rural development, fishing, and aquaculture; education; efficient and sustainable infrastructure and transportation; land-use planning of human settlements and urban development; natural resources and environmental protection

within their own jurisdiction; hazardous waste; civil protection; and prevention of and attention to diseases resulting from the effects of climate change;

b) Develop and implement their own climate change programs. This includes establishing monitoring and evaluation for: compliance with their climate change program, realization of goals, program effectiveness, and performance indicators for the mitigation and adaptation actions implemented;
c) Foster scientific and technological research and the development, transfer, and deployment of technologies, equipment, and processes for climate change mitigation and adaptation;
d) Develop comprehensive greenhouse gas mitigation strategies, programs, and projects in order to promote efficient and sustainable public and private transportation;
e) Process and integrate state-level emission source data for incorporation into the National Emissions Inventory and the state risk atlas.

National Association of Municipal Officials is composed of the Mexican National Confederation of Municipalities, the Mexican Association of Local Authorities, and the National Association of Mayors.

The functions of the municipalities include:

a) Develop, conduct, and evaluate municipal climate change policy. This means implementing policies and actions to combat climate change in the following ways: provision of potable water and sanitation services; local ecological and urban planning; local natural resource and environmental protection; civil protection; management of municipal solid waste
b) Foster scientific and technological research and the development, transfer, and deployment of technologies, equipment, and processes for climate change mitigation and adaptation;
c) Develop comprehensive strategies, programs, and projects on climate change mitigation in order to promote efficient and sustainable public and private transportation;
d) Participate in the design and implementation of incentives and;
e) Process and integrate municipal-level emissions source data for incorporation into the National Emissions Inventory.

Policy instruments and principles

The GLCC establishes 3 main climate-planning instruments:

a) The National Climate Change Strategy: provides the long-term vision for the country with a time horizon of 10, 20 and 40 years.

b) Special Climate Change Program: incorporates the planning for each administration, considering specific programs, goals and resources.
c) State Climate Change Programs: incorporates the planning of each state, considering their specific competences, resources and climate state level regulations.

In addition to the guiding and planning instruments, the GLCC defines specific policy instruments on financing, market instruments, policy evaluation, and enforcement to produce critical information, incentivize and mandate mitigation action in line with national mitigation targets, and reduce vulnerability and increase resilience of strategic infrastructure, economic activities and that of society at large.

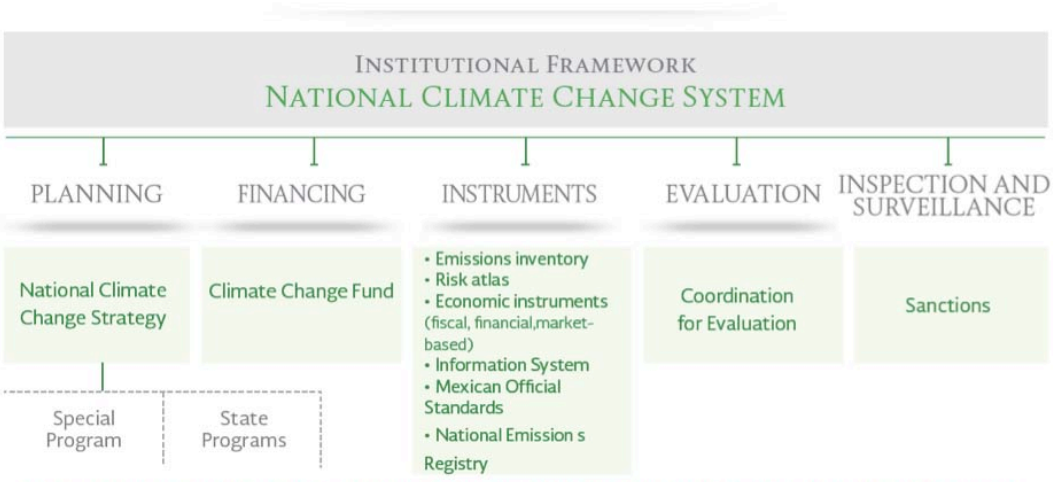

Figure 7 Climate Change Institutional Arrangements and Policy Instruments
Source: (SEMARNAT, 2013a)

Regarding information, the GLCC mandates INECC to elaborate the National GHG Emissions Inventory, an essential input for domestic policy design and for international reporting. Also as an information instrument, the National Emissions Registry is created under the law, with a specific mandate for industries and other sources to report emissions and quantified mitigation actions. The Climate Change Information System was also established under the GLCC to collect, integrate and make publicly available all information considered of "national interest", including the national GHG inventory and other information, such as the vulnerability atlas.

On financing, the GLCC provides the legal basis for market-based instruments, such as emissions trading and carbon taxes. It also creates the Climate Change Fund, to help finance climate projects in the country. Regulatory instruments are also included in the law, particularly emissions limits standards and efficiency standards and regulations. Figure 7 summarizes the institutional arrangements and instruments set by the GLCC.

Principles

The GCCL climate policy guiding principles are the following:

- Sustainable use natural resources and ecosystem stewardship
- Co-responsibility between the government and society
- Precaution when faced with uncertainty
- Prevention of environmental damage and preservation of ecological equilibrium
- Adoption of responsible production and consumption patterns
- Comprehensiveness and cross-cutting nature of policy design considering cooperative approaches between different levels of government, as well as with the social and private sectors
- Effective public participation
- Environmental responsibility
- Transparency and access to information and environmental justice
- Commitment to low-carbon economic development without undermining competitiveness in international markets

Objective

The National Climate Change Strategy is the guiding instrument of the national climate change policy, both in the medium and long-term, to face the impacts of climate change and to transition towards a competitive, sustainable low-carbon economy. As the guiding instrument and based on best available information, it describes the strategic lines of action guiding policies of the three government levels. It also aims to encourage social participation and co-responsibility. More broadly, the long-term climate strategy aims to address climate change along with national priorities, and to contribute in building the Mexico we envision in the long-term.

Scope

The Strategy does not intend to define concrete short-term actions or specific responsible federal institutions. At the federal level, the Special Climate Change Program will define, for each six-year term, the objectives and specific actions for mitigation and adaptation, as well as allocate human and financial resources to achieve these goals. State and Municipal Climate Change Programs at the local level will similarly describe specific plans of action for the short-term.

The medium and long-term goals will be achieved through the instrumentation of all GCCL planning instruments, the effective operation of the institutional framework, the development of economic instruments and other instruments, including regulatory technical standards. All instruments should be aligned with the ultimate goals of this Strategy.

Elaboration process

The technical and scientific inputs have been provided mainly by INECC, and other research centers across the country. The Strategy has been elaborated by SEMARNAT, with the participation of the INECC. It has been enriched with contributions from every

federal institution within the CICC and with contributions gathered in bilateral meetings with climate change areas of the federal government. The Strategy was also reinforced through an ample participative and consultative process. Firstly, inputs were received from Core Advisory Councils on Sustainable Development in all states.[5] Secondly, input was also received from a workshop carried out in Mexico City with over 80 experts from the organized civil society, the academic community, and the private sector. Thirdly, a nationwide online consultation process was carried out. In addition, important contributions by the Climate Change Council were considered in Strategy.

Structure

The Strategy contains 6 cross cutting issues that set the foundation of climate policy in the country, both for adaptation and mitigation. Then, it delves into our adaptation three specific strategic lines of action, considering Mexico's vulnerability assessment and an ecosystem-based adaptation approach. Thirdly, it presents Mexico's lines of action envisioned for a transition towards a long-term low greenhouse gas emission development. This strategy has five main lines of action, including plans for the clean energy transition, energy efficiency and sustainable consumption, sustainable cities, agriculture and forestry mitigation, and action to reduce Short-lived Climate Pollutants (SLCP). Figure 8 presents a snapshot of Mexico's Strategy.

Both adaptation and mitigation sections include prioritization criteria. Considering the limited resources for policy implementation, these criteria are expected to guide decision-makers to maximize benefits.

[5] Core Advisory Councils on Sustainable Development are plural spaces integrated by actors from private, academic, and governmental sectors

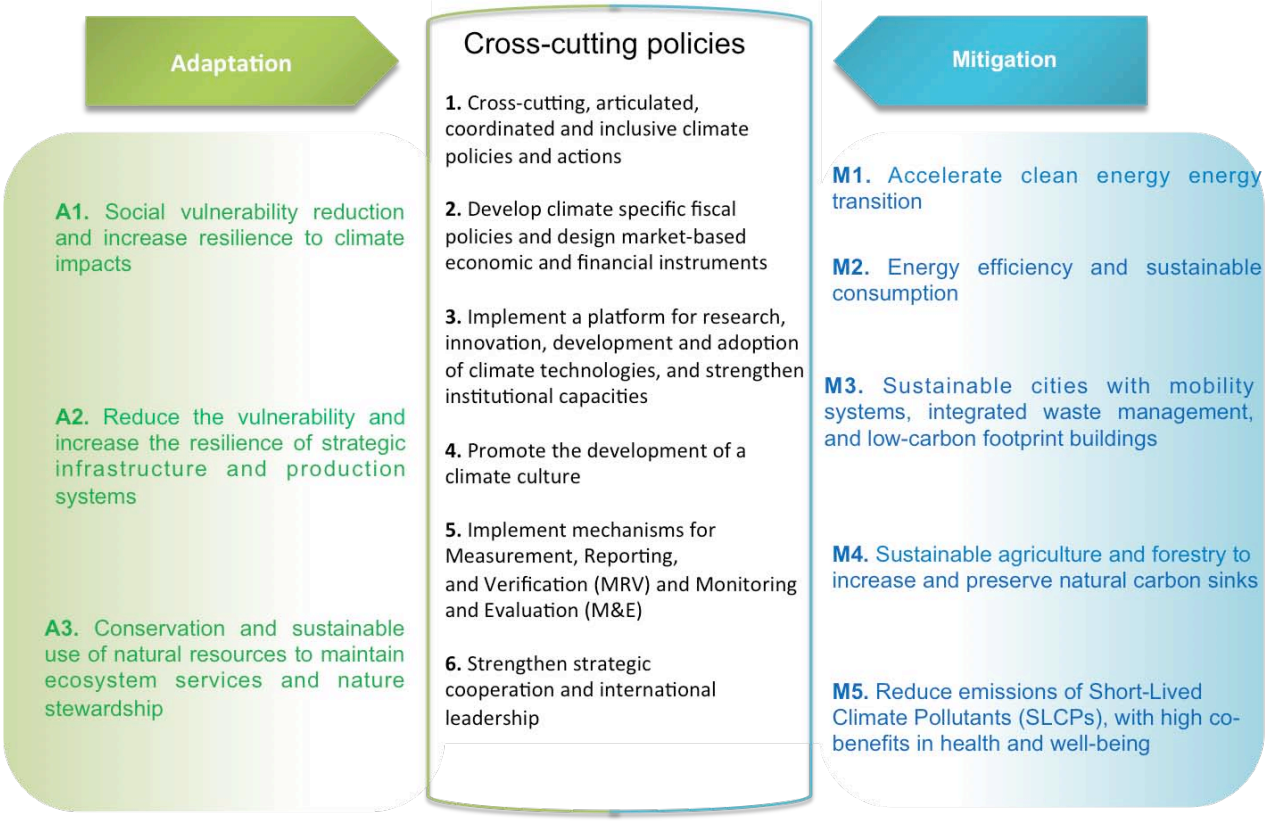

Figure 8 Structure of Mexico's Climate Change Strategy
Source: (SEMARNAT, 2013a)

Long-term vision

Mexico experiences sustainable development and low-emissions growth through an efficient management of natural resources and the use of clean and clean energy resources. Mexico is a thriving, competitive, socially inclusive, and globally responsible country. The Mexican population has rewarding and well-paid jobs, and especially the most vulnerable population has advancement opportunities. Mexico has a climate resilient society and ecosystems, sustainable cities, and a green economy. Table 1 describes the milestones for the next 10, 20, and 40 years to build our envisioned country.

AREA	10 YEARS	20 YEARS	40 YEARS
Society	• Policy actions reach the most vulnerable groups reducing impacts of climate change on them. • Society is involved and actively participates in climate policy.	• Society is committed to reducing impacts of climate change. • Human settlements have expanded their capacity to adapt climate risks.	• Society is culturally and socially integrated to tackle climate change. • Rural vulnerability has been reduced and is low
Ecosystems	• The most vulnerable ecosystems are protected, with appropriate policies and financial resources • Ecosystem and sustainable management are part of a natural conservation strategy. • Actions for conservation and sustainable consumption are implemented across the country. • Integrated land-management schemes are implemented. • Appropriate financing schemes to promote	• Ecosystems and all species are conserved or used sustainably. • Natural resources are economically valued and adequately managed • Sufficient infrastructure exists for a sustainable and efficient water management • Efficient use of water resources helps restoring ecological and physical functions of water bodies. • Improving its natural capital enhances the economic and social development of the	• Water balance is ensured through sustainable and efficient use • Conservation and sustainable ecosystems management improve climate resilience • Local levels of resilience are adequate.

AREA	10 YEARS	20 YEARS	40 YEARS
	sustainable landscape planning are in place • Technologies for local adaptation are used • Mexico has zero percent rate of carbon loss in original ecosystems.	country.	
Energy	• Clean technologies are deployed and start advancing the energy transition, with a goal of 35% of clean energy in the power sector • Specific schemes are developed to incentivize clean energy, energy efficiency and saving, and sustainable public transportation, reducing our use of fossil fuels.	• At least 40% of electric power generation comes from clean energy resources. • Power generation through clean sources creates jobs, including jobs for the vulnerable population. • Residential, tourism, and industrial sectors use clean energy resources, energy efficiency and power saving schemes.	• Clean energy generation supports economic development of every sector in a sustainable way. • At least 50% of energy generation comes from clean sources.
Emissions	• Mexico substantially reduces emissions of Short-Lived Climate Pollutants • State-productive-industries in the energy sector implement energy efficiency schemes in all its operations and increase the use of renewable energy • Urban centers with population size larger than fifty thousand inhabitants have waste management infrastructure, mitigating all methane emissions.	• Economic growth decoupled from the dependency on fossil fuels and their environmental impacts. • Short-lived Climate Pollutant emissions are minimized.	• 50% emissions reduction compared to those of 2000.
Productiv	• Environmental	• Positive rate in forest	• Production systems

AREA	10 YEARS	20 YEARS	40 YEARS
e Systems	impacts in the production sector are understood, acknowledged, monitored and addressed. • New technologies and practices reduce the climate change risk. • NAMAs (Nationally Appropriate Mitigation Actions) are implemented in various economic sectors.	carbon sinks. • Sustainable forest management stops deforestation • Sustainable management practices in extractive, agricultural and livestock and forestry sectors increase productivity, reduce vulnerability and conserves land.	are climate resilient.
Private sector	• The climate concern is considered in production planning • Industry reports GHG emissions in the National Emissions Registry. • Companies reduce their gas and compound emissions, and take advantage of opportunities in energy efficiency, power saving, and use of clean and renewable energy.	• Companies adopt advance waste-management practices • Production and sustainable consumption schemes are implemented.	• Companies have sustainable production cycles.
Mobility	• Both public and private sectors adopt sustainable mobility systems. • Socioeconomic schemes encourage the use of sustainable transportation. • Common use of electric vehicles in public transportation.	• Freight transportation is multimodal, efficient and low emissions • Cargo transportation is multimodal, efficient, and low-emission.	• Common use of trains and electric vehicles

Table 1 Milestones of the Strategy for the next 10, 20 and 40 years
Source: (SEMARNAT, 2013a)

Cross-cutting policies

Inter-institutional collaboration

Climate change is identified as a crosscutting challenge because of the variety of stakeholders from the public and private sectors that interact, make decisions, and ultimately drive climate change mitigation and adaptation in the country. The country envisioned by the Strategy considers that society sectors such as non-governmental organizations or interest-based groups, together with private sector and the institutions and organizations from three levels of government play a role. Thus, the fight against climate change implies and requires dialogue, information generation and dissemination, and decision-making. The government has instruments that require recognizing regional, state, and local realities. To date, however, only one fourth of the Mexican states have completed their State Climate Change Programs; five states have enacted state legislation on climate change; and at the municipal level, the creation of climate change programs has begun.

Market-based instruments

To tackle climate change, Mexico needs accessible, timely, and sufficient economic resources that allow for timely and decisive action on mitigation of and adaptation to climate change. The limited resources of the country – while facing a diversity of challenges – force us towards more efficient planning and execution. On that regard, Mexico has been exploring different market-based instruments to support policy implementation and action on climate change. One instrument is a carbon tax. As a fiscal instrument, Mexico's carbon tax aims to induce a reduction in the importation and commercialization of fossil fuels. He tax assigns a price per unit of fuel and exempts natural gas, as a way to create an incentive to switch from more to less carbon intensive fuels. The tax has adopted as fiscal instrument in 2014.

In addition to the carbon tax, Mexico is exploring the development of a cap and trade system that would provide the means for cost-effective emission reductions in certain economic activities. The development of the technical and regulatory components of such a system is under way. In addition, Mexico has been collaborating with other governments for the development of an offsets generation and validation system particularly for those

activities or sectors that may not be incorporated into a cap and trade system but that may equally contribute to mitigation actions that also support adaptation to climate change.

Innovation, research & development and technology adoption

Science-based action to limit climate change implies knowledge, innovation, and technology. Applying knowledge through the use of science, technological innovation, and education will protect and enhance sustainable development. Research on climate change is relatively new in Mexico. Therefore, building knowledge and awareness around this topic has become extremely significant and requires an ongoing dedication from the three levels of government, academic institutions (universities and research networks, among others), the private sector, and society as a whole.

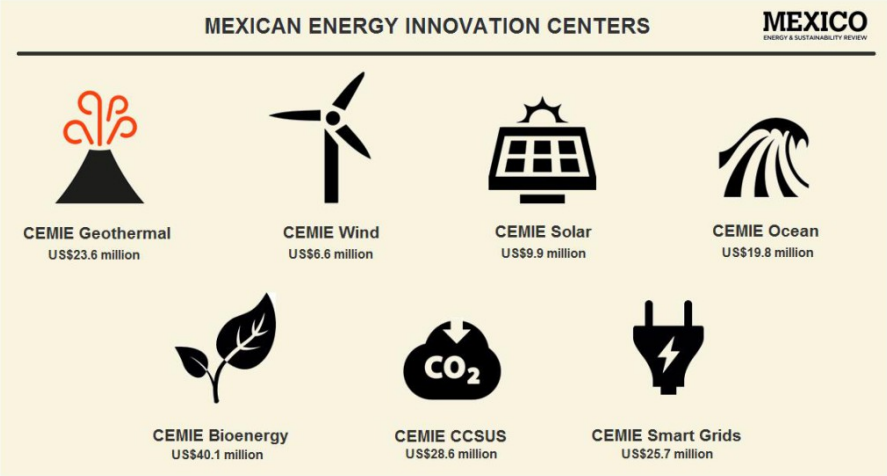

Illustration 1 Mexican Energy Innovation Centers
Source: (Mexico Energy & Sustainability Review, 2015/16)

Training of professionals that understand and act on climate change requires a transformation of the courses and programs of study used by public and private universities, technical colleges and other education institutions in the country. The content of what it thought and learned must clearly consider the causes and implications of climate change, and must drive research and development, and become an incentive for innovation and technology development and adoption. Some support programs for innovation, research and development on climate change exist in Mexico, but must be upgraded and enhanced, and their number and funding increased. Research programs that address national needs on mitigation and adaptation must be created and supported, to complement the spectrum of what exists in public and private organizations such as INECC, IMTA,

INEL[6], or others. Efforts are also being carried out to promote adaptation actions and to strengthen mitigation actions. However, we need to integrate the research on climate change effects in a single platform to facilitate its accessibility and use. Similarly the development of mitigation technology and the identification of best practices is a matter of utmost importance. This will result in the generation, spreading, integration and use of climate change knowledge towards different regions of the country. Knowledge requirements include: research on habitat fragmentation through land management; vulnerability assessment of the population; identification of infrastructure projects; private sector equipment to improve adaptation; private sector related research; the diffusion of technologies to measure climate parameters; clean energy production accompanied by patent generation; and waste management, among others.

Building a climate culture

Mexico has a growing population that is increasingly diverse and dynamic, producing and demanding intellectual, cultural, and scientific resources. Education and knowledge are indispensable tools for citizens to exercise their rights, acknowledge their responsibilities, and become capable of well-informed decision-making in everyday life. In our country, the scope of basic level schooling is practically universal, which makes it an effective vehicle for spreading climate change awareness. Moreover, elementary and middle level schools already teach principles of environmental education. Training programs about sustainability and climate change have been implemented in the private, social, and academic sectors. A few products and

Climate Change Exhibition,
National Institute of Ecology and Climate Change
Mexico City, 2016

[6] IMTA is the Mexican Institute for Water Technology and INEL is the National Institute for Clean Energy.

services already inform consumers of their ecologic footprint. Alas, those that account for and inform their users about life-cycle emissions are few and far between.

A study conducted between 2009 and 2012 to measure climate change perception levels among citizens (CECADESU, 2009, 2010, 2011, 2012) provided a first glimpse of how climate change is understood in Mexico.[7] In 2009, 87% of the polled population said they were concerned about climate change; in 2012, almost 97% of the polled people expressed they were very, somehow, or a little concerned about climate change, and only less than 4% said they were not worried at all. These results show that the Mexican population is concerned about the matter. This strategy's proposed lines of action will serve as guides for citizens to cooperatively protect the environment and act on climate change.

Social participation

This strategy emphasizes the 10th principle of the 1992 Rio Declaration on Environment and Development:

> "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities […] and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided."

The introduction of "environmental responsibility" to our Constitution – through an amendment to article 4 in February 2012 – along with the approval of the Environmental Responsibility Federal Law in April 2013 – strengthens environmental law in Mexico. These amendments allow individuals to access the national justice system to demand the remedy of environmental damage.[8]

[7] In the context of the 6th National Communication, INECC is conducted a new study on social perception of climate change.
[8] In principle, this could include damages associated with climate change.

Illustration 2 Workshop for community involvement on mapping vulnerability to climate change
Source: INECC, 2016

Measurement, Reporting, and Verification (MRV) and Monitoring and Evaluation (M&E)

A system for Measurement, Reporting, and Verification, along with that for Monitoring and Evaluation, help us ensure transparency, whilst also guaranteeing environmental integrity, comparability, consistency, and data accuracy. Their development and use reinforce the quality of adaptation and mitigation actions, and are fundamental in the design, implementation, and evaluation of the national climate change policy. Mexico has actively participated in the setting of international criteria that define the use and scope of methodologies for MRV of mitigation actions and M&E of adaptation measures. We have also begun training to incorporate MRV and M&E into national activities against climate change. Regarding this national strategy, the GCCL mandates that the national climate change policy be based upon essential MRV and M&E activities. Thus, the three levels of government must actively incorporate these criteria in public policy.

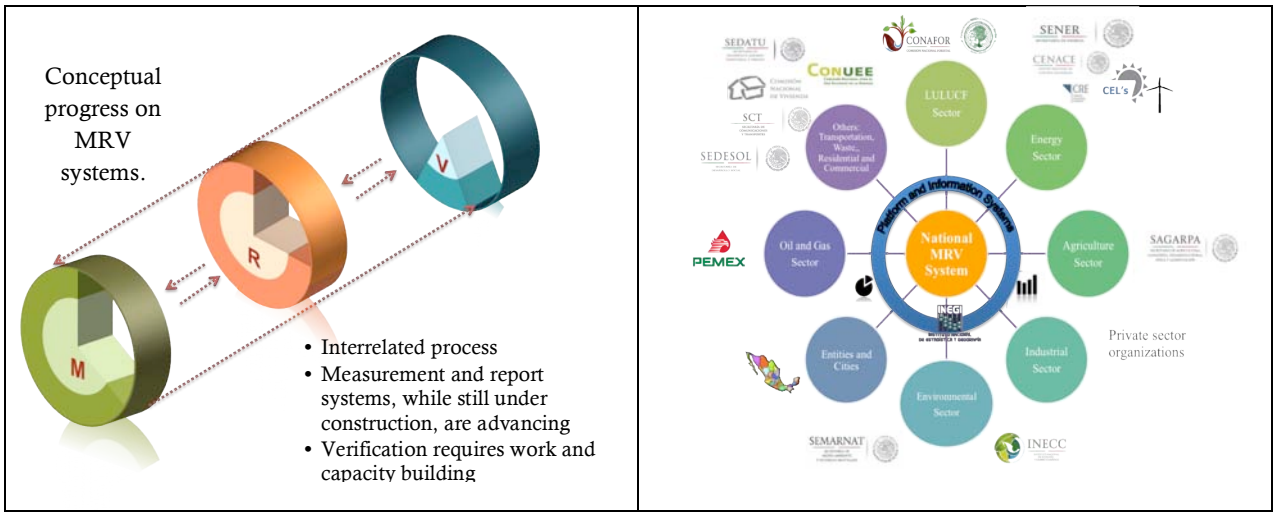

Illustration 3 Towards a strong Mitigation MRV System
Panel a shows the conceptual progress and Panel b the interaction of different institutions on building the MRV system for mitigation.

International leadership

Mexico has positioned itself as a key actor among developing countries, and among those countries committed to effectively combatting of climate change. The country is a party of the UNFCCC and the Kyoto Protocol. Additionally, Mexico served as president and host of COP 16 in 2010, and participates in other institutions and international organizations related to climate change. Our active participation in negotiations to secure and improve the international response to climate change is a reflection of the values of the people of Mexico. This has resulted in a unique leadership position. We have been able to strengthen climate change action within Latin America and the Caribbean through South-South cooperation.

Mexico aspires to maintain and increase its leadership role, whilst seeking to translate it into the achievement of more and better global agreements. For that, we will position ourselves as a key actor in the region, and we will serve as a bridge to other developing countries. A solid national commitment will signal a congruent stance towards solving problems faced by the international community whilst fighting climate change.

This topic has gained prominence in Mexico. However, it is necessary to reinforce past achievements and to generate better results in the future through the exploration of new ways of implementing public policies which reach the whole population. Remaining tasks consist of improved coordination between the different branches of government and their

institutions. This coordination must then be expanded to the rest of society. This will be achieved by: implementing new governance systems, greater public participation, and the generation of a strong sense of shared responsibility which will lead to the establishment of useful institutional agreements to combat climate change. In next few years, Mexico must set standards that allow for the lines of action proposed in this strategy to be implemented in a coordinated, coherent, cross-cutting manner in order to achieve the objectives set for the country. Therefore, the pillars of the national climate change policy constitute the cornerstone of this National Climate Change Strategy.

Lines of action

Inter-institutional collaboration

The effective implementation of national climate change policy requires crosscutting coordination between sectors and actors, the revision of the judicial framework in order to avoid opposition, and the inclusion of all social groups. The participation of these actors is indispensable for the execution of adaptation and mitigation policies and actions posed in the National Climate Change Strategy

- To integrate objectives and goals for climate change adaptation and mitigation into the National, State and municipal level plans and programs.
- To implement the National Climate Change System as a coordination mechanism between public, private, and social sectors, and as a platform for articulated planning between branches of government.
- To encourage the involvement of academic, private, and social sectors through the Climate Change Council to inform the CICC decision-making
- To harmonize and strengthen the current legal framework, incorporating climate change criteria throughout the coordination the branches of government.
- To promote individuals' access to environmental justice and remediation of environmental damage whenever possible, or else equivalent improvements in priority zones for climate change.
- To consolidate the climate change institutional framework through intersectoral, crosscutting agreements, and the creation of climate change specific areas and local advisory groups, among others, within all levels of government and sectors of society.
- To consider gender, ethnicity, disability, inequality, wellbeing, and inequity whilst designing climate change policies, as well as the involvement of different sectors of society in their implementation. Wherever relevant, introduce the principle of "free, prior, and informed consent".

- To implement intersectoral mitigation and adaptation actions through the coordination and cooperation between federal institutions, public actors, and private actors.
- To guarantee the integration of climate change adaptation and mitigation criteria in political instruments such as: the evaluation of environmental impacts; general, state, and municipal land-use planning; ecological marine planning, and land-use planning for tourism and urban development.
- To align land-use planning, urban development, sustainable buildings, housing, energy, transport, mobility, green areas, coastlines, comprehensive waste management, and water policies, in order to reduce the carbon footprint of human settlements.
- To guarantee crosscutting integration of water-related criteria in the formulation and implementation of climate change policies.
- To guarantee the coherence between climate change and rural sustainable development policies, programs, and institutional agreements regarding deforestation and woodland degradation as a multifactorial problem in the three government levels.
- To introduce climate change criteria for articulating and improving legislation, policies, and instruments that promote sustainable forest management.
- To encourage inter-state and inter-municipal associations of producers and other technical public agents towards environmental management that is coherent at a landscape unit level.
- To create and strengthen local institutions for the regulation and planning of regional and metropolitan transportation, particularly in terms of mobility, infrastructure optimization, transportation routes, and maximized efficiency.
- To guarantee the consistency between instruments and programs of the agriculture, fishing, forestry, and urban sectors, in order to achieve synergies between adaptation and mitigation, and to avoid contradictory policy.
- To encourage the evaluation of environmental impacts in sectoral programs and projects.
- To strengthen existent epidemiological surveillance systems and to include the following in the design of actions for epidemiological attention: climate change related health impacts such as infectious intestinal disease; acute respiratory infections; food-poisoning related to phenomena like red tide; and attention to populations affected by disasters as hurricanes and flooding.

Market-based instruments

To effectively implement actions against climate change, we need accessible, timely, and sufficient economic resources. Simultaneously, economic signals need to be sent to reflect the cost of environmental damage caused by greenhouse gases. Mexico can increase the use

of market-based instruments. The development of climate-specific fiscal policies and economic instruments will promote a low-emission economic development and will increase our global competitiveness.

- To design a national policy of economic, fiscal, financial, and market-based instruments in order to incentivize mitigation and adaptation actions, including: the use of targeted subsidies, the elimination or decoupling of inefficient subsidies, and the creation of both public and private financial instruments.
- To establish the mechanisms needed to turn the National Climate Change Fund into an efficient and effective platform for channeling resources, including those of international origin.
- To assign enough budgetary resources to execute adaptation and mitigation actions, and to allocate them in federal, state, and municipal budgets.
- To articulate bring together national funds and other financial sources in order to foster climate change actions.
- To ensure that economic and financial resources are directed towards priority climate actions, including the consideration of social and environmental safeguards.
- To promote sustainable production in the country through the use of economic incentives.
- To favour the funding of national research and technology development for climate change adaptation and mitigation.
- To encourage new economic and financial mechanisms, including NAMAs and possible emissions markets, in order to incentivize mitigation actions.
- To define energy prices according to a life cycle analysis that considers externalities, including the cost of greenhouse emissions.
- To redefine the current energy and water subsidies structure in order to increase efficiency both in power and water consumption.
- To gradually adjust residential electricity and water prices to more accurate prices, compensating the vulnerable groups through targeted measures.
- To redirect fossil fuel subsidies in order to strengthen sustainable, efficient, and safe public transportation such as the railway system, among others.
- To guarantee the incorporation of climate change criteria in development bank guidelines for favoring projects that involve renewable and clean energies, and that promote the transition towards less carbon-intensive technologies.
- To encourage a mechanism to promote voluntary carbon markets, including forest carbon offset credits.
- To identify, strengthen or create specific economic and financial instruments that incentivize the restoration, conservation, sustainable use, and resilience of ecosystems and the ecosystem services they provide.
- To design and adjust economic and financial instruments and incentives for REDD+, whilst guaranteeing a fair and equitable distribution of the benefits obtained for avoiding emissions.

- To consolidate the participation of social and private sectors in financial and market-based mechanisms which promote climate change adaptation and mitigation.

Innovation, research & development and technology adoption

In order to make the right choices for climate change abatement and adaptation, our country needs to produce scientific and technological knowledge which can be shared. This will create synergies, promote collaboration and avoid duplicity. Technological innovation will permit the development of new production capacities as well as the recovery of economic resources. Simultaneously, Mexico needs to create national capacities in the three government branches through training in priority adaptation and mitigation opportunities. Training decision-makers as a base for the formulation of policy will promote climate change awareness and successful policy application.

- To create and operate an information platform in order to make publicly available the advances in the climate change national research.
- To conduct national, regional, and local research, as well as developing technological exchange and development platforms in order to communicate state, municipal, and regional priorities.
- To establish consortiums for research, development, and innovation in low-emission services and technologies.
- To generate mechanisms so that every governmental and social actor can make decisions founded on scientific information and climate change knowledge.
- To promote climate change-related scientific and technological research studies and projects within a state, regional or municipal scope through research groups. These research groups will include an effective coordination between academia, the public sector, the private sector, national research institutions, and international institutions.
- To identify, organize, analyze, and disseminate existing climate change knowledge in the country, according to national requirements, in order to serve as the foundation of the national climate change policy.
- To encourage research and technological innovation on assessing vulnerability and designing adaptation measures, by region, ecosystems, population settlements, equipment and infrastructure, production sectors, and social groups; in order for the country infrastructure to be prepared for the risks of disasters caused by climate change. The technological innovation will also lead to Mexico becoming an emergent power in the following years.
- To ensure academic-private sector collaboration for development and transfer of technology for reducing and controlling greenhouse gases.

- To encourage research, development and national integration of advanced technologies for generating renewable, clean energy such as tidal, solar, hydrogen, and biofuel energy sources, among others.
- To encourage technology improvement for monitoring meteorological, climatological, and hydrometric conditions.
- To identify, organize, and analyze existing climate change information in the country, particularly on adaptation. This analysis will focus research on industries facing climate risks such as droughts and hurricanes
- Too define the country's infrastructurevulnerability and to generate building and urban planning regulations which allow for ecologically-resilient land-use planning.
- To produce national research for understanding and forecasting climate change and its impacts in Mexico.
- To create and strengthen coordination, collaboration and networking that integrate and make the most of the local knowledge.
- To create and strengthen climate change training schemes in the three levels of government, as well as in the Legislative and Judicial Branches.
- To strengthen capacities ithroughout government in order to gain access to both national and international financial sources.
- To train different government branches in the use of effective planning instruments for mitigation and adaptation.
- To strengthen the capacities for land management on a landscape unit level, by creating, for example, local technical agents, local development agents and new spaces for collaborative management agents.
- To train those responsible for budget assignment in government on climate change, with a special focus on the importance of allocating funds to adaptation, disaster prevention and mitigation actions.
- To create institutional capacities for establishing mechanisms and procedures to measure, report, verify, monitor, and evaluate mitigation and adaptation actions.
- To encourage the development of a strategy for connectivity and complementarity among terrestrial, coastal, and marine ecosystems. This will result in well-managed regional ecological processes and promote state and municipal natural protected areas.
- To build capacity for research and technological innovation on SLCPs and their warming potential, in order to identify local and national actions that could be included in mitigation strategies due to its co-benefits.

Building a climate culture

The climate challenge mandates a transformation of production and consumption patterns. To do so, Mexico requires a civically engaged society that demands accountability from the

government. Educational programs and effective knowledge diffusion are fundamental to successfully implement such a transcendent policy.

- To induce a change towards sustainable consumption and production patterns through massive communication campaigns and training programs which educate, inform and raise awareness..
- To offer educational projects focused on climate change for elementary schools, middle schools, and beyond.This will form a recognition of climate change as a problem which can be overcome.
- To encourage social participation in the formulation, implementation, and surveillance of the national climate change policy.
- To encourage government accountability on climate change from by effectively disseminating national climate change policy and the associated results.
- To enact consumer regulations to obtain timely and relevant information on emissions resulting from production and consumption of goods and services available in the market.
- To use technology to keep the public informed about the climate change situation in the country, greenhouse gas emissions inventories, the National Emissions Registry, and the Climate Change Information System.
- To design and enforce an effective communication strategy for every sector of society according to the appropriate context, be it cultural, economic, political, ethnic, or gender-related.

Measurement, Reporting, and Verification (MRV) and Monitoring and Evaluation (M&E)

Climate change mitigation and adaptation actions require the development of greenhouse gas Measurement, Reporting and Verification, as well as Monitoring and Evaluation instruments. These instruments provide transparency and certainty to actions, whilst guaranteeing environmental integrity, comparability, consistency, transparency and data accuracy. MRV in particular will allow for evaluation and feedback to inform climate change policies. This emissions data will also improve policy efficiency and impact. Particularly, the correct and efficient use of resources will directly impact the achievement of national adaptation and mitigation policy objectives .

- To implement Measurement, Reporting and Verification, as well as Monitoring and Evaluation instruments for mitigation and adaptation measures.
- To develop an M&E system for public policies including climate change adaptation criteria and indicators.
- To measure, report and verify the source, use and results of international, private, and public support resources for tackling climate change in Mexico.

- To gradually strengthen verification mechanisms according to the type of measure and financial impacts.
- To provide information about emissions, reductions and potential carbon market transactions from stationary and mobile sources reporting to the National Emissions Registry.
- To transparently establish and update emissions inventories, national and sector baselines and mitigation trajectories in order to monitor evaluate mitigation policies.
- To establish mechanisms for ensuring that recommendations from the Evaluation Committee are considered and, where appropriate, reflected in the national climate change policy.
- To establish and develop transparent methodologies for the measurement, monitoring, verification and reporting of mitigation actions.
- To develop a national forestry monitoring system for the transparent and rigorous monitoring, reporting, and verification of mitigation actions in the forestry sector.
- To develop and maintain a national information system for safeguards related to the implementation of REDD+ actions. This will ensure implementation of the safeguards and provide a grievance system.
- To establish mechanisms for measuring financial, human, and ecological risks related to diverse climate effects in all economic sectors and regions of the country.
- To strengthen the design of climate change related health indicators. This includes analyzing environmental, labor, and social factors to provide updated information to the National Epidemiologic Surveillance System. That system will carry out preventative and reactive actions to protect vulnerable populations.

International leadership

With these efforts, we aim to maintain and strengthen Mexico's position as a relevant actor in the international arena, as well as in the Latin American and Caribbean region. This positioning will incorporate recognition of our high vulnerability to climate change, and our potential for greenhouse gas emissions mitigation. This position may result in international climate funding and strengthened bilateral and regional cooperation.

- To contribute to global efforts towards strengthening climate change action within the United Nations, seeking to increase the level of ambition, and seeingparticipation from all countries.
- To promote and benefit from the implementation of additional efforts in mitigation and adaptation within the framework of multilateral, regional, or bilateral processes complementary to the UNFCCC.
- To promote opportunities for bilateral cooperation and sharing of experiences and best practices within a South-South cooperation framework.

- To maintain a proactive presence in international climate change negotiations. This presence will be based on an inclusive national dialogue.
- To position Mexico in the international arena by increasing its level of ambition in regards to mitigation and its need for adaptation. This is especially important due to Mexico's elevated climate vulnerability.
- To identify and promote access to international climate funding sources. These sources should permit recipient countries to define specific mitigation and adaptation actions..
- To capitalize on synergies between the three Rio conventions (the Convention on Biological Diversity, the United Nations Convention to Combat Desertification, and the UNFCCC) in order to enhance their impact.
- To consistently link Mexico's international climate change position to national actions.

Climate change adaptation

The Special Climate Change Program SCCP 2014-2018 (PECC 2014-2018 in Spanish) is one of the planning instruments of the Climate Change General Law and is aligned to the National Development Plan and related programs, as well as to the Climate Change National Strategy: 10-20-40 Vision, and to the sector programs of the 14 Secretariats or Ministries.

The Secretariats that participated in the development of the PECC 2014-2018 were: Environment and Natural Resources; Agriculture, Livestock, Rural Development, Fisheries and Food; Health; Communications and Transportation; Economy; Tourism; Social Development; State Department; Naval; Energy; Public Education; Treasury and Public Credit; Foreign Affairs; and Rural, Land, and Urban Development.

In the PECC 2014-2018, the adaptation section describes the objective of reducing the vulnerability of the populations and the productive sectors, as well as to preserve and protect ecosystems and environmental services, and increase resistance of the strategic infrastructure to the adverse impacts of climate change. It also presents the contribution of the Federal Public Administration for the 2014-2018 period to meet the objective set for 2020 of reducing by 30% the Greenhouse Gases (GHG) with respect to a trend scenario. To reach the objectives set by Mexico on climate change mitigation and adaptation, however, it is essential to have the contribution of all states and municipalities, the private sector, and the society at large.

The Program includes 5 objectives, 26 strategies and 199 lines of action, of which 77 lines of action correspond to climate change adaptation, 81 to mitigation, and 41 to the development of a governmental policies in these matters.

The assessment section related to adaptation includes information on the impacts that the population, the ecosystems, productive sectors, and infrastructure are and would be exposed to as a result of climate change. It also presents data of the economic impact due to extreme hydrometeorological events from 2009 to date, as well as the asymmetry in public financial support between prevention and attention of disasters during the period 2005-2011.

Likewise, the assessment identifies those municipalities with a higher vulnerability to climate change in Mexico.

Aligning with those national guidelines, Mexico included in the INDC an adaptation component with unconditional and conditional commitments by 2030. Priority actions are: the protection of the population from adverse impacts of climate change, such as extreme hydrometeorological events; as well as to increase the resilience of strategic infrastructure and ecosystems. In order to reach these adaptation priorities Mexico will strengthen the adaptive capacity of at least 50% the number of municipalities in the category of "most vulnerable", establish early warning systems and risk management at every level of government and reach a rate of 0% deforestation by the year 2030.

These unconditional commitments are grouped into three sections: social sector, ecosystem-based adaptation, and strategic infrastructure and productive systems.

Vulnerability assessment

Mexico has geographical characteristics that make it a highly vulnerable country to climate change impacts. Its location between two oceans, and its latitude and topography increase the country´s the exposure to extreme hydrometeorological phenomena.

Mexico has become warmer since the 1960s (MET Office Hadley Centre, 2012). Average temperatures nationwide have risen 0.85°C, which coincides with the global increase reported by the Intergovernmental Panel on Climate Change (IPCC), and for winter temperatures have increased 1.3°C.

The numbers of cooler days have also declined, and warm nights have increased. Rainfall has decreased in southeast Mexico in the last 50 years. Temperatures have risen by region, with the northern areas showing the highest increase, 0.25°C to 0.50°C per decade (MET Office Hadley Centre, 2012), between 1960 and 2010 (MET Office Hadley Centre, 2012, p. 14).

Several models that project possible changes in temperature and rainfall have been developed and perfected in the last decade. The most recent for Mexico were developed

based on the best available information using the results of 15 climate models (Cavazos et al., 2013), and those regional scenarios where updated recently.[9]

Considering precipitation, different models show different projections, although in average for Mexico, it is estimated that precipitations will decline to -10% in most areas of Mexico, but there will be regions where such decline could be higher (e.g. Northwestern area in Figure 9). Worth noting is that the State of Baja California would show the highest decline in annual precipitation (- 40%).

As it may be seen in Figure 10, Northern Mexico could show a 3-4°C increase in temperature, while in most areas of the country changes are projected within a range of 1.5°C–2.5°C, except for some areas in the peninsular zones where changes could be lower to a maximum increase of 1-2°C.

A number of vulnerability assessments for several climate change scenarios have been developed in Mexico during the last two decades. There is evidence showing that the effects of climate change together with other pressure factors will have very negative ecological, economic, and social consequences.

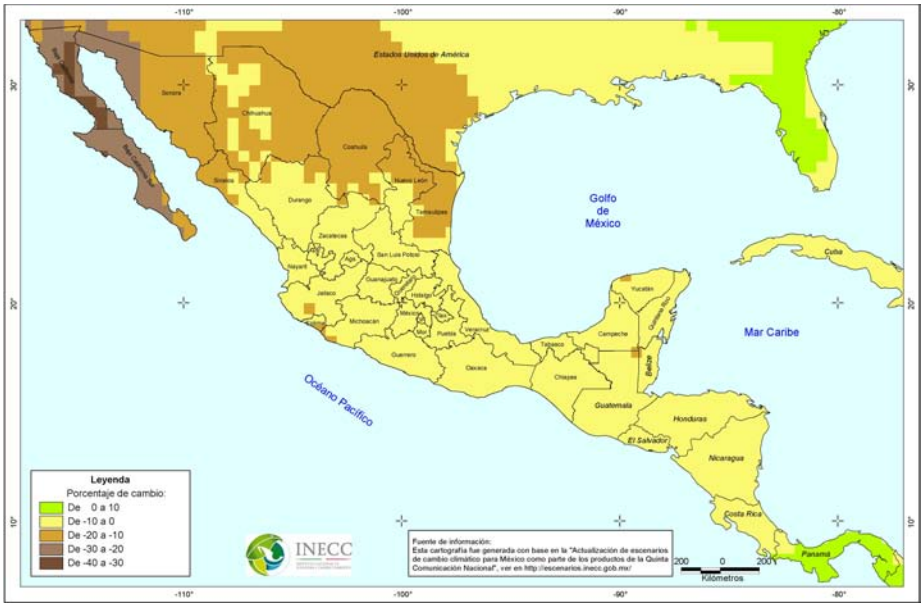

Figure 9 Change in mean annual precipitation (in percent) according to RCP 8.5 scenario in the 2075-2099 time-horizon.
Source: (SEMARNAT, 2014)

[9] http://www2.inecc.gob.mx/cgacc/escenarios_cu/act_escenarios.html

Vulnerability depends not only on adverse climate conditions, but also on the capabilities of society to anticipate, face, resist, and recover from an impact. Thus, the vulnerability of a society is determined by its exposure to climate events, its sensitivity and its adaptive capacity (institutional and social capacities).

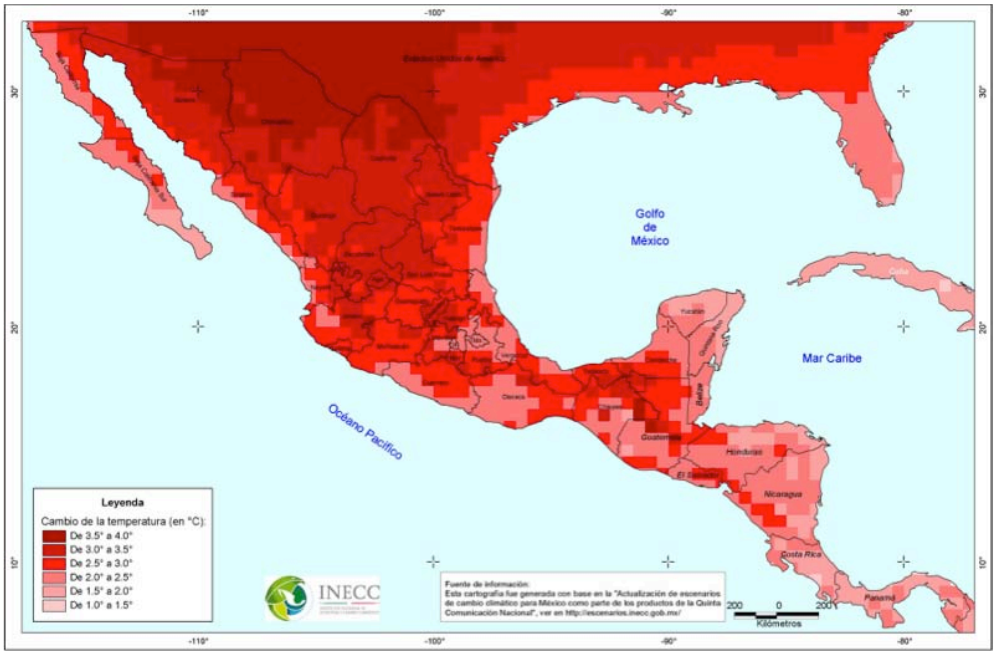

Figure 10 Change in mean annual temperature (°C), according to RCP 8.5 scenario in the 2075-2099 time-horizon.
Source: (SEMARNAT, 2014)

Given the vulnerability described above it is imperative to strengthen risk management in Mexico. The country has been characterized until now for having a reactive responses, more than a preventive ones to disasters. An example of this is the federal budget allocated to the National Natural Disaster Fund (FONDEN) and the Natural Disasters Prevention Fund (FOPREDEN) shown in the Figure 11.

Given the greater recurrence of extreme weather phenomena and their impact on the social sector, as well as the scarce budget dedicated to disaster prevention, we must reinforce our expertise on hazards and threats to which we are exposed and give priority to prevention to address those disasters. Likewise, it is crucial to continue promoting research on the vulnerability and adaptation to climate change in Mexico, as it is an instrumental tool to a well-informed decision-making.

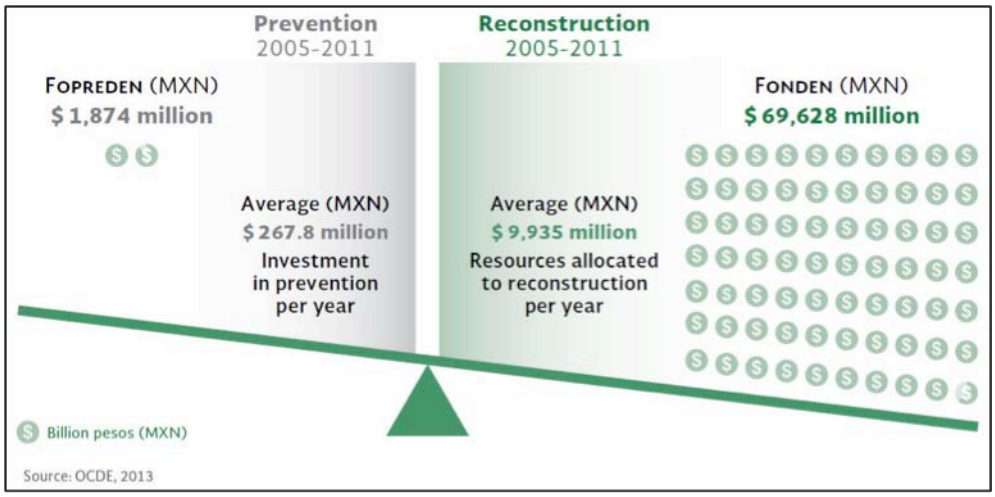

Figure 11 Comparison of federal budget allocated to FONDEN and to FOPREDEN
Source: (SEMARNAT, 2013b)

An example of this is the research conducted by the National Institute of Ecology and Climate Change (INECC in Spanish), which defined the municipalities most vulnerable to climate change. This research considered in a first stage three studies (Monterroso, Conde, Gay, Gómez, & López, 2014; Monterroso R. . and A. Fernández and R. Trejo and C. Conde and J. Escandon and L. Villers and C. Gay, 2014) and took as reference another two (Arreguín Cortés, 2015; Borja-Vega & de la Fuente, 2013; CENAPRED, 2016).

As a result of this analysis 480 municipalities of Mexico were identified with "very high" or "high" vulnerability. In a second stage, and taking those 480 selected municipalities as a baseline, the most vulnerable to climate change municipalities (state by state) were identified. This analysis resulted in a list of 319 municipalities (a 13% of the total municipalities of Mexico; shown in Figure 12).

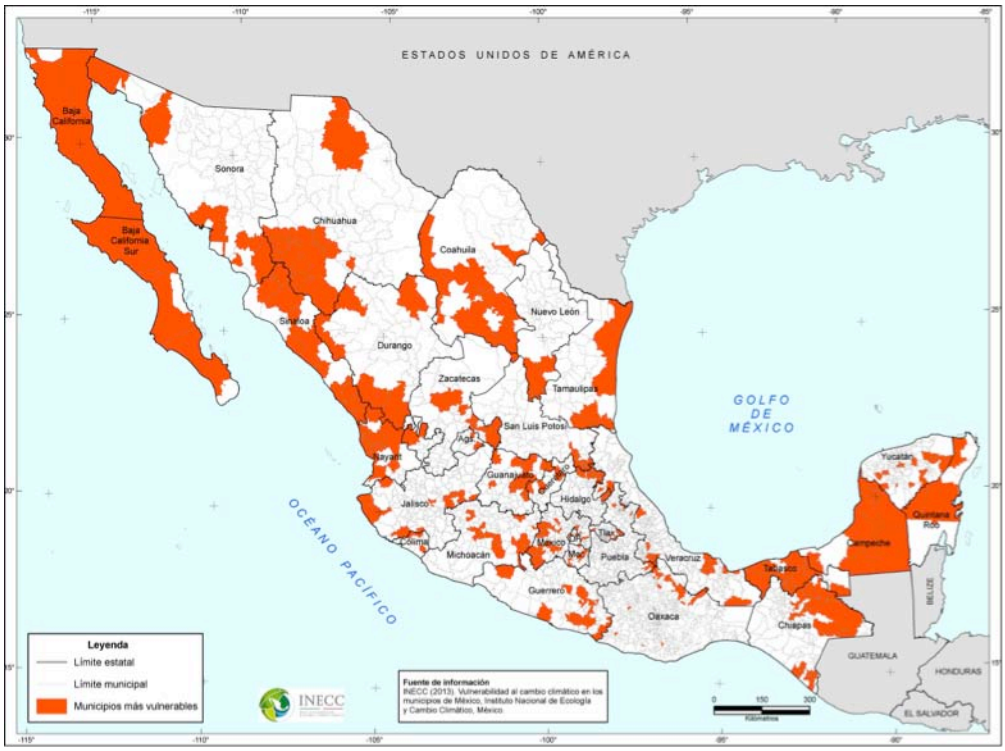

Figure 12 Municipalities most vulnerable to climate change at a state-level analysis.
Source: (SEMARNAT, 2013b)

The climate change adaptation process in Mexico

The climate change adaptation process (CCAP) followed in Mexico is a methodological framework embedded in a system holistic approach (SEMARNAT-INECC, 2015). This process is constructed by means of the sum of actions aimed to reduce the vulnerability of communities, ecosystems and other priorities systems, such as infrastructure. The first phase of CCAP considers:

I.1. Geographical characterization of the natural, social and economic environment in terms of priority issues linked to climate change.

I.2. Establishment of the spatial units of reference through the study area, which defines a regionalization from an integrated territorial approach considering: the political-administrative units (municipalities), biophysical landscapes, watersheds, urban-peri-urban systems, socio-ecosystems, coastal zones, natural protected areas, etc.

I.3. Identification of the possible climate change impacts in priority sectors, based on experts and stakeholders involvement (i.e. climate agenda), and the spatial localization of the causes and its impacts (from climatic and non-climatic sources).

The second phase of the process considers:

II.1. Current vulnerability assessment, taking into account the climate drivers and its dominant impacts in the sectors identified in the climate agenda, as well as the conditions of future vulnerability that result from climate change scenarios analysis. The conceptual framework applied follows the one suggested by the IPCC (IPCC, 2007), which integrates the indices of exposure, sensitivity and adaptive capacity.

II.2. Analysis of the possible adaptation actions to climate change, designed to respond to the results of the climate agenda and the dimensions obtained from current and future vulnerability. These actions should be linked to strategies, objectives and adaptation approaches of public policy instruments. The main adaptation approaches considered in the described processes could be: ecosystem based adaptation (EbA)(Lhumeau & Cordero, 2012), human communities based adaptation (HCbA) (International, 2010) and disaster risk reduction based adaptation (DRRbA) (UNEP, 2015). These are non-exclusive and complementary to each other.

The third phase of the process considers:

III.1. Proposals of climate change adaptation measures (CCAM). A set of possible measures for climate change adaptation should be stated, based on participatory workshops with different local stakeholders and experts in different, focal (Social, economic, biophysical) and sub focal topics (Health, education, agriculture, energy, infrastructure, biodiversity, water, etc.). Their viability and relevance must be considered.

III.2. Prioritization of CCAM. Different methodologies, i.e., cost-benefit analyzes; cost-effective, multi-criteria analysis, participatory approach, engineering of optimization decision-making, etc., must be applied. In the case of Mexico the criteria published in the National Strategy of Climate Change Vision 10-20-40 (INECC, 2013), must be taken into account.

III.3. Design and implementation of priority CCAM. Adaptation actions must respond to the problems identified in the corresponding diagnoses; therefore, they must meet the following characteristics: Feasible, budgeted, synergistic, co-benefits, alignment, evaluable, equity, credibility, no regret, reversibility (non-hard measures) and barriers.

III.4. Monitoring and evaluation (M&E) of CCAM is essential in the design of a climate change program at subnational level. This process helps to know the impact and effectiveness of the implementation of actions and if necessary consider adjustments, rethinking the design or if the CCAM have the expected results in the first stage of process. In addition, the M&E will promote better data for decision making also allow to have adaptation indicators.

Characteristics of climate change adaptation measures (CCAM)

Some characteristics of the adaptation measures that could be considered are as follows:

Feasible. A feasibility analysis should be developed, that takes into account different variables: political, financial, legal, technical or technological, social, institutional, among others. This will ensure a more effective implementation.

Budget. Actions should identify and include in their description the source of funding with which the action will be implemented. This will ensure, as far as possible, their implementation and monitoring. It should include a cost-benefit analysis.

Synergy. Providing benefits or impacts for both, adaptation to climate change and mitigation of GHG.

Co-benefits. Actions should consider or include additional co-benefits such as environmental, social, or economic (e.g., employment generation, positive health impacts), among others.

Alignment. Actions should take into account the national climate change policies and instruments (e.g., General Law on Climate Change, National Strategy on Climate Change 10-20-40 Vision, Special Program on Climate Change 2014-2018 and Mexico's INDC) as well as in legislation and programs at local level (State Programs on Climate Change).

Evaluable. They should consider a baseline and a unit of measurement in order to develop monitoring and evaluation of adaptation measures (M&E).

Objectives and strategies of climate change adaptation (PECC 2014-2018)

The PECC 2014-2018 (SEMARNAT, 2013b) program propose two objectives that promote the strengthening of institutional and population capacities, and the design, prioritization and implementation of actions to reduce the vulnerability of different systems (i.e. environmental, social and economic).

Moreover, these objectives seek to give a priority to prevention acknowledging that it has a lower cost in comparison to disaster attention. The PECC 2014-2018 seeks the cross-cutting character and the integration of actions to consolidate climate change adaptation in Mexico.

Objective 1

Reduce vulnerability of population and productive sectors and increase its resilience and the resistance of strategic infrastructure. The objective seeks to consolidate actions and instruments that reduce social vulnerability, favoring prevention and risk management over disaster reconstruction.

Strategies

1.1 Develop, strengthen and modernize necessary tools to reduce vulnerability to climate change.

The aim of this strategy is designing and implementing territorial planning instruments, early risk detection and management which incorporate climate change criteria to reinforce decision-making and reduce the vulnerability of the population, the productive sector and the infrastructure of Mexico.

1.2 Implement actions to reduce climate change risks in rural and urban populations

Giving priority to disaster prevention is crucial to strengthen the climate change adaptation process. Undertaking specific actions in the territory, such as those contained in this strategy, as well as incorporating a climate change approach to programs and regulations, with the participation of society, could contribute to the reduction of the risks to which the population is exposed in a climate change context.

1.3 Strengthen strategic infrastructure adding climate change criteria in its planning and building stages

Mexico's strategic infrastructure, including the communications, transportation, tourism and energy infrastructure, is vulnerable to climate change effects. Therefore, it is essential to incorporate climate change criteria into its design, construction, and maintenance, to reduce its vulnerability and increase its resistance.

1.4 Promote adaptation actions in productive sectors

Mexico's productive sector is key to the economy and social welfare. Given the effects of climate change, this strategy intends to implement actions to reduce its vulnerability and ensure productivity and competitiveness.

Objective 2

Conserve, restore and sustainably manage ecosystems to guarantee their environmental services to promote climate change mitigation and adaptation. This objective seeks to implement and modernize actions and instruments that simultaneously reduce emissions and the vulnerability of ecosystems.

Mexico has a great diversity of ecosystems which provide significant environmental services currently under threat. This objective sets 6 strategies and 45 lines of action aimed to strengthening the sustainable preservation, use, management and development of ecosystems to guarantee the environmental services which they provide and face the negative impacts of climate change.

Moreover, this objective intends to reinforce the community management of ecosystems, reduce environmental threats aggravated by climate change and develop instruments that enhance ecosystemic connectivity.

Strategies

2.1 Promote protection, conservation and restoration actions and schemes of terrestrial, marine and coastal ecosystems and their biodiversity

This strategy aims at implementing climate change adaptation actions in Mexico which lead to reduce the vulnerability of ecosystems by means of their restoration, protection, and preservation.

2.2 Increment and strengthen ecosystem connectivity

The ecosystem connectivity is essential to protect wildlife against the changes projected under climate change scenarios. This strategy contains actions oriented to promote this connectivity.

2.3 Implement sustainable agriculture

The strategy includes actions aimed at sustainable practices in the agricultural sector.

2.4 Develop tools to promote sustainability and emission reductions in agriculture

This strategy considers the development of economic, legal, and technical instruments which incorporate climate change criteria to foster better practices in the agricultural sector and that promote side benefits during the development of the production chain.

2.5 Reduce environmental threats aggravated by climate change

Climate change induces the recurrence of phenomena such as wildfires and the presence and settlement of invasive species in native habitats. This strategy aims at preventing these threats and ensuring the conservation of the ecosystems.

2.6 Integrated restoration and management of hydrological basins

This strategy includes actions related to land and soils. Specifically, a hydrological basin approach allows the development of an integrated management of the territory and its resources. This approach should involve the population and all parties involved in the management of hydrological basins.

Equity. Adaptation measures must consider the gender equity approach.

Credibility. Adaptation measures must include scientific support and cultural and social acceptance.

No Regret. Verify that the implementation of an action does not have a negative impacts on sites or sectors

Reversibility. This issue considers the approach of those measures or actions that could irreversibly affect ecosystems (EbA), highlighting the recovery of goods, services and ecosystem functionality.

Barriers. The design of adaptation measures should consider possible barriers in the implementation phase (e.g., legal, cultural, technological, economic, social and institutional).

Adaptation action areas

Reducing vulnerability and building a resilient society (A1)

Mexico is especially vulnerable to climate change effects. In recent decades, some of these effects have occurred, such as: a decrease in water availability and the presence of floods, droughts, and diseases such as dengue or acute diarrheic infections. The intensity of the problem may grow due to geographical characteristics and socio-environmental, economic, and public health conditions. The vulnerability assessment and the implementation of adaptation measures must be carried out locally, in response to specific conditions. This section establishes lines of action that create the conditions for vulnerability reduction and the increase of systems and population resiliency, contributing to a better quality of life.

Illustration 4 Adaptation project in Cardenas, Tabasco. Refugees for domestic animals help people secure their property and relocate during natural disasters (instead of refusing to leave).
Source: INECC (2016)

Lines of action:

A1.1 To better identify and attend to zones, settlements, and social groups which are priorities for reducing vulnerability and increasing resilience.

A1.2 To strengthen Integral Risk Management for climate vulnerability. This will include communication systems, early warning systems, local evacuation plans, and the reduction and management of risk caused by extreme hydrometeorological events.

A1.3 To increase resources for disaster management, with a focus on prevention.

A1.4 To strengthen, as part of civil protection plans and actions, mechanisms for immediate and effective responses in zones impacted by the effects of climate change.

A1.5 To strengthen enforcement of land-use regulations to reduce the number of illegal settlements in endangered zones.

A1.6 To implement and strengthen public policies which guarantee water quality and quantity availability in priority zones. These zones are identified as priorities due to the probability of climate change related water scarcity. The public policies will emphasize the strengthening of eco-hydrological services provided by ecosystems.

A1.7 To ensure food security against climate threats by giving preference to integrated watershed management measures, biodiversity conservation, and soil restoration, among other ecological support systems.

A1.8 To implement and strengthen public policies focused on reducing health risks associated with climate change effects. These policies will focus on the most susceptible and sensitive groups.

A1.9 To design and strengthen public policies which protect assets (housing, infrastructure, etc.) from climate change impacts.

A1.10 To increase and strengthen public policies focused on reducing risk to public health infrastructure.

A1.11 To design social vulnerability reduction strategies which include a gender approach.

A1.12 To implement and strengthen public policies for raising awareness of disaster risk management.

A1.13 To implement transparent and inclusive public participation mechanisms in the design and implementation of climate change adaptation strategies. This may include communal, district, municipal, and state councils focused on reducing social vulnerability.

Illustration 5 Mangrove restoration to protect coastline in Alvarado, Veracruz (25 ha using "chinampas")
Source: (INECC, 2015)

Infrastructure and productive systems

Climate change poses huge challenges to the adaptation of economic sectors. The characteristics and respective responses to its impacts will depend on the type of system: agriculture, forestry, exploitation of wildlife, aquaculture, fishing, industrial, extraction, tourism and strategic infrastructure. Likewise, the sectoral response will depend on the risk exposure of the system. Each economic sector needs to take into account different aspects of climate change in order to increase its productivity and competitiveness. This section presents lines of action that aim to strengthen resilience and reducing climate change vulnerability in economic sectors and strategic infrastructure.

Lines of action:

A2.1 To publish periodic vulnerability assessments for each economic sector, and to disseminate them to the private sector and policymakers.

A2.2 To integrate climate change adaptation criteria in existing economic development programs.

A2.3 To ensure public participation through the creation of inter-municipal boards for defining and applying adaptation criteria in local production projects. These projects require collaboration between municipal governments and local residents.

A2.4 To design and strengthen tools for local risk monitoring, vulnerability analysis, and adaptation options for economic sectors.

A2.5 To consider climate change scenarios in job development and adaptation of land-use for economic development activities.

A2.6 To encourage efficient and sustainable use of water resources in every economic activity by periodically updating total water availability.

A2.7 To build quality infrastructure, employ state-of-the-art techniques, and strengthen operations for guaranteeing water availability for agriculture.

A2.8 To identify economic opportunities presented by climate change through the elaboration of local and regional adaptation strategies.

A2.9 To implement techniques and technologies which foster efficient use of resources and manage climate change associated risks in various economic sectors.

A2.10

A2.11 To strengthen existing strategic infrastructure (communications, transportation, energy, among others) in light of climate change scenarios.

A2.12 To incorporate climate change criteria into the planning and building of new infrastructure.

Ecosystems based adaptation (A3)

Mexico has great ecological diversity that provides a vast quantity of environmental services to society (such as oxygen, water, fuels, and food). These ecosystems are seriously threatened by human activities, including by the effects of climate change. The following lines of action aim to guide policies and instruments in order to sustainably exploit ecosystems and restore their eco-hydrological functionality and the services provided to society, thereby increasing their resilience.

Lines of action:

A3.1 To encourage integrated land-use planning for reducing ecosystem vulnerability to climate change. With emphasis on priority regions and watersheds this land-use planning includes: sustainable use and management, protection, conservation and restoration.

Illustration 6 Coral reef restoration project (high temperature resilient corals), Punta Allen, Quintana Roo, Mexico
Source: INECC, 2016

A3.2 To guarantee restoration, connectivity, sustainable use, and conservation of ecosystems such as forests, jungles, coastal systems, oceans, riparian ecosystems, wetlands, and the biotic communities contained within, as well as associated environmental services.

A3.3 To define, by territory, existing programs which foster activities that stabilize agricultural-urban boundaries. This is a way to reduce pressure on ecosystems and ensure their ecological functionality.

A3.4 To ensure that ecosystem vulnerability, biological communities, and priority species are included in climate change vulnerability atlases.

A3.5 To guarantee eco-hydrological connectivity for the preservation of biodiversity and environmental services, the integrity of ecosystems, the conservation of species, and the increase of their resilience in the face of climate change.

A3.6 To generate or modify legal and land-use planning instruments for the reduction of climate change vulnerability of ecosystems and biological communities. This will start with the implementation of adaptation measures.

A3.7 To develop adaptation programs to maintain and increase surface and ground water availability, with a focus on integrated watershed management.

A3.8 To establish and strengthen sustainable community management schemes for forest ecosystems.

A3.9 To increase the amount of reforestation and ecosystem restoration with native species suitable for regional climate conditions.

A3.10 To increase awareness of problems exacerbated by climate change. These problems include forest fire management, and an increase in disease.

A3.11 To guarantee environmental protection of ecosystems from public works, industrial services and economic development projects (mining, textiles, cement, energy, agriculture, tourism, etc.). This will be accomplished by incorporating climate change criteria in planning instruments, such as environmental impact assessments and ecological land-use planning.

A3.12 To develop tools and create valuation schemes for ecosystem services in order to contribute to conservation and sustainable development.

A3.13 To allocate state funds for the restoration of the most degraded and vulnerable ecosystems, as well as for the prevention and recovery of ecosystems that have been affected by extreme climate events.

A3.14 To establish and implement mechanisms for assessing the impact of locally implemented adaptation measures as a means to ensure their effectiveness in the face of climate change.

A3.15 To strengthen environmental surveillance and protection institutions; to foster their cooperation and coordination, as well as to reinforce their inspection, monitoring, and enforcement capacities.

A3.16 To encourage public participation and training in processes that incentivize ecosystem adaptation to climate change. This can include the establishment of bodies such

as citizen watchdogs groups for forest fires, disease outbreaks, and plant and animal lifecycle changes, among others.

Prioritization criteria for adaptation measures

Within the scope of this Strategy, a guide is provided for the selection, design and implementation processes of specific adaptation measures. Adaptation to climate change must be achieved through local processes; the design of measures to be developed will depend on the region and context of implementation. Assuming that resources will always be limited to face the magnitude of this challenge, it is necessary to strategically choose the measures to carry out.

This section provides criteria for guiding the prioritization of measures at the local level, in order to serve as a tool for decision- makers. The main criteria to be considered for the selection of adaptation measures are described on the following page. The review of prospecive measures must be based on a multi-criteria analysis that considers environmental, social, and economical perspectives. Each criterion could be assigned a different weight, according to its importance within a specific context, or new criteria might be added as needed. Table 2 describes the criteria to prioritize adaptation actions.

CRITERIA	DESCRIPTION
Attention to the most vulnerable population	The measure focuses on supporting the population whose conditions make them most vulnerable to climate change effects
Cross-cutting policies, programs or projects	The measures are coherent and articulated with climate change policy instruments, such as the National Climate Change Strategy, State and Municipal Programs, Sector Programs of different government order, among others
Prevention encouragement	The measure promotes organized adaptation based on a preventative approach and invests in prevention rather than reaction.
Sustainability in the use and exploitation of natural resources	The measure promotes sustainable management of natural resources, including water, soil and biotic resources.
Conservation of ecosystems and their biodiversity	The measure considers preservation and restores ecosystems and the services they provide, in order to increase climate change resilience and stop the deterioration processes.

Active participation of target population and strengthening of adaptation capacities	The population is actively involved and takes control of the measure, contributing their knowledge and experience in each stage of the process.
Strengthening of adaptation capacities	The measure encourages strengthening individual, group or network capacities in matters of adaptation to climate change.
Feasibility	The measure considers institutional, financial, political, regulatory, technical and social capacities that will allow for implementation and sustainability.
Cost-effectiveness or cost-benefit	The measure costs are low compared with its effectiveness or benefits, thus reducing vulnerability.
Coordination between actors and sectors	The measure promotes the coordination between sectors and institutions from the three government branches, academy and civil society.
Flexibility	The measure can be adjusted in response to specific needs, and produces benefits under any climate change scenario.
Monitoring and evaluation	The measure includes a monitoring and evaluation proposal that contains strategic impact indicators focused on its fulfillment and effectiveness.

Table 2 Criteria to prioritize adaptation actions

Source: (SEMARNAT, 2013a)

Climate change mitigation

Low-carbon emissions development should start with cost-effective mitigation action that, while addressing climate change, have important social and environmental benefits. Energy efficiency and strategies to reduce short-lived climate pollutant (SLCP) emissions are example of measures that Mexico's strategy has prioritized. In order to design mitigation policy and prioritize actions, the General Law on Climate Change provided specific criteria and directed policymakers to consider short-term, lower-cost alternatives first while develop alternatives to reduce future technology costs. Table 3and Figure 5 summarize this decision-making guidance.

CRITERIA	DESCRIPTION
Mitigation potential	The quantity of emissions that can be reduced or avoided by implementing mitigation actions, compared to current trends and technologies.
Marginal abatement cost	Cost of an additional unit of carbon reduced. It is an economic concept that allows a comparison of the marginal cost and benefits in order to assess "optimal" reduction goals in terms of economic efficiency.
Environmental and social co-benefits	Mitigation action can derive important benefits in terms of improving life quality and development of marginalized population. For example, access to renewable energy infrastructure in marginal communities can trigger important benefits for the population promoting low-carbon development and access to services from education to better equipped hospitals; reforestation programs and good practices for soil management increase environmental services and thus benefits for the population; better municipal solid waste management reduces diseases, odors, and improve the environment of population close to landfills and other waste disposal sites . While difficult to quantify and value, these benefits must be incorporated into selection of mitigation measures.
Health co-benefits	Some mitigation actions, generally associated to fossil fuels reduction, generate economic savings because of their positive health impacts. The actions focused on SLCPs reduction are a clear example of measures that contribute to improving air quality, and thus improve health.

Increased productivity	Other benefits that should be considered include increases in productivity associated with mitigation measures. For example, the optimization of urban transportation routes, urban planning, and large-scale transportation projects reduce traffic congestion whilst diminishing travel-times, vehicle operation costs, and increasing mobility. Energy efficiency measures come often with productivity increases in the industrial sector.
Enabling environments	Financial, technology, regulatory, and social barriers might prevent the implementation of mitigation actions. Barriers must be analyzed during the planning and measures selection process, considering ways to overcome them and policies to promote adequate enabling environments.

Table 3 Criteria to prioritize mitigation actions

Source: (SEMARNAT, 2013a)

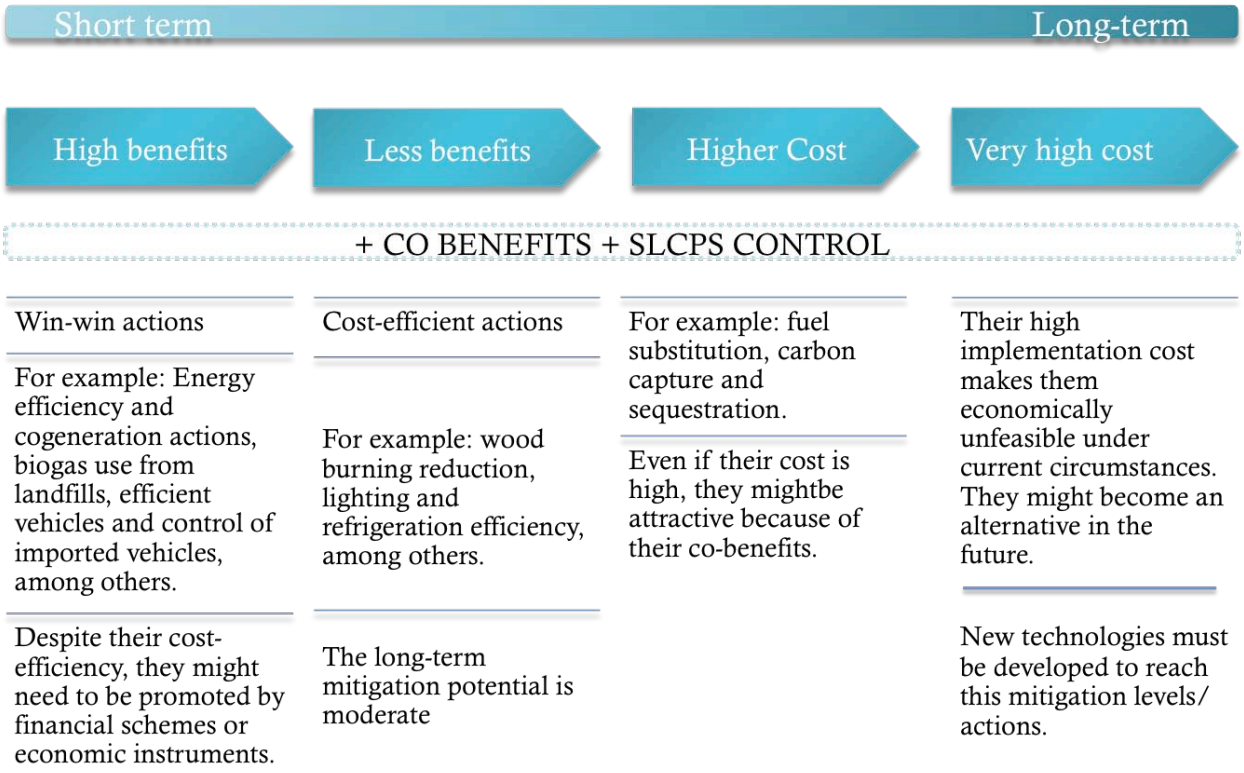

Figure 13 Short-term vs. long-term alternatives
Source: (SEMARNAT, 2013a)

GHG emissions

In 2013, Mexico's GHG emissions from all economic activities in the country totaled 665,304.92 Gg of CO_{2e}. These emissions include energy, industrial processes, agriculture, land use, land use change and forestry (LULUCF), and waste sectors, without including carbon removals. Accounting for removals is important to estimate Mexico's net emissions, since the LULUCF sector acts as a net sink, offsetting approximately 26 percent of greenhouse gas emissions. Thus, net emissions, including removals, were 492,307.31 Gg of CO_2 equivalent (see Figure 14 and Table 4). A full description of methodologies and developments to improve the reporting of national emissions can be found in Mexico's First Biennial Report to the UNFCCC (INECC and SEMARNAT, 2015).

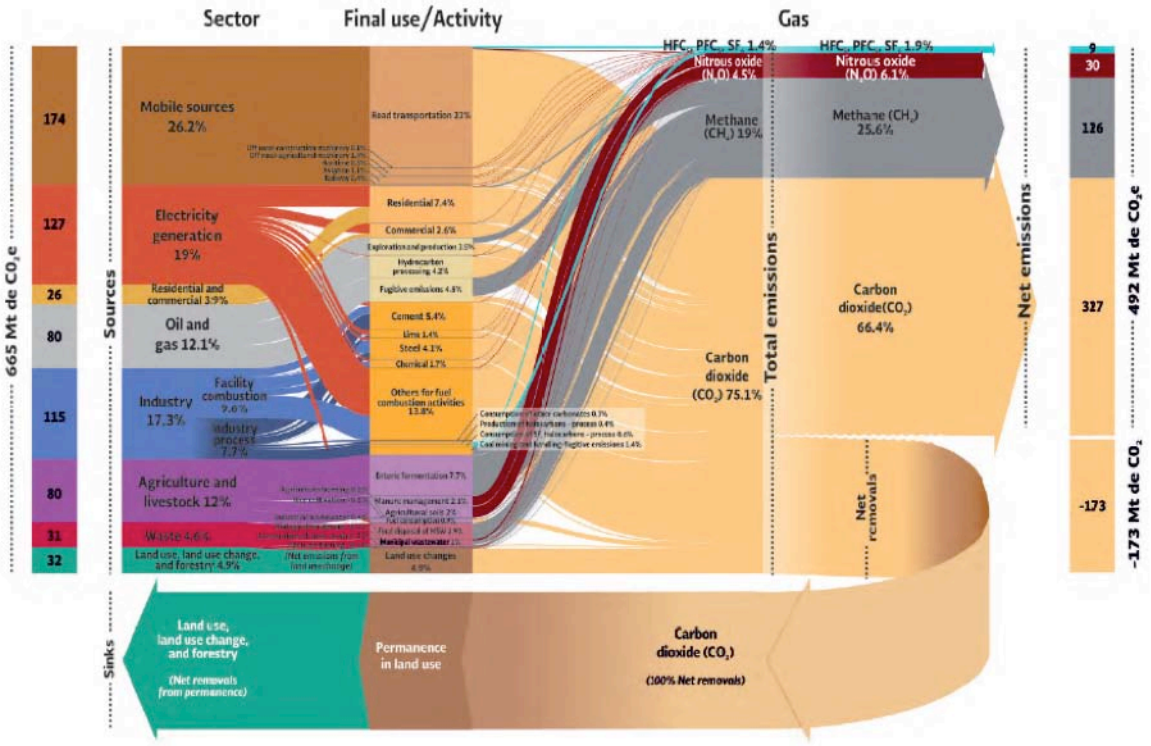

Figure 14 Mexico's GHGs emissions by economic sector and gas
Source: (INECC and SEMARNAT, 2015)

Emissions in 2013 increased 40%, compared to the level in 1990. Figure 15 shows historical emissions, without considering LULUCF sector removals. Energy related GHG emissions have experienced the largest growth, with an annual growth rate of 2.3% between 1990 and 2010, growing in absolute terms 63% in that period. In the period 2002-2012, GHG emissions' average annual growth rate was 2.5%, whilst GDP average annual growth for the

same period was 2.4%; showing that emissions in Mexico and GDP have not yet been decoupled.

GHG emissions by economic sector (Gg de CO_{2e})							
Total: 665,304.92							
Sector	Total GHG	CO_2	CH_4	N_2O	HFC	PFC	SF_6
Mobile sources	174,156.53	169,863.14	273.16	1334.66	2,685.59		
Electricity Generation	126,607.66	125,966.81	110.29	530.56			
Industry	114,949.19	97,864.44	9910.3	518.7	6,464.06		191.69
Oil and Gas	80,455.26	4,9510.6	30,944.66				
Residential and Commercial	25,639.35	23,028	2,281.06	330.28			
Agriculture	80,169.09	376.99	54,620.3	25,171.79			
LULUCF[1]	32,424.86	31,461.6	633.51	329.75			
Waste[2]	30,902.99	1,630.11	27,391.44	1881.44			
Total emissions	665,304.92	49,9701.68	126,164.73	30,097.18	9,149.64		191.69
Permanences USCUSS[3]	-172,997.61	-172,997.61					
Net emissions	492,307.31	32,6704.07	126,164.73	30,097.18	9,149.64		191.69

Table 4 Mexico's GHG emissions by sector baseline year 2013

Table notes: 1) Includes absorptions from forestland; 2) Includes urban solid waste, hazardous waste and water treatment; 3) Includes permanences from forest, grasslands and agriculture.
Source: (INECC and SEMARNAT, 2015)

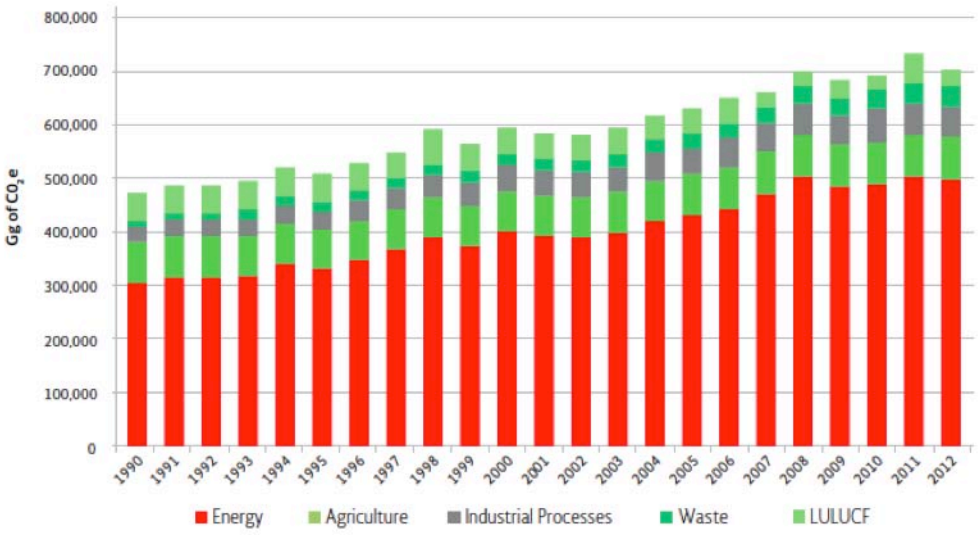

Figure 15 Mexico's emissions trends
Source: (INECC and SEMARNAT, 2015)

Mobile sources

In 2013, emissions from on-road and non-road mobile sources reached 174,156.53 Gg of CO_{2e}, contributing 26% of the total national emissions. Important methodological improvements were used in our latest inventory for this sector, including the use of modeling tools that include in-detail vehicle fleet characteristics to obtain emission factors (i.e. technology characteristics, maintenance parameters, and travel-speed estimations, among others.)

Electricity

Emissions from electricity generation sector contributed 126,607.66 Gg of CO_{2e}, corresponding to 19% of total GHG emissions nationally. This sector has experienced important technological changes in past years. Between 2010-2013, an important retirement of conventional thermal power plants and gas turbines occurred, with new combined cycle and wind plants coming online. Compared to 2010, changes in fossil use are as follows: Coal: -1.7% (from 344.2 to 338.4 PJ); fuel oil: 12.8% (from 362.1 to 408.6 PJ); diesel: 97.2% (from 12.8 to 25.3 PJ); and natural gas: 20.3% (from 988.3 to 1,189.3 PJ) (SENER, 2014).

Industry

Emissions of CO_2, CH_4, and N_2O from the burning of fuels in the industrial sector and CO_2, CH_4, and N_2O, HFCs, and SF_6 coming from industrial processes totaled 114,949.19 Gg of CO_{2e}, contributing to 17% of national emissions. Subsectors that contribute the most to this category include cement, steel, chemical, mining and metallurgy.

Oil and gas

Oil and gas sector plays an important role in Mexico. Emissions from production, transportation, distribution, processing, and use of hydrocarbons in the country were estimated, considering fuel used in different combustion processes as well as fugitive emissions from processes of production, burning, venting, and distribution of hydrocarbons. In 2013, the oil and gas sector emitted 80,455.26 Gg of CO_{2e}, which accounted for 12% of total GHG total emissions.

Agriculture

In the agriculture and livestock sector, CH_4, N_2O, occur from livestock activities (livestock enteric fermentation and manure management), as well as agricultural activities (soil management, rice cultivation, and field burning for crop residues). Also, CO_2, CH_4, and N_2O emissions from the use of fuels for energy purposes - mainly used in irrigation systems - contribute to the sector's emissions. Emissions from the sector were 80,169.09 Gg of CO_{2e}, which represents 12.0% of total GHG total emissions.

Land Use, Land Use Change, and Forestry

In 2013, emissions from the LULUCF sector were 32,424.86 Gg of CO_{2e}, representing 4.9% of total emissions. Thus, emissions from land converted to grassland, settlements, and other land, as well as fires, contributed 45,007.61 Gg of CO_{2e} in total. Meanwhile, reforestation and afforestation sequestered a total of 12,582.75 Gg of CO_2. Carbon sequestration from permanence of forest land, grassland, and agricultural land totaled -172,997.61 Gg of CO_2. Therefore, net LULUCF emissions totaled 141,536.00 Gg of CO_{2e}, which makes this sector an important carbon reservoir. Important improvements in the methodology used to estimate LULUCF emissions include: the use of data on carbon content of different types of vegetation from the updated National Forest and Soil Inventory (CONAFOR, 2013) in two sampling periods (2004-2007 and 2009-2013); updated information on vegetation and land use cover from the National Institute of Statistics, Geography and Informatics (INEGI, 2013); derivation of allometric equations suitable for Mexico; and estimation of national emission and removal factors.

Waste

This sector includes emissions of municipal solid waste (MSW) and hazardous waste as well as the treatment and disposal of municipal and industrial wastewater. In 2013, emissions from this sector totaled 30,903.02 Gg CO_{2e}, of which 21,462.65 Gg CO_{2e} correspond to MSW and 9,440.37 Gg CO_{2e} to wastewater. A full bottom-up approach was used, accounting for emissions at a very disaggregate level, particularly for MSW and wastewater treatment.

Short Lived Climate Pollutant emissions

Short-lived climate pollutants (SLCPs), also known as short-lived climate forcers, include: methane, black carbon, tropospheric ozone, and some hydro fluorocarbons. These pollutants shorter lifespan in the atmosphere compared to CO_2, but therefore have a relevant short-term impact on climate. In general, the impact of different gas species on climate change is determined by its radiative forcing (W/m^2). Along with global efforts to reduce CO_2 and the other long-lived climate pollutants (LLCP), action on SLCPs offers significant opportunities to tackle climate change in the coming decades with significant co-benefits for public health.

Due to the role that these emissions could play on climate change mitigation, and its important co-benefits in human health, Mexico has already included in its inventory and in its NDC the quantification and mitigation action for black carbon.[10]

[10] The country is working on developing strategies for the other SLCP.

In 2013, total BC emissions were estimated in 125.1 Gg (see Table 5). Again, transportation was the main source of emissions, with 37.8%, followed by the industrial sector and the residential sector with 28.3%, the latter mainly due to household's wood use. Electricity generation and agriculture contributed 6.8% and 7.1%, respectively. The remaining sectors, oil and gas, LULUCF, and waste sum up the remaining 4.8%.

Sectors	Gg
Mobile Sources	47.34
Industry	35.42
Residential and Commercial	19.01
Agriculture and Livestock	8.86
Electricity Generation	8.46
LULUCF	3.61
Oil and Gas	2.17
Wastes	0.23
Total	125.1

Table 5 Mexico's Black Carbon Emissions
(INECC and SEMARNAT, 2015)

Emissions projections

Designing a long-term GHG development strategy requires an exercise of emissions projection often expanding many decades into the future. Economic modeling normally assists this type of analysis in order to integrate social, economic and technology variables that influence future emissions development. Given the complexity of estimating future emissions, economic models are often supported by sector-specific models such as energy, land, agriculture and water models, as well as by climate models which provide some feedback effects with the earth system. Modeling frameworks that integrate different types of models to understand policy issues are often refer to as "integrated assessment models". They have been widely used in the climate change research community.

The IPCC Fifth Assessment Report on mitigation issues recognizes that there are multiple pathways towards a world that limits temperature change to 2ºC. Our current state of knowledge indicates that significant emissions reductions over the next few decades must be realized in all of the 2ºC scenarios, and the global economy must reach near zero emissions of CO_2 and other GHGs by the end of the century. Scenario analysis shows that stabilizing GHG concentrations at 450 ppm by 2100 would require a reduction of 40 to 70% of global anthropogenic GHG emissions reductions by 2050 compared to 2010 (IPCC, 2014).

Of course, an important ethical question arises regarding the fair burden sharing of the global mitigation effort. The Paris Agreement helped us break the impasse in the climate negotiations by providing a framework through the NDCs submissions where all countries act considering a fairness principle and their national circumstances. Also, a number of studies have provided some basis of analysis to assist countries crafting climate policy, particularly considering cost-effective mitigation. For instance, Figure 16 shows abatement potential in 2030 for different stabilization scenarios for selected Latin American countries, including Mexico. These scenarios were run under the auspices of the CLIMACAP and LAMP project.[11]

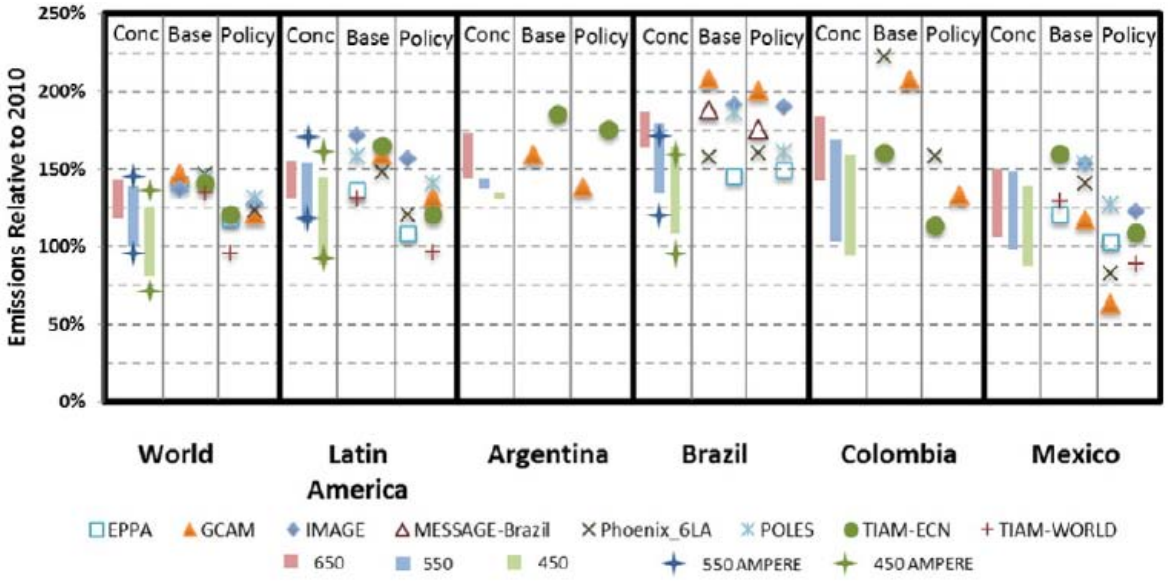

Figure 16 Fossil fuel and industrial CO_2 emissions in 2030 relative to 2010 in the 650, 550, and 450 concentration scenarios

Table Notes: Fossil fuel and industrial CO_2 emissions in 2030 relative to 2010 in the 650, 550, and 450 concentration scenarios (bars, 1st column, from the CLIMACAP–LAMP scenarios; stars are the high and low values from the AMPERE study for the 450 and 550 scenarios—see (Kriegler et al., 2015), under projected baselines (2nd column), and policy baseline (3rd column) for the world, Latin America, Argentina, Brazil, Colombia, and Mexico. For Mexico, the policy scenario shows a policy of 30% emissions reduction from 2010.

Source: (Clarke et al., 2016)

[11] An important research effort to study climate policy in Latin America was funded by the European Union in the context of the CLIMACAP project (EuropeAid/131944/C/SER/Multi) and of the U.S. Agency for International Development and U.S. Environmental Protection Agency in the context of the LAMP Project. This section draws from results of this international collaboration project for the literature review, given the wide arrange of modeling tools that were used in that assessment and the participation of modeling groups from Latin America and international experts.

As shown in the figure, for a 450 ppm world, important reductions worldwide must be accomplished by 2030. This goal is consistent with previous literature that looked at the global effort. Latin American countries show different feasible reductions depending on their demographics and abatement cost, which varies regarding country resource endowments and current technology mix (Octaviano, Paltsev, & Gurgel, 2016).

In principle, the results of the abovementioned multi-model analysis suggest that Mexico should, based on cost-effectiveness mitigation criteria to reach global temperature goals by 2030, keep emissions within a range close to its emissions in 2010.[12] Mexico's NDC falls within this range, since economy-wide emissions in our NDC compared to 2010 would only increase 10% by 2030 (Gobierno de la República de México, 2015).

Quantification of the mitigation effort and cost provides an important set of information for the Paris global stocktake. Therefore, we aim in this section of our strategy to run specific modeling scenarios that can help us assess our mitigation to 2050. While Mexico is a developing country, we acknowledge the need to take action that can trigger the level of ambition needed to reach the 40 to 70% global reduction by 2050. We believe these metrics could be useful as we discuss both the 2050 targets, and the means required to implement them.

Literature review

In this section, we briefly discuss some results from the literature looking at mitigation pathways for Mexico, in order to provide a brief overview and identify key studies that can support the long-term mitigation goal of Mexico. In the following section, we develop original modeling analysis to assess the NDC goal of Mexico and the 2050 trajectory.

A first quantification of the mitigation potential often starts with a bottom-up analysis of abatement opportunities and costs. Mexico has conducted a number of these type of studies over the last years, which have been important to help us design our National Climate Change Strategy (SEMARNAT, 2013a) and the Special Program on Climate Change (SEMARNAT, 2014). Figure 17 shows an estimation of the marginal abatement cost curve

[12] For a 450 ppm the Figure shows that Mexico could hold emissions approximately between 90-140% of 2010 levels.

in the country (INECC and SEMARNAT, 2012). As shown, several negative cost measures were identified, mainly regarding energy efficiency potential.[13]As aforementioned, Mexico's GLCC and NSCC mandate the evaluation of marginal costs of mitigation actions, and thus marginal abatement curves (MAC) are useful to help us comply with the legal criteria for assessing measures.

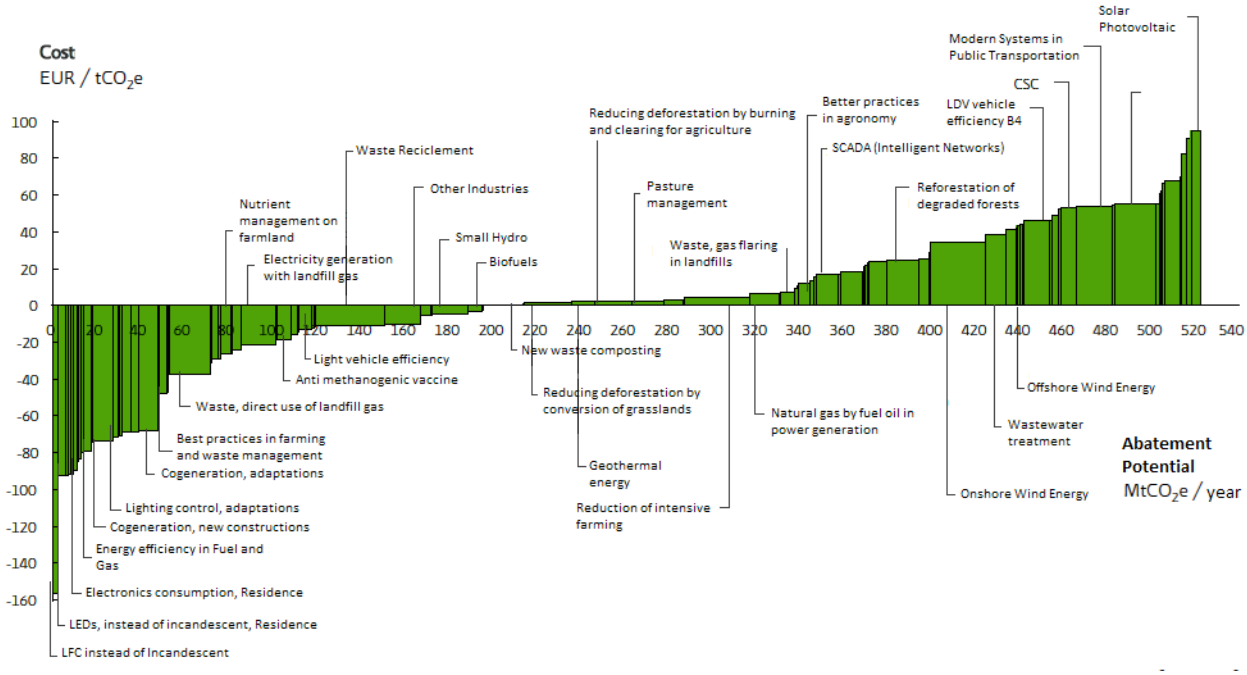

Figure 17 Marginal abatement cost in Mexico estimated for 2030 (using 2010 data)
Source: (INECC and SEMARNAT, 2012)

While this type of bottom-up analysis is useful as a first approximation, economy-wide mitigation policy can have price effects and interactions between different systems in the economy (i.e. the energy system with the transportation system, and others) that make an isolated bottom-up analysis limited. For this, economy-wide and energy systems models have been used to look at the interaction of different technologies and potential mitigation costs in Mexico. Figure 18 and Figure 19 present marginal abatement cost curves for Mexico in 2030 and 2050, respectively, resulting from CLIMACAP/LAMP cross-modeling exercise which included a wide-range of modeling techniques such as general equilibrium models, energy systems models and market equilibrium models.

[13] Some of these measures, while cost-effective, often require policy actions and incentives to change current behavior. In strict terms of course, they are no zero cost, but their implementation could report more economic benefits than costs.

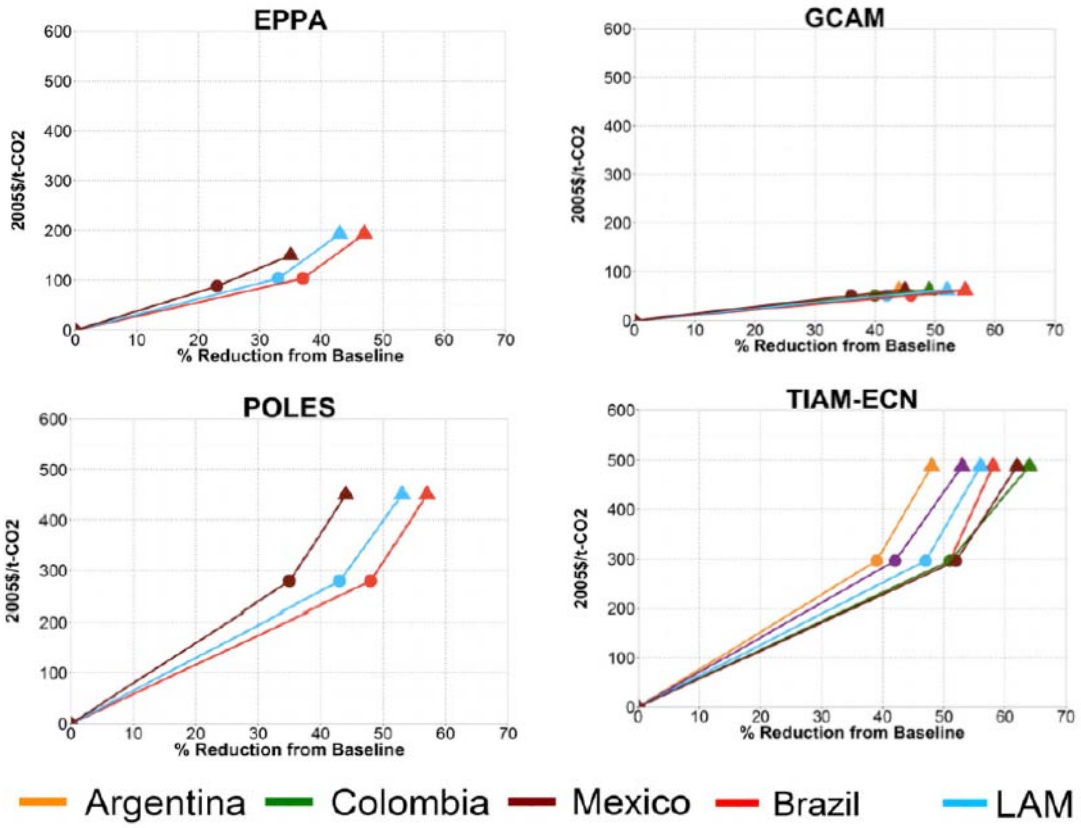

Figure 18 Marginal abatement cost functions in 2030 for fossil fuel and industrial CO_2 emissions, relative to baseline emissions, across countries in Latin America
Source: (Clarke et al., 2016)

As shown in the figures, marginal abatement costs differ among countries and across models. Also, the curves are different if we compare 2030 to 2050. For the same 50% reduction from baseline in 2050, more abatement is needed than in 2030, and thus more expensive mitigation measures are required. By comparing different abatement costs of the models presented, we can infer that marginal mitigation costs could range from less than 50 to around 200 dollars per ton considering fossil and industrial emissions. This range is for CO2 per ton from a scenario similar to Mexico's NDC of 22% reduction by 2030. A mitigation of 50% reduction of emissions from fossil energy by 2050, could imply costs from 100-450 dollars per ton looking only at results from fossil fuel and industrial CO_2 (Clarke et al., 2016).[14]

[14] A brief description of the models used in this cross-comparison exercise by the authors Clarke et al is included in the annex for quick reference.

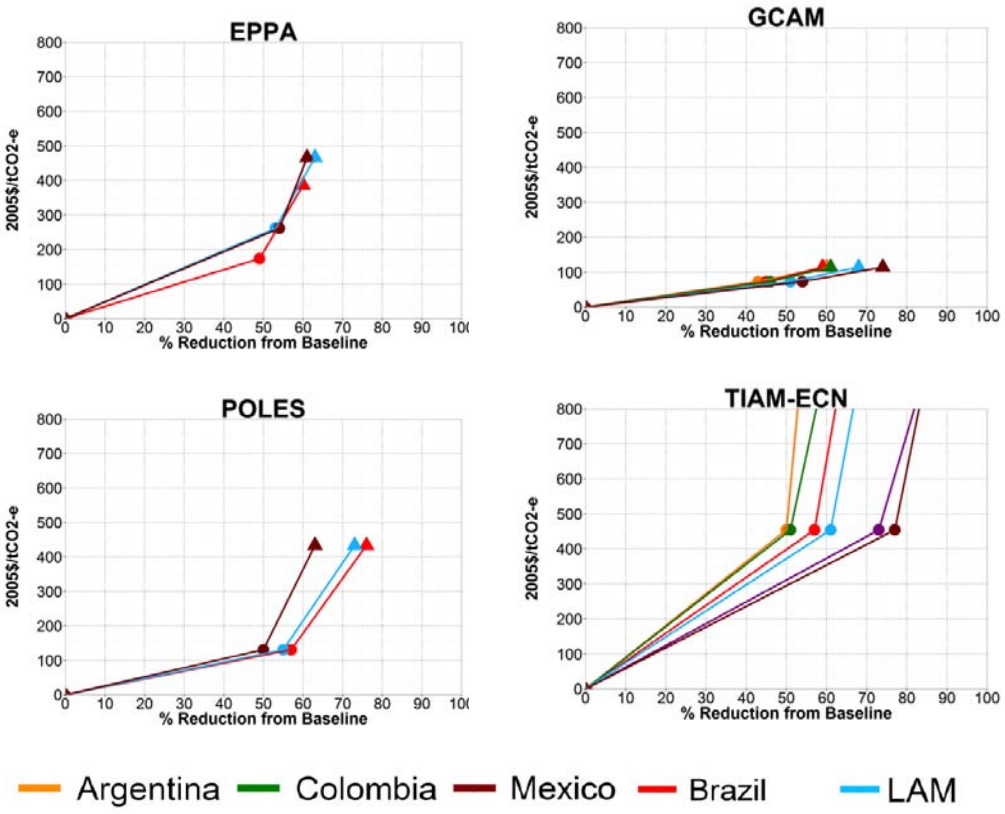

Figure 19 Marginal abatement cost functions in 2050 for fossil fuel and industrial CO_2 emissions, relative to baseline emissions, across countries in Latin America
Source: (Clarke et al., 2016)

Many variables influence differences across models, such as: baseline assumptions (van Ruijven et al., 2016), assumptions regarding the potential deployment of low-carbon technologies (van der Zwaan et al., 2016) and structural differences among models (i.e. whether models include all sectors of the economy, different gases, land-use or focus mainly in the energy sector). While models differ in their specific answer to technology options and overall cost, there is a clear agreement of the need of low-carbon technologies rollout. As an example, Figure 20 shows modeling results for the penetration of low-carbon technologies in Mexico's electricity sector. For an scenario of 50% reduction of emissions by 2050, all models rely on energy efficiency measures and the deployment of renewable energy. This includes important shares of bioelectricity in some cases, or gas or coal with carbon capture and storage, in other cases.

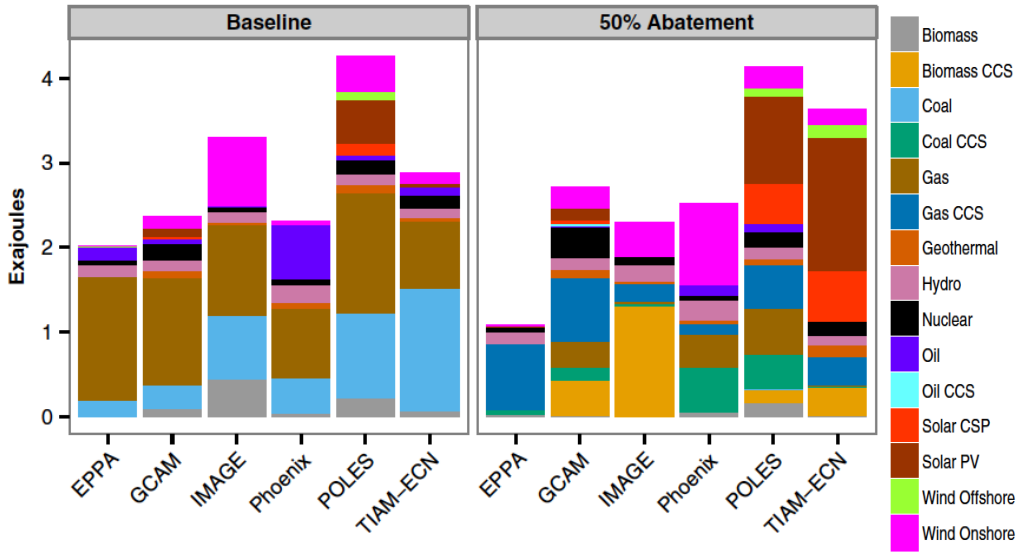

Figure 20 Electricity generation in 2050 by technology and scenario
(Veysey et al., 2016)

Recent studies in Mexico, funded by the Ministry of Energy, have also found a large potential for energy efficiency measures in combination with renewable energy for low-carbon energy supply by 2030 (Jorge Islas Samperio and Fabio Manzini and Paloma Macías and Genice Grande, 2016). This study assessed 84 mitigation actions in the residential, commercial, public, industrial, hydrocarbon and transportation sectors. Such actions were estimated to cost 98.3 billion US dollars .[15] These researchers' findings point out that the transportation sector has the highest abatement potential at 49%, followed by electricity at 27% and industry at 15%.

Also, Mexico participated in the *Deep decarbonization project* under the UN Sustainable Development Solutions Network with a modeling exercise funded by INECC in 2015 (Tovilla, 2015). The deep decarbonization modeling exercise in Mexico showed an important role for natural gas CCS technology for 2050, along with energy efficiency improvements in the industry and a fast penetration of electric vehicles. In particular, this study estimates that full electric light duty vehicles are expected to represent a 45% of the fleet while the rest uses flexi fuel systems. It also projects a full decarbonization of the power sector.

[15] In 2007 prices.

In sum, there is already a nascent body of literature focusing on understanding and quantifying climate change mitigation policy in Mexico. Studies point to an important mitigation potential in the country, with different pathways available for Mexico to transition to low-carbon development (Veysey et al., 2016).

Mid-century mitigation scenarios

For the economic analysis and emissions projection of the Mid-century Strategy (MCS), we selected one model that has the capability of simulating the global mitigation efforts. This model considers Mexico in detail, and captures all of GHGs and economic sectors. *The Massachusetts Institute of Technology Economic Projection and Policy Analysis (EPPA) Model* is a multi-sector, multi-region computable general equilibrium (CGE) model of the world economy, with Mexico disaggregated as a region. It has updated information for Mexico regarding economic structure and the energy sector, resulting from a scientific research collaboration project between Mexico and the MIT.[16] It utilizes the GTAP dataset[17], augmented by data on the emissions of greenhouse gases, aerosols and other relevant gases, taxes, and details of selected economic sectors. For this exercise, we also updated information regarding current cost of renewable energy technologies in Mexico.[18]

The model projects economic variables (GDP, energy use, sectoral output, consumption, etc.) and emissions of greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) and other air pollutants (CO, VOC, NO_x, SO_2, NH_3, black carbon, and organic carbon) from the combustion of carbon-based fuels, industrial processes, waste handling, and agricultural activities. EPPA can simulate emissions limits, carbon markets with domestic and international trading, and technology regulations, such as energy efficiency standards for vehicles, among others (Y.H. Chen and S. Paltsev and J. Reilly and J. Morris, 2015). This model has been widely used for the analysis of climate and energy policy, including a number of studies in the US, EU, Mexico, Brazil, China and other developing countries (H.

[16] The model version used is EPPA 6 and has been updated with Mexico's information as part of the research collaboration between Centro Mario Molina and the MIT Joint Program for the Science and Policy of Global Change, with funding from the Molina fellowship and Mexico's Council for Science and Technology (CONACYT).

[17] Global Trade Analysis Project (GTAP), hosted by Purdue University, is a global network of researchers and policy makers conducting quantitative analysis of international policy issues. The dataset compiles and systematizes input-output tables to be used for economic analysis.

[18] The last electricity bidding processes in Mexico showed record low prices for solar energy, and also lower costs than previous projects for wind energy. We reduced the "mark-up" parameters of renewable energy technology in the EPPA model to make them similar to efficient combined cycle technologies; although they are not perfect substitutes due to intermittency of solar and wind.

Jacoby and H. Chen & 2014., 2014; Jacoby., 2012; Octaviano et al., 2016; Sergey Paltsev, 2009).

From the outset, we must acknowledge that all modeling exercises have limitations and that there are intrinsic uncertainties in predicting such long-term horizons. Our purpose in presenting the quantitative analysis of Mexico's mitigation goal is to advance the understanding of our mitigation options. It should not, at any moment, be understood that Mexico has fixed mitigation policies for the decades to come, nor that all of the reductions resulting from the model will be required for sectors strictly based on economic efficiency. On the contrary, we will remain flexible in the face of a quickly changing technology and climate policy innovation environment. What are fixed are our commitments, long-term goals, and policy principles as mandated by our laws. We present the modeling analysis for the insights it provides to guide long-term action, as it helps in identifying critical actions to scale-up mitigation.

We believe that there is high value in systematizing the information of Mexico and other countries' emissions and emissions drivers. This systematization can be done with our best available modeling tools, without being dogmatic about their use. The quantification of our strategy can provide a basis to better address potential implications. It can also inform a discussion about the importance of international collaboration for the fast mobilization of means of implementation, including technology, finance and capacity building needs.

Baseline emissions projection to 2050

Mexico's population of 121 million people in 2015 is expected to reach 137 million by 2030; and by mid-century Mexico's total population could reach 150 million (CONAPO, 2010). The size of our economy, as measured by GDP, in 2015, was 1.144 trillion dollars, making it the second largest economy in Latin America (World Bank, 2016). The EPPA model endogenously estimates GDP growth rate for the policy scenarios; however, the business as usual scenario requires data about future growth expectations. A 3% average annual growth was used, which was derived from domestic data and the IMF mid-term projection for Mexico (International Monetary Fund, 2016; SENER, 2016).[19]

For the **baseline projection**, we allow the MIT EPPA model to estimate the emissions trajectory **without imposing climate or energy policy constraints**. The model considers

[19] SENER uses a 3.3% growth rate for long-term planning; IMF projected worth rate for the medium term 2021 is 2.9%.

population growth, GDP growth rate, technology costs and resource endowments in the country to assess the business as usual scenario.

Mitigation scenarios

We defined two mitigation scenarios:

a) **NDC policy**. This mitigation scenario simulates a reduction target of **22% of economy-wide GHGs by 2030**, and 51% of black carbon. For 2050, the MCS goal simulated a trajectory after 2030 that reaches a **50% reduction of GHGs**, compared to Mexico's 2000 emissions. For assumptions regarding the rest of the world's mitigation, we consider that all countries deliver on their INDC mitigation pledges by 2030, and that by 2050, global mitigation reaches 50% below 2010 level. We consider this could be in line with a 2ºC stabilization scenario of 450 ppm, drawing from previous IPCC reviewed research. We also allowed for domestic trading of GHGs using IPCC AR5 global warming potentials for trading tons of CO_2 equivalent across gases. We did not simulate international emissions trading.[20]

b) **NDC more ambition**. This mitigation scenario simulates a more ambitious policy of reducing **36% of economy-wide GHGs** in the economy by 2030, and **70% of black carbon**. For 2050, the MCS goal simulated a trajectory after 2030 that reaches a 50% reduction of GHGs, compared to Mexico's 2000 emissions. It has additional constraints to simulate a minimum of 50% of clean electricity production by 2025, in line with Mexico's energy transition law, and a 40% methane reduction considering coordinated action in North America. For assumptions regarding the rest of the world's mitigation, we consider that all countries deliver on their INDC mitigation pledges by 2030, and that by 2050, global mitigation reaches 50% below 2010 level. We consider this could be in line with a 2ºC stabilization scenario of 450 ppm, drawing from previous IPCC reviewed research. We also allowed for domestic trading of GHGs using IPCC AR5 global warming potentials. We did not simulate international emissions trading.

Modeling results

GHGs emissions pathways resulting from our modeling exercise are shown in Figure 21. Our **baseline projection** (in blue) shows that economy-wide emissions could reach 973

[20] This can of course be added to the analysis since the EPPA model allows for international exchange of emissions permits; however, we considered premature to simulate a global emissions trading system at the moment.

million tons of CO_{2e} by 2030, and 1,236 million tons of CO_{2e} by 2050.[21] Our **NDC policy** emissions trajectory (orange) shows that emissions would be reduced to 762 million tons by 2030, a 22% reduction compared to the baseline projection, and reach 311 million tons by 2050. The **NDC more ambition** trajectory (green) estimates a reduction of 36% GHG emissions reductions from the baseline and reaches the 311 million tons of CO_{2e} by 2050. The gray area represents the total cumulative emissions reduction that our economy could deliver in the NDC policy scenario. Total emissions reduction potential, with additional efforts to accelerate mitigation actions, is represented by the gray area plus the orange area. As shown in Figure 21, the NDC more ambition trajectory implies a peaking of national GHG emissions by or before 2026, as stated in Mexico's NDC.

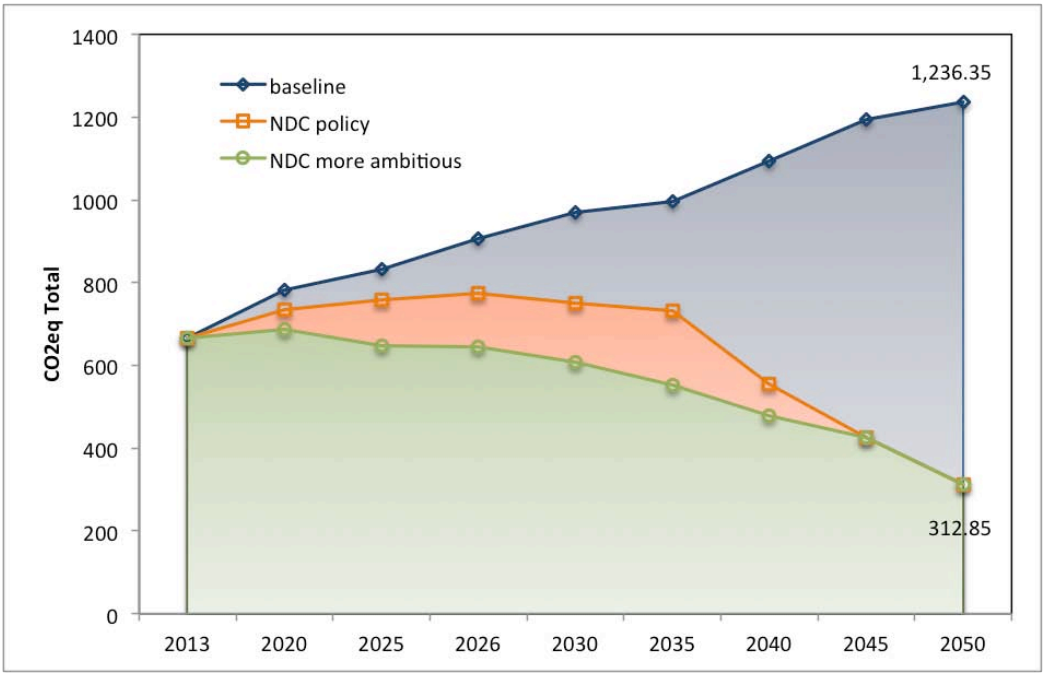

Figure 21 Mexico's GHG mitigation scenarios

Figure 22 shows emissions reductions for CO_2 (the size of the bubble represents total emissions by source; and on the vertical axes the CO_2 baseline allows comparison with the baseline projection). These reductions are defined by gas species for all other GHGs, including methane (CH_4), nitrous oxide (S_2O), perfluorocarbons (PFC), sulfur hexafluoride

[21] This estimate is lower than the previous emissions projection in the NSCC, mainly driven by reduced costs of renewable energy that allow for some penetration of it in the baseline trajectory.

(SF_6). An important flexibility mechanism in our simulation is emissions permits trading including different gases. Understanding the critical role of emissions trading for cost-effective mitigation, Mexico has started the policy design of this instrument and plans to launch a pilot trading exercise this year.[22]

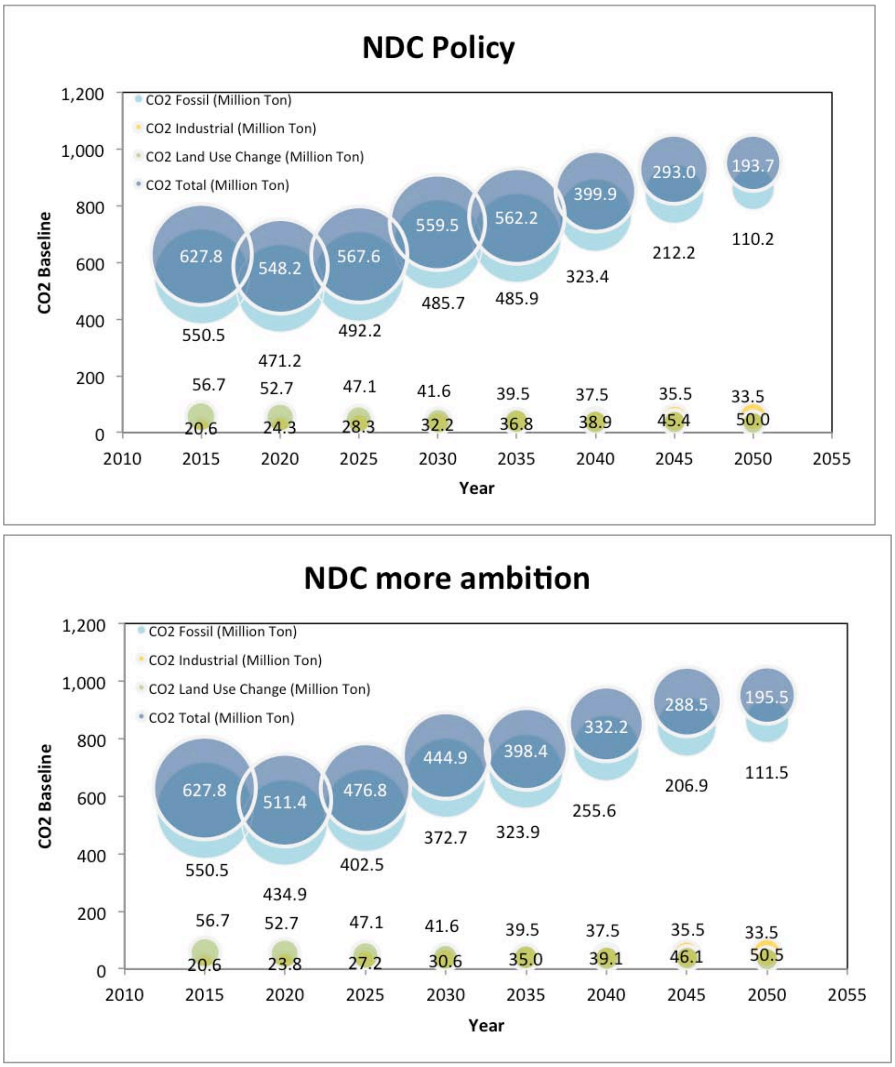

Figure 22 CO_2 emissions reductions in the policy scenarios

[22] Due to the importance of this instrument, accelerated policy design and implementation is required. More collaboration and capacity building in this area could help speed the process.

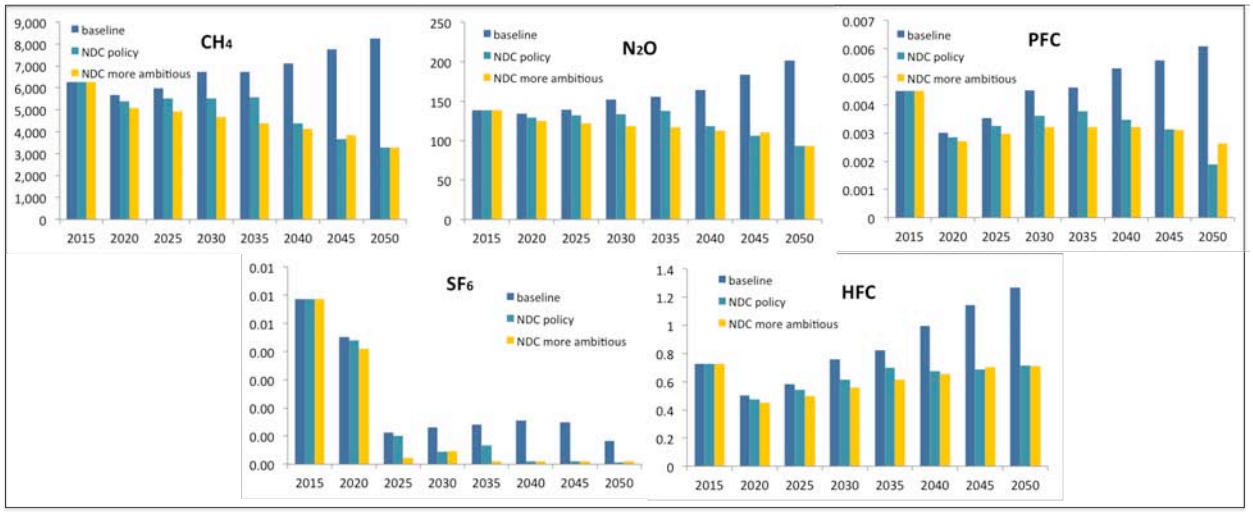

Figure 23 Other GHG emissions by scenario

An essential component of Mexico's climate policy is the reduction of **short-lived climate pollutants**. We also modeled explicitly the goals for black carbon (see Figure 24).[23] We underscore that these are additional policies that can help raise global ambition, and thus Mexico has started unilateral action in this regard and committed to this as part of our NDC. As explained in previous chapters, Mexico prioritized these measures for their important benefits in health and ecosystems. Figure 25 shows the reductions of other air pollutants that could be associated with both the GHGs and BC policy goals.[24] The pollutants in Figure 25 (SO_2, NO_x and VOC) are well known ozone precursors which is a secondary pollutant that is of major concern in many cities in Mexico, as shown by our National System for Air Quality monitoring (SINAICA).[25]

[23] An additional constraint was needed to reach the 51% reduction goal on BC, meaning that the level of reduction of this pollutant will not be achieved only with GHG policy measures and thus requires additional policies.

[24] We did not model other policies targeting particularly SO_2, NO_x or VOC. Of course some policies targeting specifically this pollution could be analyzed as a follow-up study to better understand the interaction with climate policies (i.e. measures to introduce emissions control equipment for these pollutants such as current standards for fuel charging stations, power plants, etc.)

[25] Air quality can be monitored in real time in many cities of Mexico http://sinaica.inecc.gob.mx/

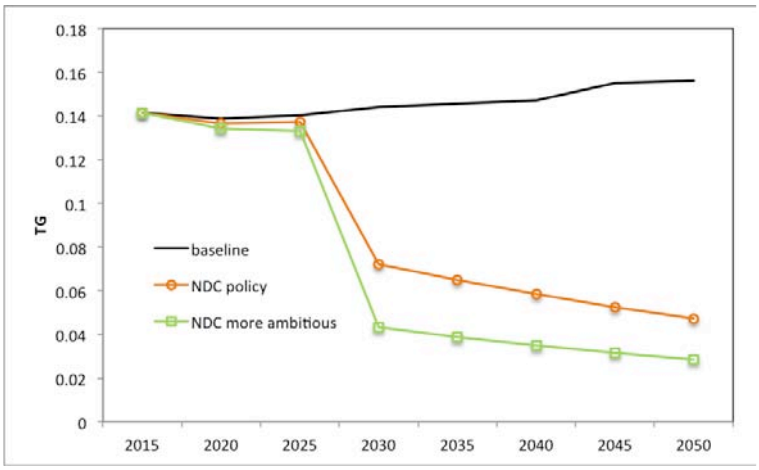

Figure 24 Black carbon emissions by scenario

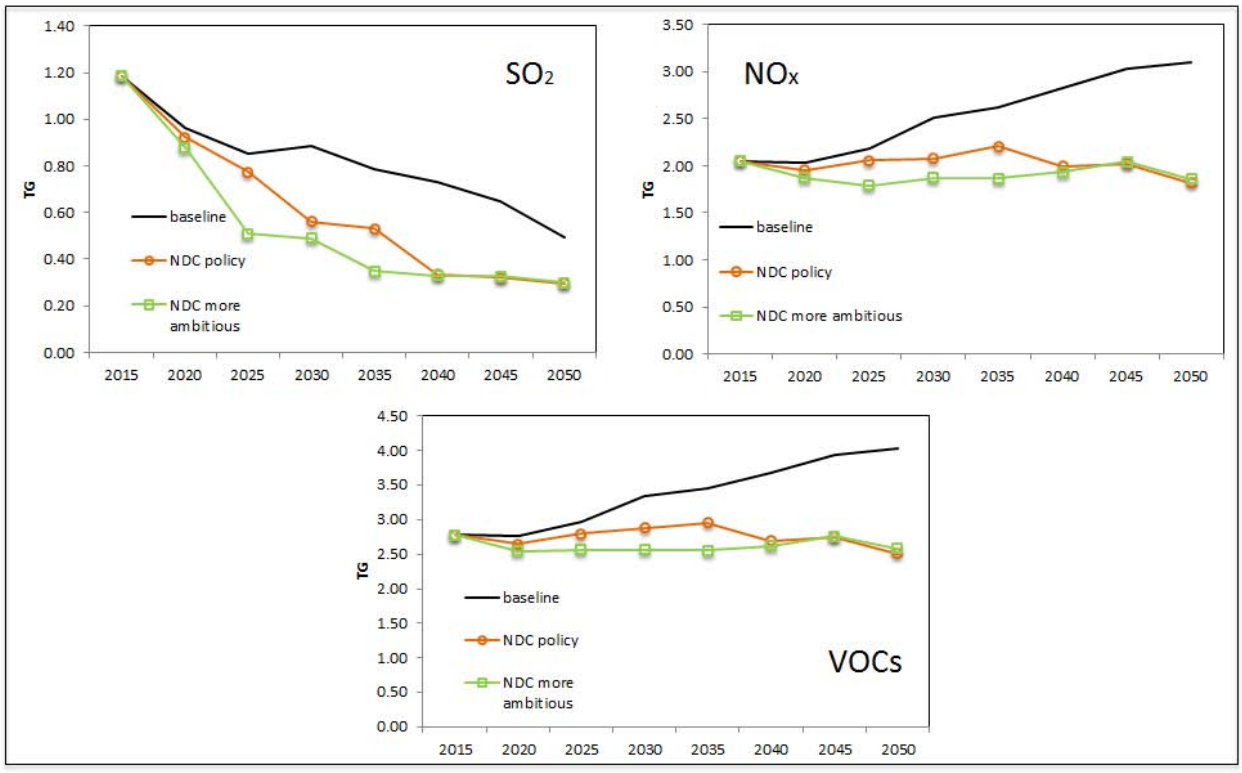

Figure 25 Other air pollutants reduction (other co-benefits of climate action)

Regarding technological trends, the model allows evaluation of the potential role of new technology adoption in different sectors. For example, in the energy sector, the model allows forecasting required changes in energy use. Figure 26 shows primary energy use in the different scenarios. As shown in the figures, in a baseline scenario oil and natural gas dominate the energy mix. It is interesting to point out that renewable energy does gradually enters the mix in a business as usual scenario, though only slowly without specific policies supporting adoption. In both policy scenarios renewable energy penetrates rapidly replacing oil and coal use.[26] The relevance of renewables as a mitigation option was explored by the IPCC work on renewable energy mitigation potential, as well as other reference studies for the future of renewable energy (Maureen Hand and Sam Baldwin and Ed DeMeo and John Reilly and Trieu Mai and Douglas Arent and G. Porro and M. Meshek and D Sandor, 2012; Ottmar Edenhofer and R. Pichs-Madruga and Y.Sokona and K. Seyboth, Gerrit, & Stechow, 2011).

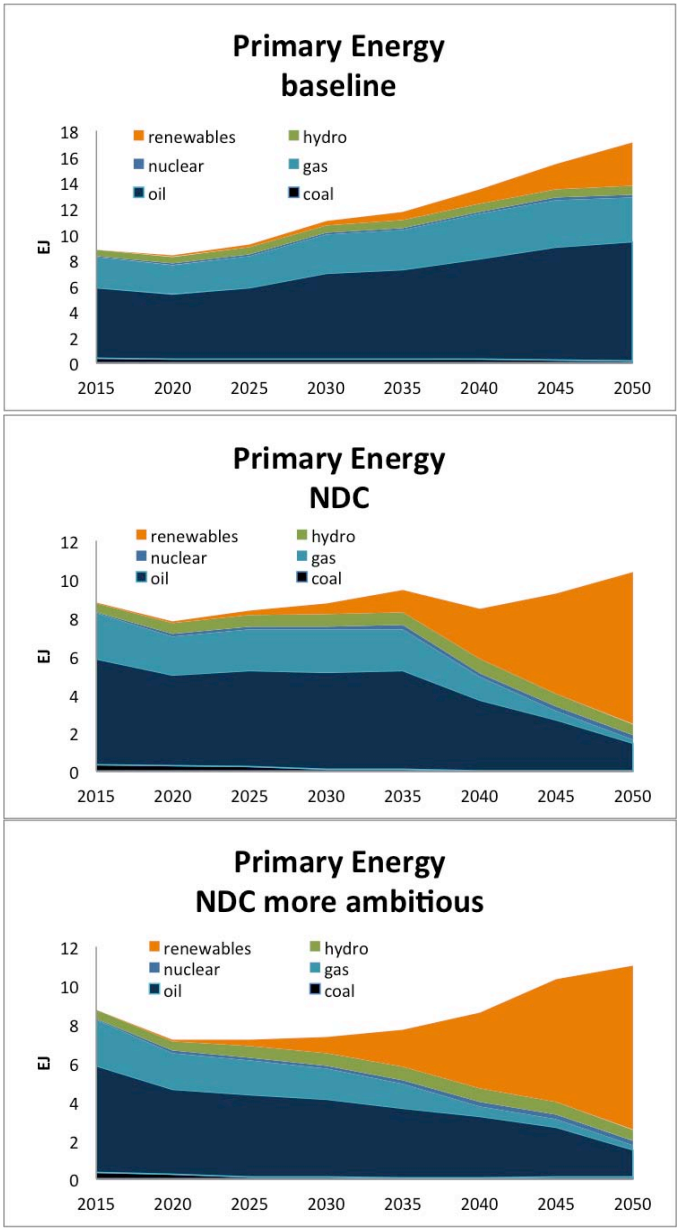

Figure 26 Primary Energy Use by Scenario

Energy efficiency is also a critical mitigation option, as shown by the decrease in total energy demand in both scenarios. The replacement of oil though more energy efficiency is a critical component of the policy scenarios. Particularly, the transportation sector requires fast new efficient technologies in a short timeframe, as shown

[26] Renewable energy reported is a sum of solar, wind and biomass (both biofuels and bioelectricity). In Mexico, an important resource could also be geothermal energy, which is not explicitly modeled here.

by the miles per gallon indicator resulting from the policy simulation exercise (see Figure 27.) In addition to energy efficiency, an important share of reductions comes from the introduction of electric vehicles. Modeling results suggest that incentives for a rapid increase of fleet efficiency and hybrid and electric vehicle adoptions will be important to achieve the 2050 goal.

Clean electricity is particularly important in both policy scenarios for all sectors in the economy. As shown in the policy scenarios for a 50% economy-wide emissions reduction, the power sector must be almost fully decarbonized by 2050.[27] This is particularly relevant in the context of the transformation of the electricity market where solar and wind power are increasing their share in the electricity matrix, driven in part by changes in the legal framework for the sector, and by important reductions in the cost per MWh for those technologies.

It should also be noted that Mexico has already established in its long-term Energy Transition Strategy a goal of 50% clean electricity by 2050. Compliance with that goal relies on the design and operation of the recently created Clean Energy Certificates market, and on compliance with annual targets on clean energy for qualified electricity suppliers. Whether a full decarbonization of the electricity sector can be achieved is still an open discussion in Mexico. For that reasons, other mitigation options could complement the clean electricity goal if more time is required, such as more or enhanced action on reducing emissions of SLCP.

Of course, the complete transformation of electricity supply comes with a myriad of challenges ahead; particularly as the sector has long-lived infrastructure and the lock-in problem of fossil-fuel based generation. In addition to the economic questions, deploying large shares of renewable energy could be technically challenging given the intermittent nature of solar and wind resources (IEA, 2011; NERC, 2009; Pérez-Arriaga, 2011), although the recently created CENACE, as independent electricity dispatcher, estimates that the integration of up to 30% intermittent renewable energy in the system is manageable. Mexico is collaborating with the USA, Canada, Denmark and other countries in the assessment and resolution of integration challenges and the identification of needed infrastructure. Collaboration in planning for new technology adoption will surely be important as our countries advance in climate policy goals.

[27] This finding is supported by the deep decarbonization modeling exercise for Mexico, and has been also found in other countries' analysis of 50% and more mitigation strategies.

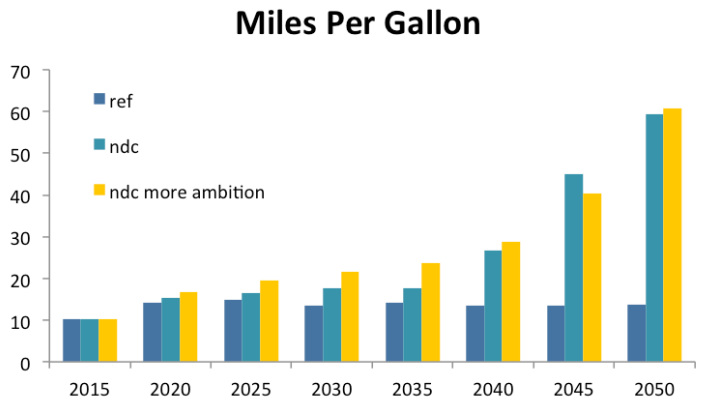

Figure 27 Transportation Energy Efficiency Improvement

Finally, in addition to emissions and technology trends, the economic model provides socioeconomic indicators to assess potential climate policy costs. Figure 28 shows populations trends (input data), GDP per capita and consumption component of GDP.[28] As shown in the figure, it is particularly in the last decade of the policy evaluated, where emissions reduction becomes more burdensome for the economy. The results underscore the value of investing today in innovation and research development in order to reduce low-carbon technologies cost and prepare for the high ambition mitigation scenarios needed. It is important to highlight that this model estimates only mitigation costs, and does not include the benefits of reducing climate change impacts in the economy or the value of reducing the climate risk more generally. The benefits of action, while difficult to quantify in economic terms, are much higher.

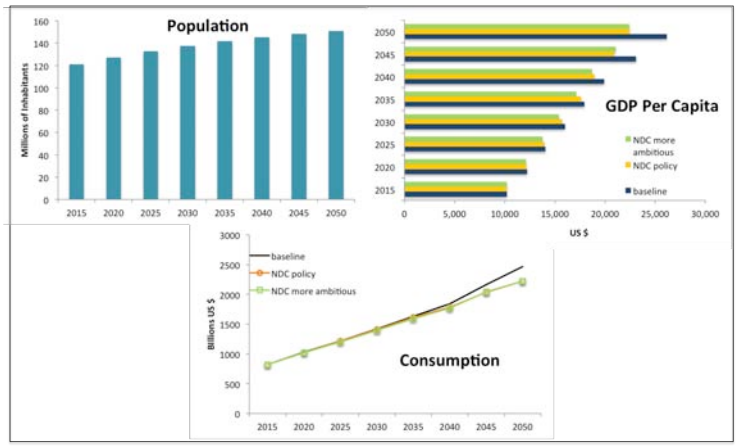

Figure 28 Socioeconomic indicators of climate policy cost

[28] Consumption is a good indicator of welfare changes to the domestic population.

A closer look at the electric power sector

Given the critical role of the electricity sector for reaching climate goals, having a closer look at technology deployment in the sector is important. The power sector is a very complex one, since many variables are required for the proper analysis of power demand and supply at many different time scales.[29] Sector specific models can support the analysis of top-down models in this sector to better understand the technology implications of climate policy.

Denmark and Mexico have initiated The Climate Change Mitigation and Energy Programme, with a specific component on developing more tools to support planning in the electric power sector. Therefore, the Ministry of Energy provided some modeling results from the Balmorel model that explore the technology implications of reaching the current clean electricity medium and long-term goals.

The Danish-Mexico project used the Balmorel model.[30] This tool is useful for analyzing the electricity and combined heat and power sectors. It may be applied for long range planning as well as shorter-term operational analysis. This cost-optimizing model can compute both the capacity needed to meet demand and the energy dispatch for short-term time horizons. It has been calibrated to represent Mexico's electricity system and is used along with the SIMICE model platform, a modeling tool by SENER.[31] Figure 29 shows the expansion of the system estimated by the Balmorel model, and total electricity generation for the MCS period.

This modeling was done with the goal of assessing electricity system needs to meet a 50% clean energy goal. As shown in the detailed electricity sector model, a wide range of technologies could be expected to play a role. Consistent with the EPPA model results, renewable energy plays an important role (wind, solar, bioenergy, geothermal and hydro). Cogeneration also plays an important role, along with natural gas technologies.

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[29] Electricity supply and demand must be balanced at all time, thus timescales span from seconds to minutes and hours. Also, medium and long term planning requires careful consideration of fixed and operational variables costs, demand projections and other uncertainties both in short term and long term variables.

[30] The Balmorel model information can be found here: http://www.eabalmorel.dk/

[31] A Mexican model system that integrates other important energy and economic variables.

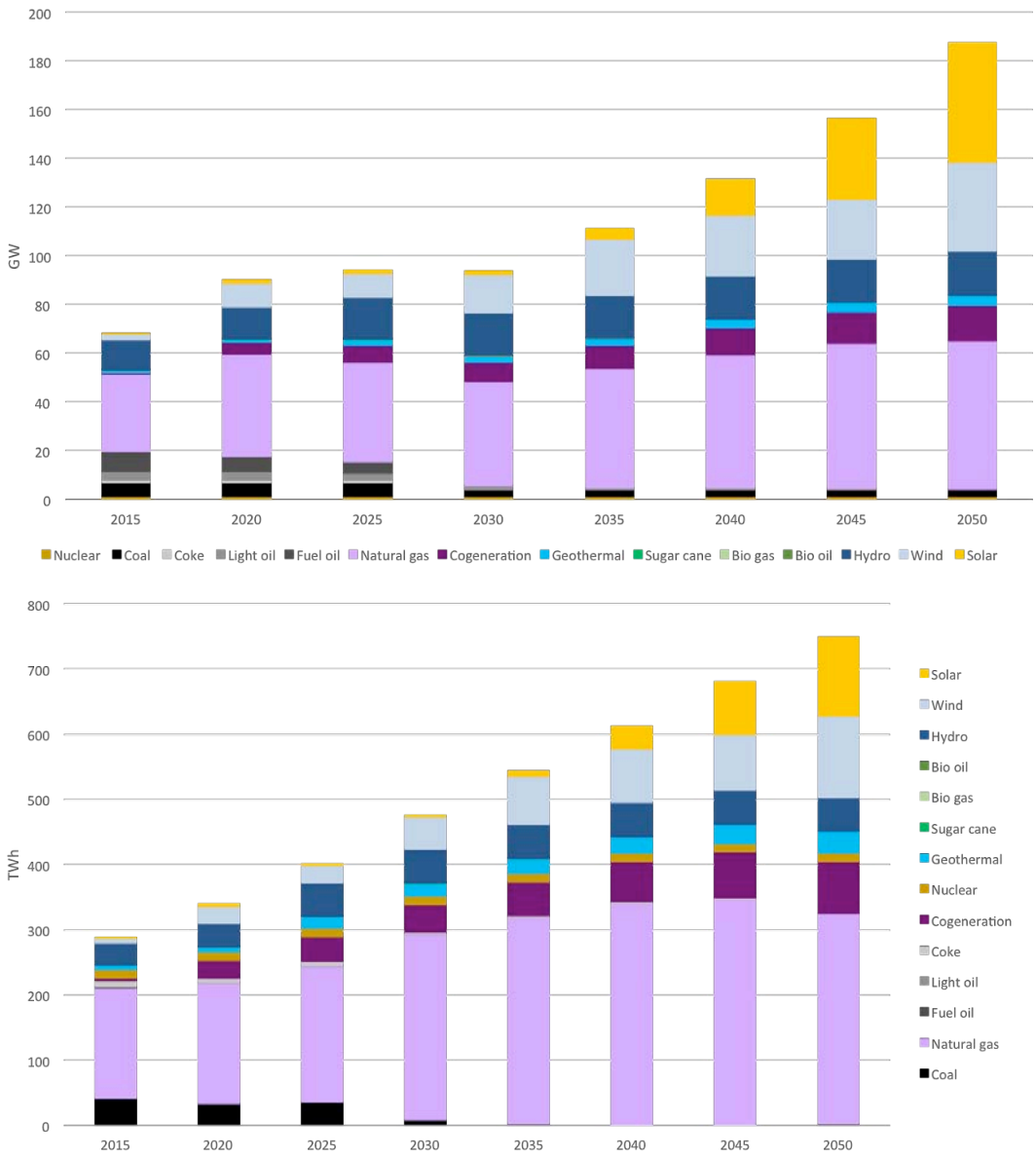


Figure 29 Results of the Balmorel Model: Installed capacity and Electricity Generation in Mexico for the Clean Energy Standard Policy
Source: (Togeby, 2016)

Design and assessment of forest carbon mitigation actions[32]

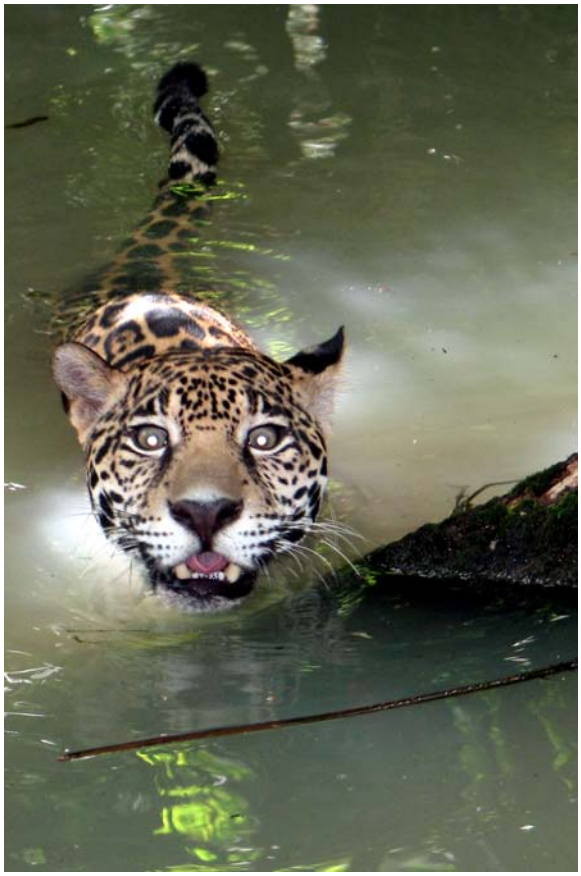


Illustration 7 Panthera onca, Mexico
Source: National Commission for Biodiversity, CONABIO

Mexico's Land Use, Land Use Change, and Forestry (LULUCF) sector is considered a net greenhouse gas (GHG) sink and thus has an important role in balancing GHG emissions and removals at the national level (INECC and SEMARNAT, 2015). However, key challenges remain to identify and understand the main drivers of this sink, and consequently, to design and prioritize mitigation action that reduce future GHG emissions and increase sinks in a cost-effective manner. Since 2012, the National Forestry Commission (CONAFOR), with international cooperation of the Government of Norway, the Canadian Forest Service (CFS), the U.S. Forest Service (USFS), and the Commission for Environmental Cooperation (CEC), has been developing methods and tools to advance the understanding of the role of natural carbon sinks in climate change mitigation for Mexico (Olguín M. and Kurz W.A. and Wayson C. and Fellows M. and Maldonado V. and López-Merlín D., 2016; Olguín M. and Wayson C. and Kurz W. and Birdsey R. and Fellows M. and Maldonado V., 2015). This collaboration recognizes the importance of policy priorities for the Mid-Century Strategy, and thus identifies short-term (avoided deforestation), medium-term (degradation and forest restoration) and long-term (sustainable forest management, ecosystem-based adaptation) mitigation strategies. Both the role of ecosystems in vulnerability reduction and future potential impacts of climate change on forests and climate sensitive ecosystems are considered in this collaboration.

Methods

[32] This section was elaborated by Mexican forestry researcher, M.Sc. Marcela Olguín, with funding from the Commission for Environmental Cooperation (CEC), a trinational organization through which the governments of Canada, Mexico and the United States collaborate on environmental issues. The National Forestry Commission (CONAFOR), and experts from the Canada and the US provided useful comments.

The analytical framework used was the Carbon Budget Model CBM-CFS3 (Kurz et al., 2009). This model follows the Gain-Loss method of the IPCC to estimate annual GHG emissions and removals from all five IPCC carbon pools and has been used in many other countries (e.g. Canada, 26 EU countries, Korea, Russia, and China). During the initial phase of the model adaptation, Mexico was stratified based on the intersection of the 32 federal states and 7 ecoregions of the North America Level 1 classification creating 94 spatial units nation-wide (Olguín M. and Wayson C. and Kurz W. and Birdsey R. and Fellows M. and Maldonado V., 2015). The model was then run for CONAFOR's early actions on REDD+ (Figure 1). Using the CBM-CFS3 in a spatially-referenced approach (IPCC, 2003), forest GHG emissions and removals were estimated by combining: a) forest distribution and forest growth data (derived from Mexico's National Forest and Soil Inventory), rates on fires and land-use changes (i.e., deforestation and forest recovery/afforestation), ecological parameters (e.g., litter fall and decomposition of dead organic matter) and climate data.

Results

Figure 31a shows an example of the business-as-usual scenario generated for the Yucatan peninsula (3 states, 6 spatial units) by extending the historic time series of activity data into the future and calculating the resulting GHG fluxes. Overall, forests represent a net sink of CO_2e due to removals from growth of remaining and newly established forests. However, the size of the sink decreases over time (even when a constant disturbance rate is assumed) due to the cumulative effect of the aging of the forest (lower average growth rate and higher biomass), plus the reduction of forest area by deforestation.

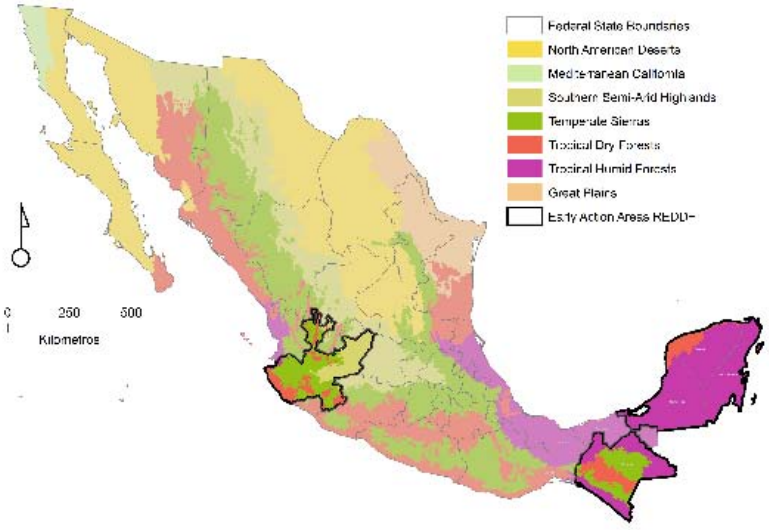
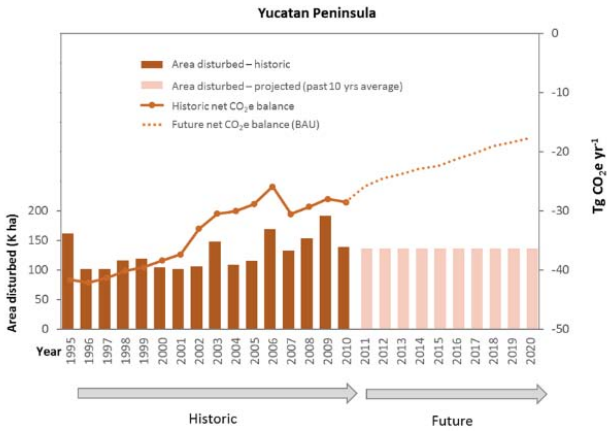


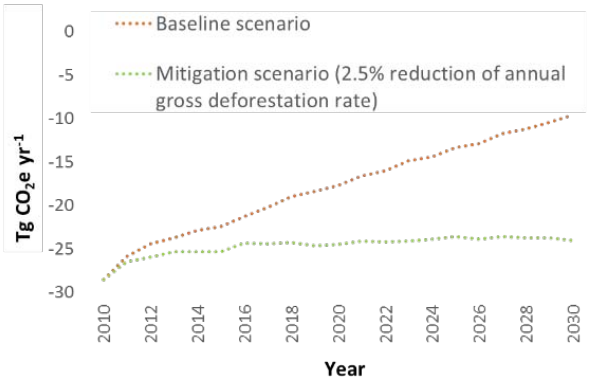
Figure 30 Proposed spatial framework highlighting the five states used in the first phase of modeling mitigation scenarios.

Figure 31 shows the effect of a mitigation scenario that gradually reduces the rate of deforestation by 2.5% per year for the period 2011 to 2030. The estimated trends show that halving the deforestation rate over 20 years would yield a cumulative 40% reduction in net GHG emissions (Olguín et al. 2016). Relative to other activities, such as increasing

reforestation (results not shown in the figure), reducing deforestation generates immediate and significant avoided GHG emissions. This type of analysis can be extended to the remaining forested states in Mexico.



30a. Net GHG fluxes in the Yucatan Peninsula, affected by forest growth and disturbances, from 1995 to 2020 (negative values represent sinks).



30b. Estimated mitigation potential in the Yucatan Peninsula (negative values represent sinks).

Figure 31 Evaluation of forestry dynamics and mitigation potential in the Yucatan Peninsula

Progress and next steps

Several activities are being conducted to refine the simulation of carbon dynamics in Mexico and to increase the level of complexity of the scenarios (e.g. by including forest degradation and sustainable forest management). However, even at this preliminary stage, this study showed the potential use of an analytical framework that integrates data from multiple Mexican sources and resolutions into an internally-consistent reporting and accounting system of past and future GHG emissions in Mexico. This approach can also assess the effect of different human activities on future GHG fluxes and enhances the collaboration between policy-makers and the scientific community in Mexico to analyze and rank alternative policy scenarios.

Finally, improving information exchange and capacity building on the design and assessments of mitigation activities in the forest sector contributes to harmonizing GHG emissions reductions strategies at a regional level in North America, where forests cover about 720 million hectares (FAO-FRA 2015) and all three countries are among the top 12 highest GHG emitters globally (IEA 2013). Thus, collaborative work continues with support from the CEC to assess carbon in forests ecosystems and the use of harvested wood products (including trade among the three countries) to assess portfolios of mitigation options (e.g. NDCs and Mid-Century emission reductions assessments).

Mitigation action areas

Clean energy transition (M1)

Mexico's energy reform has set in motion a complete transformation of the energy sector in the country. New legal arrangements provide incentives for the participation of the private sector in many areas previously reserved for the State. While maintaining some activities to independent regulatory bodies and the Ministry of Energy, the new environment uses market forces to attract investment and new technologies to the energy sector.

An important instrument of the energy reform is the mandate to craft an Energy Transition Strategy.[33] This strategy has the goal to promote clean electricity generation to reach the General Law on Climate Change and promote the use of clean fuels. During 2016, Mexico ran an extensive consultation process for the development of the Energy Transition Strategy. A Council for Consultation of the Energy Transition Strategy was on April 7, 2016, pursuant to the Energy Transition Law, with four working groups: 1) production, 2) consumption, 3) energy efficiency and 4) energy storage.

A vision for 2050 for the sector has two components:

- An energy sector operating with clean technologies that is energy efficient and promotes productivity, sustainable development and social equity in the country.
- An energy supply that allows for universal access and that is diversified, sufficient, of high quality and competitive prices.

In terms of clean energy, the reform:

- Eliminates entry barriers and simplifies interconnections, to promote investments
- Sets clean energy goals
- Establishes the evaluation of social impacts of projects
- Promotes energy trading through a competitive approach, by using the new electricity market
- Creates the Clean Energy Certificates program, and specific fiscal incentives.
- Creates regulation to allow the participation of clean distributed energy resources
- Promotes more transmission infrastructure

For each energy technology, the Energy Strategy states measures in four areas: regulation and policies, capacities and human resources, institutions, markets and financing.

[33] The Energy Transition Strategy will be launched by the end of 2016.

Lines of action:

- M1.1 To strengthen the regulatory and institutional framework, as well as the use of economic instruments in order to harness clean energy sources and more efficient technologies.
- M1.2 To encourage less-polluting power generation and more efficient technologies to replace fossil fuels, minimizing environmental and social impacts.
- M1.3 To increase the penetration of renewable energies and to reduce energy losses by using smart grids and distributed generation in national electric system.
- M1.4 To turn state-owned power enterprises into a central platform for fighting climate change, so they foster a strategy for the development of renewable energy and energy saving.
- M1.5 To encourage participation of private in power generation through renewable energy sources and efficient cogeneration.
- M1.6 To facilitate interconnections between power plants and renewable energy projects in the regions of the country with greater potential and economic feasibility.

Figure 32 Wind Energy in Mexico
Source: SENER

Wind

- M1.7 To encourage wind powered energy generation and to benefit from its onshore and offshore potential to ensure technological, social, and environmental compatibility.

Photovoltaic

- M1.8 To promote investment in photovoltaic systems in high potential regions of the country.
- M1.9 To encourage distributed generation by using photovoltaic systems in industrial, residential, and service sectors.

Illustration 8 PV installations in Yucatán and University of Querétaro, Mexico
Source: SENER

Geothermal

- M1.10 To promote technological development of geothermal energy projects to reduce exploration risks and guarantee resource rights.

Hydroelectric

- M1.11 To harness existing electric power potential by installing new large hydropower plants. These plants would only be built in zones where social and environmental impacts can be compensated. Likewise, to use water stored in these installations for other uses such as irrigation, protection against floods, water supply for cities, roads, recreation, environmental services, landscaping, and tourism.
- M1.12 To encourage power generation in small, mini, and micro hydroelectric plants. The niches for this technology is in industrial self-sufficiency, rural production, and in areas with high costs of interconnection to the grid. These niches ensure thei ecological and social compatibility of small hydro.

Nuclear

- M1.13 To consider, among the plans for diversification of generating facilities, the implementation of a nuclear program as a possible substitute to fossil fuel use.

Solar Thermal

- M1.14 To encourage the use of solar thermal energy, including using it for water heating in the services, industry, residential, and tourism sectors.

Energy efficiency and sustainable consumption (M2)

Energy efficiency, whilst resulting in savings, also contributes to reducing GHG emissions. This dual role supports the goals of growth and competitiveness in the country. This effort aims to promote measures that accompany responsible energy consumption resulting from
changes in consumption patterns and technological improvements.
Lines of action:

Illustration 9 Los azufres geothermal plant
Source: Alstom

- M2.1 To promote energy efficiency and savings in the national energy system, and in every activity that contributes to the economy.
- M2.2 To harness the mitigation potential of actions including: efficient cogeneration, energy efficiency in lighting, air conditioning, efficient refrigeration, and water heating.

Consumption habits and Certification

- M2.3 To promote changes in the practices and behavior of end users. Primarily, this would be in the residential, service, tourism, and industry sectors. Such changes could be incentivized through economic instruments, energy efficiency and power saving campaigns.
- M2.4 To promote and encourage the development of mechanisms to provide reliable and timely information to consumers on energy efficiency and GHG emissions. Examples of such efforts include labeling and certification.
- M2.5 To implement sustainable practices in the public and private sectors, using high efficiency standards and green procurement criteria.
- State of the art technology
- M2.6 To increase energy efficiency of public and private passenger and freight transportation by establishing Official Standards and logistic and technological improvement programs, including modal shift for fuel consumption and emissions reductions.
- M2.7 To reduce emissions through the modernization of the vehicle fleet and removal and disposal of inefficient units.
- M2.8 To develop wáter-efficiency in agriculture, including efficient irrigation systems. This will in turn reduce energy consumption.
- M2.9 To continue exploring carbon capture and sequestration(CCS) technologies aimed at the implementation of projects. This will include the possibility of using CCS for enhanced hydrocarbon recovery.

Transformation processes

- M2.10 To promote highly efficient technologies,, fuel substitution, industrial process redesign, and CO_2 capture technologies in energy-intensive industries such as cement, steel, petroleum, chemical, and petrochemical industries.
- M2.11 To reduce energy consumption and GHG emissions by implementing energy efficiency projects informed by comprehensive energy audits in the petroleum, industrial, and electrical sectors.
- M2.12 To reduce losses in power transmission and distribution by modernizing electric lines and substations as well as improving the distribution grid.

Regulation and standards

- M2.13 To adapt and, if necessary, design the legal and regulatory framework applicable to fuels in order to reduce GHG emissions. This would particularly focus on fuels which are not currently regulated, such as fuel oil and marine diesel.
- M2.14 To create a national system of mandatory vehicle inspection, including control mechanisms. Additionally, to review and adjust emission standards of the vehicle fleet with the participation of the three levels of government to ensure high levels of efficiency in all additions to the national vehicle fleet, including imported used vehicles.

Sustainable cities

This line of action is based upon an urban development model that is capable of regulating land-use, considering efficient transportation systems, low-carbon buildings, and integrated water and waste management. The policy is implemented fundamentally on a local scope.

Lines of action:

Sustainable urban development

- M3.1 To increase planned and efficient land-use by diminishing urban sprawl and guaranteeing access to intra-urban land; to promote mixed-use development and vertical buildings; to incentivize densification instead of greenfield development; to connect urban forests; and to define urban growth limits.

Buildings

- M3.2 To promote strengthening, adoption, and application of regulations, standards, and legislations which boost efficient technologies for new and existing buildings in the following áreas: water, energy, gas, thermal isolation, renewable energy, and carbon capture practices (for example: green roofs, vertical gardens, and urban orchards).

Mobility

- M3.3 To encourage the evolution towards safe, clean, low-emission, accessible, and comfortable public transportation systems. This is to be accomplished by strengthening regional and national interconnectivity through the generation of multimodal efficient networks supported by the Federal Government.Greater interconnectivity will take place in a context of urban development and transportation policy that reduces travel times and distances.
- M3.4 To develop transport regulatory entities with understanding of national and regional demand. The regulatory entity will optimize transportation systems to reduce travel times and distances.
- M3.5 To encourage programs which reduce the need for transportation, such as: telework, housing exchange or leasing to bring people closer to their academic or work placess, collective transportation services for companies, and flexible work schedules. To accomplish this, Mexico will diversify and prioritize urban services and equipment in areas with mixed—use development.
- M3.6 To promote efficient and low-emission transportation systems, and to modify the regulatory and pricing framework in order to foster reinvestment and continuous improvement.
- M3.7 To generate incentives, infrastructure, and programs for non-motorized transportation as part of integrated transportation systems in which the pedestrian and the cyclist are given priority. This will create immediate environmental and health benefits.

Integrated waste management

- M3.8 To incentivize private sector participation in projects for waste sorting, reuse and recycling, the development of biogas plants, water treatment plants, and the establishment of recycling centers. These type of projects will be incentivized by developing an adequate enabling environment with new mechanisms, regulations, and markets.
- M3.9 To encourage new technologies and infrastructure for wastewater treatment, integrated solid waste management, and biogas energy exploitation. These developments will be financed through co-investment schemes and economic instruments which cover the operating costs and maintenance of new and existing infrastructure.
- M3.10 To create regional bodies with a long-term national and regional vision for the development of landfills and wastewater treatment plants. These regional bodies will give certainty to projects with long development periods and benefit from economies of scale. To encourage reinvestment and continuous improvement, Mexico will adjust the regulatory and pricing framework.
- M3.11 To promote and develop state and municipal integrated waste management plans which foster social participation in waste sorting and recovery in accordance with the National Integrated Waste Management Program..

- M3.12 To revise and promote pricing systems for collection and disposal services in order to incentivize reinvestment in technological and logistic improvements.
- M3.13 To improve monitoring, inspection, and enforcement actions for compliance with integrated waste management regulation.

Agriculture and Forestry

Forests are important carbon reservoirs; their destruction and degradation constitutes one of the most important emission sources globally. Simultaneously, conservation and sustainable management can contribute to increasing the quantity of carbon stored in forests. On the other hand agriculture and livestock activities are key for food security, but significantly contribute to GHG.

Illustration 10 Maíz Zea.
Source: National Commission for Biodiversity, CONABIO

In this strategic effort, key lines of action are proposed within the agriculture and forestry sectors in order to encourage practices that reduce emissions and avoid policies that may diminish their mitigation scope. Applying a landscape-level approach on policies of large compacted areas such as biological corridors or watersheds, is key for deeply considering the conditions of: natural resources, trends, human influence, conservation, restoration and development opportunities.

Lines of action:

- M4.1 To encourage local communities to plan the sustainable use of forest resources to incentivize preservation and conservation of forests. This will reduce deforestation and avoid land-use changes whilst protecting natural assets.
- M4.2 To strengthen sustainable forest management and restoration of degraded forest ecosystems in order to increase carbon capture and storage.
- M4.3 To promote the incorporation of forests into sustainable management and certification schemes in order to stop degradation and maximize the carbon capture and storage.

- M4.4 To encourage programs for the preservation of forest ecosystems in priority regions in order to maintain carbon sinks and guarantee federal, state, and municipal intervention.
- M4.5 To formulate and implement plans, programs, and policies for reducing deforestation and degradation of forests within a REDD Strategy.These policies must include a sustainable rural development and landscaping approach, and they must observe social and environmental safeguards.
- M4.6 To establish restoration, regeneration, or reforestation schemes for carbon capture and storage in Natural Protected Areas. This may include other instruments for land and terrestrial ecosystem conservation.
- M4.7 To implement land conservation programs that guarantee integrity and increase carbon capture.
- M4.8 To increase the establishment of agriculture, livestock and forestry production programs with greater mitigation potential and environmental and social co-benefits.This can include silvopasture agroforestry systems and linking traditional knowledge with current agriculture and livestock problems.
- M4.9 To encourage agriculture practices that preserve and increase carbon capture in soil and biomass, such as conservation cultivation and productive reconversión. These practices replace monoculture with polyculture or perennial crops.
- M4.10 To generate programes which result in reducing emissions from the inefficient use of fire in forests and agriculture and livestock lands.
- M4.11 To implement agricultural policies oriented towards the better use of fertilizers, a more calculated application of fertilizers, producing and applying biofertilizers, as well as efficiently using nitrogenates.
- M4.12 To implement efficient resource recovery programs for livestock waste management.
- M4.13 To implement actions for energy efficiency and use of renewable energy in agriculture, livestock, and fishing projects. This may includ the encouragment of biodigesters.
- M4.14 To establish livestock production programs that reduce emissions and capture carbon in grazing lands through appropriate livestock management, stocking rate, and planned grazing.
- M4.15 To strengthen forest monitoring in order to avoid illegal logging and forest fires. This may be accopmlished through the establishment of community monitoring groups.

Short-Lived Climate Pollutants and health co-benefits of climate action

These actions focus on reducing SLCP emissions, targeting cost-effective mitigation actions that have multiple benefits including air quality improvement, reduced water pollution, reduced crop damages and other important co-benefits.

Lines of action:

- M5.1 To promote the regulation of SLCP sources and uses.
- M5.2 To classify SLCP emission sources according to emissions magnitude, global warming potential, and mitigation costs. This is to be followed by the development of abatement mechanisms.
- M5.3 To accelerate the penetration of low global warming potential refrigerants in different sectors including: air conditioning, refrigeration, and foaming agents. This will be accompanied by the reduction of leaks, HFCs management and adequate disposal.
- M5.4 To strengthen best practice programs for refrigeration, recovery and final disposal of chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), and hydrochlorofluorocarbons (HCFCs).
- M5.5 To strengthen regulation and programs for preventing and controlling forest fires, prescribed fires, and slash and burn practices.
- M5.6 To implement sustainable resource recovery programs for forest biomass and agriculture waste.
- M5.7 To implement clean transportation systems in freight corridors.
- M5.8 To encourage the implementation of emission reduction and operational efficiency programs focused on operational, administrative, technological, and financial characteristics within the freight sector. This will be balanced by the needs of the owner-operator and small truckers.
- M5.9 To substitute cooking overa n open fire for efficient, low- emission stoves. To disincentive the unsustainable use of wood, we will focus on municipalities with high and very high level of marginalization.
- M5.10 To encourage the use of technologies and fuels that reduce BC emission, such as particle filters and ultra-low sulfur diesel.
- M5.11 To encourage BC emissions reduction in medium and large scale industries by changing coke fuel, fuel oil, and diesel for low black carbon emission fuels. Additionally, emission control systems and energy efficiency will be implemented within processes.
- M5.12 To encourage BC emissions reduction in the micro and small scale industries through productive reconversion, technological change, and energy efficiency in industries such as the brick industry.
- M5.13 To eliminate open air burning in dumps, landfills, and in backyards.
- M5.14 To establish MRV mechanisms in operations of methane burning and venting during gas and petroleum production. This MRV will be reinforced through monitoring.
- M5.15 To implement actions which reduce fugitive methane emissions coming mainly from petroleum, gas, and mining operations. These emissions may also be reduced in natural gas piping, processing, and distributing systems.

- M5.16 To encourage electricity generation from biogas projects in landfill and wastewater treatment plants. This will have the additional benefit of avoiding methane and volatile organic compound (VOC) emissions.
- M5.17 To incentivize the control of VOC emissions and tropospheric ozone precursors in organic waste aerobic treatment (composting).
- M5.18 To control VOC emissions in industrial sources, gasoline service stations, and from solvent use.
- M5.19 To implement a measurement and accounting system for SLCP emissions, for tracking emission sources, and for monitoring and evaluating the effectiveness of implemented policies for SLCP emission reduction.

Evaluation and updating of the MCS

The Ministry of Environment and Natural Resources, with the participation of the Inter-Ministerial Commission on Climate Change, will review the National Climate Change Strategy at least once every ten years regarding mitigation policy, and every six years regarding adaptation policy. Corresponding scenarios, projections, objectives, and goals must then be updated, and deviations from previously stated projections must be explained.

Based upon these reviews and the evaluations results conducted by the INECC's Coordination for Evaluation and the Climate Change Council, the National Climate Change Strategy might be updated. The Special Climate Change Program and the State Programs must be adjusted to consider these updates. Under no circumstance will the reviews and updates lessen the goals, projections, and objectives previously stated.

The IMCC may propose and approve adjustments or modifications to scenarios, trajectories, actions, or goals comprised in the National Strategy when: 1) new international commitments on the matter have been adopted; 2) new relevant scientific or technological knowledge is developed; 3) required by environment, natural resources, economy, energy, sustainable transportation, health, and alimentary security policies; and 4) indicated by the evaluations results carried by INECC Coordination for Evaluation.

Mexico will resubmit its MCS to the UNFCCC, if as a result of the evaluation process new information becomes available germane to the Convention and the global stocktake referred in the Paris Agreement.

References

Arreguín Cortés, F. I. a. L. P. M. a. R. L. O. a. M. M. M. J. (2015). *Atlas de vulnerabilidad hídrica en México ante el cambio climático*

I. M. d. T. d. Agua (Ed.) (pp. 148). Retrieved from https://www.imta.gob.mx/biblioteca/libros_html/atlas-2016/files/assets/common/downloads/publication.pdf

Borja-Vega, C., & de la Fuente, A. (2013). Municipal Vulnerability to Climate Change and Climate-Related Events in Mexico. *Policy Research Working Paper. The World Bank, Social Development Department*

Sustainable Development NetworkDC. © World Bank., 6417.

Cavazos, T., Salinas, J. A., Martínez, B., Colorado, G., Grau, P. d., González, R. P., . . . Bravo, M. E. (2013). *Actualización de escenarios de cambio climático para México como parte de los productos de la Quinta Comunicación Nacional. Informe Final del Proyecto al INECC*. Retrieved from http://escenarios.inecc.gob.mx/

CECADESU. (2009). *National Study on Climate Change Perception*. Retrieved from Mexico City, Mexico:

CECADESU. (2010). *National Study on Climate Change Perception*. Retrieved from Mexico City, Mexico:

CECADESU. (2011). *National Study on Climate Change Perception*. Retrieved from Mexico City, Mexico:

CECADESU. (2012). *Assessment on Climate Change Social Perception*. Retrieved from Mexico City, Mexico.:

CENAPRED. (2016). *Mapas de índices de riesgo a escala municipal por fenómenos hidrometeorológicos*. Retrieved from http://www.cenapred.unam.mx/es/documentosWeb/Enaproc/fenomenos_2016.pdf

Clarke, L., McFarland, J., Octaviano, C., van Ruijven, B., Beach, R., Daenzer, K., . . . van der Zwaan, B. (2016). Long-term abatement potential and current policy trajectories in Latin American countries. *Energy Economics, 56*, 513-525. doi:http://dx.doi.org/10.1016/j.eneco.2016.01.011

CONAFOR. (2013). *Inventario Nacional Forestal y de Suelos*. Retrieved from

CONAPO. (2010). *Proyecciones de población 2010-2050*. Retrieved from

Earth System Research Laboratory. (2016). *Trends in Atmospheric Carbon Dioxide*. Retrieved from Hawaii. USA: http://www.esrl.noaa.gov/gmd/ccgg/trends/

Fedorov, A. V. E., Kerry. (2010). Tropical cyclones and permanent El Niño in the early Pliocene epoch. *Nature, 463 7284*, 1066-1070.

Gobierno de la República de México. (2015). *Intended nationally determined contribution*. Retrieved from
H. Jacoby and H. Chen, & 2014. (2014). *Expectations for a New Climate Agreement.* Retrieved from
IEA. (2011). *Harnessing variable renewables, a guide to the balancing challenge*. Retrieved from
INECC. (2013). *Desarrollo de la Estrategia Nacional de Adaptación al Cambio Climático. Gestión de Riesgos ante el Cambio Climático y Diagnóstico de Vulnerabilidad. Resumen Ejecutivo y Anexo Metodológico. I*. Retrieved from
INECC. (2015). Proyecto de Adaptación de Humedales Costeros del Golfo de México ante los Impactos del Cambio Climático.
INECC and SEMARNAT. (2012). *Bases para una estrategia de desarrollo bajo en carbono en México*. Retrieved from Mexico City:
INECC and SEMARNAT. (2015). *First Biennial Update Report to the United Nations Framework Convention on Climate Change.* Retrieved from Mexico City, Mexico:
INEGI. (2013). *Conjunto de datos vectoriales de Uso del Suelo y Vegetación. Escala 1:250 000, Serie V (Capa Unión).* Retrieved from
International, C. (2010). *Community -Based Adaptation Toolkit* I. I. f. S. D. (IISD) (Ed.) (pp. 66). Retrieved from http://www.careclimatechange.org/files/toolkit/CARE_CBA_Toolkit.pdf
International Monetary Fund. (2016). *World Economic Outlook: Subdued Demand: Symptoms and Remedies.* . Retrieved from Washington, DC:
IPCC. (2003). *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. Retrieved from Hayama, Japan:
IPCC. (2007). *Summary for policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from Cambridge, UK: https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf
IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]*. Retrieved from Cambridge, United Kingdom and New York, NY, USA:
IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)].* . Retrieved from Geneva, Switzerland:
Jacoby., S. P. a. J. M. a. Y. C. a. V. K. a. H. (2012). The role of China in mitigating climate change. *Energy Economics*.
Jorge Islas Samperio and Fabio Manzini and Paloma Macías and Genice Grande. (2016). *Hacia un sistema energético mexicano bajo en carbono*: UNAM.
Kriegler, E., Riahi, K., Bauer, N., Schwanitz, V. J., Petermann, N., Bosetti, V., . . . Edenhofer, O. (2015). Making or breaking climate targets: The AMPERE study on

staged accession scenarios for climate policy. *Technological Forecasting and Social Change, 90, Part A*, 24-44. doi:http://dx.doi.org/10.1016/j.techfore.2013.09.021

Kurz, W., Dymond, C., White, T., Stinson, G., Shaw, C., Rampley, G., . . . Trofymow, J. (2009). CBM-CFS3: a model of carbon-dynamics in forestry and land-use change implementing IPCC standards. *Ecological modelling, 220*(4), 480-504.

Lhumeau, A., & Cordero, D. (2012). *A. Lhumeau, D. Cordero (2012). Adaptación basada en Ecosistemas: una respuesta al cambio*

climático. UICN, Quito, Ecuador. 17 pp. U. I. p. l. C. d. l. N. y. d. l. R. Naturales (Ed.) Retrieved from https://portals.iucn.org/library/sites/library/files/documents/2012-004.pdf

Maureen Hand and Sam Baldwin and Ed DeMeo and John Reilly and Trieu Mai and Douglas Arent and G. Porro and M. Meshek and D Sandor. (2012). *Renewable Electricity Futures*

Study. Retrieved from

MET Office Hadley Centre. (2012). *Climate: Observations, projections and impacts Mexico* M. Office (Ed.) (pp. 149). Retrieved from http://www.metoffice.gov.uk/media/pdf/c/6/Mexico.pdf

Mexico Energy & Sustainability Review. (2015/16). Mexico Energy & Sustainability Review Retrieved from http://www.renewableenergymexico.com/mexico-joins-20-other-countries-bill-gates-in-a-mission-to-boost-clean-energy-investments/

Monterroso, A., Conde, C., Gay, C., Gómez, D., & López, J. (2014). Two methods to assess vulnerability to climate change in the Mexican agricultural sector. *Mitigation and Adaptation Strategies for Global Change, Volume 1 / 1996*

Volume 21 / 2016, 19: 445. doi:10.1007/s11027-012-9442-y

Monterroso R. . and A. Fernández and R. Trejo and C. Conde and J. Escandon and L. Villers and C. Gay. (2014). *Vulnerabilidad y adaptación a los efectos del cambio climático en México* U. N. A. d. México (Ed.) *Centro de Ciencias de la Atmósfera. Programa de Investigación en Cambio Climático* Retrieved from http://atlasclimatico.unam.mx/VyA

Nations, U. (2016). *The World Economic and Social Survey 2016: Climate Change Resilience- An Opportunity for Reducing Inequalities.* Retrieved from New York, USA.:

NERC. (2009). *Accommodating high levels of variable generation.* Retrieved from

Octaviano, C., Paltsev, S., & Gurgel, A. C. (2016). Climate change policy in Brazil and Mexico: Results from the MIT EPPA model. *Energy Economics, 56*, 600-614. doi:http://dx.doi.org/10.1016/j.eneco.2015.04.007

Olguín M. and Kurz W.A. and Wayson C. and Fellows M. and Maldonado V. and López-Merlín D., C. O. a. a. Á. G. (2016). *Estimating Past and Projected Future GHG Emissions.* . Retrieved from Montreal, Canada. :

Olguín M. and Wayson C. and Kurz W. and Birdsey R. and Fellows M. and Maldonado V. (2015). Hacia un enfoque Tier 3 en paisajes estratégicos en México, modelos

ecosistémicos y sitios de monitoreo intensivo del carbono. *Proceedings of the XIV World Forestry Congress 7-11 September 2015, Durban, South Africa*.

Ottmar Edenhofer and R. Pichs-Madruga and Y.Sokona and K. Seyboth, Gerrit, P. M. a. S. K. a. T. Z. a. P. E. a., & Stechow, H. a. S. S. a. C. v. (2011). *Special Report on Renewable Energy Sources and Climate Change Mitigation*. Retrieved from United Kingdom and New York, NY, USA, 2011.:

Pérez-Arriaga, I. (2011). *Managing large scale penetration of renewable energy*. Retrieved from

Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., . . . Foley, J. A. (2009). A safe operating space for humanity. *Nature, 461*(7263), 472-475.

Schleussner, C.-F., Rogelj, J., Schaeffer, M., Lissner, T., Licker, R., Fischer, E., . . . Hare, W. (2016). Science and policy characteristics of the Paris Agreement temperature goal. *Nature Climate Change, 6*(9), 827-835. doi:10.1038/nclimate3096

http://www.nature.com/nclimate/journal/v6/n9/abs/nclimate3096.html - supplementary-information

Scott, K. (Producer). (2016, October 16, 2016). Hurricane Patricia 2015. *Astronaut Scott Kelly's Awesome Storm Photos from Space*. Retrieved from http://www.space.com/31730-astronaut-scott-kelly-jonas-storm-photos.html

SEMARNAT. (2013a). *National Climate Change Strategy. 10-20-40 Vision*. Retrieved from Mexico City, Mexico:

SEMARNAT. (2013b). *Special Climate Change Program 2014-2018 (SCCP 2014-2018) Mexico: Federal Government of Mexico*. Retrieved from Mexico: https://www.iea.org/media/workshops/2015/15thghgtradingworkshop/SpecialClimateChangeProgram20142018Englishversion.pdf

http://dof.gob.mx/nota_detalle.php?codigo=5342492&fecha=28/04/201

SEMARNAT. (2014). *Special Program on Climate Change*. Retrieved from Mexico City:

SEMARNAT-INECC. (2015). *Elementos Mínimos para la Elaboración de los Programas de Cambio Climático de las Entidades Federativas* S. d. M. A. y. R. N. (SEMARNAT) (Ed.) Retrieved from http://www.inecc.gob.mx/descargas/cclimatico/2015_elem_minims_prog_cc_efederativas.pdf

SENER. (2014). Sistema de información energética. Retrieved from http://sie.energia.gob.mx/

SENER. (2016). *Estrategia de Transición para Promover el Uso de Tecnologías y Combustibles más Limpios. (Strategy to Promote Clean Technologies and Fuels).* . Retrieved from Mexico City:

Sergey Paltsev, a. J. M. R. a. H. D. J. a. J. F. M. (2009). The cost of climate policy in the United States. *Energy Economics*.

Shindell D., Kuylenstierna Johan C. I., Vignati E., Rita van Dingenen, Markus Amann, Zbigniew Klimont, . . . Martin Williams. (2012). Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security. *Science, 335*, 183-189.

Togeby, A. V. a. N. D. a. M. (2016). *Renewable energy scenarios for Mexico: Project phase completion and next steps (preliminary results)*. SENER.

Tovilla, J. (2015). *Modelación de descarbonización profunda del sistema energético en México al 2050*. Retrieved from Mexico City:

UNEP. (2015). *Promoting ecosystems for disaster risk reduction and climate change adaptation: Opportunities for Integration, Discussion Paper*. Retrieved from New York: http://www.unep.org/disastersandconflicts/portals/155/publications/EcoDRR_Discussion_paper_web.pdf.

UNFCCC. (2016a). *Aggregate effect of the intended nationally determined contributions: an update*. Retrieved from http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf:

Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015, (2016b).

van der Zwaan, B., Kober, T., Calderon, S., Clarke, L., Daenzer, K., Kitous, A., . . . Di Sbroiavacca, N. (2016). Energy technology roll-out for climate change mitigation: A multi-model study for Latin America. *Energy Economics, 56*, 526-542. doi:http://dx.doi.org/10.1016/j.eneco.2015.11.019

van Ruijven, B. J., Daenzer, K., Fisher-Vanden, K., Kober, T., Paltsev, S., Beach, R. H., . . . van Vuuren, D. P. (2016). Baseline projections for Latin America: base-year assumptions, key drivers and greenhouse emissions. *Energy Economics, 56*, 499-512. doi:http://dx.doi.org/10.1016/j.eneco.2015.02.003

Veysey, J., Octaviano, C., Calvin, K., Martinez, S. H., Kitous, A., McFarland, J., & van der Zwaan, B. (2016). Pathways to Mexico's climate change mitigation targets: A multi-model analysis. *Energy Economics, 56*, 587-599. doi:http://dx.doi.org/10.1016/j.eneco.2015.04.011

World Bank. (2016). World Development Indicators.

Y.H. Chen and S. Paltsev and J. Reilly and J. Morris. (2015). *The MIT EPPA6 Model: Economic Growth, Energy Use, Emissions, and Food Consumptions.* . Retrieved from Boston, USA: