BASE SCENARIO FOR THE EMISSION OF GREENHOUSE GASES BY 2030 IN THE STATE

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UNDER 2°

SECRETARIAT THE °CLIMATE GROUP

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The collaboration with The Climate Group aims and impulses the corporation of mitigation strategies into the State Action Plan of of the State of Colima, and showcases the policy framework towards 2050 to avoid dangerous climate change.

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Executive summary

The State of Colima is one of the thirty-one states of Mexico. With 0.3% of the Mexican territory, 5,627 km^2 make it the fourth smallest state in the country.

Colima has one of the most important ports in the country, where large quantities of goods are mobilized internationally. It has installed up to 2,700 MW for power generation and has multiple protected natural areas and 123 endemic animal species, of which at least 5 are endemic to the state.

In order to continue improving the state and guarantee a good quality of life for the more than 711 thousand citizens, the government, in its three orders, has been working on different projects related to the environment. One of them is the conservation and creation of carbon sinks with actions such as reforestation. Last year, 72,070 trees were planted in coordination with the National Forestry Commission of Mexico and the State of Colima; there were protected 22,468 hectares of continental natural areas; and it was established a biotic-cultural corridor that connects 14.5 million hectares of land to preserve species from different states of the central-western region.

A second action was the creation of the Law of Mitigation and Adaptation to the effects of climate change for the State of Colima, which provides the basis for the development of programs and strategies focused on reducing the vulnerability of economic activities, natural areas and society facing climate change.

In addition, the state government is working to achieve sustainable transport. In 2018, the Sustainable Mobility Law of the State of Colima was approved, which establishes a way to promote the use of cleaner technologies in the public and private sectors, without motorized and with ecological means of transport. With this, there are already 3 new cycle paths that are the beginning of a 324.62 km cycle path network. Along with its action, 180 efficient taxis were introduced last year to reduce pollutant emissions, and last year 2 new buses were tested to introduce low-carbon units for collective public transport.

Last year, with the help of The Under2 Coalition Future Fund, the government of the State of Colima updated the Inventory of Greenhouse Gases of the state of Colima to base year 2015. It contains the estimation of anthropogenic GHG emissions and the absorption by the sinks in the State, this disclosed the sectors with the highest GHG emissions.

As part of the Under2 Coalition and human beings, mitigation in the most polluting sectors is a priority, and needs to be supported by projects at medium and long term. In this sense, in this project, the need to have an emissions baseline that provides a broader vision of emissions growth in the most important sectors at current rate, which will help to identify the best mitigation of GHG emissions actions.

The inventory will provide a baseline and the contribution of each sector which is a fundamental tool in the development of the Climate Change Action Program (PEACC). The State of Colima aims to develop the PEACC, which is a solid tool that serves as a planning instrument and is a guide for state policy on climate change with scope, projections and forecasts in the medium and long term.

As a result of this project, the energy and land and vegetation use sectors were recalculated, considering that to compare the developed years they must have the same methodology.

The results obtained from the recalculation are observed in Chart 1, where the previous results and those that were recalculated for the development of the emission scenario are presented. Where CO_2e emissions increased by 12% due to the use of CO_2 emission factors in Mexico and considering black carbon.

Chart 1. Results of the 2005 and 2015 recalculation (Gg / year).

SECTOR	SUBCATEGORY	Calculation 2005				Recalculation 2005				
		CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	Black carbon	CO_2e
Energy	Electric generation	7,174.10	0.28	0.06	7,197.18	7,364.12	0.28	0.06	0.43	7,776
	Manufacturing and construction industries	578.69	0.06	0.01	583.07	463.16	0.06	0.01	0.68	1,077
	Residential	230.37	0.35	0.00	239.13	223.68	0.35	-	0.08	306
	Comercial	21.10	0.00	0.00	21.16	20.85	0.00	0.00	0.00	22
	Farming	11.63	0.00	0.00	11.69	10.67	0.00	0.00	0.01	18
	Navigation	377.72	0.03	0.01	381.49	84.70	0.01	0.00	0.04	118
	Railways	0.28	0.00	0.00	0.31	0.27	0.00	0.00	0.00	3
	Aviation	0.78	0.00	0.00	0.79	0.78	0.00	0.00	0.00	1
	Motor transport	857.80	0.26	0.11	897.44	1,211.46	0.15	0.05	0.06	1,281
	Total	**9,252.47**	**0.99**	**0.19**	**9,332.26**	**9,379.69**	**0.85**	**0.12**	**1.30**	**10,602**
Land Use	Period 1993-2005 Period of recalculation 1993-2007	52.30				706				
	Total	52.30				**706**				

Regarding the development of the emission scenarios, the GAINS model for the sectors of energy, industrial processes and use of products, wastes and agriculture was considered; The TerrSet model (Geospatial Monitoring and Modeling Software, for its acronym in English) was used for the land and vegetation change sector.

Two emission scenarios of the energy, industrial processes and product, waste and agriculture sectors were obtained, it is presented in Figure 1. While the scenario of change in land and vegetation use is presented in Figure 2.

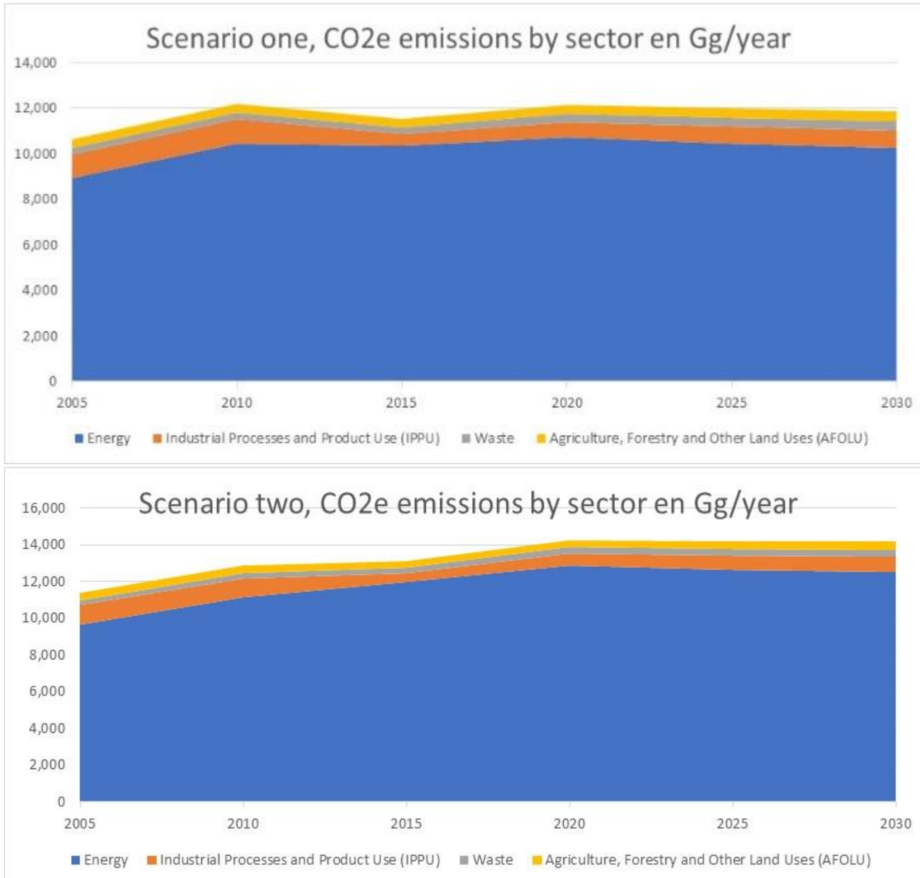

Figure 1. Scenario one and two, CO_2e emissions in Gg / year, by sector for the state of Colima 2005 to 2030.

The scenario for the change of land use in the period from 1993 to 2030 is presented in Figure 2. The approach of the scenario begins in 1993 and not in 2005, this is because the change in land use must consider at least five years before from the base year.

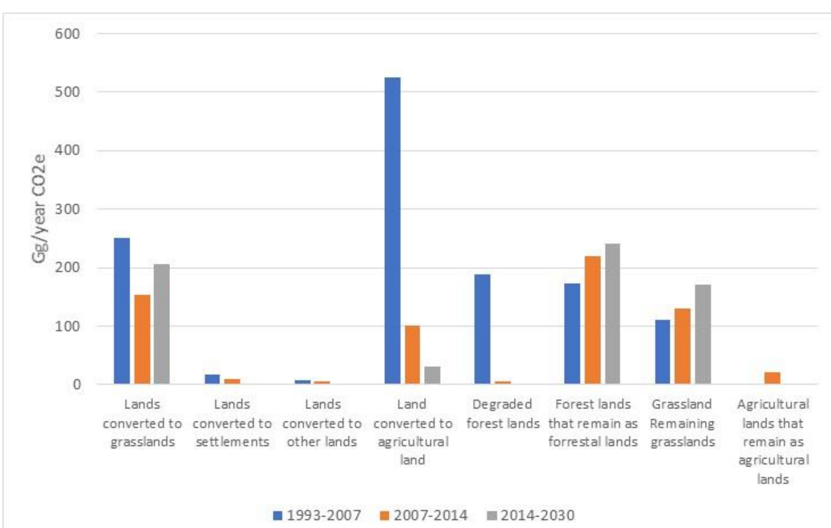

Figure 2. Results for 1993 to 2030 of CO2e due to change in land and vegetation use for the state of Colima (Gg / year).

Acronym summary

By its meaning in English

FAOSTAT	Food and Agriculture Organization of the United Nations Statistics
IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
UN Environment	United Nations Environment Program
WMO	World Meteorological Organization

By its meaning in Spanish

CANACEM	National Chamber of Cement Cámara Nacional del Cemento
CECYTCOL	State Council of Science and Technology of the State of Colima Consejo Estatal de Ciencia y Tecnología del Estado de Colima
CFE	Federal Electricity Commission Comisión Federal de Electricidad
CINPRO	Project Engineering Consulting Consultoría en Ingeniería de Proyectos
COA	Annual Operating Form Cédula de Operación Annual
CONAFOR	National Forestry Commission Comisión Nacional Forestal
CONAGUA	National Water Comission Comisión Nacional del Agua
CONAPO	National Population Council Comisión Nacional de Población
CRE	Energy Regulatory Commission Comisión Reguladora de Energía
DENUE	National Statistical Directory of Economic Units Directorio Estadístico Nacional de Unidades Económicas
IMADES	Institute for the Environment and Sustainable Development of the State of Colima Instituto para el Medio Ambiente y Desarrollo Sustentable del Estado de Colima
INECC	National Institute of Ecology and Climate Change Instituto Nacional de Ecología y Cambio Climático

INEGEI	National Inventory of Greenhouse Gas Emissions Inventario Nacional de Emisiones de Gases y Compuestos de Efecto Invernadero
INEGI	National Institute of Statistics and Geography Instituto Nacional de Estadística y Geografía
INFOMEX (PNT)	National Transparency Platform Plataforma Nacional de Transparencia
OEIDRUS	State Information Office for Sustainable Rural Development Oficina Estatal de Información para el Desarrollo Rural Sustentable
SAGARPA	Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación
SCT	Ministry of Communications and Transportation Secretaría de Comunicaciones y Transporte
SEDER	Ministry of Rural Development of the State of Colima Secretaría de Desarrollo Rural del Estado de Colima
SEMARNAT	Ministry of Environment and Natural Resources Secretaría de Medio Ambiente y Recursos Naturales
SEMOV	Secretariat of Mobility of the State of Colima Secretaría de Movilidad del Estado de Colima
SENER	Ministry of Energy Secretaría de Energía
SIAP	Agrifood and Fisheries Information Service Servicio de Información Agroalimentaria y Pesquera
SIE	Energy Information System Sistema de Información Energética

Summary

Introduction

Climate change is the great challenge that we, as living beings, will have to confront in the present century. It is a result of the social dysfunction that arises between the human-nature relationship. While global warming only refers to surface temperature increases, climate change includes all aspects on which these warming influences weather events and nature processes. The evidence is based on observations of rising air and ocean temperatures, melting ice and glaciers worldwide and rising sea levels worldwide.

The effects of climate change are indisputable: temperatures are rising worldwide; 11 of the last 12 years have been the hottest years since 1850. The average temperature increase in the last 50 years is almost double of the last 100 years, and the average global temperature increased 0.74 ° C during the 20th century (IPCC, 2007).

The problem of climate change can be analyzed from the perspective of risk, considering both: the natural hazards of weather and climate and the factors that generate vulnerability to these conditions. It is through the understanding of risk that disasters, misnamed "natural", must be analyzed beyond the naturalist paradigm (INECC-PENUD, 2012). In this context, it is clear that global climate change requires risk management, reducing the danger through adequate mitigation of greenhouse gases (GHG), as well as through adaptation, reducing vulnerability factors built by society. In communion, mitigation and adaptation are forms of risk management that countries aspire to achieve to confront one of the greatest environmental problems of the present century.

The State Programs of Action against Climate Change (PEACC), constitute an opportunity to build a more prepared society in the face of the current changing climate and the adverse climate expected in the future. Also, they open the possibility for a society to be more creatively aware of the benefits and services it receives from the environment and, in this way, society will also be able to understand and attend to the commitments they have to conserve it. Much of the effort to create a PEACC is aimed at building a disaster prevention model, both in society, as well as in the economy and the environment. The goals and priorities of state development plans; the state inventory of greenhouse gas (GHG) emissions; and GHG emissions and climate change scenarios at the regional level identify actions and measures to reduce vulnerability to the impacts of climate change, as well as GHG emissions from natural and human systems of interest to the State.

At the state of Colima, four inventories of criteria pollutants have been developed to date, 2005, 2008, 2013 and 2016, which were carried out by SEMARNAT-INECC, as part of the National Emissions Inventory of Mexico (INEM). It should be noted that since the inventory carried out in 2008, Greenhouse Gas (GHG) pollutants were already considered as CO_2, CH_4, N_2O and black carbon, although the calculation methodology is not that of IPCC.

In terms of the GHG emissions inventory, the state of Colima has two: one with base year 2005 and its projection to 2010, carried out in 2013 for the State Climate Change Action Program (PEACC), and another with base year 2015 carried out in 2018 with updated methodologies and emission factors for Mexico. Colima also has the PEACC 2009-2015, which needs to be enhanced with better and more precise information to stand to the guidelines from the National Institute of Ecology and Climate Change.

This project focuses on the construction of the GHG emission base scenario, deriving from this the need to recalculate inventories prior to 2015 to make them comparable. These measures aim to generate strategic knowledge which can be used to develop accurate and effective mitigation actions in the State of Colima.

Objective

Develop the base scenarios for the emission of greenhouse gases and compounds by 2030 in the State of Colima.

Specific objectives

1) Update or recalculate the inventory of greenhouse gas emissions for the State of Colima base year 2005, in the sectors where the methodology has been changed or where there is new or better information.
2) Estimate the base scenarios of the sectors: Energy, Industrial processes and product use (IPPU), Waste and Agriculture, forestry and other land uses (AFOLU), 2030 for greenhouse gases and compounds.

Scope

The scope of this project considers the recalculation of the 2005 inventory, in the sectors and sub-sectors where comparing methodologies are different.

Also, it considers the modeling of scenarios that should be done based on the inventories 2005 and 2015, and a projection to 2030 by sector and subsector.

Methodology

The greenhouse gases to be estimated are those considered in the National GHG Inventory, which correspond to what is stated in the IPCC 2006 guidelines, plus black carbon:

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Nitrous Oxide (N_2O)
4. Hydroflourocarbons (HFC)
5. Perflourocarbons (PFC)
6. Sulfur hexaflouride (SF_6) y
7. Black carbon
8. As well as carbón dioxide equivalent (CO_2e)

The global warming potentials (GWP) for 100-years, reported in the 5th IPCC Report (IPCC, 2007), will be used for each greenhouse gas.

The following activities will be carried out for the development of this project.

Collection, search and integration of information

With the support of the Institute for the Environment and Sustainable Development of the State of Colima (IMADES), the necessary information was obtained for the development of the project, through the consultancy of useful information available on the internet from corresponding agencies and institutions.

To perform the scenarios and recalculation of the inventory, information was collected from:

a. GHG inventories 2005 and 2015 (databases and reports), provided by IMADES.
b. Information on key variables for the projection of scenarios for the entire period 2005 to 2030 (population, gross domestic product (GDP), energy intensity, number of homes with and without energy, characteristics of the homes, etc.).
c. Specific emission factors for Mexico for the appropriate recalculation of certain subsectors of the Colima GHG Inventory base year 2005.

Recalculation of the GHG Emissions Inventory of the 2005 base year in accordance with the guidelines of the Intergovernmental Panel on Climate Change 2006

In order to have a baseline scenario that reflects more precise conditions and aspects, it is necessary to start with the recalculation of the Inventory of Emissions of Greenhouse Gases of the State of Colima base year 2005; this considering that the State has an inventory base year 2005 and a 2015 with different methodologies in certain sectors.

The methodology used was that of the Intergovernmental Panel on Climate Change (IPCC) 2006. The most common simple methodological approach is to combine information on the extent to which a human activity takes place (called activity data or AD) with the coefficients that quantify the emissions or removals per unit of activity, they are called emission factors (EF, of Emission Factors). Therefore, the basic equation is:

$$Emissions = AD \times EF \qquad \text{Equation 1}$$

The recalculated sectors were carried out based on the methodology established in the Intergovernmental Panel on Climate Change (IPCC, 2006). The sectors for which this recalculation was carried out are: Energy (transport, energy industry, manufacturing and construction industries and other sectors), and AFOLU.

Chart 2. Emission factors used in the calculation of the Inventory (Kg/Tj).

Subcategory	CO_2	CH_4	N_2O
Energy generation, Manufacturing and construction industry			
Fuel oil	79,450	3	0.6
Diesel	72,881	3	0.6
LP gas	65,083	1	0.1
Natural gas	57,756	1	0.1
Kerosene	71,900	10	0.6
Biogas	54,600	1	0.1
Petroleum coke	78,991	3	0.6
Residential, commercial and agricultural			
Kerosene	71,900	10	0.6
LP gas	65,083	5	0.1
Natural gas	57,756	5	0.1
Wood	103,237	300	4
Diesel	72,881	10	0.6
Railways			
Diesel	72,881	4.15	28.6
Maritime			
Diesel	72,881	7	2
Ground transportation			
Gasoline, diesel, natural gas, LP gas	Emission factors generated by the MOVES Mexico model by type of vehicle and model year (See Annex)		
Aviation			
Turbosina, gas plane	EDMS Model		

Source: INECC-IMP, 2014; IPCC, 2006.

The emission factors used for the estimation of greenhouse gases were, for carbon dioxide (CO_2), those generated for Mexico (INECC-IMP, 2014) for the different fuels; in the case of CH_4 and N_2O they were the default of the Intergovernmental Panel on Climate Change (IPCC, 2006) (Chart 2). In the case of land transport (motor transport) the emission factors used were by type of vehicle and model year generated through modeling with MOVES Mexico for this inventory and the EDMS model for aviation.

The calorific powers used in this inventory, obtained from the 2015 National Energy Balance reported by SENER (Chart 3), are shown below. The units in which fuel consumption was reported were converted to Terajoules (TJ) for the application of emission factors.

Chart 3. Calorific value of the fuels used

Fuel	Calorific value	Units
LP gas	4,124	MJ/bl
Natural gas	38,268	KJ/m^3
kerosene or turbosine	5,881	MJ/bl
Gasolina	5,176	MJ/bl
Combustóleo	6,531	MJ/bl
Diésel	6,294	MJ/bl
Coque de petróleo	32,658	MJ/ton
Leña	14,486	MJ/ton
Biogás	19.93	MJ/m^3

Source: SENER, 2016a

The determination of the equivalent carbon dioxide (CO_2e) emissions was carried out by quantifying CO_2, CH_4, N_2O, HCFC-141b, HCFC-22, SF_6 and black carbon emitted taking into account global warming potentials (GWP) acronym in English) of each of the greenhouse gases for 100 years reported in the 5th IPCC Report. Chart 4 shows the GWP used to calculate the equivalent CO_2 emissions (CO_2e).

Chart 4. Global Warming Potentials of Greenhouse Gases.

Gas	GWP for 100 years
CO_2	1
CH_4	28
N_2O	265
HCFC-141b	725
HCFC-22	1,810
SF_6	23,500
Black carbon	900

Source: https://www.ipcc.ch/publications_and_data/ar4/wg1/es/tssts-2-5.html

It is worth mentioning that the recalculation of the 2005 inventory also changed the global warming potential considered, since the IPCC makes periodic reviews and there is an update. Another important point to mention is the addition of the calculation of black carbon for the year 2005.

Each sector is described below:

1. Energy sector

Energy industry, Manufacturing and construction industries and Other Sectors

These subcategories for both inventories were calculated with activity data from similar sources of information, which varied was the use of emission factors in the calculation, since in 2015 there were specific CO_2 emission factors for Mexico, so It was necessary to recalculate the 2005 inventory emissions using these factors and not the global IPCC.

In addition, black carbon was calculated in 2005 in all these categories.

Ground Transportation or Auto Transport

This subcategory was calculated in the base year 2005 with the Mobile 6.2 Mexico model, which does not make it comparable to 2015 using MOVES-Mexico and the scenarios could not be performed by 2030, in this sense it was necessary to calculate with the same model used in 2015. The methodology to follow was as follows:

a. Classification of the vehicle standard base year 2005 state by municipality, model year and vehicle category, according to the MOVES model.
b. Generate inputs to the MOVES model (meteorology, fuel characteristics, vehicular activity, IM programs, etc. for the base year 2005).
c. Run with MOVES to obtain the emission factors of greenhouse gases and compounds at the state level.
d. Calculation of emissions of vehicular origin base year 2005, by municipality and pollutant.

2. AFOLU sector

CONAFOR in 20015, developed emission factors characteristic of the regions of Mexico in the study called "Estimation of carbon stocks in forest biomass in Mexico"; In it, so far estimates for aerial and underground biomass have been developed in all of its transitions. For the rest of the warehouses there is an evaluation of their deposits and construction continues. This differs from what was done for the 2005 inventory where the IPCC 2006 emission factors are used.

The methodology for the 2005 recalculation considers the following changes:

1. To evaluate changes in land use during the analysis period, the change matrix is used to identify the different conditions that can be found, jointly prepared by INEGI-CONAFOR-INECC; said matrix arrangement allows identifying those areas whose primary condition changed to a secondary one, recording a loss of carbon in forest lands.
2. The characteristic emission factors of Mexico determined by CONAFOR in 2015 are designated.

Desarrollo de escenario base (2005-2015-2030)

The Atmospheric Emissions Projections is an environmental prospective exercise through which a possible scenario of evolution of greenhouse gas emissions and atmospheric pollutants is proposed.

The GAIMS 6 model is a widely used tool to integrate air quality and climate planning, which was developed by scientists in close cooperation with decision makers in working groups under the Convention on Long-Range Transboundary Air Pollution (CLRTAP).

GAINS means "Greenhouse gas - Interactions and synergies of air pollution", like LEAP-IBC, GAINS calculates greenhouse gas emissions and air pollutants based on development scenarios, and subsequently quantifies the impacts on health, climate impacts and damage to vegetation due to air pollution.

LEAP-IBC and GAINS are just two examples of integrated climate modeling and air quality frameworks and, while sharing essentially the same objective, they differ in technical aspects, including the ease of use of the interface and the details of the modeling scheme . While both tools are designed for economic planning, an integrated framework to analyze air quality and climate measures and impacts also makes sense at the sector level, for example, in the context of mobility and transport planning.

The construction of the base emission scenario (2005-2015-2030) for the state of Colima, uses the GAINS model; Below is a brief description of its operation:

1. Historical emissions of air pollutants and GHGs are estimated for each country based on international emissions inventories and statistics, as well as contributions from teams of collaborating national experts. Emissions are evaluated in a medium-term time horizon until 2030 with five-year intervals.
2. Critical and critical level load data is compiled exogenously and incorporated into the GAINS modeling framework.

GAINS organizes in three categories for the development of scenarios (baseline and control scenarios):

a. The economic activities that generate emissions are organized in avenues of activity. GAINS divides the activity data into five groups: energy (ENE), mobile sources (MOB), agriculture (AGR), process (PROC).
b. The emission factors and the unit costs of the control technologies, together with all the background information, form the so-called emission vector.
c. The implementation of technology for each activity is specified in the control strategies.

Each emission scenario in GAINS is created through a combination of these three categories of data: activity paths, emission vectors, and control strategies. Each combination determines the level of actual emissions. The data is site specific.

GAINS contains historical data on energy statistics, as well as alternative ways of energy use until 2030 derived from national and international energy projections, for example, scenarios developed for Europe by the PRIMES model, projections of the International Energy Agency, scenarios based on national studies etc. While these data are stored in the GAINS database, they are exogenous entries to GAINS.

GAINS takes into account macroeconomic data such as population and GDP by productive sector (agriculture, industry, power generation, transportation, etc.) for the construction of scenarios.

It should be clarified that the GAINS model was used for the Energy, IPPU, Waste and Agriculture sectors.

For the change of land and vegetation use, the projection of the type of soil generated by cartographic maps was used.

QA / QC procedure (database structure and project documentation)

To count on the quality of the information, the procedure for the recalculation and construction of the scenario of the state of Colima 2005-2015 will be described in Figure 3.

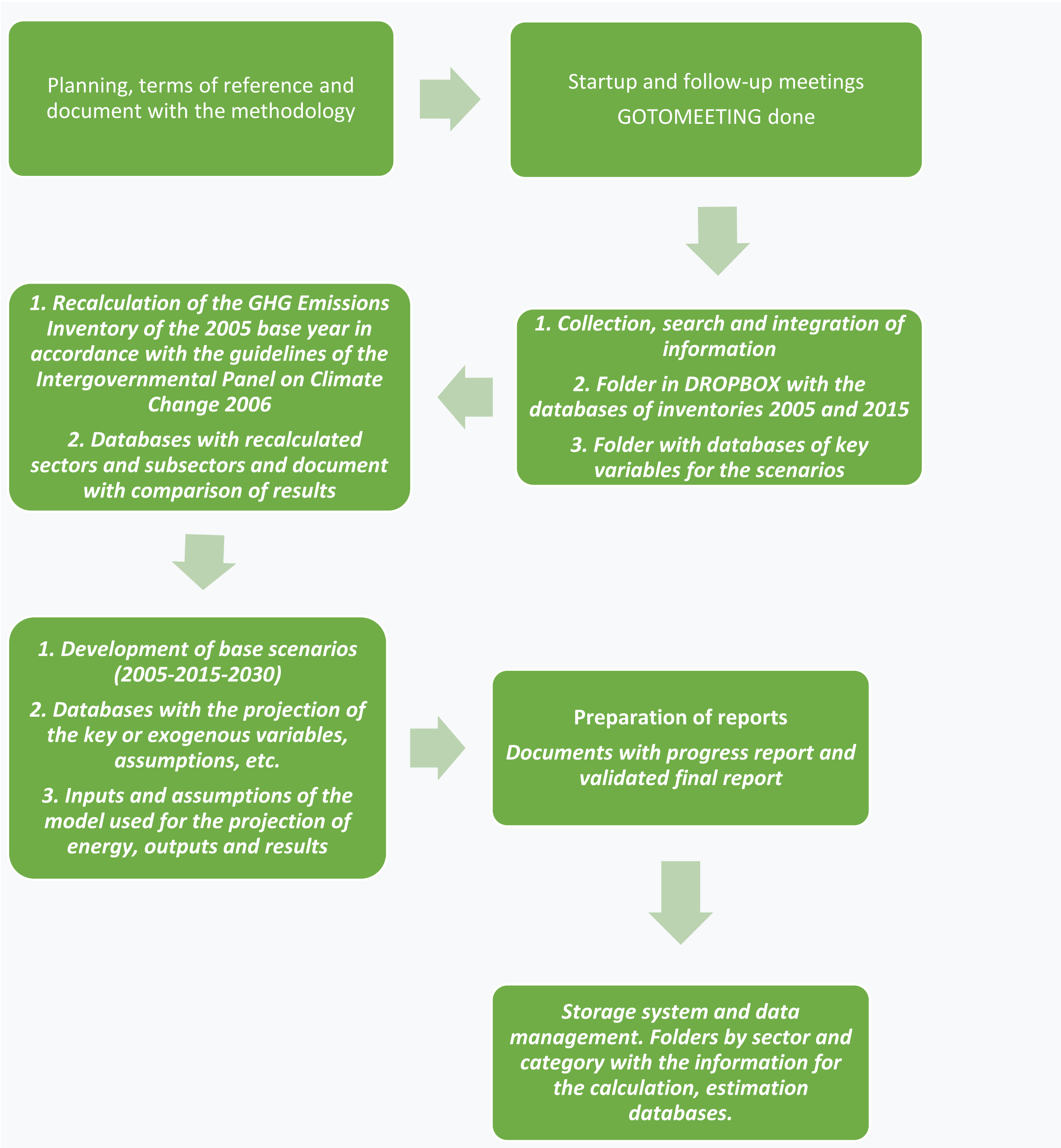

Figure 3. Procedimiento para el recalculo y construcción de los escenarios del Estado de Colima 2005 – 2015-2030.

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Results

Information collected for recalculation

Chart 5 presents the list with the necessary information for the recalculation of the Inventory of Emissions of Greenhouse Gases of the State of Colima, base year 2005. As well as the status of the same, which of it has already been collected.

Chart 5. Information necessary for the recalculation of the GHG emissions inventory in the State of Colima, base year 2005 and its status.

Category	Subcategory	Type of 2005 Inventory Information	Type of 2015 Inventory Information	Source of information	Status
ENERGY	Energy industry	Amount and type of fuel used for electric power generation in 2005, amount of electric power generated in 2005.		SEMARNAT, CRE	Information is available from the 2005 inventory databases.
		IPCC 2006 Emission factors.	Emission factors of Mexico. Calculation of black carbon.	INECC document on CO_2 EF for fuels used in Mexico.	There are the EF, we must calculate the emissions for 2005 with EF of Mexico.
	Energy industry, Manufacturing and construction industries and Other Sectors	Amount and type of fuel used for by sector in 2005.		SEMARNAT, CRE, SENER	Information is available from the 2005 inventory databases.
		IPCC 2006 Emission factors.	Emission factors of Mexico. Calculation of black carbon.	INECC document on CO_2 EF for fuels used in Mexico.	EF are available, we must calculate the emissions for 2005 with EF of Mexico.
	Ground transportation	State vehicle registry by: Municipality, Brand, sub-brand, body, vehicle use, displacement, model year and type of fuel, for 2005.		Secretariat of Planning and Finance	Information is available from the 2005 inventory databases.
		Emission factors generated with Mobile 6.2 Mexico.	Emission factors generated with MOVES- Mexico for Colima base year 2005.	Calculated with MOVES for 2005	Still to calculate the emissions with MOVES EF-Mexico and calculate the emissions
LAND USE	CO_2 emissions due to land use change	State forest inventory, information on land use and vegetation in the state of Colima in different years (twenty years ago). For the calculation of 2005.	Vector data set of the INEGI Series II IV and VI land and vegetation use chart	INEGI, CONAFOR, SEDER	The information of the 2005 inventory databases is available and the corresponding hectares must be

					assigned to the new classification
		IPCC 2006 Emission factors.	Clasificación de uso de suelo y asignación de FE para México.	CONAFOR. 2015, INEGI	The FE is available, emissions must be calculated for 2005.

Information collected for the scenarios

Chart 6 presents the list with the necessary information to carry out the scenarios and projections of GHG emissions 2005-2015-2030 for the different inventory categories.

Currently such information is in the process of being collected.

Chart 6. Information needed for emission scenarios and projections 2005-2015-2030.

Categoría	Tipo de información	Fuente de información
ENERGY	Fuel consumption prospects, prices, technological parameters, technology costs, historical data. Electricity generation and consumption, etc. All for the state of Colima.	SENER CFE INEGI
IPPU	Gross domestic product (GDP), historical and trends for the State of Colima. Production by subcategory for the entity.	INEGI
Waste	Historical generation of urban solid waste and its final disposal. Historical generation of wastewater and its treatment. Population in the current entity, historical and projections.	SEMARNAT IMADES INEGI CONAPO
AFOLU	Gross domestic product (GDP), historical and trends for the State of Colima. Agricultural and livestock production, statistics for the state of Colima. Historical information on land use change in the entity.	INEGI SEDER

Results of the 2005 recalculation

1. Energy sector

Energy industries

For 2005, GHG emissions from the energy industry, which included electricity generation, were recalculated.

Activity Data:

Colima has a combined cycle thermoelectric power plant of the CFE called Thermoelectric CCC Gral. Manuel Álvarez Moreno, located in the municipality of Manzanillo which delivered a total of 8,784 Gigawatts per hour (GWh) of electricity in 2005 (SENER, 2012). This plant uses within its fuel oil generation process, using 2.4 million of said fuel, equivalent to 92,688.68 TJ.

Emission results by municipality (tab and chart)

For the State of Colima, an emission of 7,775.86 Gg of CO_2 equivalent derived from the generation of electricity in 2005 was estimated.

Chart 7. GHG emissions from the energy industries.

	CO_2	CH4	N2O	Black carbon	CO_2eq
Emission (Gg/año)	7,364.12	0.28	0.06	0.43	7,775.86

Manufacturing and construction industry

The industry established in the state of Colima varies from chemical, cement and lime, metallurgy, food, and others.

Activity Data:

This industry uses fuels such as fuel oil, diesel, LP gas, cane bagasse and petroleum coke, this fuel consumption data was obtained from the annual operating cards reported to the state government and the federation by the industrialist of the year of activity 2005. In addition, to complement the fuel consumption by this sector, the number of employees of the industry by municipality of the 2004 INEGI Economic Census was used, multiplying the per capita fuel consumption of SENER publications, for diesel, fuel oil, LP gas and kerosene.

Chart 8. Energy consumption by municipality in TJ / year.

Municipality	Total busy staff	Fuel oil	Diesel	LP gas	Kerosene	Bagasse	Petroleum coke
Armería	586	18.65	69.33	13.69	0.00		
Colima	2,922	116.60	345.70	68.25	0.02		
Cómala	223	7.10	26.38	5.21	0.00		
Coquimatlán	129	4.11	15.26	3.01	0.00		
Cuauhtémoc	981	652.00	116.06	22.91	0.01	1,631.80	
Ixtlahuacan	14	16.31	1.66	0.33	0.00		
Manzanillo	2,137	1,386.06	252.83	49.91	0.02		
Minatitlán	38	1.21	4.50	0.89	0.00		
Tecomán	2,483	992.96	293.77	58.00	0.02		536.17
Villa de Álvarez	1,435	45.68	169.78	33.52	0.01		
Total	**10,948**	**3,240.68**	**1,295.26**	**255.72**	**0.09**	**1,631.80**	**536.17**

* There are no sales of Natural Gas in Colima for the year 2005 in any category according to GN Perspectives 2006-2016, SENER.

Emission results by municipality:

Chart 9 shows the GHG emissions of the manufacturing and construction industry for 2005 where CO_2 equivalent emissions amounted to 1,077 Gg.

Chart 9. GHG emissions by municipality in Gg / year.

Municipio	CO_2	CH_4	N_2O	CN	CO_2e
Armeria	-	-	-	-	-
Colima	10.86	0.00	0.00	0.00	12.65
Comala	-	-	-	-	-
Coquimatlán	-	-	-	-	-
Cuauhtémoc	214.98	0.05	0.01	0.66	811.99
Ixtlahuacan	1.89	0.00	0.00	0.00	2.44
Manzanillo	111.14	0.00	0.00	0.01	118.13
Minatitlan	-	-	-	-	-
Tecoman	124.13	0.00	0.00	0.01	131.44
Villa de Alvarez	0.16	0.00	0.00	0.00	0.26
Total	**463.16**	**0.06**	**0.01**	**0.68**	**1,076.89**

Other sectors:

Comercial

Activity Data:

In the commercial, institutional or service subcategory, the fuels used in the State of Colima were liquefied petroleum gas and diesel. The activity data was determined based on the information obtained from the Prospectives of the Liquefied Petroleum Gas Market (SENER, 2007) and SENER Oil (SENER, 2006), taking into account the sectoral sales of the Central region -West; and of the INEGI Economic Censuses where the total number of personnel employed in activities related to commercial services was obtained, determining the energy consumption per capita of both fuels per municipality; resulting in the data in Chart 10.

Chart 10. Energy consumption of the commercial subsector by municipality.

Municipality	Total employed personnel in activities related to commercial services	Energy consumption LP gas (TJ)	Energy consumption Diesel (TJ)
Armería	1632	9	1.07
Colima	20726	112	13.62
Cómala	849	5	0.56
Coquimatlan	716	4	0.47
Cuauhtémoc	1293	7	0.85
Ixtlahuacan	231	1	0.15
Manzanillo	13962	76	9.17
Minatitlan	277	1	0.18
Tecoman	9156	50	6.02
Villa de Álvarez	5254	28	3.45
Total	**54096**	**293**	**36**

* There are no natural gas sales in Colima for the year 2005 under any heading according to SENER.

Emission results by municipality:

Chart 11 shows the results of the recalculation of the commercial sector, where CO_2 equivalent emissions amount to 22.43 Gg during 2005.

Chart 11. GHG emissions from the commerce sector by municipality in Gg / year.

MUNICIPALITY	CO_2	CH_4	N_2O	Black carbon	CO_2e
Armeria	0.63	5.E-05	1.E-06	5.E-05	0.68
Colima	7.99	7.E-04	2.E-05	6.E-04	8.59
Comala	0.33	3.E-05	7.E-07	3.E-05	0.35
Coquimatlan	0.28	2.E-05	6.E-07	2.E-05	0.30
Cuauhtemoc	0.50	4.E-05	1.E-06	4.E-05	0.54
Ixtlahuacan	0.09	7.E-06	2.E-07	7.E-06	0.10
Manzanillo	5.38	4.E-04	1.E-05	4.E-04	5.79
Minatitlan	0.11	9.E-06	2.E-07	9.E-06	0.11
Tecoman	3.53	3.E-04	7.E-06	3.E-04	3.80
Villa de Alvarez	2.03	2.E-04	4.E-06	2.E-04	2.18
Total	**20.85**	**2.E-03**	**4.E-05**	**2.E-03**	**22.43**

Residencial

Activity Data:

The residential subcategory demands the use of L.P. gas, kerosene and firewood as fuels. The 2005 activity data was obtained from the Prospectives of the Liquefied Petroleum Gas Market (SENER, 2007) and SENER Oil (SENER, 2006), taking into account the sectoral sales of the Central-West region which is at which belongs the state of Colima; In addition to the number of inhabitants and dwellings per municipality obtained from the 2005 Population and Housing Census of INEGI. The percentage of inhabitants who use firewood or coal for cooking food was obtained from INEGI (2010). The fuel consumption per capita was obtained for each of these variables of the different fuels used. Giving as result in energy consumption by municipality what is presented in Chart 12.

Chart 12. Energy consumption of the residential subsector by municipality.

Municipality	Energy consumption LP gas (TJ)	Energy consumption Kerosene (TJ)	Energy consumption Firewood (TJ)
Armería	96	0.36	11
Colima	53	1.92	166
Cómala	7	0.28	83
Coquimatlan	7	0.25	74
Cuauhtémoc	100	0.37	12
Ixtlahuacan	19	0.07	20
Manzanillo	555	2.00	585
Minatitlan	28	0.11	12
Tecoman	362	1.43	45
Villa de Álvarez	404	1.45	125
Total	**1,631**	**8.25**	**1,133**

* Kerosene includes both residential and commercial, as reported in the Prospects.

Emission results by municipality:

Chart 13 shows the results of GHG emissions for the residential sector, where by 2005 the equivalent CO_2 emissions amounted to 305.60 Gg. Being Manzanillo the one that generate more emissions for the population present.

Chart 13. GHG emissions from the residential sector by municipality in Gg / year.

MUNICIPALITY	CO_2	CH_4	N_2O	Black carbon	CO_2e
Armeria	7.45	4.E-03	6.E-05	8.E-04	8.31
Colima	20.65	5.E-02	7.E-04	1.E-02	32.54
Comala	9.04	2.E-02	3.E-04	6.E-03	14.98
Coquimatlan	8.06	2.E-02	3.E-04	5.E-03	13.35
Cuauhtemoc	7.75	4.E-03	6.E-05	8.E-04	8.64
Ixtlahuacan	3.30	6.E-03	8.E-05	1.E-03	4.76
Manzanillo	96.68	2.E-01	2.E-03	4.E-02	138.87
Minatitlan	3.07	4.E-03	5.E-05	8.E-04	3.93
Tecoman	28.33	2.E-02	2.E-04	3.E-03	31.71
Villa de Alvarez	39.35	4.E-02	5.E-04	9.E-03	48.51
Total	**223.68**	**0.35**	**0.00**	**0.08**	**305.60**

Agropecuario

Activity data:

Fuel consumption and therefore the energy use of this subcategory was determined from what was reported in the Agricultural Census (INEGI g, 2009). obtaining the number of tractors in operation, as well as ejidos and communities with machinery for agricultural or forestry use; in addition to the fuel consumption obtained from the National Energy Balance 2005 (SENER, 2006) (Chart 14).

Chart 14. Energy consumption of the agricultural subsector by municipality.

Municipality	Ejidos and communities with tractors	Energy consumption LP gas (TJ)	Energy consumption Kerosene (TJ)	Energy consumption Diesel (TJ)
Armería				
Colima				
Cómala				
Coquimatlan				
Cuauhtémoc				
Ixtlahuacan	2	10	0.041	87
Manzanillo				
Minatitlan				
Tecoman	1	20	0.020	44
Villa de Álvarez				
Total	**3**	**30**	**0.061**	**131**

Emission results by municipality:

Chart 15 shows the results of GHG emissions for the agricultural sector, where by 2005 the equivalent CO_2 emissions amounted to 18.31 Gg. Developing this activity in the municipalities of Ixtlahuacán and Tecomán.

Chart 15. GHG emissions from the residential sector by municipality in Gg / year.

MUNICIPIO	CO_2	CH_4	N_2O	CN	CO_2e
Armeria	-	-	-	-	-
Colima	-	-	-	-	-
Comala	-	-	-	-	-
Coquimatlan	-	-	-	-	-
Cuauhtemoc	-	-	-	-	-
Ixtlahuacan	7.05	0.00	0.00	0.01	12.14
Manzanillo	-	-	-	-	-
Minatitlan	-	-	-	-	-
Tecoman	3.62	0.00	0.00	0.00	6.17
Villa de Alvarez	-	-	-	-	-
Total	**10.67**	**1.E-03**	**8.E-05**	**8.E-03**	**18.31**

Civil aviation

Activity data:

The state of Colima has two airports: one located in the municipality of Colima which makes domestic flights mainly to Mexico City with an influx of approximately 42 thousand passengers per year; and another located in the municipality of Manzanillo which performs domestic flights and some international flights mainly to the United States and Canada, and handles around 157 thousand passengers a year. The airport activity data was obtained from the SCT Statistical Yearbook 2005 (SCT, 2005) as well as the SCT Flight Operations Database 2006-2012; assuming that the numbers of 2006 operations were equal to those of 2005 due to lack of more information; The fuel used by this subcategory is turbosine or kerosene. (SCT, 2009)

Chart 16. Energy consumption by airport.

Municipality	Airport	Type of aircraft	Number of operations of LTO	Fuel consumption (Kg/LTO)**	Fuel consumption (TJ)*
Manzanillo	Playa de Oro	Airbus A318-100 Series	285	730	8.5
Colima	Licenciado Miguel de la Madrid	ATR 42-500 PT6-45	191	200	1.6

* The density of the turbosine is 0.8045 kg / l (NOM-086-SEMARNAT-SENER-SCFI-2005).

Railways

Activity data:

According to the Ministry of Communications and Transportation nationwide during 2005 freight trains consumed 641.7 million liters of diesel to serve the trade; In Colima, the municipalities of Manzanillo and Cuauhtémoc are the ones with the highest number of roads, so it is assumed that they have the greatest dynamism of this source. Data from this activity were taken from the 2005 Statistical Yearbook of the SCT; (SCT, 2005) the freight traffic by rail for the year 2005 of the Pacific-North zone, as well as the roads concessioned to the Pacific-North Company (main operator located in Manzanillo), assuming that the percentage of kilometers traveled is proportional with that of fuel consumption and that the load only travels 128 km within the state of Colima, the results of Chart 17 are obtained.

Chart 17. Energy consumption by municipality in TJ / year.

Municipality	Track length in Km in 1999	Fuel consumption (TJ)
Armería	21.1	0.60
Colima	13.6	0.39
Cómala	0	0.00
Coquimatlan	21.8	0.62
Cuauhtémoc	25.9	0.73
Ixtlahuacan	0	0.00
Manzanillo	26.1	0.74
Minatitlán	0	0.00
Tecoman	24.2	0.69
Villa de Álvarez	0	0.00
Total	**132.7**	**3.76**

Maritime

Activity data:

The state of Colima, because it is located on the Pacific coast, has one of the ports with important international commercial exchange which is located in Manzanillo, where cargo and passenger ships arrive. The activity data of this subcategory was obtained from what was reported by the SCT about the number of cruise ship arrivals in national ports and the number of ships in commercial ports, made in 2005 (SCT, 2005). As well as the fuel consumption by this sector reported in the National Energy Balance 2005 (SENER, 2006) (Chart 18).

Chart 18. Energy consumption by vessels in TJ / year.

Municipality	Type of boat	Number of arrivals	Fuel type	Fuel consumption (TJ)
Manzanillo	Cruise ships	50	Diesel marino	514.23
Manzanillo	Cargo ships	1,558	Combustóleo	4,387.89

**IPCC, 2006 Mobile sources.

Transporte Terrestre o autotransporte

It refers to all emissions from burning and evaporation emanating from the use of fuels in land vehicles, which circulate on paved roads, for the calculation of motor transport emissions the following parameters must be considered:

1. Number and type of vehicles that circulate.
2. Amount of fuel consumed by type of vehicle.
3. VKT (Total Kilometers Vehicles) by Vehicle Type.
4. Proportion of trips made partially within the área.

Activity data:

The activity data for this subsector is: the number of vehicles and the distance traveled in the year of study.

The number and type of vehicles that circulate through each of the municipalities and at the state level was provided by the Institute for the Environment and Sustainable Development of the State of Colima (IMADES) which in turn this information was provided by the State Finance area Colima year 2005. The base provided was classified and disaggregated by vehicle category, obtaining a total of 148,112 vehicles distributed in the state of Colima for 2005. The vehicle classification was based on the Moves model categories.

Figure 4 shows the distribution by type of vehicle in the State of Colima in 2005. According to this figure, pick-ups have the largest contribution with 34.7%, passenger vehicles with 33.28% follow, 19% are Light truck 3.

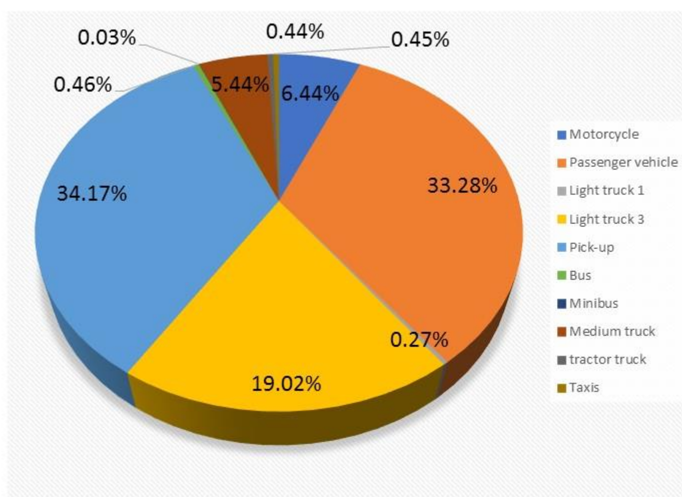

Figure 4. Porcentual distribution per vehicle category in the State of Colima 2005.

Figure 5 shows the distribution of the vehicle fleet per model year, for 2005 the average model year of the fleet throughout the state is 1993.

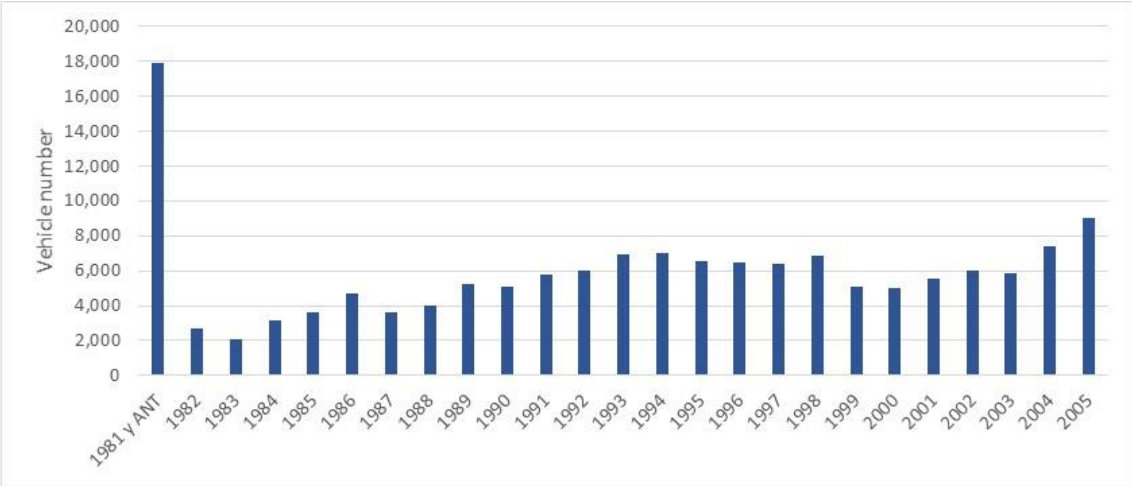

Figure 5. Distribution by model year of the vehicle fleet of the state of Colima 2005.
Source: Finance State Government, 2015

98% of vehicles use gasoline as fuel.

Emission results by municipality (Chart and graph)

In terms of emissions, it is observed that emissions are generated where there is greater urban development, that is, in the Metropolitan Area of Colima-Villa de Alvares, it represents 58% of the equivalent CO_2 emissions, while the municipality of Manzanillo (where the port) represents 20% of emissions.

Chart 19. GHG emissions (Gg / year), by municipality base year 2005 for the state of Colima.

Pollutant	CO_2	CH_4	N_2O	Black carbon	CO_2 e
Armería	52.39	0.01	0.00	0.00	55.41
Colima	371.58	0.04	0.02	0.02	390.85
Comala	38.53	0.01	0.00	0.00	40.14
Coquimatlán	33.45	0.01	0.00	0.00	34.63
Cuauhtémoc	69.23	0.01	0.00	0.00	73.64
Ixtlahuacán	11.95	0.00	0.00	0.00	12.47
Manzanillo	243.30	0.03	0.01	0.01	259.00
Minatitlán	13.94	0.00	0.00	0.00	14.94
Tecomán	183.77	0.02	0.01	0.01	196.32
Villa de Álvarez	193.32	0.02	0.01	0.01	203.12
Total	1,211.46	0.15	0.05	0.06	1,280.52

Total transport subcategories emissions

Figure 6 shows the contribution of CO_2e emissions from the transport subcategories, where it is appreciated that motor transport is the subcategory that contributes the most, followed by navigation.

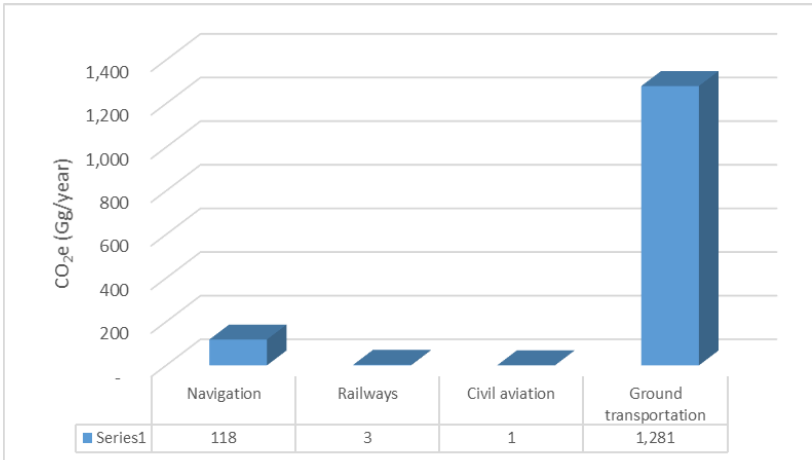

Figure 6. CO_2e emissions by transport subcategory.

2. AFOLU Sector

Land use change

Activity data:

The estimation of the emission or absorption of greenhouse gases, for the agriculture, forestry and other land uses sector, was carried out as established by the Guidelines of the Intergovernmental Panel on Climate Change (IPCC) for 2006 National inventories of greenhouse gases. The 2006 IPCC Guidelines consider estimation methods for three levels of detail, depending on their accuracy and precision, as well as the information required for their evaluation. Level 1 is the one with the greatest uncertainty and considers the use of default data and simple equations; Level 2 uses country-specific data, and Level 3 uses data and models adapted to local conditions. The estimation of the content of greenhouse gases and their associated uncertainty depends, then, on the available information (forest inventories, information on land and vegetation use, satellite images, estimation models, etc.) for evaluation at different times. In order to obtain the least uncertainty, the most recent information available for Mexico and for the state of Colima was used, to obtain the change of land use the period from 1993 to 2007 was worked, so to have annual emissions for 2005, the submitted issue must be divided by 14.

Annex II describes in more detail the method for obtaining the surface by type of vegetation or land use in two stages, to subsequently evaluate the changes, by municipality and by type of vegetation or land use. This information is what is known as activity data and is an input to estimate the emission of greenhouse gases.

Results of the emission by municipality:

The evaluation of the change in land use indicates, among other results in the analysis period, that there is degradation in 18% of the state area. Regarding the emissions for this category, these amounted to 706 Gg for the period and 50.4 for each year.

In the period 1993 to 2007, the USCUSS sector in the state of Colima had a sink effect, due to the absorption of CO_2, mainly from the permanence (forest land and grassland). The contribution of CO_2 emissions by this category is shown in Figure 7.

Chart 20. Total CO_2 emissions by municipality in 2005 for Colima (Gg / 1993-2007).

Municipality	Land converted to grassland	Land converted to settlements	Lands converted to other lands	Land converted to agricultural land	Degraded forest land	Permanency	
						Forest lands that remain as forest lands	Pastures that remain as pastures
Armería	7.87	0.00	---	28.45	9.00	16.04	0.01
Colima	17.83	1.24	---	99.50	24.38	14.80	23.55
Comala	7.57	---	3.24	7.94	5.53	7.92	19.90
Coquimatlán	---	---	---	75.71	15.96	28.10	---
Cuauhtémoc	7.03	0.03	---	51.94	0.00	2.68	24.80
Ixtlahuacán	31.96	---	---	45.91	12.60	13.21	3.08
Manzanillo	125.84	14.11	4.30	71.69	84.39	42.61	23.22
Minatitlán	51.49	0.00	0.46	10.03	15.82	19.34	9.55
Tecomán	0.85	---	---	95.68	12.73	14.32	0.69
Villa de Álvarez	0.22	1.33	---	38.95	7.35	13.47	4.99
Total	**250.66**	**16.71**	**8.00**	**525.79**	**187.75**	**-172.50**	**-109.80**

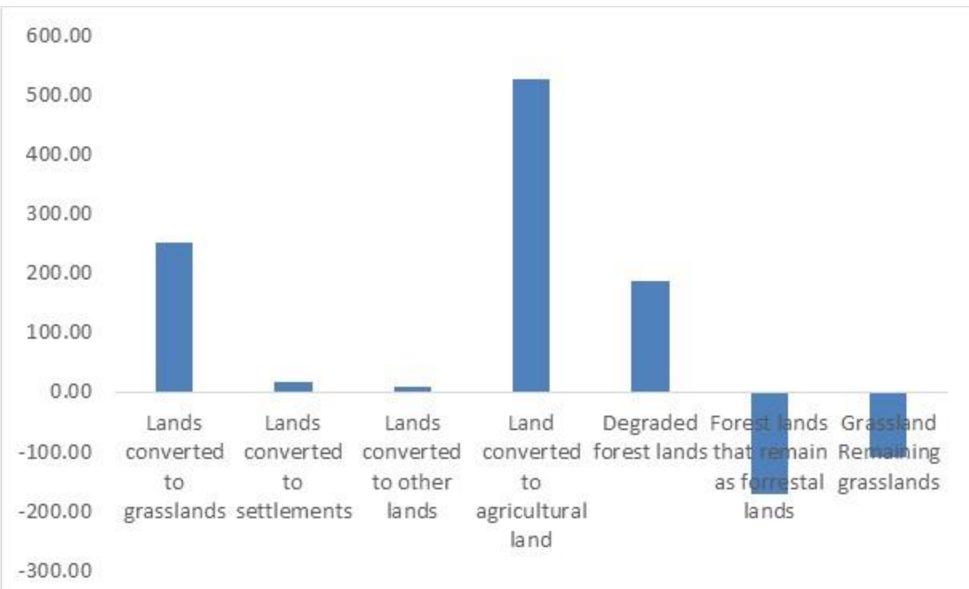

Figure 7. GHG emissions (Gg CO_2e) by USCUSS category.

Chart 21 shows the comparison of the emissions obtained by the recalculation of the 2005 emissions inventory for the energy and land use categories. In the case of energy, the equivalent carbon dioxide emissions increased by 12% due to the use of Mexico's CO_2 emission factors and considering black carbon. Increasing from 9,332 Gg to 10,602 Gg of CO_2e.

While in the subcategory of Land Use in the original estimate for 2005 the period of 1993-2005 was evaluated, and for the recalculation by the methodology used the period of 1993-2007 was considered. Resulting in very different CO_2 emissions, increasing significantly with the recalculation methodology when using specific information on emission factors for Mexico.

Chart 21. Results of the 2005 and 2015 recalculation (Gg / year).

SECTOR	SUBCATEGORY	Calculation 2005				Recalculion 2005				
		CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	Black carbon	CO_2e
Energy	Electric generation	7,174.10	0.28	0.06	7,197	7,364.12	0.28	0.06	0.43	7,776
	Manufacturing and construction industries	578.69	0.06	0.01	583	463.16	0.06	0.01	0.68	1,077
	Residential	230.37	0.35	0.00	239	223.68	0.35	-	0.08	306
	Comercial	21.10	0.00	0.00	21	20.85	0.00	0.00	0.00	22
	Farming	11.63	0.00	0.00	12	10.67	0.00	0.00	0.01	18
	Navegation	377.72	0.03	0.01	381	84.70	0.01	0.00	0.04	118
	Railways	0.28	0.00	0.00	0.3	0.27	0.00	0.00	0.00	3
	Aviation	0.78	0.00	0.00	0.8	0.78	0.00	0.00	0.00	1
	Motorized transportation	857.80	0.26	0.11	897	1,211.46	0.15	0.05	0.06	1,281
	Total	**9,252.47**	**0.99**	**0.19**	**9,332**	**9,379.69**	**0.85**	**0.12**	**1.30**	**10,602**
Land use	Period 1993-2005	52.30								
	Period of recalculation 1993-2007					706				
	Total	52.30				**706**				

Base scenarios development (2005-2015-2030)

1. 2005 and 2015 Inventories Information

Chart 22 shows the energy consumption by sector in the State of Colima during 2005 and 2015, where we can highlight the changes in the use of fuels in the entity, for example, the decrease in the use of heavy fuel oil, firewood and coke, and the increase in the use of natural gas, diesel and gasoline. In 2005, energy consumption amounted to 114.12 PJ in the entity, increasing in 2015 to 196.32 PJ.

Chart 22. Energy consumption in PJ by sector during 2005 and 2015.

Sector / Fuel	Fuel oil	Petroleum coke	Diesel	L.P. Gas	Natural Gas	Kerosene	Firewood	Gasoline	Coal coke	Biomass	Biogas	Total (PJ)
2005												
Residential	-	-	-	1.63	-	0.01	1.13	-	-	-	-	2.77
Comercial	-	-	0.02	0.29	-	-	-	-	-	-	-	0.32
Farming	-	-	0.13	0.02	-	0.00	-	-	-	-	-	0.15
Industrial	3.16	0.54	0.08	0.00	-	-	-	-	-	1.63	-	5.42
Electric Generation	92.69	-	-	-	-	-	-	-	-	-	-	92.69
Transport	-	-	2.12	0.01	0.02	0.01	-	10.61	-	-	-	12.77
2015												
Residential	-	-	-	0.83	-	0.02	0.76	-	-	-	-	1.61
Comercial	-	-	-	0.21	-	-	-	-	-	-	-	0.21
Farming	-	-	0.33	0.14	-	-	-	-	-	-	-	0.47
Industrial	2.02	0.20	3.45	0.19	1.10	-	-	-	1.38	4.76	-	13.09
Electric generation	16.95	-	0.03	-	98.44	-	-	-	-	-	0.01	115.43
Transport	-	-	30.09	0.43	-	0.23	-	34.76	-	-	-	65.52

Chart 23 shows the results of the 2005 and 2015 emissions inventory for the state of Colima, which highlights the increase in emissions from 2005 to 2015 of CO_2e by 20%.

Chart 23. CO_2e emissions in 2005 and 2015.

Sector	Subcategory	2005					2015				
		CO_2	CH_4	N_2O	Black carbon	CO_2e	CO_2	CH_4	N_2O	Black carbon	CO_2e
Energy	Electric generation	7,364	0.28	0.06	0.43	7,776	7,034	0.45	0.02	0.09	7,137
	Manufacturing and construction industries	463	0.06	0.01	0.68	1,079	1,860	1.90	0.05	0.03	1,950
	Residential	224	0.35	-	0.08	305	134	0.23	0.00	0.05	189
	Comercial	21	0.00	0.00	0.00	23	14	0.00	0.00	0.00	14
	Farming	11	0.00	0.00	0.01	18	33	0.00	0.00	0.02	50
	Navegation	85	0.01	0.00	0.04	118	67	0.01	0.00	0.03	95
	Railways	0	0.00	0.00	0.00	3	33	0.00	0.01	0.00	42
	Aviation	1	0.00	0.00	0.00	1	17	0.00	-	0.00	17
	Motorized transportation	1,211	0.15	0.05	0.06	1,283	3,610	0.46	0.14	2.13	5,577
IPPU	Cement production	836				836	409				409
	Lime production	21				21	21				21
	Iron production	175				175	137				137
AFOLU	Enteric fermentation		8.32			233		8.48			237
	Emissions by Manure Management		0.22	0.06		21		0.21	0.11		36
	CH_4 Rice crops		0.71			20		0.44			12
	CO_2 Liming	4				4	22				22
	Indirect N2O fertilizer application			1.27		338			0.25		67
	Indirect N2O volatilization due to MMS manure management			0.01		2			0.30		80
	CO_2 per Urea application	1				1	16				16
	Biomass burning	0	0.01	0.00		0	59	0.12	0.00	0.02	82
	Land use change	706				706	700				700
Waste	CH_4 emissions from wastewater treatment		3.94			110		4.60			129
	N_2O emissions from wastewater treatment (Gg / year)			0.02		5			0.03		8
	Emissions of CH_4 by solid waste disposal		5.40			151		2.60			73
	Emissions burning of open-air waste CO_2 Gg / year	414				414	1	0.00	0.00	0.01	11
Total		11,536	19.45	1.48	1.30	13,644	14,167	19.50	0.93	2.39	17,109

For the development of the base scenarios 2005 to 2030, as mentioned in the methodology, two types of methodologies were used; the first one considers the use of the GAINS model for the energy, IPPU, waste, livestock and agriculture sectors; and the second the change of land use.

2. Scenarios determined with the GAINS model

For the use and adaptation of the scenarios, as explained in methodology, State of Colima information's was considered for the in the analysis period.

Gross domestic product

The gross domestic product (GDP) expresses the monetary value of the production of goods and services of final demand of a country or region during a given period; that product is determined by sector and subsector. In general terms, it comprises three types: primary, secondary and tertiary. Within the primary or agricultural sector, there would be included the activities through which food and raw materials are acquired from nature. The secondary or industrial sector encompasses the economic activities that transform raw materials into processed products. Finally, in the tertiary or services sector, activities that provide services to society, such as commerce, transport, education, leisure, etc., take place.

For the state of Colima, 68.1% of GDP is generated by tertiary activities and 24.9 by secondary activities; for 2015 there is a 68.9% is generated by tertiary activities or a 26.5% secondary activities, this means that the activities of the industry and services are those that mark the economic increase or decrease, Figure 8 shows how it has gone GDP growth in the state.

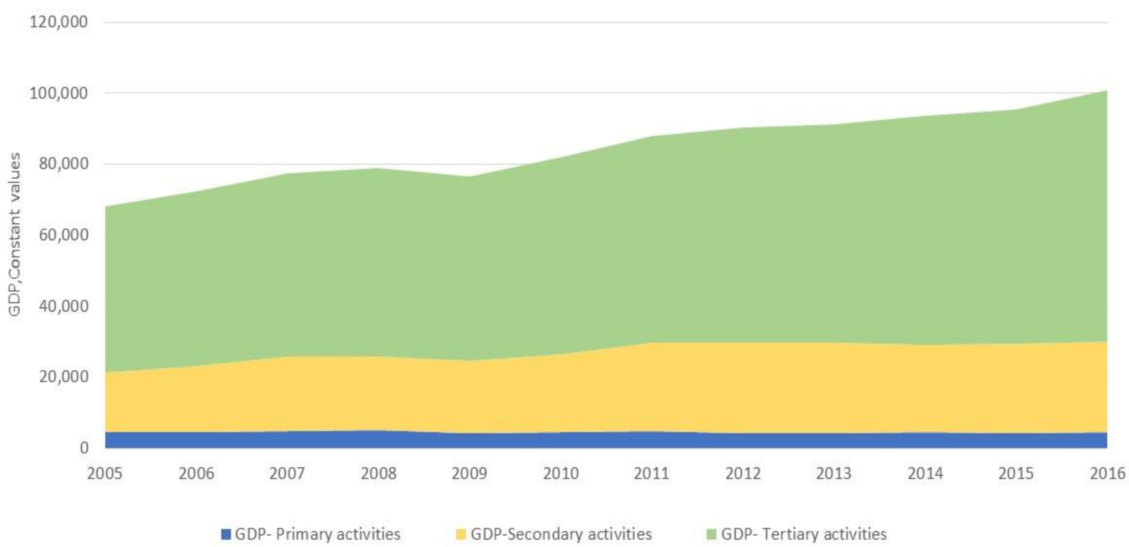

Figure 8. GDP by activity for the state of Colina 2005-2016, (Millions of those). Source: INEGI, 2020

Population

The population growth is presented in Figure 9, the growth from 2005 to 2015 was 24% and a growth from 2015 to 2030 of 24% is projected.

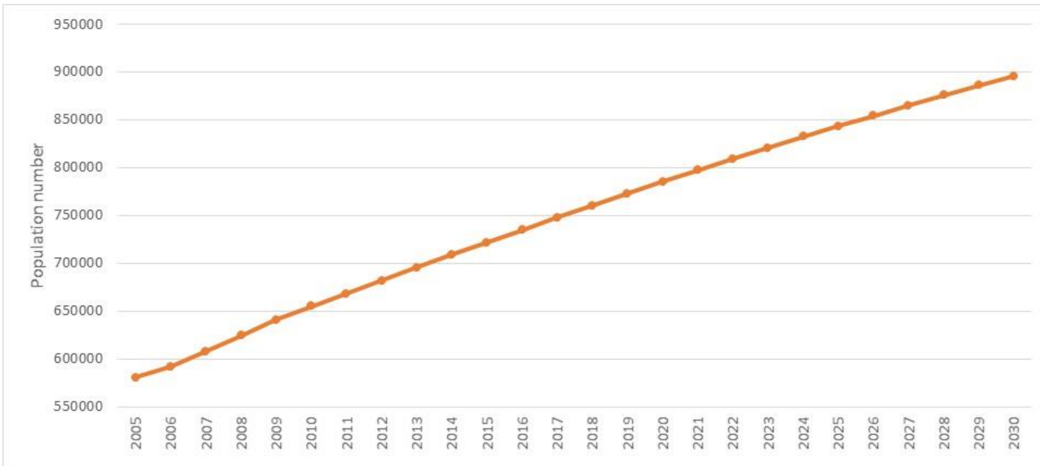

Figure 9. Number of inhabitants per year in the period 2005 to 2030 for the state of Colima. Surce: INEGI, 2020.

To obtain the baseline comprising the period from 2015 to 2030, Chart 24 shows the projection information, which was calculated or obtained from national or state sources of information.

Chart 24. Parameters and values used for the baseline (2015-2030).

Parameter	Proyection	SOURCE
Number of inhabitants (Population)	895,870 in 2030	CONAPO
Number of households	216,000 to 2030	CONAPO
Number of vehicles	Growth rate (1.74%) at 2030	INEGI
Number of commercial establishments	Growth rate (2.19%) at 2030	INEGI
Number of Production Units with Agricultural or Forest Activity with Tractor Use	Growth rate (1.4%) at 2030	INEGI
Total GDP GDP primary activities GDP secondary activities GDP tertiary activities	1.03% growth rate 1.001% growth rate 1.02% growth rate 1.03% growth rate	INEGI
Household size	3.8	INEGI
Percentage of homes with electricity in urban and rural areas in Colima	90% by 2030 in urban households	El Colegio de México, 2010

Before presenting the results with the GAINS model of the projection for the State of Colima, a comparison was made of the National Inventory of Greenhouse Gases of Mexico prepared by the National Institute of Ecology and Climate Change (INEC, nd) in different years and the one carried out with the GAINS model. The scenario for Mexico that is online was carried out in the model by CONACYT at the national level in 2015; it considers:

The period from 1990 to 2050 at intervals of five years. The main source of energy and process data is the statistical data of the International Energy Agency (IEA) for the period 1990-2010 and the Energy Technology Projections of the IEA / OECD (ETP, 2012) for energy projections that are widely consistent with the IEA World Energy. Outlook 2011 (IEA, 2011). For agriculture, data from the Food and Agriculture Organization of the United Nations (FAO) is used for historical and future projections (Alexandratos and Bruinsma, 2012. WORLD AGRICULTURE TOWARDS 2030/2050: THE REVISION 2012. FAO, Rome).

Figure 10 shows the CO_2e comparison of the INECC inventories and that obtained through the online scenario of the GAINS model for Mexico. As we can see in the graph, the results of the INECC is lower than the one in the mode. It can be understood by the fact that the scenario uses global historical data and information, while the one prepared by INECC contains specific information for Mexico, although in recent years the difference is smaller (10%).

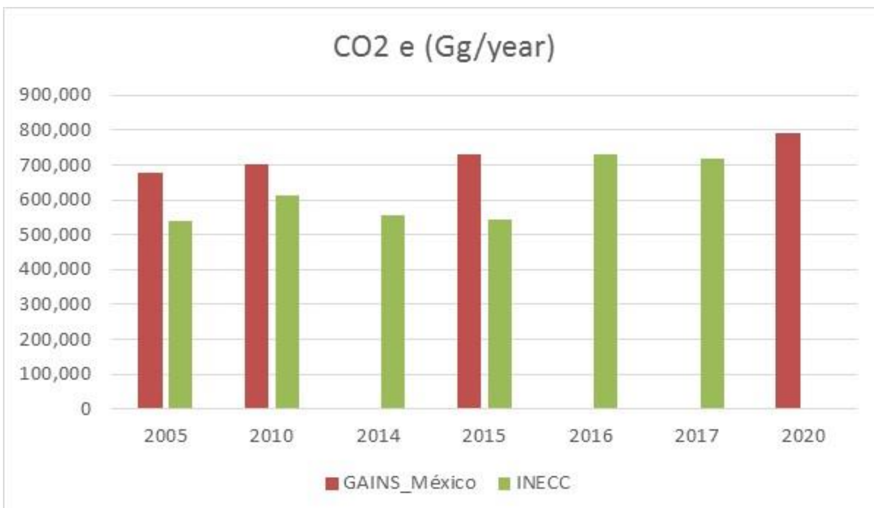

Figure 10. Comparison of CO_2e emissions for Mexico in Gg / year. Source: INECC and GAINS.

For the present projection, the results contained in the GAINS model for Mexico online were used as a basis and a new scenario was carried out, to consider the aforementioned data of the state of Colima and based on the results of activity that were obtained in the inventories 2005 and 2015.

Scenario One

Scenario one represents the emissions considering the emission factors contained in the IPCC 2006 guidelines and the projected activity data of the state of Colima.

The results by sector, subsector and CO_2e fuel of the projection of scenario one per pollutant, sector is presented Annex III, Chart 25 shows the CO_2 e emissions for the period 2005 to 2030 for the state of Colima by sector and subsector for Scenario one.

Chart 25. Scenario one; CO_2e emissions for the state of Colima by Sector, activity and fuel in the period 2005 to 2030 (Gg / year).

Sector	Activity	Fuel	2005	2010	2015	2020	2025	2030
Residential-commercial	DOM	Gasoline	0.514	0.379	0.276	0.296	0.303	0.309
Residential-commercial	DOM	LPG	133.353	127.684	72.126	73.243	75.115	76.582
Residential-commercial	DOM	Diesel	2.632	3.162	0.004	0.003	0.003	0.003
Residential - kerosene lamps	DOM_LIGHT	Gasoline	8.118	4.934	16.099	4.245	1.120	0.296
Cooking stoves	Fuelwood	Fuelwood (leña)	85.961	55.738	57.923	20.296	10.600	8.231
Chemical industry (boilers)	IN_BO_CHEM	Heavy fuel oil	7.050	2.096	0.040	0.079	0.103	0.098
Other industry (boilers; liquid and gaseous fuels)	IN_BO_OTH	Natural gas (incl. other gases)	0.000	0.000	65.628	66.898	67.868	68.472
Other industry (boilers; liquid and gaseous fuels)	IN_BO_OTH	Heavy fuel oil	87.257	24.974	10.362	27.615	21.255	16.932
Other industry (furnaces)	IN_OCTOT	Derived coal (coke, briquettes)	53.617	59.368	157.126	157.392	157.659	169.428
Other industry (furnaces)	IN_OCTOT	Heavy fuel oil	150.842	70.940	144.963	550.586	582.792	572.179
Other industry (furnaces)	IN_OCTOT	LPG	0.038	0.044	12.908	11.289	8.803	7.102
Other industry (furnaces)	IN_OCTOT	Diesel	6.201	8.056	251.518	171.842	149.215	128.242
Other industry (furnaces)	IN_OCTOT	Waste fuels, non-renewable	0.000	0.000	100.520	100.520	110.876	113.493
Power & district heat plants - existing (excl. coal)	PP_EX_OTH	Natural gas (incl. other gases)	0.000	4,542.943	5,730.372	5,633.882	5,538.986	5,445.743
Power & district heat plants - existing (excl. coal)	PP_EX_OTH	Heavy fuel oil	7,252.796	4,182.677	1,326.418	881.216	616.014	428.198
Power & district heat plants - new (excl. coal)	PP_NEW	Fuelwood	0.163	0.075	0.484	0.238	0.467	0.658
Cement and lime	PR_CEM	No fuel use	937.540	960.263	458.296	626.576	701.164	724.518
Lime production	PR_LIME	No fuel use	23.973	24.562	23.973	35.162	42.172	50.046
Agriculture	TRA_OT_AGR	LPG	1.295	0.832	10.321	6.894	4.671	3.227
Agriculture	TRA_OT_AGR	Diesel	15.784	18.810	40.042	45.125	45.808	45.695
Domestic aviation	TRA_OT_AIR_DOM	Gasoline	0.700	0.663	15.677	11.015	11.304	11.620
Railways	TRA_OT_RAI	Diesel	2.955	3.481	38.619	174.368	155.614	137.065
Buses	TRA_RD_HDB	Diesel	15.420	18.511	133.887	136.064	147.442	158.821
Heavy duty vehicles	TRA_RD_HDT	Diesel	21.779	26.114	301.536	553.358	597.909	642.280
Cars	TRA_RD_LD4C	Natural gas	147.420	175.889	780.909	859.290	871.006	882.892
Cars	TRA_RD_LD4C	Gasoline	6.774	8.008	35.824	44.132	44.915	45.697
Cars	TRA_RD_LD4C	LPG	690.654	824.065	861.872	948.382	961.312	974.429
Light duty vehicles	TRA_RD_LD4T	Gasoline	134.630	161.410	65.576	88.883	93.241	97.589
Light duty vehicles	TRA_RD_LD4T	Diesel	5.173	6.175	20.975	34.154	34.618	46.725
Motorcycles	TRA_RD_M4	Gasoline	70.157	72.155	23.327	24.718	23.812	23.653
Trash burning	WASTE_RES	No fuel use	180.008	184.190	140.681	190.803	212.843	219.559
Steel or Iron Production	PR_STE	No fuel use	50.338	55.424	0.000	0.000	0.000	0.000
Coastal shipping, large vessels	No control	Heavy fuel oil	33.250	36.609	67.449	74.264	81.768	90.030
Coastal shipping, large vessels	No control	Diesel	0.324	0.357	0.667	0.753	0.741	0.719
Other cattle	Other cattle - solid systems		225.151	236.605	250.936	261.559	272.181	282.804
Dairy cattle	Dairy cows - liquid (slurry) systems - enteric fermentation		3.917	4.226	10.070	12.452	14.955	17.608
Other livestock (sheep, horses)	Horses		3.915	3.944	3.915	3.915	3.915	3.915

Other livestock (sheep, horses)	Sheep and goats		2.407	2.558	3.027	3.110	3.194	3.277
Pigs	Pigs - liquid systems		6.862	6.903	3.546	3.855	4.174	4.502
Poultry	Laying hens		0.068	0.077	0.040	0.042	0.043	0.045
Poultry	Other poultry		0.757	0.822	0.128	0.143	0.158	0.173
Industrial furnaces		Derived coal (coke, briquettes)	0.736	0.779	2.157	2.202	2.206	2.371
Industrial furnaces		Heavy fuel oil	2.447	1.266	2.351	2.392	2.438	2.506
Industrial furnaces		LPG	0.000	0.000	0.097	0.079	0.061	0.049
Industrial furnaces		Diesel	0.035	0.046	1.420	1.390	1.360	1.402
Food, organic waste in MSW	Activity at 10yr before the respective - present year, i.e. 1980 and 1985 - Used to emulate stocks (pools) of landfilled waste		11.171	12.133	19.022	20.122	22.388	24.755
Waste composition: fraction or tex. INW_TEX_SWD_USE			0.695	0.758	1.242	1.349	1.410	1.491
Waste composition: fraction of paper in MSW			14.425	15.725	24.639	26.761	27.974	29.592
Waste composition: fraction of wood in MSW			40.566	44.200	66.711	72.457	75.756	80.130
Power & district heat plants - new (excl. coal)		Biomass fuels	3.701	6.559	10.799	12.795	26.143	41.814
Continously flooded rice cultivation area	Area of activity		7.535	5.507	10.465	10.465	10.465	10.465
Intermittently flooded rice cultivation area (>3 days aeration during the vegetation period)	Area of activity		8.492	5.661	5.500	5.500	5.500	5.500
Agricultural waste burning	No fuel use		0.000	0.000	0.000	0.000	0.000	0.000
Waste water treatment (domestic)	Population		32.688	34.412	40.932	43.337	45.486	47.437
Arable land in temperate climate	Mass of Nitrogen added		78.599	81.848	28.601	30.769	33.206	35.961
Residential-commercial		Natural gas (incl. other gases)	0.001	0.001	0.000	0.000	0.000	0.000
Residential-commercial		Biomass fuels	1.201	1.171	0.809	0.847	0.886	0.920
Manure management	Dairy cows - solid systems		0.456	0.493	4.243	4.222	4.192	4.153
Manure management	Horses		0.125	0.125	0.142	0.142	0.142	0.142
Manure management	Laying hens		0.250	0.282	0.093	0.097	0.101	0.105
Manure management	Other poultry		0.001	0.001	0.098	0.110	0.121	0.133
Manure management	Other cattle - solid systems		24.648	25.903	51.765	53.956	56.147	58.338
Manure management	Pigs - solid systems		0.000	0.000	3.488	3.419	3.344	3.263
Manure management	Sheep and goats		0.093	0.099	0.155	0.159	0.163	0.167
Pig iron, blast furnace	No fuel use		20.328	20.893	6.217	6.516	6.244	5.974
		Total	10,617.984	12,173.584	11,519.004	12,137.745	11,995.873	11,859.521

Scenario Two

Scenario two represents the emissions considering the emission factors contained in the 2006 IPCC guidelines and those determined for Mexico in the case of the energy sector (for motor transport they are the emission factors obtained with the MOVES model for Colima) and the data of projected activity of the state of Colima

The results by sector, subsector and CO_2e fuel of the projection for pollutant of scenario two, sector, Annex III. Chart 26 shows the CO_2e emissions for the period 2005 to 2030 for the state of Colima by sector and subsector for Scenario two.

Chart 26. Scenario two; CO_2e emissions for the state of Colima by Sector, activity and fuel in the period 2005 to 2030 (Gg / year).

Sector	Activity	Fuel	2005	2010	2015	2020	2025	2030
Residential-commercial	DOM	Gasoline	0.514	0.379	0.276	0.296	0.303	0.309
Residential-commercial	DOM	LPG	125.817	120.468	68.050	69.105	70.870	72.254
Residential-commercial	DOM	Diesel	2.628	3.157	0.004	0.003	0.003	0.003
Residential - kerosene lamps	DOM_LIGHT	Gasoline	8.199	4.983	16.259	4.287	1.131	0.299
Cooking stoves	Fuelwood	Fuelwood (leña)	202.882	126.795	136.707	41.066	16.076	9.675
Chemical industry (boilers)	IN_BO_CHEM	Heavy fuel oil	0.738	0.219	0.004	0.008	0.010	0.009
Other industry (boilers; liquid and gaseous fuels)	IN_BO_OTH	Natural gas (incl. other gases)	0.000	0.000	65.628	66.898	67.868	68.472
Other industry (boilers; liquid and gaseous fuels)	IN_BO_OTH	Heavy fuel oil	89.989	25.756	10.686	28.482	21.922	17.464
Other industry (furnaces)	IN_OCTOT	Derived coal (coke, briquettes)	58.763	65.066	172.207	172.499	172.791	185.690
Other industry (furnaces)	IN_OCTOT	Heavy fuel oil	155.641	73.198	149.576	568.105	601.335	590.385
Other industry (furnaces)	IN_OCTOT	LPG	0.035	0.042	12.175	10.649	8.303	6.699
Other industry (furnaces)	IN_OCTOT	Diesel	6.191	8.043	251.108	171.562	148.972	128.033
Other industry (furnaces)	IN_OCTOT	Waste fuels, non-renewable	0.000	0.000	100.520	100.520	110.876	113.493
Power & district heat plants - existing (excl. coal)	PP_EX_OTH	Natural gas (incl. other gases)	0.000	4,542.943	5,730.372	5,633.882	5,538.986	5,445.743
Power & district heat plants - existing (excl. coal)	PP_EX_OTH	Heavy fuel oil	7,479.883	4,313.637	1,367.948	908.760	635.269	441.582
Power & district heat plants - new (excl. coal)	PP_NEW	Fuelwood	0.163	0.075	0.484	0.238	0.467	0.658
Cement and lime	PR_CEM	No fuel use	937.540	960.263	458.296	626.576	701.164	724.518
Lime production	PR_LIME	No fuel use	23.973	24.562	23.973	35.162	42.172	50.046
Agriculture	TRA_OT_AGR	LPG	1.228	0.789	9.788	6.551	4.451	3.085
Agriculture	TRA_OT_AGR	Diesel	15.768	18.791	40.003	45.079	45.761	45.649
Domestic aviation	TRA_OT_AIR_DOM	Gasoline	0.700	0.663	15.677	11.015	11.304	11.620
Railways	TRA_OT_RAI	Diesel	27.669	33.124	40.656	170.533	151.801	133.274
Buses	TRA_RD_HDB	Diesel	63.194	75.806	433.901	785.533	848.610	911.430
Heavy duty vehicles	TRA_RD_HDT	Diesel	30.699	36.814	425.097	781.062	843.938	906.559
Cars	TRA_RD_LD4C	Natural gas	294.233	351.030	1,183.161	1,291.566	1,308.717	1,326.145
Cars	TRA_RD_LD4C	Gasoline	6.869	8.058	35.728	43.961	44.740	45.519
Cars	TRA_RD_LD4C	LPG	899.533	1,073.199	1,438.116	1,569.882	1,590.728	1,611.910
Light duty vehicles	TRA_RD_LD4T	Gasoline	81.786	97.957	89.824	141.876	150.440	158.973
Light duty vehicles	TRA_RD_LD4T	Diesel	14.489	17.286	62.755	102.675	104.044	140.518
Motorcycles	TRA_RD_M4	Gasoline	70.157	72.155	23.327	24.718	23.812	23.653
Trash burning	WASTE_RES	No fuel use	180.008	184.190	140.681	190.803	212.843	219.559
Steel or Iron Production	PR_STE	No fuel use	50.338	55.424	0.000	0.000	0.000	0.000
Coastal shipping, large vessels	No control	Heavy fuel oil	33.250	36.609	67.449	74.264	81.768	90.030
Coastal shipping, large vessels	No control	Diesel	0.324	0.357	0.667	0.753	0.741	0.719
Other cattle	Other cattle - solid systems		225.151	236.605	250.936	261.559	272.181	282.804

Dairy cattle	Dairy cows - liquid (slurry) systems - enteric fermentation		3.917	4.226	10.070	12.452	14.955	17.608
Other livestock (sheep, horses)	Horses		3.915	3.944	3.915	3.915	3.915	3.915
Other livestock (sheep, horses)	Sheep and goats		2.407	2.558	3.027	3.110	3.194	3.277
Pigs	Pigs - liquid systems		6.862	6.903	3.546	3.855	4.174	4.502
Poultry	Laying hens		0.068	0.077	0.040	0.042	0.043	0.045
Poultry	Other poultry		0.757	0.822	0.128	0.143	0.158	0.173
Industrial furnaces		Derived coal (coke, briquettes)	0.736	0.779	2.157	2.202	2.206	2.371
Industrial furnaces		Heavy fuel oil	2.447	1.266	2.351	2.392	2.438	2.506
Industrial furnaces		LPG	0.000	0.000	0.097	0.079	0.061	0.049
Industrial furnaces		Diesel	0.035	0.046	1.420	1.390	1.360	1.402
Food, organic waste in MSW	Activity at 10yr before the respective - present year, i.e. 1980 and 1985 - Used to emulate stocks (pools) of landfilled waste		11.171	12.133	19.022	20.122	22.388	24.755
Waste composition: fraction or tex. INW_TEX_SWD_USE			0.695	0.758	1.242	1.349	1.410	1.491
Waste composition: fraction of paper in MSW			14.425	15.725	24.639	26.761	27.974	29.592
Waste composition: fraction of wood in MSW			40.566	44.200	66.711	72.457	75.756	80.130
Power & district heat plants - new (excl. coal)		Biomass fuels	3.701	6.559	10.799	12.795	26.143	41.814
Continously flooded rice cultivation area	Area of activity		7.535	5.507	10.465	10.465	10.465	10.465
Intermittently flooded rice cultivation area (>3 days aeration during the vegetation period)	Area of activity		8.492	5.661	5.500	5.500	5.500	5.500
Agricultural waste burning	No fuel use		0.000	0.000	0.000	0.000	0.000	0.000
Waste water treatment (domestic)	Population		32.688	34.412	40.932	43.337	45.486	47.437
Arable land in temperate climate	Mass of Nitrogen added		78.599	81.848	28.601	30.769	33.206	35.961
Residential-commercial		Natural gas (incl. other gases)	0.001	0.001	0.000	0.000	0.000	0.000
Residential-commercial		Biomass fuels	1.201	1.171	0.809	0.847	0.886	0.920
Manure management	Dairy cows - solid systems		0.456	0.493	4.243	4.222	4.192	4.153
Manure management	Horses		0.125	0.125	0.142	0.142	0.142	0.142
Manure management	Laying hens		0.250	0.282	0.093	0.097	0.101	0.105
Manure management	Other poultry		0.001	0.001	0.098	0.110	0.121	0.133
Manure management	Other cattle - solid systems		24.648	25.903	51.765	53.956	56.147	58.338
Manure management	Pigs - solid systems		0.000	0.000	3.488	3.419	3.344	3.263
Manure management	Sheep and goats		0.093	0.099	0.155	0.159	0.163	0.167
Pig iron, blast furnace	No fuel use		20.328	20.893	6.217	6.516	6.244	5.974
		Total	11,354.471	12,844.835	13,123.709	14,262.530	14,186.572	14,152.969

Figures 11 and 12 show scenarios one and two of the CO_2e emissions in the 2005-2030 period of the different sectors.

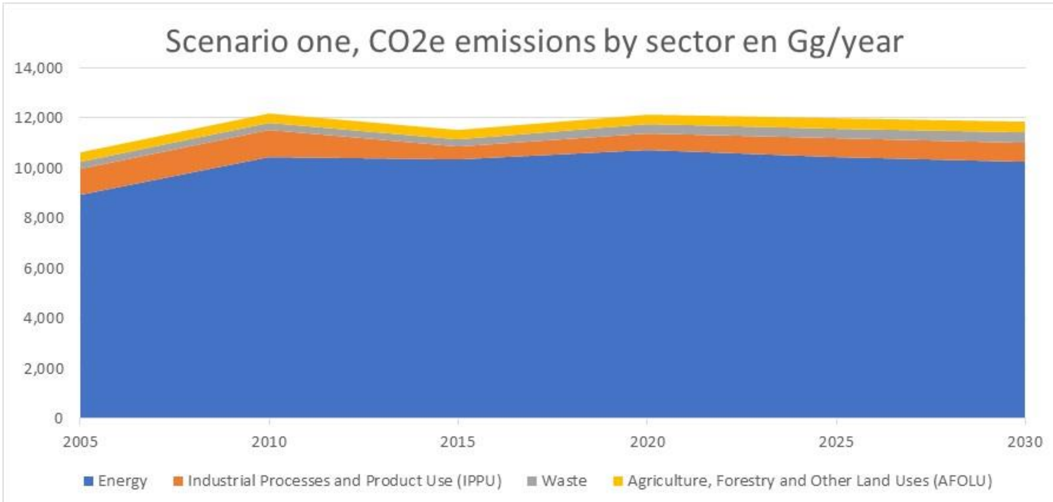

Figure 11. Scenario one, CO_2e emissions in Gg / year, by sector for the state of Colima 2005 to 2030.

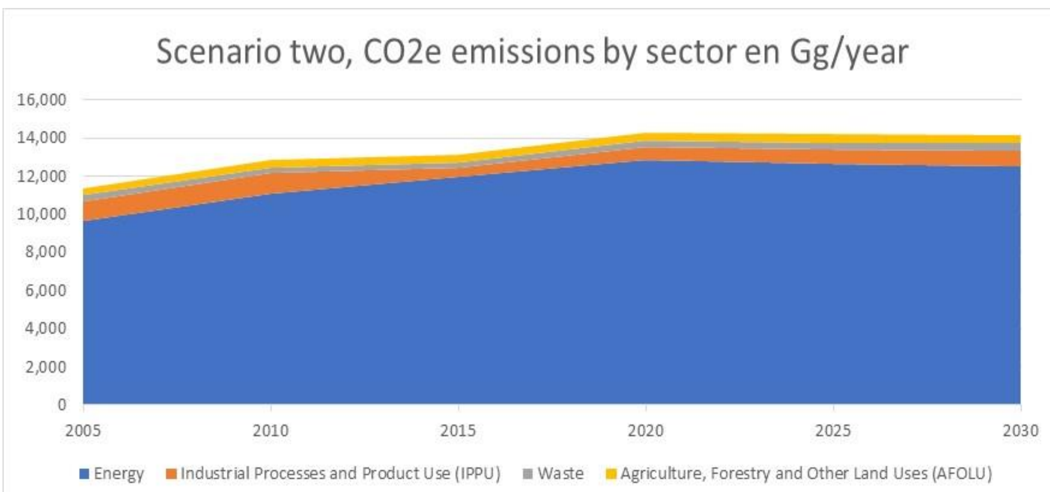

Figure 12. Scenario two, CO_2e emissions in Gg / year, by sector for the state of Colima 2005 to 2030.

Land-use change

The results of the projection towards 2030 of the emissions due to the change in land use are presented in Chart 27. This projection was made for the period 2014 to 2030.

The change in the emission of CO_2e in the period from 1993 to 2030 is presented in Figure 13. The approach of the scenario begins in 1993 and not in 2005, this because the change in land use must consider at least five years ago of the base year.

Chart 27. Total CO_2 emissions by municipality in the 2014-2030 period for Colima (Gg / year).

Municipality	Lands converted to gasslands	Lands converted to settlements	Lands converted to other lands	Land converted to agricultural land	Degraded forest land	Permanencies	
						Forest lands that remain as forest lands	Pastures that remain as pastures
Armería	14.481	0.108	0.004	0.748	0.055	18.97	4.32
Colima	24.097	0.019	0.009	1.217	0.209	23.93	24.57
Comala	1.036	0.045	0.068	16.247	0.063	10.28	14.46
Coquimatlán	8.746	0.046	0.021	3.894	0.282	32.10	4.03
Cuauhtémoc	35.239	0.034	0.000	0.497	0.117	18.07	11.42
Ixtlahuacán	98.811	0.771	0.093	1.717	0.590	66.51	62.95
Manzanillo	1.446	0.038	0.045	1.316	0.258	25.08	22.21
Minatitlán	1.446	0.038	0.045	1.316	0.258	25.08	22.21
Tecomán	20.492	0.041	0.110	0.922	0.091	19.53	0.85
Villa de Álvarez	0.072	---	0.016	3.342	0.036	2.43	4.88
Total	205.866	1.138	0.410	31.219	1.959	241.97	171.91

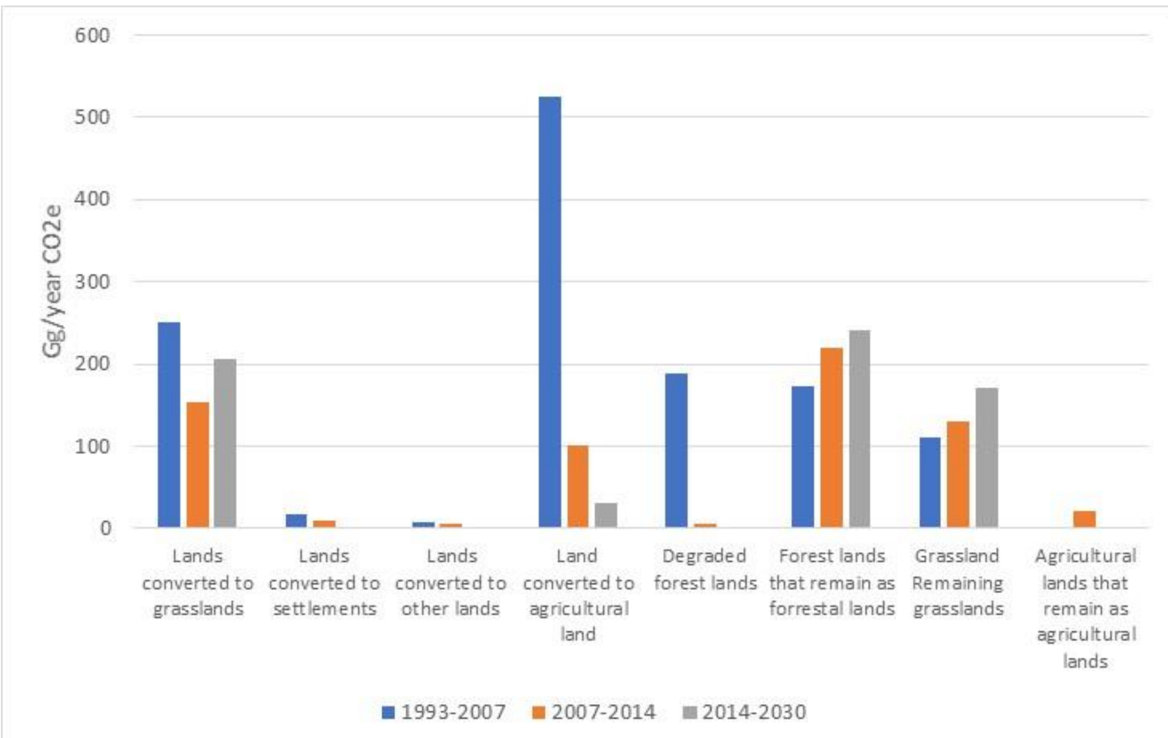

Figure 13. Results for 1993 to 2030 of CO_2e due to change in land and vegetation use for the state of Colima (Gg / year).

Conclusions

As a result of the recalculation of the inventory of greenhouse gas emissions for the State of Colima base year 2005, an increase in CO_2 emissions equivalent to 12% was obtained in the energy sector, increasing the emission from 9,332 Gg to 10,602 Gg; for the use of CO_2 emission factors for Mexican fuels and considering the estimate of black carbon.

One of the subcategories with the greatest change in the energy sector was the motor transport, increasing the emissions of 897Gg with the Mobile 6 Mexico model and with the recalculation resulting in 1,281Gg with the use of the MOVES-Mexico model.

In the case of the land use category, the recalculation results showed a significant increase in CO_2 emissions from 52.3Gg to 706Gg, due to the change in methodology and the use of specific information on emission factors for Mexico.

The baseline scenarios of the sectors were estimated: Energy, Industrial processes and product use (IPPU), Waste and Agriculture, forestry and other land uses (AFOLU) at 2030 for greenhouse gases and compounds (CO_2, CH_4, N_2O and black carbon).

Two scenarios for the 2005-2030 projection were evaluated, using the GAINS model for the energy, IPPU, waste, livestock and agriculture sectors; the first considered the emission factors contained in the IPCC 2006 guidelines and the projected activity data of the state of Colima, resulting in an increase in CO_2e emissions in 2030 of 10%, these emissions being of the order of 11,859,521 Gg.

While in scenario two that considers the emission factors contained in the IPCC 2006 guidelines and those determined for Mexico in the case of the energy sector (for motor transport those obtained with the MOVES model for Colima) and the projected activity data of the state of Colima where emissions at 2030 of CO_2e amount to 14,152,969 Gg. Given the same increase from 2005 to 2030 of 10% in emissions.

Although the change in fuel use, towards cleaner fuels that generate less CO_2e emissions, is the trend in the entity; The demand for energy due to population, industrial and vehicular growth causes CO_2e emissions to increase according to time.

In the case of the change in land use in the projected period from 2014 to 2030, a decrease in emissions was obtained for the subcategories of land converted to grassland, to settlements, to other land, to agricultural land and degraded forest land. And there is an increase in emissions from forest lands that remain as forest lands and from pastures that remain as pastures; this regarding the behavior presented in the periods 1993-2007 and 2007-2014.

Initial progress, challenges and potential of the Project

Since most of the information used in this project was already gathered in previous documents and databases of the IMADES, the initial process with the gathering of information and methodology definition was satisfactory. These documents and databases are from the previous Inventories of GHG emissions. The missing information was obtained from online platforms from national institutes and dependences.

Also, giving the previous experience with the Inventory of GHG emissions base year 2015, the developers of this project analyzed from the first time the necessity of the process in quality and assurance of the information. IMADES and the consultants in charge of this project would be attentive to resolve any comment or misunderstanding, and correct wrong information given the case.

There were two main challenges in the elaboration of this document:

- The first one was the selection of the modeling program to use; the quoted modeling program at the beginning was the LEAP model, but at the moment of trying to download it, it had a price that wasn't considered in the quotation. This problem is intricated with the development of the country: the LEAP model is free for third world countries, but recently México developed to a second world country, which changed the LEAP model price.
  To solve the problem, the consultants looked for a second option, leading the research to the use of GAINS model, which is explained in methodology chapter and is a free modeling program.
- The second challenge was the modeling of the AFOLU sector because of the land use change. It required a special analysis of the land change until 2015 to determine the probability of change in future years.

The elaboration of this project with both base sceneries is the parting point to stablish a mitigation goal and define objective actions to reduce emissions. As seen in the base sceneries models, the principal problem is and will continue to be the energy generation by transport and electric generation subcategories; followed by the IPPU sector. Next steps will be really important because they will be the establishment of the mitigation goal and the definition of actions, which requires the acknowledgment of technologies, procedures and social and political willing necessary to make the change to face climate change.

The progress and technical information in this project will be available and shared via webinar and other means facilitated by contributors with Under2 Coalition peers as an example for future projects of this nature and as open information. Also, this document and its annexes will be available online in the IMADES webpage for all the interested public.

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