Effectiveness of Greenhouse Gases Reduction Strategies and Policies in Mexico

Violeta Mugica-Alvarez, Leticia Ramos-Guillén, Jesús Figueroa-Lara, and Miguel Torres-Rodríguez

***Abstract*—Mexico as one of the No Annex I countries signatories of Kyoto protocol has conducted several activities to face climate change. This paper presents the assessment and discussion of the actions comprising the three programs in the country during the period 2009-2012: The federal program named Climate Change Special Program (PECC from its Spanish initials), the Clean Development Projects (CDP) registered in the IPCC, and the State Government Actions (SGA). Only 36 of the quantitative 53 PECC's goals achieved some progress, although the global goal of reducing 129.03 Mt CO_2eq/year by the end of 2012 was fulfilled and exceeded, but several important goals were not met. Some actions were performed in order to generate clean energy, such as the construction of an Eolic Park and a hydroelectric, but the government has continued benefiting the extraction of fossil fuels. The estimated effectiveness for PECC actions was 13.4 million of euros/ Mt CO_2eq.**

***Index-terms*—Mitigation, GHG policies, climate change.**

I. Introduction

Climate change is the major global environmental challenge of this century, so much so that in the medium and long terms it has been assumed as one of the greatest threats to processes of societal development and human welfare [1]. In recent years, a large number of tests and scientific studies that reduced uncertainty and improved detection of the early effects of climate change have shown that the concentrations of several greenhouse gases are significantly influenced by human activities, increasing in the last decades and contributing to the climate change [2].

Mexico is the 11th most populated country with around 115 million of inhabitants. Last GHG Emission Inventory of 2010 [3] reported an increase of 33.4% of CO_2eq compared to 1990, with more than 748, 252 Gg, of which 67.3% were from energy sector, 12.3% from industrial processes, 8.2% from land use, land use change and forestry, and 5.9% from wastes.

Mexico has participated actively during the last 20 years with the Intergovernmental Panel on Climatic Change [4], [5] to contribute to the GHG reduction (Fig. 1). Also, Mexico has the goal of reducing 50% of its greenhouse gases emissions by 2050, based on year 2000 with an estimated emission of 643.6 Mt CO_2eq. This implies achieving a turning point during the second decade of this century, and then gradually descend to the level indicated in 2050, approximately to 340 Mt CO_2eq [6].

Mexico became the first developing country to enact comprehensive climate change laws, The Climate Change General Act (LGCC, after the Spanish initials) is an instrument of public interest enforceable throughout the national territory [7].

Three Mitigation programs cover the most important actions carried out from 2009 to 2012. Even when the first is most important, the contributions from the other two kinds of actions are also relevant.

A. Special Climate Change Program (PECC from Its Spanish Initials)

This was of the utmost importance at federal level to face Climate Change in Mexico. This document describes the long-term vision for Mitigation, Adaptation and key elements for policies. For the short-term 2009-2012, 39 targets and 86 goals were established for Mitigation, although only 53 goals are related to GHG reduction actions, whereas 33 goals are associated to regulation, definition of strategies, criteria and programs, education and research activities, among others. The sectors considered were: energy (use and generation), wastes, agriculture, forests and other land uses (Table I).

B. Clean Development Mechanism (CDM)

The main objective of CDM projects is to assist parties not included in Annex I in achieving sustainable development, as well as to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction of emissions (Kyoto Protocol 1998). Mexico had the fourth largest number of projects registered in CDM, at the end of 2012 which summed a total of 178 [8], [9].

C. State Government Actions (SGA)

Even when the PECC established that by 2012 all the 32 states of the country should have their "State Plan of Action against Climatic Change" (PEACC, after its Spanish initials), only 8 states published their respective PEACCs by the end of 2012. Nonetheless, most of the states with or without PEACC proposed local mitigation actions in order to contribute to GHG reductions. These were independent actions from the federal government [10].

In this study, we collected the available information related to the fulfillment degree of the measures, in order to carry out and present the assessment and effectiveness of each one of the 53 goals established for Mitigation in the PECC as well as the goals proposed by the CDM projects and the state government actions.

Manuscript received May 9, 2014; revised July 15, 2014. This work was supported in part by CONACYT Project 181231 and by the Universidad Autónoma Metropolitana-Azcapotzalco.

The authors are with the Universidad Autónoma Metropolitana-Azcapotzalco México (e-mail: {vma, jjfl, trm}@correo.azc.uam.mx, leticiaramosg@hotmail.com).

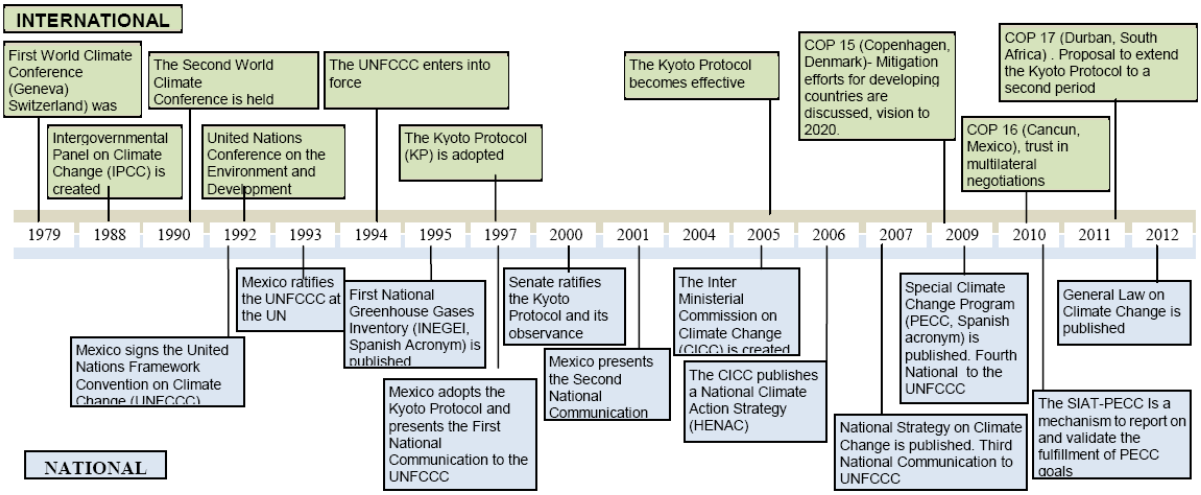

Fig. 1. Participation of Mexico government with IPCC.

TABLE I: PECC GOALS FOR 2009-2012

Sector and subsector	Goals $MtCO_2eq$	Number of goals
Energy production	**51.78**	**14**
Oil and gas	40.83	6
Electricity	10.95	8
Energy use	**22.21**	**16**
Transportation	11 .35	9
Residential, commercial and municipal sectors	8.8	4
Industry	1.82	2
Federal Public Administration	0.25	1
AFOLU	**46.46**	**20**
Agriculture	2.52	7
Livestock	2.14	2
Forests	30.20	9
Farming-Forest Frontier	11.60	2
Wastes	**8.58**	**3**
USW Disposal	7.56	1
Wastewater discharge and treatment	1.02	2
Total	**129.03**	**53**
Source: Official Journal of the Federation, 2009 [7]		

II. Methodology

Dozens of files and data published by the federal, state and municipality governments were reviewed in order to collect all the GHG mitigation actions.

Most annual official reports published by the different states and by the federal government were reviewed in order to collect all the mitigation activities performed in Mexico from 2009 to 2012 [11].

Although in Mexico several information instruments has been implemented such as the Information System of Special Climate Change Program (SIAT-PECC) [12], independent assessment of PECC, as well as the published, state government annual reports from 2009 to 2013, were reviewed. In general the information is incomplete and dispersed since there are no evidences on the methodology of initial or final estimations of PECC and CDM projects, in addition, most of the information related to 2012 has not been published yet. Then, several reports and personal communications from the Ministry of Environment that had the information were consulted; in the case of state government actions, the estimations of reduced CO_2eq were performed following the IPCC protocols.

As there is no information about most of the investment to conduct mitigation actions, the GHG reduction costs were determined using three studies carried out in Mexico and interpolating the data, so, these costs represent only a first approximation.

The first study was performed by McKinsey & Company in 2009 and contains an abatement cost curve for GHG reductions to 2030 [13]. The second study, known as MEDEC is related with de carbon emission reduction [14]. The third one was published by the National Institute of Ecology with the aim to know the GHG reduction potential by 2020 [15].

III. Results and Discussion

Total reductions of GHG are presented in Fig. 2, showing that most emissions reductions are due to PECC actions. Further, it is important to clarify that some of the Clean Development Mechanism projects are included in PECC, especially those related to Wastes. In the same way, several of the actions carried out in the states are considered in PECC as federal measures, and they were not included in order to avoid duplicating the results.

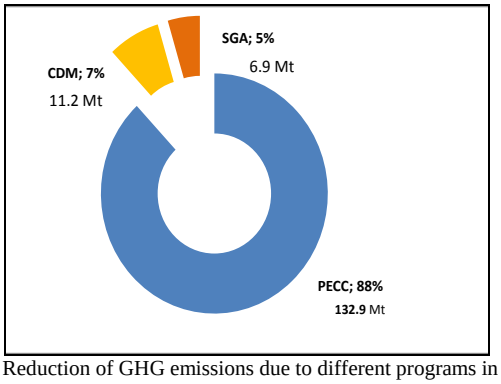

Fig. 2. Reduction of GHG emissions due to different programs in Mt of CO_2eq during 2009-2012.

The cost reduction for PECC was 1787 million euros, whereas for CDM and SGA the savings or profits were -116 and -441 million euros, respectively.

A. Results of Mitigation Actions due to PECC (2009-2012)

The Energy Sector had the greater contribution with 55% of mitigation achievements through this program, AFOLU had 42% and the Wastes sector had a very small contribution of 3%.

Table II shows the results of reductions and their respective costs reported for PECC per year and per sector, where the Energy sector has the greater contribution, with more than 70% of mitigation achievements through this program, but also with the highest costs; although the Wastes sector had a very small contribution, it presented net savings or profits.

As a summary of the reductions accomplished by PECC, the total was 132.86 Mt CO_2eq that in comparison with the original goal of 129.03, it exceeded 3%. The actions relating to Energy, attained the 99.4% of the original goal of 73.99 Mt CO_2eq, the AFOLU sector surpassed the objective of 46.5 Mt CO_2eq, with a total reduction of 55 Mt CO_2eq (an extra 18%); conversely, the Wastes sector only completed 51.3% of the original goal of 8.58 Mt CO_2eq, achieving only 4.4 Mt CO_2eq.

TABLE II: GHG REDUCTIONS (MT CO_2EQ) AND COSTS (MILLION EUROS) FOR PECC 2009-2012

Year	ENERGY		AFOLU		WASTES		TOTAL	
	Red	Cost	Red	Cost	Red	Cost	Red	Cost
2009	8.3	60.6	6	79	0.7	-26.3	**15**	**113.3**
2010	12.4	82.37	7.7	105.7	1.1	-41.6	**21.3**	**146.4**
2011	22	241.8	17.7	333	1.1	-39.4	**40.7**	**535.4**
2012	30.7	648.8	23.6	400.1	1.5	-57.4	**55.9**	**991.5**
Total	**73.5**	**1034**	**55**	**917.8**	**4.4**	**-165**	**133**	**1787**

Red=reduction

B. Results of Mitigation Actions Due to the Clean Development Mechanisms

TABLE III: GHG REDUCTIONS (MT CO_2EQ) AND COSTS (MILLION EUROS) FOR CDM 2009-2012

Year	ENERGY		AFOLU		WASTES		TOTAL	
	Red	Cost	Red	Cost	Red	Cost	Red	Cost
2009	2.4	2.4	0.6	-41.7	0.01	0.19	3.0	-39.2
2010	2.6	1.7	0.7	-45.2	0.01	0.1	3.3	-43.5
2011	2.5	1.1	0.5	-31.0	0.0	0.0	3.0	-29.9
2012	1.9	2.8	0.1	-6.2	0.0	0.0	2.0	-3.4
Total	**9.4**	**7.9**	**1.8**	**-124**	**0.01**	**0.3**	**11.2**	**-116**

Red=reduction

Mexico has a total of 178 CDM projects registered in the Kyoto Protocol. During the period from 2009 to 2012, 27 projects received Emissions Reduction Certificates. The Energy sector contributed again with the greater reductions of GHG followed by AFOLU, although as reported before, most of the CDM related to Wastes Management, which had an important contribution, were accounted in PECC, since they were federal actions. Table III displays the GHG reductions as well the estimated costs of these mitigation actions, of which their reductions correspond to 61 projects, which are independent of PECC. Nowadays Mexico had the fourth largest number of projects registered and the fifth largest number of certificates obtained by the expected reductions of projects registered at international level.

Some of the costs are negative since they represent a net saving or profits. That is the case of the AFOLU sector with around 124 million euros as net savings or profits, mainly due to some projects in animal wastes treatment. For the Energy sector, the total profits were 116 million euros.

C. Results of Mitigation Actions due to State Government Actions

The measures and actions conducted by the state governments had their most important reduction of GHG emissions in the Energy sector with the 93%. The other 7% corresponds to mitigation actions in the Wastes sector since AFOLU was not included due to they were accounted in the PECC actions or in the CDM projects, whereby the total reduction of SGA is the lowest of the three kind of programs, is important to consider than the information of the 32 states is not uniform for all of them, and maybe some actions have not been reported.

GHG emission reductions and costs of SGA are presented in Table IV where it is observed that all the implemented actions produced net savings or profits with more of 400 million of euros.

TABLE IV: GHG REDUCTIONS (MT CO_2EQ) AND COSTS (MILLION OF EUROS) FOR SGA 2009-2012

Year	ENERGY		WASTES		TOTAL	
	Red	Cost	Red	Cost	Red	Cost
2009	1.7	-117.9	0.0	0.0	1.7	-118.0
2010	1.8	-124.5	0.1	-1.8	1.9	-126.3
2011	1.7	-105.4	0.1	-2.9	1.9	-108.3
2012	1.3	-84.5	0.2	-3.9	1.5	-88.4
Total	**6.4**	**-432.3**	**0.5**	**-8.7**	**6.9**	**-441.0**

Red=reduction

D. Reductions of GHG Emissions by Sector

The total reduction of GHG emissions by the different sectors is presented in Fig. 3, where, as has been shown previously the Energy sector had the major contribution.

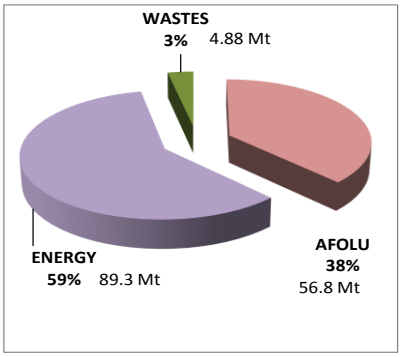

Fig. 3. Reduction of GHG emissions due to different programs in Mt of CO_2eq.

Table V shows the total GHG reductions and costs of the

three kinds of programs, where AFOLU sector had the highest costs followed by Energy. Wastes sector is the only one that in total represents net savings or profits of 173 million of euros.

TABLE V: TOTAL GHG REDUCTIONS (MT CO_2EQ) AND COSTS (MILLIONS OF EUROS) DURING 2009-2012

Year	ENERGY		AFOLU		WASTES		TOTAL	
	Red	Cost	Red	Cost	Red	Cost	Red	Cost
2009	12	-55	7	37	1	-26	20	-44
2010	17	-40	8	60	1	-43	26	-23
2011	26	137	18	302	1	-42	46	397
2012	34	567	24	394	2	-61	59	900
Total	**89**	**609**	**57**	**794**	**5**	**-173**	**151**	**1230**

Red=reduction

1) Power generation

The greatest contribution to GHG emissions reduction through power generation was due to the first goal of the PECC, consisting in "Reducing gas flaring from the Cantarell oil producing well through sour gas reinjection" in the state of Campeche, this goal of 27.60 Mt CO_2eq (2009 - 2012); 6.90 Mt CO_2eq/year (in 2012), was not only met but it was duplicated in 2012, although it had also the highest cost of all the conducted actions. More than 1.7 Mt CO_2eq/year reductions were achieved through operative and thermic efficiency, as well as energy saving plans in several refineries' boilers. More than 1,090 projects related with energy efficiency and use of renewable energy in agriculture, livestock and fisheries could reduce 0.52 Mt CO_2eq/year. Furthermore, promoting the use of renewable energy only reached 0.88 Mt of CO_2eq/year, corresponding to 24% of this goal. No progress is reported in actions related to the increase of power generation with geothermal, solar and wind farms: the same situation is observed for the PECC ́s goals related with gas co-generation, and the construction of La Yesca hydroelectric Plant and Manzanillo thermoelectric plant, although the constructions are in progress and soon they will be finished.

PEMEX, the Mexican Petroleum industry has registered several CDM projects in order to increase the thermic effectiveness, such as energetic recovery from combustion gases in the dehydration process of Maya crude oil, as well as the use of heat recovery technologies from the turbo machine exhausts with a reduction potential of 0.53 Mt CO_2eq.

States such as Oaxaca, Tamaulipas, San Luis Potos ́ı, Coahuila and Nuevo Le ́on registered CDM projects related with the generation of Eolic energy, whereas Puebla registered one for geothermic energy generation.

The future of mitigation actions in the energy sector are uncertain as the new energetic reform suggests that exploitation and exploration of oil will increase by large proportions, leaving behind the small efforts of power generation from renewable sources and privileging again the fossil fuels.

2) Energy use

The PECC ́s goal linked with the renovation of federal vehicular fleet over 10 years was met and exceeded with 1.28 Mt CO_2eq/year, other goals with interesting reductions are linked to savings in municipalities as well as with installation of thousands of efficient stoves instead of open fires in the rural households: other goals that reached more than 50% and completed the reduction of around 3 Mt CO_2eq are associated with the improvements of freight transportation, voluntary removal of shrimp boats, refrigerators replacement, credits for new homes with eco-technologies and energy savings in federal buildings. Goals that reported no progress were savings in gasoline and diesel consumption and the increasing use of railroad. Some laws considered in the PECC will contribute to energy savings in the next years, for instance the lighting efficiency law and the efficiency standard for light vehicles.

The Federal District, Mexico State and Hidalgo registered CDM projects related with the introduction of bus rapid transit (BRT) as Clean Public Transport. Puebla, Yucatan and Jalisco, among other states registered also several projects for the use of biomass as fuel.

Related with SGA, the most important cities of the country according with the Clean Transport Initiative, replaced public transport units and new buses with low environmental impact technology that were put in operation. In addition, all the states with PEACCS established state programs for energy savings in public facilities and invested in street lightening by no conventional techniques. In general programs such as energy efficiency in pumping and water treatment systems, sustainable households, and renewable energy were carried out, among others.

3) Agriculture, forestry and other land use (AFOLU)

This category exceeded about 20% the PECC ́s committed reduction of 15.3 Mt CO_2eq. In livestock (management of grazing lands) and forestry the progress exceeded up to 176% and 115% with respect to the goals set. The goals linked with environmental forestry management and payment of environmental management contributed with more than 80% of the mitigation commitment in this sector. More than 3 million ha were incorporated (4.99 Mt CO_2eq) to the conservation and utilization of forest resources and more than 8 million ha were converted from agriculture to forest use. In Agriculture, the progress was 61% of the 2012 goal, whereas more than 1 million ha have been decreed protected areas. The forest conservation and restoration included as a PECC ́s goal promote a reduction of 72 Mt CO_2eq/year and reforestation projects in the country with around 50% progress.

The quantification of reductions due to the application of bio-fertilizers or the progress by REDD+ or by Carbon Market is not clear and has not been well established.

The most important CDM projects in this sector were those related with manure management where 68 projects in the whole country were registered. The estimated reduction during the period was 8.54 Mt CO_2eq and the states with more projects were Sonora, Jalisco and Coahuila.

Regarding SGA, most of the states implemented many reforestation actions, improvement of agriculture practices, forest fires prevention, and sustainable forestry production chains, among others.

4) Wastes

The evolvement in this category is the lowest of the PECC actions, since from the three goals linked to this sector, only

one has a small progress (19.2%) throughout the implementation of methane capture mechanisms in 11 landfills: Ciudad Juárez, Mérida, Monterrey, Morelos, Cancún, León, Culiacán, Puebla, Tecámac, and Durango. Although the implementations of wastewater treatment plants in Hidalgo, as well as two other plants in Jalisco were planned by the end of 2012, they are still in construction. These plants will represent an important reduction of methane fugitive emissions, and the biogas will be used for power production.

28 CDM projects were registered related with the manure management in wastewater, most of them in Veracruz; 10 CDM projects of methane use in landfills were carried out in Mexico State, Nuevo León and Jalisco.

Most of the state government actions are related to the improvement of municipal solid waste management.

E. Effectiveness of GHG Reduction Programs

Table VI displays the compendium of the goals and compliance as well as their effectiveness by millions of euros/ $MtCO_2eq$. As was discussed before the PECC has the highest costs whereas the state government actions the best economic benefice. The Federal District was the state with the highest effectiveness with -55.8 million of euros/ Mt CO_2eq, followed by Nuevo Leon with -3.9 million of euros/ Mt CO_2eq.

TABLE VI: SUMMARY OF GOALS (MT CO_2EQ), RESULTS (MT CO_2EQ), AND EFFECTIVENESS (MILLIONS OF EUROS/(MT CO_2EQ) OF GHG REDUCTIONS IN MÉXICO DURING 2009-2012, BY PROGRAM AND SECTOR

Sector	PECC				CDM including PECC				SGA without PECC			
	Goal	Result	%	Effectiveness	Goal	Results	%	Effectiveness	Goal	Results	%	Effectiveness
Energy	74.0	73.5	99.4	14.1	13.1	9.40	71.9	0.84	11.5	6.4	55.7	-67.3
AFOLU	46.5	55.0	118.3	16.7	8.5	1.82	21.2	-68.2	2.12	--	--	--
Wastes	8.6	4.4	51.3	-37.4	1.1	0.01	0.9	28.0	10.3	0.5	4.7	-18.1
Total	**129**	**132.9**	**103.0**	**13.4**	**22.7**	**11.2**	**49.4**	**-10.3**	**23.9**	**6.9**	**28.9**	**-63.8**

The GHG reductions in the states are mainly in the Energy sector by the use of renewable energies and energy efficiency actions, such as the modernization of public transport and renewal of vehicle fleet.

IV. CONCLUSIONS

The implementation of the Special Program to face Climate Change (PECC) achieved around 88% of the GHG reductions from 2009 to 2012. The most important contributor was the Energy Sector followed by AFOLU, however these actions represented important costs. In opposite, although wastes sector contributed only with the 3% of PECC reductions, significant profits and savings were obtained showing the importance to support new actions in this sector to increase GHG reductions in this sector.

Despite contribution to GHG reductions due to CDM and SGA were lower than obtained by PECC, results showed that those actions represent an economic opportunity for private and public sector, and then they should be promoted.

Mexico has implemented programs to reduce GHG emissions recording significant progress; nevertheless, we did not find evidence that the GHG mitigation efforts may have been sufficient to fulfill the reduction committed, of special concern is that Mexican government has continued privileging the extraction and use of fossil fuels and the new energy reform passed recently through the senate upholds this situation.

ACKNOWLEDGMENTS

The authors thank CONACYT for the support to the Project 181231 and for the student scholarship given to Leticia Ramos.

REFERENCES

[1] S. V. V. Raman, S. Iniyan, and R. Goic, "A review of climate change, mitigation and adaptation," *Renewable and Sustainable Energy Reviews*, vol. 16, pp. 878-897, January 2010.
[2] K. Nibleus and R. Lundin, "Climate change and mitigation," *Ambio*, vol. 39, pp. 11-17, July 2010.
[3] INE, *National Greenhouse Gases Inventory*, 2010.
[4] SEMARNAT, "Inter-Ministerial Climate Change Commission," Special Climate Change Program Progress Report 2009-2012, Mexico, 2011.
[5] UNEP, *Annual Report of United Nations Environment Program*, 2012.
[6] L. Ramos, V. Mugica, A. Hernández, M. Torres, and J. Figueroa, "Assessment of climate change mitigation actions in Mexico," in *Proc. 106th AWMA Annual Conference & Exhibition*., Chicago, USA, 2013.
[7] PECC, *The Climate Change Special Program 2009-2012*, Mexico, 2009.
[8] SEMARNAT, *5 National Communication to the UNFCCC United Nations on Climate Change*, 2012.
[9] CDM. (2013). Proyectos MDL. [Online]. Available: http://cdm.unfccc.int/Projects/projsearch.html
[10] State Government National Reports 2009-2012, 2013.
[11] SEMARNAT, Special Climate Change Program Progress Report 2009-2012, Mexico, 2013.
[12] SIAT-PECC, *Information System for a Cross-Cutting Agenda, Component of the Special Climate Change Program*, 2010.
[13] McKinsey & Company, *Routes to a Low Carbon Economy, and Global Costs Curve for GHG Reduction*, 2009.
[14] M. Todd, C. Alatorre, Z. Romo, and F. Liu, *México Medec: Study about Carbon Emission Reductions/Estudio Sobre La Disminución De Emisiones De Carbono*, 2009.
[15] INE, *Potential Mitigation of Greenhouse Gases in Mexico to 2020 in the International Cooperation Context*, 2010.

Violeta Mugica-Alvarez was born in Mexico City. She is a chemist for the Universidad Nacional Autónoma de México (UNAM). She has a master degree and a PhD degree in environmental engineering, which also from the UNAM.

She is a full time professor at the Universidad Autónoma Metropolitana and is the coordinator of the

master degree in science and environmental engineering.

Dr. Mugica has carried out research related to air and soil pollution, and related to the control and prevention of environmental pollution and emission of greenhouse gases. She is the author of more than 40 papers published in International Journals, several book chapters in the field of environmental Sciences, mainly in air and soil pollution. She has participated in more than one hundred national and international conferences.

Dr. Mugica has been a consultant of the Environment Ministry and of the United Nation Development Program for the assessment of the Actions to prevent air pollution in Mexico City and for the assessment of adaptation actions to face climatic change. She is a member of the National System od Researchers (SNI) at level two, which is a distinction that awards for Mexican researchers.

Leticia Ramos-Guillén was born in Guanajuato, Mexico. She is a chemical engineer from the University of Guanajuato, México. She got a master degree in environmental science and engineering from the Universidad Autónoma Metropolitana-Azcapotzalco in 2014.

She is a member of the Air Waste Management Association where recently presented a paper about Mitigation actions. She has experience as a chemical engineering in the industry where she worked by 6 years as a process engineer. She has worked in the Public Sector in the management and assessment of climate change programs.

Jesús Figueroa Lara was born in Mexico City. He is a chemical engineer by the National Polytechnic Institute and he has a master degree in chemical engineering from Manhattan University. He is a professor of the Universidad Autónoma Metropolitana-Azcapotzalco.

Professor Figueroa has several indexed papers related with prevention and control of environmental pollution. He has constructed several devices for measurements of emission factors of gases and particles and for the clean production of chemical productos.

Mr. Figueroa has participated in studies related to adaptation and mitigation actions and their assessment in governmental programs.

Miguel Torres-Rodríguez was born in Mexico City. He is a chemical engineer and received his master degree from the National Polytechnic Institute and his PhD degree in process engineering in 1993 from Claude Bernard University in Lyon France. He is a full time professor in the Universidad Autonoma Metropolitana-Azcapotzalco. His research interest has been addressed in the synthesis, characterization and application of materials in environmental catalysis. He has been a visitor professor during his sabatic periods in the Institute de Recherches sur la Catalyse in Lyon France in 2006 and in the Universidad Federal do Rio Grande do Norte, Brasil in 2011. Dr. Torres is member of Mexican Academy of Catalysis, ACAT and member of the Mexican Membrane society.

Dr. Torres is the author of more than 30 papers published in Indexed Journals related to materials applied to the environment as well as related to environmental quality. He is a member of the National System od Researchers (SNI) at level two.