

# ***Mexico's Advances With Regard to Climate Change 2001-2002***

***General Directorate for Research into Urban, Regional  
and Global Pollution***

***National Institute of Ecology  
Federal Ministry of the Environment and Natural Resources***

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The present document was prepared by the General Directorate for Research into Urban, Regional and Global Pollution, of the National Institute of Ecology (INE), of the Federal Ministry of the Environment and Natural Resources (SEMARNAT), with information from the Federal Ministry of Energy (SENER), Mexican Petroleum (PEMEX/SENER), the National Energy Saving Commission (CONAE/SENER), the Electrical Energy Saving Fund (FIDE), the National Forest Commission, of the Department of the Environment and Natural Resources (CONAFOR/SEMARNAT), and from the following Sub-departments of the SEMARNAT: Planning and Environmental Policy, Management for Environmental Protection, and Advancement and Regulation of the Environment.

The information contained in this document should be considered technical support for studies carried out on this topic.

We would greatly appreciate any relevant comments and suggestions in order to improve it.

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# I. NATIONAL CONTEXT

## POPULATION

Mexico is a Federal Republic formed by 31 Federative Entities (states) and a Federal District that are made up of 2,430 municipalities and 16 political "delegations" respectively. 199,369 localities exist in the country, 178 of which have 50 thousand or more inhabitants; 2,863 localities have between 2,500 and 49,999 inhabitants and in 196,328 towns there are fewer than 2,500 inhabitants (CNA-SEMARNAT, 2002). Table 1.1 shows the population development over the last eight years.

TABLE 1.1. NATIONAL POPULATION, 1995-2002 (MILLIONS OF INHABITANTS)

YEAR	TOTAL POPULATION	URBAN POPULATION	RURAL POPULATION
1995	91.2	67.0	24.2
1996	92.7	68.2	24.5
1997	94.3	69.3	25.0
1998	95.8	70.5	25.3
1999	97.3	71.6	25.7
2000	98.7	73.7	25.0
2001	100.1	74.7	25.4
2002	103.0	76.9	26.1

SOURCE: CNA-SEMARNAT, 2003 y CONAPO, 2002.

According to the National Council on Population (CONAPO, 2000), the rate of population growth in 2000 was 1.4% and for 2005 the prediction is for 1.2%. If this rate continues, the population will grow from 99 million to 106 million during that period. The State of Mexico, which was the most populated state in the country in the mid nineties, will maintain the lead over the next twenty-five years, increasing from 12 million inhabitants in 1995 to 18 million in the year 2020. This increase of almost six million people - the greatest of all the states - will represent almost one fifth of the increase undergone throughout the country. In relative terms, the greatest growth is predicted in the states of Quintana Roo, Aguascalientes, and Baja California, which will show average annual growth rates of 4%, 3%, and 3%, respectively. The population in the Federal District and Sinaloa will grow at a rate of 0.3%.

In the foreseeable future it is expected that the aging of the population in all states will be accentuated and toward the year 2050, when a level is reached of almost 132 million inhabitants in the country, one out of every four will be senior citizens (CONAPO, 2000).

## **PRODUCTION OF WASTE**

The production of waste is becoming greater as the country's population increases. According to a study published by the Federal Ministry of Social Development in 1999 (El Norte, 2002), the average national production is 865 grams per day per person. The highest level of production is that of the inhabitants of the Guadalajara Metropolitan Area (GMA) with 1.5 kilograms a day per inhabitant. The increase in the production of waste is due to the change in the habits of Mexican consumers, and to the fact that plastic packages have become almost indispensable. In the Federal District (DF, Distrito Federal), 12,000 tons of garbage are produced per day - 1.37 kilograms per person - (GDF, 2002a). Classified by sources of production, 46.2% comes from the homes (where a greater percentage of organic waste is found), 29% from businesses, 15.2% from providers of services, 3.2% from special areas and 6.4% from others. Mexico City's sanitary landfill will soon reach its saturation point, a situation that represents a serious problem for the City and that requires a rethinking as to the best complete handling of these wastes. Some individual and community initiatives have helped to advance in that direction, by promoting the separation, reuse, and recycling of subproducts, as well as the use of organic waste for compost. Other alternatives for degrading this material have also been sought, but this culture is still very limited and mechanisms for promoting it will have to be found.

10% of all waste produced in this country is recycled; this figure is not far below the level of recycling in other countries such as Germany or the United States, where they manage to utilize 15% of what is thrown out (El Norte, 2002). In the GMA between 5 and 6% is recycled. As a result of the increase in this country of waste disposal in sanitary landfill, without the recovery of the emissions and their consequent escape into the atmosphere, methane emissions doubled from 1992 to 1998 (INE-SEMARNAT, 2000). Also, the risk represented by burying elements with dangerous substances, such as batteries, expired medicines, pesticide containers, solvents, or paints, is not considered. These are classified as hazardous municipal wastes, and are often inadequately handled by collectors, which can cause damage to their health.

Carbon dioxide (CO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O), produced in the incineration of dangerous wastes, showed a significant growth beginning in 1994. The contribution of these gases to the national inventory is not significant, but locally they can have important impacts, especially N<sub>2</sub>O emissions.

TABLE 1.2. GREENHOUSE GAS EMISSIONS FROM WASTE(Gg/YEAR)

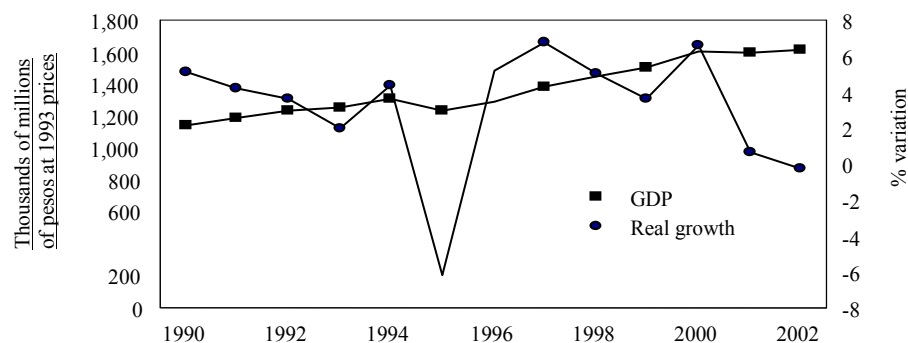
Year	Solid municipal* waste	Incineration of hazardous waste	
	CH <sub>4</sub>	CO <sub>2</sub>	N <sub>2</sub> O
1992	1,055.5	---	---
1994	1,038.7	3.4	0.0005
1996	1,6778.2	15.3	0.0022
1998	1,981.1	631.7	0.09

\* Dumps in the open are considered here.  
Source: INE-SEMARNAT, 2000.

## ECONOMY

After suffering a process of contraction during most of 2001, the cycle of the Mexican economy entered a phase of recovery at the beginning of 2002. However this new stage has lacked sufficient strength for extensive sectors of the population to perceive a significant improvement in their standards of living (SHCP, 2003). The Gross Domestic Product (GDP) with taxes was 5,830 and 6,153 thousand million current pesos in 2001 and 2002 respectively. For the latter year, this indicator was distributed as follows: 4% from the agricultural sector; 25% from the industrial (the manufacturing industry contributed 72% of this); 19% from the commercial sector, restaurants and hotels; 10% from transportation and communications, and 42% from services and financial activities (INEGI, 2003a).

FIGURE 1.1. EVOLUTION OF GROSS DOMESTIC PRODUCT AND ITS REAL GROWTH, 1990-2002  
(THOUSANDS OF MILLIONS OF PESOS AT 1993 PRICES)



SOURCE: Own preparation based on INEGI, 2003a.

TABLE 1.3. MEXICO'S MACROECONOMIC FRAMEWORK, 1996–2002

INDICATOR	1996	1997	1998	1999	2000	2001*	2002*
GDP (Tmp @ 1993)**	1,293.9	1,381.8	1,451.4	1,503.9	1,603.8	1,598.8	1,609.7
GDP (Tmp current)	2,529.9	3,179.1	3,848.2	4,599.4	5,497.4	5,830.1	6,152.8
% Real growth	5.1	6.8	5.0	3.8	6.6	-0.6	-0.2
Inflation	41.6	19.2	12.2	17.1	10.9	5.6	4.5

\* Preliminary figures

\*\* Thousands of millions of pesos

SOURCE: SHCP, 2002 and INEGI, 2003a.

### INDUSTRY

The industrial Gross Domestic Product was 1,434 and 1,486 thousand million current pesos, in 2001 and 2002 respectively (INEGI, 2003a). The cycle of industrial activities began a recessive phase that was more profound than that of the cycle of service activities (SHCP, 2003). Industrial activity, being more closely linked to the foreign market, was the first to feel the ravages of the economic deceleration of the United States, and for a more prolonged period of time. Some of the divisions that make up the industrial activity also recorded an asymmetric behaviour. The division that suffered the most severe contraction was that of manufactured goods with a growth of -1.3% in 2002, while the GDP of construction and of electricity grew by 0.3 and 0.2%, respectively (Presidency of the Republic, 2002).

### TRANSPORT

The Gross Domestic Product of the sector rose to 596 and 628 thousand million current pesos, in 2001 and 2002 respectively (10.2% of the total national GDP) (INEGI, 2003a). The sub-sector of transportation and storage contributed with 69%, and that of communications, with the remaining percentage. The transported load was concentrated mainly in highway transport (56%), followed by maritime (34%), railway (10%) and air (less than 0.1%). 84% of the federal public investment of the sector was allocated mainly to the construction, modernization, and maintenance of highways. For the same year, the infrastructure of the sector included 340,277 kilometres of highways, 26,655

kilometres of railroads, 97 sea and 11 river ports, as well as 85 airports (28 national and 57 international) and 1,128 airfields. The number of vehicles in circulation every day on toll highways in 2001 was 736,858, while in the 2000 it was 690,066 vehicles (Presidency of the Republic, 2002).

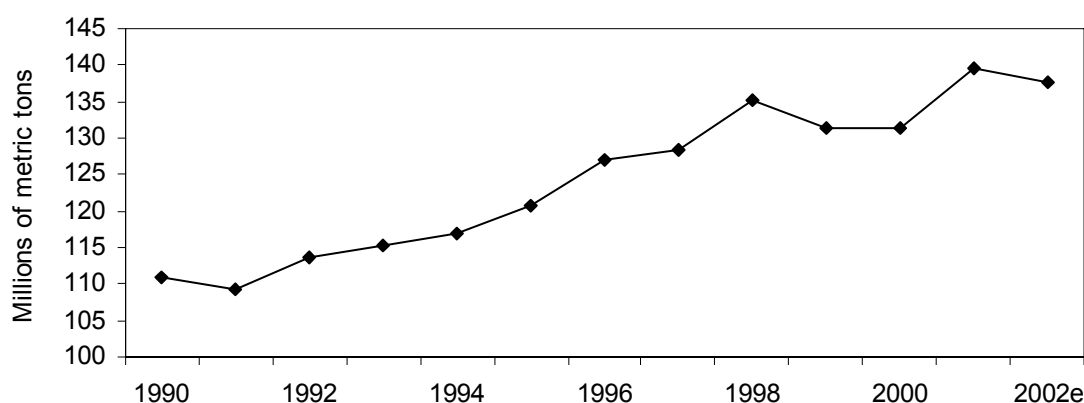
Federal public transportation transported 2,713 million people as well as a load of 409 million metric tons, which represented an increase of 3.8% with respect to 1999. These operations involved 60,788 passenger vehicles and 388,320 load units. As for railway operation, 242,000 people and a load of 74 million metric tons were transported. The number of passengers transported in aircraft came to approximately 34 million (over 50% were national and the rest international), the load transported totalled 351 thousand metric tons, mainly for international service. Finally, 244 million metric tons of load cargo were transported by sea.

### **AGRICULTURE**

According to official estimates, nearly 18 million people were engaged in agricultural activities in 2001, which represented 18% of the total national population, a lower figure than the 20 million people in 1998 (Presidency of the Republic, 2002). The Gross Domestic Product (GDP) of the Agricultural, Forestry and Fishing sector was 220 and 226 billion pesos at current prices in 2001 and 2002 respectively, and represented 4% of the total national GDP. For 2002, the GDP of the sector was distributed as follows: 65% from agriculture; 27% from livestock raising; 5% from forestry and 3% from fishing (INEGI, 2003a).

Production from the agricultural sub-sector in 2001 came to 140 million metric tons of agricultural products (25 million metric tons of basic grains; 1 million metric tons of edible oils, 7 million metric tons of grains such as barley and sorghum; 14 million metric tons of fruit products; 8 million metric tons of vegetable products and 85 million metric tons of cyclical, perennial crops such as coffee, alfalfa and oats, among others). The participation of basic grains in the total production diminished, while that of fruit products increased. Greater volumes of other valuable products are produced; for example, vegetables represented 15% of the value of the national agricultural production in 1991 and they now represent 20% (Presidency of the Republic, 2002). The basic grains have reduced their participation with regard to the total value of the sector - but not their production in metric tons. The evolution of the quantity of agricultural production is shown in figure 1.2.

FIGURE 1.2. AGRICULTURAL PRODUCTION IN MEXICO 1990-2002  
(MILLIONS OF METRIC TONS)



e Estimated figure

SOURCE: Own preparation based on Presidency of the Republic, 2002.

### LIVESTOCK RAISING

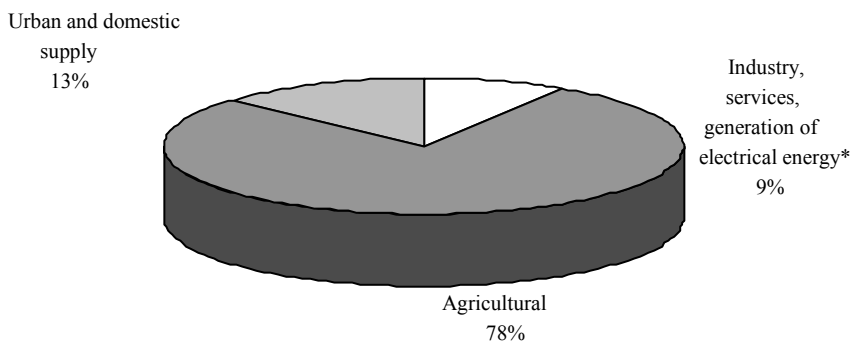
The livestock sub-sector contributed 27% of the GDP of the agricultural sector, forestry and fishing. Livestock production in 2001 was almost 5 million tons of carcasses of different species; 10 million litres of cow's milk; 882 thousand metric tons of eggs. Increases of 5%, 2% and 5% were achieved respectively for the same products with respect to the year 2000. For the first semester of 2002, the total production of meat carcasses was 4.6 million metric tons (Presidency of the Republic, 2002).

### WATER RESOURCES

The average annual natural availability of drinking water *per capita* was 4,841 m<sup>3</sup>/inhab and 4,685 m<sup>3</sup>/inhab., in 2000 and 2001 respectively (CNA-SEMARNAT, 2002; CNA-SEMARNAT, 2003). Mexico is already among the countries with low availability of water - in Canada for example there are 99,700 m<sup>3</sup>/inhab. and in Argentina 29,100 m<sup>3</sup>/inhab. Among regional variations especially noticeable is the fact that the natural availability of water *per capita* in the southeast is seven times greater than that of the centre, north and northwest (Salmon, 2003). In the Lerma-Santiago-Pacific region the average historical precipitation in the period from 1941-2001 was 981 mm, while the total gross extraction of water in 2001 was 13,816 km<sup>3</sup>; in the Valley of Mexico region, the average historical precipitation for the same period was 767 mm and the extraction in 2001 was 4,784 km<sup>3</sup>; and in the Frontera Sur region the annual precipitation was 2,320 mm, and the extraction was 1,553 km<sup>3</sup>. Based on this, the degree of pressure on the water resources (defined as the total

annual extraction / natural availability), was 126% in the Valley of Mexico; 97% in the Baja California Peninsula and 1% in the Frontera Sur region. The total gross extraction of water was 72.56 km<sup>3</sup> in 2001, mainly of surface origin (CNA-SEMARNAT, 2003). The agricultural sector was the main consumer, as may be observed in figure 1.3.

FIGURE 1.3. CONSUMER CONSUMPTION OF WATER IN MÉXICO, 2001



SOURCE: CNA-SEMARNAT, 2003.

The volume contained by the seven main lakes in Mexico during 2001 fell to 6.5 million km<sup>3</sup> (3.5% less than in 1998). There exist, besides, 4,500 dams that held a total of 150 km<sup>3</sup>. Water from the La Angostura, Malpaso, Infiernillo, Temascal, Aguamilpa and La Amistad dams were used mainly to generate electrical power.

As for underground waters, the National Water Commission (CNA-SEMARNAT, 2003) has defined nearly 654 aquifers distributed throughout national territory, 97 of which are subject to overexploitation. These aquifers provide approximately 50% of national extraction for all uses. Due to the overexploitation, the reserve of underground water is diminishing at a rate of almost 8 km<sup>3</sup> per year. There are 17 aquifers with problems of saline intrusion located in the states of Baja California Norte, Baja California Sur, Colima, Sonora and Veracruz.

## WASTE WATER

With the continuous increase in population and industrial activity, there occur conflicts due to the competition in the use of water between the different sectors, urban and rural areas, cities and neighbouring states. The excessive extraction from aquifers and the increase in their contamination, are aggravating an already serious problem of water shortage. In states such as Campeche, the population density is 12 inhab/km<sup>2</sup> (CONAPO, 1998) and each person has 25,840 m<sup>3</sup> available annually (Salmones, 2003). However the Federal District and the State of

Mexico, which have a density of 5,634 inhab/km<sup>2</sup> and 6,111 inhab/km<sup>2</sup>, have the lowest rate of water availability in the country, 190 m<sup>3</sup>/inhab. Other factors that intensify the problem of availability of the resource are the lack of maintenance of the distribution networks which causes leaks of up to 32%, as well as the use of drinking water in numerous processes that require water of lesser quality, for example in the watering of green areas, industrial processes, water for bathrooms (GDF, 2002a).

It is necessary for distribution networks to have acceptable quantities of measuring, implementation, and automation devices in order to avoid major water leakages. Also the considerable backwardness in the maintenance of the infrastructure, which contrasts with the growing social demand to increase distribution of the resource, will have to be corrected. In the Federal District for example, in the first semester of 2002, there was an advance in the detection of 2,417 non-visible leaks, the repair of 723 leaks in the secondary network and of 4,006 in home accesses; 100 kilometres of pipes were substituted in the secondary network, as well as 225 valves, making it possible to recover a flow of approximately 197 litres per second (GDF, 2002b). Future supplies of water will no longer be the product of the development of ambitious extraction and distribution projects but of conservation, recycling, reuse and efficiency in the use of water (Salmones, 2003). This will generate more methane emissions in the new treatment plants, in the face of which solutions will have to be adopted to mitigate them, right from the design of the new plants. In 2001, urban centres generated 8 km<sup>3</sup> (252 m<sup>3</sup>/s) of waste water, 20% received treatment and the rest was collected in the sewer system. Industry, in turn, generated 5 km<sup>3</sup> (171 m<sup>3</sup>/s), of which 10% was treated for reuse (CNA-SEMARNAT, 2002).

According to the National Inventory of Greenhouse Gas Emissions (INE-SEMARNAT, 2000), the increase in methane emissions generated by the treatment of municipal waste water in the period from 1992 to 1998 was low (10.7%), due to the installation of new plants with and aerobic-type treatment. In the case of treatment of industrial water, the methane emissions generated increased by 40% over the same period, in spite of the fact that in 1994 there were 177 treatment plants registered and in 1998 they increased to 1,354 plants. 70% of the plants operate outside of the specifications that have been set for them. Most of these plants operate with aerobic processes, and a faulty aerobic process produces methane.

TABLE 1.4. METHANE EMISSIONS GENERATED FROM WASTE WATER TREATMENT, (Gg CH<sub>4</sub>/ YEAR)

Waste	1992	1994	1996	1998
Municipal waste water	499.0	525.5	546.73	552.4
Industrial waste water	601.1	626.1	714.2	829.2

Source: INE-SEMARNAT, 2000.

## FOREST RESOURCES

The forest surface area (forests and rain forests) in the country is little more than 48 million hectares (ha), an area that represents 28% of the national plant surface (INEGI, 2003b).

TABLE 1.5. FOREST AREA REGISTERED IN 2002 (MILLIONS OF HA)

FORMATION	AREA
Forest	28.3
Rain forest	19.9
Scrubland	46.8
Grazing land	8.3
Other types of vegetation	13.5
Storm agriculture	20.4
Irrigated agriculture	8.3
Total agriculture	28.7

SOURCE: INEGI, 2003b.

The timber-yielding forest production reached over 9 million m<sup>3</sup>-roll in 2000, with a major production of lumber and cellulose. The apparent national consumption was 16 million m<sup>3</sup>-roll, which meant an increase of 0.4% with respect to the previous year. The national production allocated to domestic consumption with respect to the apparent national consumption was 46% in 2001 (Presidency of the Republic, 2002).

The total surface area affected by fires came to nearly 236,000 hectares; 101,555 hectares of grazing lands, 40,475 hectares of forests and 94,285 of other surface types. On the other hand just over 225,000 hectares of forest area were reforested. The number of protected areas (national parks, biosphere reserves and natural monuments) was 148 in 2002 (INEGI, 2003b).

## DEFORESTATION

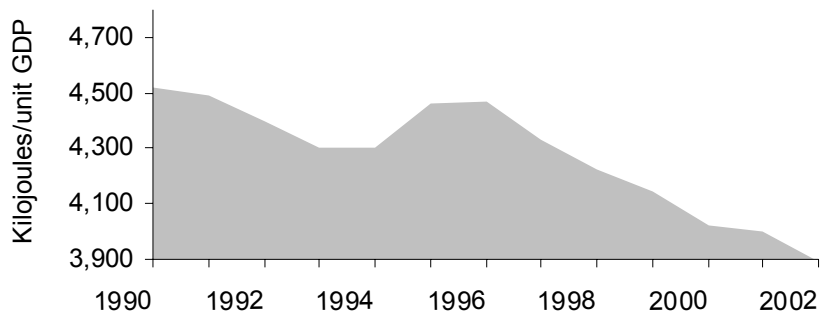
Through the analysis of satellite images of the vegetation and land use over the entire national territory, by comparing years 1993 and 2000, it was possible to determine a total loss of forest cover of 8 million hectares, which translates into an annual rate of deforestation of over a million hectares. According to the SEMARNAT, these data constitute a basic tool for planning the environmental policy in the area of forests and for reorienting the policies of promoting the productive sectors of the country (SEMARNAT, 2001).

## ENERGY RESOURCES

In the energy sector in Mexico, energy intensity, which indicates the quantity of energy that is required to produce a unit of Gross Domestic Product (GDP) calculated at prices of 1993, was situated at 4,003.7 and 3,894.4 kilojoules in 2001 and 2002 respectively (SENER, 2002a and SENER, 2003a). It is important to stress that the value observed during the year 2002 is the lowest in the last 20 years, reinforcing the tendency to produce more and more products with less and less energy and therefore with a lower level of greenhouse gas emissions (Figure 1.4).

The energy consumption *per capita* was 61.5 million kilojoules in 2002, 5.7% less than in 2000. The national energy consumption in 2002 fell by 2.5% with respect to 2000 and reached a level of 6,276.3 petajoules, 38% of which was allocated to the energy sector itself and 62% to final consumption. This decrease is associated with both the lower level of economic activity (the GDP grew -0.2%), and with the greater intensity in energy use observed during that year (SENER, 2003a).

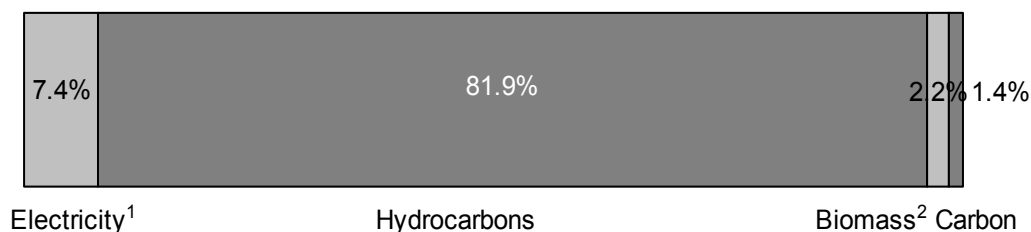
FIGURE 1.4. ENERGY INTENSITY 1990-2002, (KJ PER UNIT GDP)



SOURCE: SENER, 2003a.

The production of primary energy was made up mainly of hydrocarbons, followed by primary electricity, biomass and coal, as may be observed in the following figure.

FIGURE 1.5. PERCENTAGE DISTRIBUTION OF TOTAL GLOBAL ENERGY SUPPLY BY TYPE OF FUEL IN 2002



<sup>1</sup>. Includes hydro power, nuclear energy, geo-energy and aeolian energy.

<sup>2</sup>. Includes firewood and sugar cane bagasse.

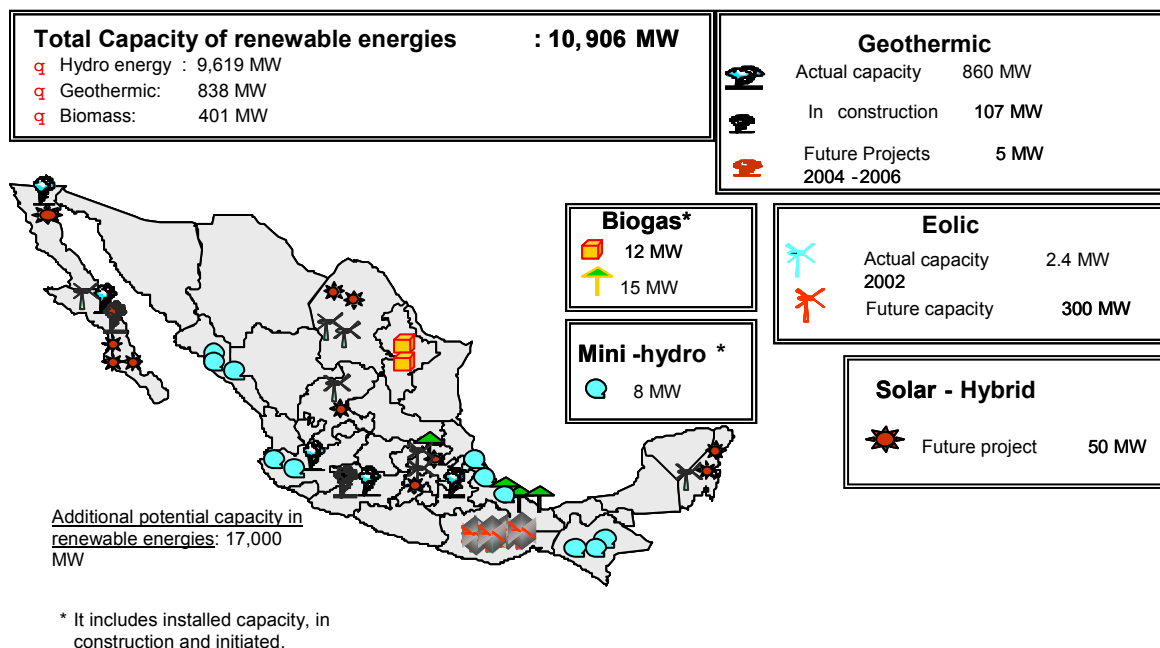
SOURCE: SENER, 2003a.

According to information provided by the Federal Electrical Commission (CFE, for its initials in Spanish), hydro power, geo-energy and aeolian energy fell respectively between 2000 and 2001 by 14.7, 6.4 and 14.5%. However, according to what has been pointed out by the National Association of Solar Energy (ANES, for its initials in Spanish), the non-public sources - without CFE - associated with the use of solar radiation and wind came to a total of 2.2 petajoules in 2001, reflecting a growth of 19.1% with respect to 1.9 petajoules for the year 2000 (SENER, 2003). Figure 1.6 shows the present and future situation of renewable energy in this country.

In the last World Summit for Sustainable Development, held in Johannesburg, South Africa, in August, 2002, the Mexican Delegation declared that energy should be considered a trans-sectoral topic, with an impact on consumption and production patterns, on environmental deterioration and on access to basic services; and they insisted that, given its global impact, it is urgent for all countries to comply responsibly with the Kyoto Protocol and for this to be adopted as a general framework for regulating the global environmental impact of energy (SEMARNAT, 2003a). They considered that access to energy, energy efficiency and renewable, clean energy are central elements of sustainable development. They also stated that in our country an increasingly higher Gross Domestic Product is generated with lower energy consumption and lower production of emissions. By the same token, they expressed the need to prepare a clear mandate of the Summit in favour of renewable energy and a cleaner use of energy. In this regard, the Mexican Delegation declared themselves to be in favour of including a goal of 15% use of renewable energy in the

overall energy mixture, as well as a substantial reduction in the use of traditional biomass (firewood and manure), as a commitment linked to the fight against poverty.

. FIGURE 1.6. RENEWABLE ENERGIES: PRESENT AND FUTURE SITUATION

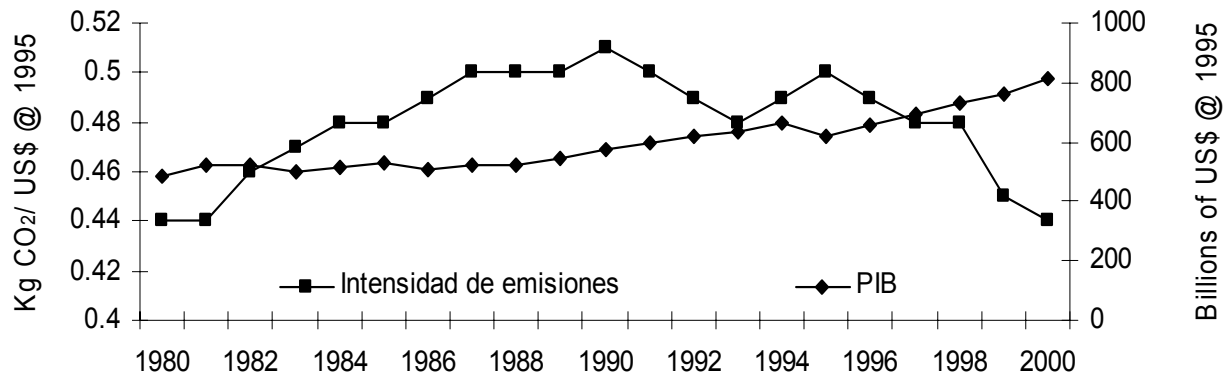


SOURCE: SENER, 2002b.

The energy consumption of the sectors and sub-sectors presented a different evolution in 2000 from 2001. The consumption of the whole of the residential, commercial and public sector grew by 0.7%, and individually by 0.4, 2.9 and 1.7% respectively (SENER, 2002a). Although that of the transport sector fell by 0.9%, the consumption of the sub-sectors of electric transportation and automobile transportation grew respectively by 3.2 and 0.1%, with marine, rail, and air sub-sectors falling by 19.8, 8.4 and 1.9% respectively. The consumptions of energy in the agricultural and industrial sector fell in 2001 with respect to 2000 by 4.4 and 8.5% respectively. In the industry, more and more alternative fuels are being used such as black liquor in the production of cellulose and paper; biogas in the beer and malt branch; used tires, in non-polluting processes in cement production. In these cases, with the exception of black liquor, growth in their consumption is observed from 2000 to 2001.

On the other hand, the consumption of compressed natural gas in the transport sector during the year 2001 was equivalent to 0.5 petajoules, 132.7% higher than the consumption of 0.2 petajoules in 2000. This figure is not significant with respect to the total of all fuels consumed by the transport sector. The rate of growth of CO<sub>2</sub> emissions of the energy sector follows a declining tendency.

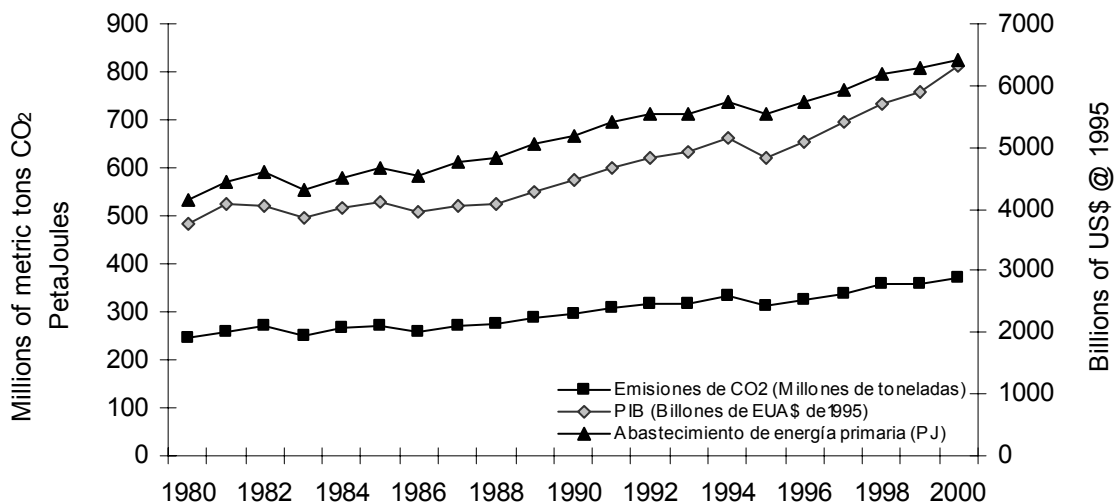
FIGURE 1.7. INTENSITY OF EMISSIONS, 1980-2000



SOURCE: Prepared by SENER with information from IEA-OECD, 2002.

The emissions of this sector have separated from the growth of the GDP, as shown by figure 1.8.

FIGURE 1.8. GROWTH IN PRIMARY ENERGY SUPPLY, GDP, AND CO<sub>2</sub> EMISSIONS



SOURCE: Prepared by SENER with information from IEA-OECD, 2002.

## II. MITIGATION POLICIES

### FORESTRY SECTOR

The National Forest Commission (CONAFOR, for its initials in Spanish) was created on April 4, 2001, as a Decentralized Public Organism of SEMARNAT. Its objective is to develop, encourage and promote productive, conservation, and restoration activities in the area of forests; as well as participating in the formulation of plans and programs, and in the application of policies of sustainable forest development (CONAFOR-SEMARNAT, 2002a). In this respect the Commission is implementing the following actions:

- I. Program for the Development of Commercial Forest Plantations (PRODEPLAN), through which these are promoted for commercial purposes for: creating employment, promoting environmental services, giving incentive to more profitable land uses, increasing carbon capture and retention, and lowering the pressure on natural forests.
- II. Program for Forest Development (PRODEFOR), which supports the promotion of productivity and sustainable management of the natural forest, in order to improve the quality of life in communities and the diversified use of ecosystems.
- III. Project for the Conservation and Sustainable Management of Forest Resources (PROCYMAF) in Mexico, is a project partially financed by the World Bank which aims at implementing the strategy of sustainable forest management described in the National Forest Plan 2002-2006 and in the Strategic Forest Program for Mexico 2025, by encouraging plans for: (i) improving the exploitation and conservation of natural resources by communities and cooperative-owned forest lands and (ii) generating and increasing the owners' income options based on their forest resources. The organization "Forest Stewardship Councils" certifies the hectares involved in this project.

- IV. National Reforestation Program (PRONARE), which supports the restoration of forest ecosystems and lands through reforestation, with high-quality processes.
- V. Soil Conservation and Restoration Program. This program includes the protection and restoration of areas degraded or eroded due to deforestation.
- VI. Research and Development. The CONAFOR-CONACYT Sectoral Fund was created in 2002 to support forest research and technological development.
- VII. Mexican Forest Fund. This is a private organism with public and private sources whose aim will be to make financing and productive strengthening of the actors of the forest sector easier. The Federal Government, social organisms, academics, producers and specialists will participate in it . This Fund will begin operating in the first trimester of 2003 and will seek to:
  - Reactivate the credit of private and commercial banking.
  - Form a project portfolio and support strategic and productive ones.
  - Strengthen the business capacity of forest owners, providers of technical forest services, micro and small businessmen.
  - Promote and strengthen productive chains.
  - Promote environmental services.
- VIII. General Law for Sustainable Forest Development. This document was passed unanimously in the Senate of the Republic, in November, 2002. It is up to the Chamber of Deputies to revise and (if such is the case) approve this new Law, which will give greater certainty to the forest sector. The general objectives of the Law are:
  - a. To contribute to the social, economic, ecological, and environmental development of the country, through the integral sustainable management of forest resources, as well as of basins and water-forest ecosystems, without affecting areas provided for in other regulations (CONAFOR-SEMARNAT, 2002b).
  - b. To encourage silviculture and the use of forest resources, so that they can contribute with goods and services that will ensure the improvement of the Mexicans' standard of living, especially of the owners and settlers of forest communities.
  - c. To develop environmental goods and services and to protect, maintain and increase the biodiversity offered by forest resources.

- d. To promote the organization, operating capacity, integration and professionalization of public institutions of the Federation, States, Federal District and Municipalities, for sustainable forest development.
- e. To respect the right to the preferential use and enjoyment of forest resources of the places occupied and inhabited by indigenous communities, under the terms of article 2 section VI of the Political Constitution of the United States of Mexico and other applicable regulations.

IX. International agreements. The CONAFOR has participated in different forums coordinated by international organisms in which Mexico undertook commitments in the preparation of inventories and mitigation studies in the forestry area during 2002. In complying with the strategies indicated in the Strategic Forest Program for Mexico 2025 (PEF, for its initials in Spanish) and the National Forest Program 2001-2006 (PNF, for its initials in Spanish), the Commission participates with the purpose of contributing to the improvement of forest management; foremost among the organisms are the following:

- ◆ USAID - United States Agency for International Development.
- ◆ USFOREST - United States Forest Service.
- ◆ USDA - United States Department of Agriculture.
- ◆ UNFCCC - United Nations Framework Convention on Climate Change (COP 8)
- ◆ NAFC - North American Forest Commission
- ◆ LACFC - Latin American and Caribbean Forestry Commission
- ◆ IITO - International Tropical Timber Organization
- ◆ Carbon fund, World Bank.

The following table presents the goals programmed by the Commission and their percentage of progress in 2002.

TABLE 2.1. ADVANCES IN PROGRAMS OF THE NATIONAL FOREST COMMISSION - SEMARNAT IN 2002\*

GOALS	PHYSICAL PROGRESS	%
1. Incorporate 2,380,000 ha into forest management (PRODEFOR-PROCYMAF)	2,976,864	125
2. Finance development of 89,000 ha of commercial forest plantations (PRODEPLAN)	96,749	109
3. Promote certification of 200,000 ha throughout the country (PRODEFOR-PROCYMAF)	126,496	63
4. Begin operation of three productive chains in this country	2	67
5. Reforest 210,000 ha (PRONARE)	204,011	97
6. Complete works on soil restoration on 30,000 ha with moderate and sever deterioration.	20,245	67
7. Complete preventive works on soil in a million ha with slight level of deterioration.	286,478	29
8. Make up and operate Mexican Forestry Fund.	Begins first trimester of 2003	
9. Comply with 9 international agreements and obligations.	12	133
10. Have Forestry Law approved by Congress of the Union.	Approved in Senate	
11. Formulate 13 operational water-forest programs at the regional level, based on strategic national forest-water programs.	6 in process	70
12. Begin 60 research projects.	45	75
13. Begin 13 projects in technological development.	15	115

\* Percentage progress between program and work carried out to Oct. 31, 2002.

\*\* Due to a budget cut, the goal was adjusted to 6 programs.

SOURCE: CONAFOR-SEMARNAT, 2002a.

In the last World Summit for Sustainable Development, held in Johannesburg, South Africa in August, 2002, the Mexican Delegation presented two projects of sustainable forest development (SEMARNAT, 2003a), which were very well received by the international community:

1. Sustainable forest management and use of non timber-yielding products, of the Purepecha community in Nuevo San Juan Parangaricutiro, Michoacán.

The community has increased the surface area of forest land from 11,000 to 12,300 ha in the last few years, maintaining an ecological balance and economic well-being. Their products - furniture and moulding, among other things -, are sold on the national and international markets and the community receives funds from private national and international foundations, as well as from the National Forest Commission.

## 2. Sustainable production of organic coffee, from the local communities of Chiapas.

The sustainable development and environmental protection project, "Café de la Selva", which brings together 1,250 indigenous families in 42 communities, was nominated by the United Nations Organization as a finalist for the 2002 World Equator Prize (UNDP, 2003). The organization of coffee-growers has replaced insecticides and chemical fertilizers with products of organic origin in 2,400 ha of rain forest, and has also planted hundreds of red cedars and other trees in order to maintain the shaded surroundings that coffee needs, besides protecting the wildlife habitat. By adopting certified techniques, the growers have been able to control erosion, limit soil pollution, and produce high-quality coffee.

## **ENERGY SECTOR**

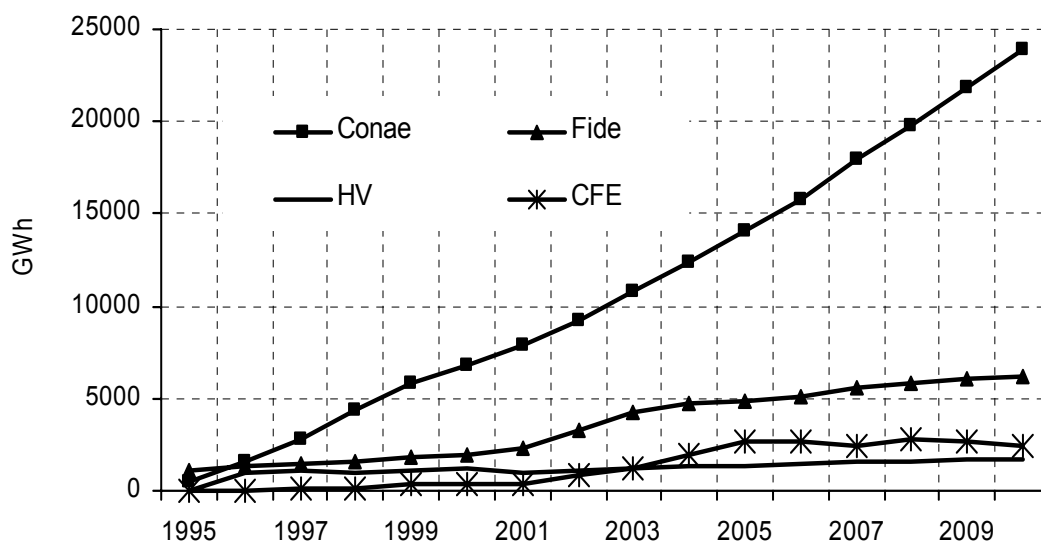
The energy sector plays a decisive role in national life: it generates electricity and hydrocarbons as inputs for the economy and the provision of public services; it contributes considerable taxes to fiscal revenues and gives employment to over three hundred thousand workers; it brings together three of the largest companies in the country: Mexican Petroleum and its subsidiary organisms (PEMEX), the Federal Electrical Commission (CFE), and Central Light and Power (LFC).

In the flowchart of the sector there are also three deconcentrated bodies: 1) the Energy Regulating Commission (CRE), whose functions are to grant permits, authorize prices and rates, approve terms and conditions for providing services, issue administrative orders of a general nature (guidelines), resolve controversies, collect information and apply sanctions, among others; 2) the National Commission on Nuclear Security and Safeguards, which is an organism in charge of handling all matters related to nuclear resources, including the functions of control and surveillance of nuclear energy production; and 3) the National Commission for Electrical Energy Saving (CONAE) whose mission is to design, encourage and promote guidelines and actions with regard to the saving and efficient use of energy and the exploitation of renewable energies in the country; offer technical assistance in this area to the public, private and social sectors; as well as arranging the implementation of energy efficiency norms.

The Electrical Energy Saving Fund (FIDE) is in turn a private, non-profit organism, created in 1990 to promote actions to encourage and advocate the saving and rational use of electrical energy. The Technical Committee of the FIDE is made up of the CFE, LFC, CONAE and different industrial chambers and consulting firms.

The following figure presents the energy saving for the implementing of the programs that the above-mentioned organisms have conducted, as well as a prospect to 2010.

FIGURE 2.1. ENERGY SAVING FROM PROGRAMS IMPLEMENTED IN THE ENERGY SECTOR: EVOLUTION AND PROSPECT 1995-2010 (GWh)



Source: SENER, 2003a.

The CO<sub>2</sub> emissions prevented by the energy saving in the sector to 2002, as well as a prospect to the year 2010, are given in the following table:

TABLE 2.2. CO<sub>2</sub> EMISSIONS PREVENTED BY ENERGY SAVING PROGRAMS IMPLEMENTED IN THE ENERGY SECTOR:  
EVOLUTION AND PROSPECT 1995-2010<sup>1</sup> (THOUSANDS OF METRIC TONS)

	1995	1996	1997	1998	1999	2000	2001	2002
CONAE <sup>2</sup>	273.3	1,185.4	2,161.6	3,598.7	4,463.8	10,114.8	11,199.3	12,753.7
FIDE <sup>3</sup>	690.7	833.0	877.5	956.2	1,082.3	1,182.6	1,403.6	2,004.2
DAYLIGHT SAVING	0.0	566.4	660.7	607.8	655.9	709.9	560.4	635.4
CFE	7.2	30.6	57.1	85.3	193.2	209.4	209.4	517.57
<b>TOTAL</b>	<b>971.2</b>	<b>2,615.4</b>	<b>3,756.8</b>	<b>5,247.9</b>	<b>6,395.1</b>	<b>12,216.7</b>	<b>13,372.7</b>	<b>15,910.8</b>
	2003	2004	2005	2006	2007	2008	2009	2010
CONAE <sup>2</sup>	14,292.8	15,945.9	17,719.6	19,605.0	21,826.1	24,007.9	26,290.3	28,944.8
FIDE <sup>3</sup>	2,558.6	2,819.2	2,935.1	3,050.4	3,378.9	3,500.9	3,627.0	3,751.3
DAYLIGHT SAVING	739.9	779.6	821.6	863.12	912.9	956.2	1,002.4	1,051.1
CFE	730.8	1,187.7	1,634.9	1,615.6	1,484.7	1,681.2	1,604.2	1,484.7
<b>TOTAL</b>	<b>18,322.1</b>	<b>20,732.5</b>	<b>23,111.3</b>	<b>25,134.1</b>	<b>27,602.6</b>	<b>30,146.2</b>	<b>32,523.9</b>	<b>35,231.8</b>

<sup>1</sup> Emissions are estimated with a caloric energy of crude oil of 5,850 MJ/barrel and a factor of 0.264 metric ton CO<sub>2</sub>/ MWh or 73.33 metric tons CO<sub>2</sub>/TJ.

<sup>2</sup> Takes into consideration only saving from application of norms.

<sup>3</sup> Includes Program of Incentives, Small business, Agricultural pumping, Industrial, commercial and municipal service premises.

Source: Own estimates based on information provided by SENER, 2003a.

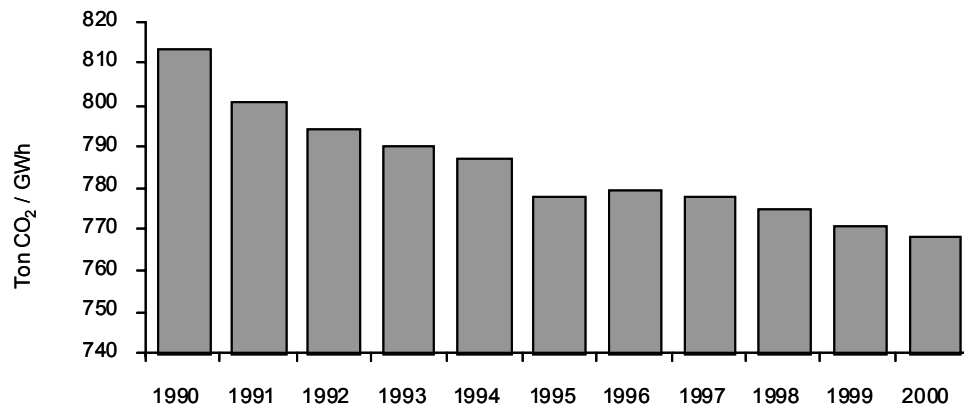
## FEDERAL ELECTRICAL COMMISSION, CFE

Among the main measures applied by the CFE that have helped in reducing greenhouse gas emissions are the following:

- Introduction of combined cycle thermoelectric plants into the national electric system.
- Replacing fuel oil with natural gas.

The carbon dioxide emissions (CO<sub>2</sub>) per GWh in the thermoelectric plants have fallen gradually over the last few years (SENER, 2002b). In the year 2001, the total consumption of natural gas on these premises represented 22% of all fuel consumption, while in 1990 it was 16%.

FIGURE 2.2. CO<sub>2</sub> EMISSIONS PER GWH IN THERMOELECTRIC PLANTS (METRIC TON CO<sub>2</sub>/GWH)



SOURCE: SENER, 2002b.

With the replacement of fossil fuels by natural gas in generating electricity, the emission of 413 thousand metric tons of CO<sub>2</sub> was prevented in the year 2000, with an accumulated reduction of 4.5 millions of tons of CO<sub>2</sub> in the period 1991-2000 (SENER, 2002b). The CO<sub>2</sub> emissions prevented in the year 2010 are predicted to be 641 thousand metric tons, due to the lower fuel oil consumption in the electric power stations of the National Electric System (SENER, 2003a).

### **MEXICAN PETROLEUM, PEMEX**

PEMEX managed a substantial reduction in its carbon dioxide (CO<sub>2</sub>) emissions, dropping from 40 million metric tons in 2001 to 37 million metric tons during 2002, which represents a decrease of 8% (PEMEX, 2003). PEMEX Refining (PR) is the main producer of CO<sub>2</sub>, with 39%, followed by PEMEX Exploration and Production (PEP), with 28%, PEMEX Natural Gas and Basic Petrochemicals (PGPB) with 17% and PEMEX Petrochemicals (PPQ) with 16%. PEP reduced its CO<sub>2</sub> emissions, mainly as a result of its projects for the use of natural gas in the Northeast Maritime Region.

TABLE 2.3. CO<sub>2</sub> EMISSIONS PREVENTED IN MEXICAN PETROLEUM, PEMEX  
(MILLIONS OF METRIC TONS)

SUBSIDIARY	1999	2000	2001	2002
PEP	13.9	14.2	13.3	10.5
PPR	15.1	14.2	13.7	14.2
PGPB	6.3	6.5	6.4	6.2
PPQ	6.3	6.5	6.7	5.9
TOTAL	41.6	41.4	40.0	36.9

SOURCE: PEMEX, 2003.

### Internal market of carbon emission permits

In June of 2001, with the technical support of “Environmental Defense”, a non-government organization of the United States, PEMEX began operation of an innovative plan for the commercialization of carbon emissions reduction permits among its subsidiaries; at the same time it now promotes, and gives an economic value to, the reduction of carbon dioxide emissions.

25 Business Units (BU) participate in this plan: the 4 regions of PEP; 6 PR refineries; 7 PGPB gas processing complexes and 8 PPQ petrochemical complexes. The Corporate Audit of Environmental Protection coordinates the development and operation of the emissions market (PEMEX, 2002). Of the 3 million tons of CO<sub>2</sub> that decreased in 2002 with respect to 2001, the 25 business units that participated in the market, during the period reported, exchanged more than 2 million metric tons of CO<sub>2</sub> with a virtual value of 145 million pesos. In 2002 an accumulated reduction of 11% was achieved with respect to the base year 1999, equivalent to almost 5 million metric tons of CO<sub>2</sub> (PEMEX, 2003). The online market operations are carried out in the System of Transaction Registration (SRT, for its initials in Spanish) developed by PEMEX, while the data on CO<sub>2</sub> emissions are from the Subsystem of Information on Industrial Security and Environmental Protection (SISPA, for its initials in Spanish).

The internal market for carbon emissions permits in PEMEX received the INNOVA award in November of 2002, granted by the Presidency of the Republic to initiatives that contribute to innovation and quality in public administration.

## Project for exploiting natural gas in the "Cactus" petrochemical complex

This Petrochemical Complex is located in Chiapas and has four turbo-generators that make it self-sufficient in electrical power. The gases produced by the combustion of the turbines, which reach temperatures of 517°C, used to be sent into the atmosphere, wasting their heating power. In 2001, two units were installed for recovering heat to generate steam, to heat and evaporate water in the boilers, and for overheating steam for engine use, respectively. With these measures, energy is saved and the environment is protected. Eliminating the burning of 10 million cubic feet of natural gas every day prevents the emission of 526 tons of CO<sub>2</sub> into the atmosphere per day (PEMEX, 2002).

## Arpel Workshop on carbon certificates and reduction of polluting emissions in Latin America

On October 23-25, 2001, PEMEX and the Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean (ARPEL), held a workshop in the City of Mexico, to train oil industry representatives in the region in the development of projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol. Actions in favour of sustainable development carried out in the international oil industry were highlighted at the Seventeenth World Congress of Petroleum, held in Rio de Janeiro, Brazil, in September, 2002. Mexican Petroleum was also invited to participate in the ARPEL Workshop "Practical Methods for identifying opportunities for emissions reduction: Examples under the mechanisms of the Kyoto Protocol in Latin America and the Caribbean", in San José, Costa Rica, December 2-4, 2002, as part of a series of events related to Climate Change (PEMEX, 2003).

## Energy Consumption

The energy used in different operations of PEMEX came to 167 million barrels of crude oil equivalent (MMBOE) in 2001 and 146 MMBOE in 2002 (for these two years the energy consumed by burning and venting of hydrocarbons is taken into consideration). The largest proportion of energy used came from fossil fuels, and only a quantity of close to 2% represented the net consumption of electricity. The fuels used were 80% natural gas, 15% fuel oil and the rest diesel.

TABLE 2.4. ENERGY CONSUMPTION OF PEMEX (MMBOE)

SUBSIDIARY	2001	2001	2002	2002
		includes burning of gas		includes burning of gas
PEP	31.6	75.8	29.6	54.6
PR	44.7	48.5	48.4	51.0
PGPB	19.0	19.4	19.8	20.0
PPQ	23.0	23.1	20.6	20.7
TOTAL	118.3	166.7	118.4	146.4

SOURCE: PEMEX, 2003.

### Permanent campaign in the efficient use and energy saving

This campaign enjoyed the participation of 193 work centres and eight administrative buildings in 2002. Goals were set for each line of business in order to compare similar fundamental activities, and these included a reduction in the index of energy consumption from 1.5 to 5%. In 2001, substantial saving was achieved estimated at 11 MMBOE, with an associated value of 197 million dollars, as well as reducing CO<sub>2</sub> emissions by more than 3 million tons. In 2002 the savings were estimated at 17 MMBOE, with an associated value of 362 million dollars, besides reinforcing the culture of efficient use and saving of energy in the company.

### Training of specialists in energy and the environment

With the support of the United States Agency for International Development (USAID), 378 professionals in the four subsidiaries were trained in 2001 in the evaluation of energy efficiency projects (PEMEX, 2002). In May of 2002 four training seminars were given to improve the qualifications of 85 engineers, whereby the company continues the process of training in technical capability, in order to support its programs in the efficient use of energy and the improvement of environmental performance (PEMEX, 2003).

72 environmental audits were concluded in the company's facilities and 50 Clean Industry Certificates were granted in 2001. PEMEX Refining carried out energy audits on its 34 processing plants and auxiliary services of the Tula refinery in 2002. There was estimated to be a potential for energy recovery of 25%, a potential saving of 56 million dollars a year and a reduction of 25% in the emission of pollutants into the atmosphere.

## Technological Development

With the participation of the Mexican Petroleum Institute (IMP), PEMEX is implementing the Institutional Program for Research into the Environment and Safety - PIMAS -, which has made it possible to show advances in the following projects related to Climate Change:

1. A technical and economic analysis of the environmental impact of the use of natural gas and liquid petroleum gas in Mexico and its implications for PEMEX Basic Petrochemical Gas. It includes campaigns for measuring SO<sub>2</sub>, NO<sub>x</sub>, HC, CO and CO<sub>2</sub> emissions in fixed sources, in the Cactus and Ciudad PEMEX petrochemical complexes.
2. A study of environmental pollution due to petroleum refining processes in Mexico, in which methodologies are developed and applied in the Tula and Salina Cruz refineries to obtain emission factors for pollutants released into the air and into bodies of water, and creating an aggregated index of indicators for use in sustainable development.
3. Research for developing fuels with low environmental impact. Samplings of emissions from mobile and domestic sources were carried out; also, two campaigns for monitoring the quality of the air were conducted in Mexico Valley. Five techniques were implemented for analyzing the toxicity of emissions from the combustion of gasolines and diesel.

## **ELECTRICAL ENERGY SAVING FUND, FIDE**

The following table presents the direct savings of electric energy by sector and by program, implemented by the FIDE to 2002.

TABLE 2.5. NUMBER OF ACTIONS TAKEN AND SAVINGS OBTAINED BY SECTOR AND PROGRAM IMPLEMENTED BY ELECTRICAL ENERGY SAVING FUND, FIDE, TO 2002

Sector	Program	Number of actions <sup>1</sup>	GWh	MW
Domestic and SME's <sup>2</sup>	ILUMEX (ended in 1999)	2,454,922	224.0	107.0
	Pilot Project	945,769 light bulbs and	2.6	31.0
		43,297 Air conditioning units	65.2	65.0
	Thermally insulated homes	76,122	31.6	22.0
	Sealing of doors		43.8	3.0
	Diagnoses carried out	11,381	109.0	74.0
	Projects in SME's <sup>2</sup>	599	15.0	14.0
Industry Businesses and Municipal Services	Industries	723	963.0	219.0
	Businesses and Services	359		
	Municipal Services	206		
	Measure applied since 1996	---	---	---
Daylight Saving				
Incentives and Market Development	CFL's Installed <sup>3</sup>	5,948,906	1,417.0	376.0
	Electrical motors	137,525		
	Units of lighting	3,168,357		
	Compressors (Ended in 2001)	1,109		
Agriculture	CFL's in chicken farms <sup>3</sup>	1,184,000	833.0	199.0
	Agricultural pumping wells	12,687		
TOTAL <sup>4</sup>			3,704.2	1,110.0

<sup>1</sup> Own estimates.

<sup>2</sup> SME's – Small and medium industrial and commercial enterprises.

<sup>3</sup> CFL: Compact Fluorescent Light Bulb.

<sup>4</sup> Total without Daylight Saving.

SOURCE: Own preparation based on information from FIDE, 2003a.

The prevented pollutant emissions from the direct saving of electrical energy obtained from programs and projects financed by the FIDE are shown in table 2.6.

TABLE 2.6. ELECTRICAL ENERGY SAVING AND PREVENTED EMISSIONS DUE TO PROGRAMS IMPLEMENTED BY FIDE, 2000-2002

YEAR	ENERGY SAVING		PREVENTED EMISSIONS (THOUSANDS OF METRIC TONS/YEAR)					
	ELECTRICAL GWH	PRIMARY MMBOE*	CO <sub>2</sub>	CO	SO <sub>x</sub>	NO <sub>x</sub>	PST	HC
2000	3,227	7	3,688	1.3	56.9	10.0	3.5	0.1
2001	3,494	8	3,950	1.4	59.9	10.6	3.7	0.0
2002	1,390	3	1,555	0.6	23.3	4.2	1.4	0.02

\* Millions of barrels crude oil equivalent

SOURCE: FIDE, 2002.

In the particular case of the year 2002, the saving obtained from the projects from January to June was considered; the electrical energy saving due to Daylight Saving is not taken into account, because it is still being evaluated (FIDE, 2002).

The pollutant emissions prevented and the savings obtained from the multiplying effect of the programs and projects carried out by FIDE are shown in table 2.7.

TABLE 2.7. MULTIPLYING EFFECT OF ELECTRICAL ENERGY SAVINGS AND PREVENTED EMISSIONS DUE TO PROGRAMS IMPLEMENTED BY FIDE, 2000-2002

YEAR	ENERGY SAVING		PREVENTED EMISSIONS* (THOUSANDS OF METRIC TONS/YEAR)					
	PRIMARY GWH	ELECTRICAL MMBOE	CO <sub>2</sub>	CO	SO <sub>x</sub>	NO <sub>x</sub>	PST	HC
2000	11,718	26	13,393	4.6	206.4	36.2	12.8	0.2
2001	13,829	30	15,634	5.6	236.9	42.1	14.7	0.2
2002	5,501	12	6,153	2.3	2.3	16.6	5.7	0.1

\* FIDE estimated emissions with emission factors from the United States Environmental Protection Agency (USEPA), so that the factor used for CO<sub>2</sub> is 1.68 metric ton/MWh.

SOURCE: FIDE, 2002.

As in table 2.6, the same presuppositions are considered for 2002. The funds spent on developing supported projects are shown in table 2.8.

TABLE 2.8. FUNDS SPENT ON DEVELOPMENT  
FIDE-SUPPORTED PROJECTS

YEAR	FUNDS SPENT THOUSANDS OF PESOS
2000	193,271
2001	273,899
2002	87,104

SOURCE: FIDE, 2002.

## Daylight Saving

Daylight Saving (DS) was applied for the first time in Mexico on April 7, 1996, except in Baja California, where it had been implemented since 1942. Since its implementation, DS has made possible a saving in electricity consumption of 7,380 GWh, equivalent to 14 million barrels of oil, as well as 900 MW capacity (table 2.9). In turn, the total benefits add up to \$9,000 million (FIDE, 2003b).

TABLE 2.9. RESULTS OF DAYLIGHT SAVING, 1996-2002

YEAR	PREVENTED EMISSIONS OF POLLUTANTS <sup>a</sup> THOUSANDS OF METRIC TONS/YEARS	SAVING OF ELECTRICITY GWH	REDUCTION IN DEMAND MW	DEFERRED INVESTMENTS <sup>b</sup> MILLIONS
1996	1,631.8	943	529	4,100
1997	1,903.2	1,100	550	4,400
1998	1,784.0	1,012	683	6,830
1999	1,895.4	1,092	613	6,130
2000	2,053.0	1,182	823	8,230
2001	1,618.4	933	908	9,008
2002	1,351.9	1,118	900	9,000
TOTAL	12,237.7	7,380		

<sup>a</sup> For more detail see table 2.10

<sup>b</sup> Due to reduction of demand in peak hours.

SOURCE: FIDE, 2003b y CONAE, 2003a.

As for atmospheric emissions, over 12 million metric tons of pollutants were prevented from being emitted into the atmosphere seven years after the introduction of Daylight Saving, which has had a positive effect on the protection of the atmosphere (table 2.10).

TABLE 2.10. REDUCTION IN POLLUTING EMISSIONS DUE TO DAYLIGHT SAVING, 1996-2002

(THOUSANDS OF METRIC TONS)\*

POLLUTANT	1996	1997	1998	1999	2000	2001	2002	TOTAL
CO <sub>2</sub>	1,587.0	1,851.0	1,735.0	1,843.5	1,997.8	1,574.2	1,326.7	11,915.2
NOx	5.7	6.6	6.2	6.5	6.1	5.6	3.6	40.3
SOx	28.4	33.1	31.0	33.0	35.7	28.1	19.9	209.2
CO	0.4	0.5	0.5	0.4	0.4	0.3	0.5	3.0
PST	10.2	11.9	11.2	11.9	12.9	10.1	1.2	69.4
HC	0.1	0.1	0.1	0.1	0.1	0.1	0.01	0.6
TOTAL	1,631.8	1,903.2	1,784.0	1,895.4	2,053.0	1,618.4	1,351.9	12,237.7

\* FIDE estimated emissions with emission factors from the United States Environmental Protection Agency (USEPA), so that the factor used for CO<sub>2</sub> is 1.68 metric ton/MWh.

SOURCE: FIDE, 2003b y CONAE, 2003a.

Another important activity that continues is the awarding of the FIDE seal of approval, through which the manufacture, purchase and use of products that are efficient in electrical energy saving are promoted and thus the emission of polluting gases into the atmosphere is reduced, as a result of the lower fuel consumption in the electrical generating plants. The seal has been awarded to compact and linear fluorescent light bulbs, motors, ballasts and presence sensors. At the moment 21 companies have the FIDE seal in 2,041 models of equipment.

### **NATIONAL COMMISSION ON ENERGY SAVING, CONAE**

Advances in the energy efficiency and energy saving programs that the Commission has implemented are the following:

#### **Official Mexican Norms**

Energy efficiency in equipment for domestic, industrial and commercial use, is promoted and supported by twenty norms in effect and being updated, and five in the project phase. From 1995 to 2002, 9,120 GWh, 1,561 MW and 8.3 MMBOE accumulated saving was obtained in electrical

energy, power and thermal energy respectively. An accumulated saving of 16,065 GWh, 2,926 MW and 10.6 MMBOE for these items is expected for 2006 (CONAE, 2003b).

#### Program for energy saving in buildings of the federal public administration

This Program began voluntarily in one hundred public buildings in 1996 and became obligatory for federal public administration buildings in 1999. Among the measures being promoted in this program are: respecting the work schedule; disconnecting idle equipment; activating the power management in computers; make energy saving ongoing; planting and caring for trees around the buildings; and acquiring equipment with the energy efficiency label. A reduction of 11% in the energy consumption index was achieved between 1998 and 2001 and an accumulated saving of 110 GWh between 1999 and 2002 (CONAE, 2003c).

#### Efficient Industry

The CONAE supports PEMEX in identifying the potential of natural gas for saving. In the period from 1999 to 2002, the company managed to save 25,000 million cubic feet. Also by means of collaboration agreements with corporations, chambers of industry, and companies making up the 16 sectors with the highest energy consumption, a saving equivalent to 960 million cubic feet of natural gas was achieved and potentials for energy saving of 1.2 MMBOE were identified to 2002 (CONAE, 2003c).

#### Efficient Transport

In this program, the CONAE has agreements with the national chambers of Cargo Trucking (CANACAR) and of Coach and Tourist Transportation (CANAPAT) and with the National Association of Private Automobile Transportation (ANTP), to achieve energy savings in the fleets of automobile transportation for cargo and passengers. A saving of nearly 6 million litres of fuel, mainly diesel, is estimated for the year 2002.

#### Program for the promotion and sale of solar heaters

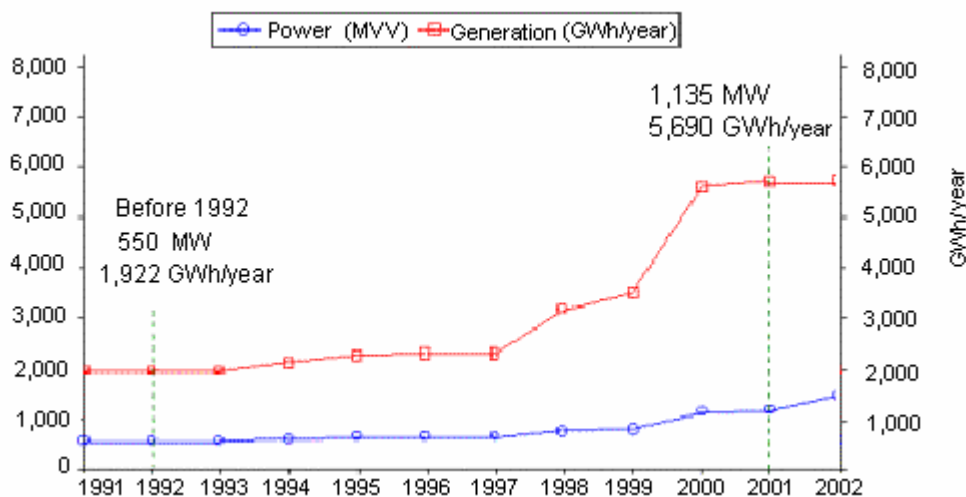
Through this program an attempt is being made to establish a system of promotion and sale of flat-plate solar heaters, oriented toward the urban residential sector in Mexico. The program began in 2002 and will operate for 3 years. In the first 18 months, solar water heaters will be sold, and beginning with the installation of each unit until the end of the program, the fuel savings that the users obtain will be monitored. The results of the program will serve as a basis for designing a

sales strategy on a national scale, in order to mass-produce the use of this technology which until now has been little exploited in Mexico, although the country has excellent solar resources due to its geographical location. It is the user's obligation to participate in this program, provide the fuel consumption for the year previous to acquisition of the solar heater, and at least one year after having it installed. This information will allow the CONAE to make the follow-up and real evaluation of the savings in gas from using the solar water heater, so that the results can be used for future projects (CONAE, 2002).

### Cogeneration

Cogeneration, defined as the combined production of electrical power and thermal energy, from the same source of primary energy, is an energy conservation alternative today for industry. There are already twenty-seven projects in operation, with a total generation of 5,690 GWh/year and a total capacity of 1,135 MW. In addition, there are 107 projects in operation in self-sufficiency: 74 of the private initiative and 33 of PEMEX. The following figure shows how the capacity for Cogeneration has evolved in Mexico, starting with modifications to the Public Service Law for Electric Power and its Regulations that allowed the participation of private enterprise in the generating of electrical power, under this modality (CONAE, 2003d).

FIGURE 2.3. EVOLUTION OF COGENERATION CAPACITY IN MEXICO, 1991-2002



SOURCE: CONAE, 2003d.

In 2002 some activities related to this topic were carried out, such as: the Eighth Seminar of Energy Saving, Cogeneration and Renewable Energy"; the "Second Seminar on Generation Distributed by means of Self-sufficiency in the Metropolitan Area of Mexico City" and five meetings of the Subcommittee on Cogeneration (XXIII to XXVII).

### Energy service companies

The CONAE has worked during the last few years on developing the elements necessary to make possible the creation and future consolidation of the market of Energy Service Companies (ESCOs) in Mexico (CONAE, 2003e). The strategies that have been followed include the promotion of this plan, and support of ESCO's and Energy Using Companies, during the development of projects, in order to provide security to both parts. Although the Mexican market is relatively new, there are companies that have already developed projects by means of "performance contracting or outsourcing" plans. The CONAE prepared a portfolio with information on 15 successful cases by means of which savings of 7.61 GWh and 5,353.84 metric ton of CO<sub>2</sub>/year were achieved in 2002.

It should be pointed out that the CONAE does not endorse or certify any of the companies, it only seeks to make the connection between supply and demand of services easier, for promoting energy saving and renewable energy projects, and to provide the actors with support information that allows them to make their own decisions.

### National Award for Electrical Energy Saving

The Federal Electrical Commission (CFE) with the support of the Federal Government instituted this Award in 1991, with the aim of giving public recognition annually to those companies and institutions that have stood out for their actions in favour of the saving and efficient use of electrical power during the calendar year immediately previous to it.

### Saving of carbon dioxide emissions

The CO<sub>2</sub> emissions prevented by programs of the CONAE from 1995 to 2002, as well as the projection to 2010, were presented in table 2.2.

The results expected for the year 2003 are given in table 2.11.

TABLE 2.11. RESULTS EXPECTED FROM PROGRAMS TO BE IMPLEMENTED BY CONAE IN 2003

ACTIVITY	PROGRAM	GOALS FOR SAVING		
		ENERGY	CURRENCY (MILLIONS OF PESOS)	CONAE BUDGET (MILLIONS OF PESOS)
Regulations	Regulations for energy efficiency.	1,440 GWh 0.53 MMBOE 280 MW	\$2,624	\$12.3
Technical Assistance	Properties of Federal Public Administration	119 GWh	\$71	\$7.8
	Municipalities	128 studies: 75 GWh	\$45	\$6.1
	Efficient industry (use of natural gas )	PEMEX: 19,200 million cu ft. Private industry: 3,840 million cu ft	\$1,152	\$14.0
	Efficient Transport	20 million litres	\$100	\$7.5
Subtotal Regulations and Technical Assistance			\$3,992	\$47.7
Consultation	Small and medium businesses	2,000 companies		\$5.9
	Distributed generation	Support to Department of Energy		\$5.3
Promotion and Dissemination	Housing	100,000 homes		\$3.0
	Education on energy saving	Participation of 100,000 children		\$3.6
	Technological promotion	25 workshops and 900,000 visitors		\$3.5
Total CONAE Programs				\$68.7

SOURCE: CONAE, 2003c.

### III. RESEARCH

The advances in research into Climate Change have been in technologies for mitigation of greenhouse gas (GHG) emissions, vulnerability evaluation and adaptation options. It is important to point out that a census has already been taken on the institutions and researchers and that carry out studies on this topic.

#### NATIONAL ECOLOGY INSTITUTE (INE)

The main research carried out at the National Ecology Institute-Department of the Environment and Natural Resources (2001-2002) consists of the following:

#### JOINT CONTROL OF URBAN ATMOSPHERIC POLLUTION AND GREENHOUSE GAS EMISSIONS IN THE MEXICO VALLEY METROPOLITAN AREA

The study was aimed at finding out what potential the measures for reducing the emissions of urban atmospheric pollutants, included in the Program to Improve Air Quality in the Mexico Valley Metropolitan Area, PROAIRE, 2002-2010, had for reducing greenhouse gas (GHG) emissions, and their cost-effectiveness, as well as estimating the potential that studies in GHG reduction technologies have for reducing local pollutants (West et al., 2002). In this way it would be possible to obtain greater benefits through an integrated vision of the strategies for mitigating local and overall contamination. Another relevant factor in planning the study was the fact that the Kyoto Protocol (KP), of the United Nations Framework Convention on Climate Change (UNFCCC), opens up the possibility of transferring the reduction of GHG emissions among Annex I (developed) countries, and Non-Annex I (developing) countries through what is called the Clean Development Mechanism (CDM). Mexico is placed in a privileged position to receive such investments, since the Senate of the Republic agreed to ratify the KP in 2000, and it is essential that these funds bring significant local advantages as soon this protocol goes into effect.

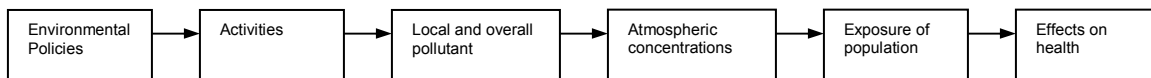
Based on this the following were estimated: a) reductions in GHG emissions due to the PROAIRE measures; b) reductions in emissions of local pollutants from the strategies for mitigating the GHG emissions; c) parameters for determining the cost-effectiveness of measures for the combined control of local and global contamination, d) measures with greatest benefits in terms of the combined control of both types of pollutants, by means of a Linear Programming model. Among the results obtained the following are emphasized:

1. The implementation of twenty-two of the measures included in the PROAIRE and ten measures for mitigating GHG would reduce nearly 8.7% of the CO<sub>2</sub> emissions projected for this area to 2010. PROAIRE has a significant reduction potential of 2.2 million metric tons of CO<sub>2</sub> (3.1%). 50% of this reduction comes from the measures for technological improvements in the vehicles and renovation of the fleet of vehicles and the rest from the improvement of the infrastructure of mass transport. The annual potential for reduction of local pollutants - 3.2% for HC, 1.4% for NO<sub>x</sub> and 1.3% for PM<sub>10</sub> - based on the measures for mitigating GHG is much less than that of PROAIRE. This is due to the fact that a great part of the electricity consumed in the MVMA is generated in electric plants located outside of the area.
2. The measures for mitigating the GHG emissions are characterized by large initial investments; however, negative Net Present Values (NPV) are obtained due to the significant saving in the fuel or electric consumption. In contrast, in the PROAIRE measures, the saving from the lower fuel consumption is generally a small component of the NPV.
3. It was found that PROAIRE goals for the reduction of PM<sub>10</sub> and HC emissions could improve with a small variation in costs, which is not the case for carbon monoxide.
4. It is less cost-effective to obtain reductions in CO<sub>2</sub> emissions based on the measures included in PROAIRE than if funds are invested in specific measures to reduce this pollutant.
5. The results of the study cannot be generalized since a limited list of measures was used, as well as a limited geographical scale (the MVMA), in which the impacts on air quality due to the generation of electric power are reduced. These results would be different if a larger geographical area were considered or if the methodology were applied to other urban areas, where most of the electricity consumed is generated locally.

The study received funding from the United States Environmental Protection Agency.

#### HEALTH BENEFITS FROM THE JOINT CONTROL OF URBAN ATMOSPHERIC POLLUTION AND GREENHOUSE GAS EMISSIONS IN THE MEXICO VALLEY METROPOLITAN AREA

The general aim of the study is to reply to the question: if actions are taken to reduce GHG or local pollutant emissions, what additional benefits will be achieved in terms of the reduction of urban air pollutant or GHG emissions and of the improving of human health? (McKinley, 2002). The analysis methodology is based on the following causal chain:



The specific tasks are:

(a) Analysis of technological control measures in order to evaluate their costs, their effects on the air pollutant and GHG emissions.

(b) Studies of atmospheric science in order to relate the changes in emissions with those of concentrations. It is also necessary to analyze the relationship between atmospheric concentration and exhibition that is often ignored because statistical health studies generally focus on health effects and environmental concentrations.

(c) Estimate of effects of the reduction of emissions of local and overall pollutants on health, and its economic benefits.

An organization similar to the project of Combined Control is proposed, in which Mexican and foreign researchers would work together. The project of Co-benefits will last nine months and will enjoy the participation of the following actors: members of the Metropolitan Environmental Commission (CAM); of the Department of the Environment of the Government of the Federal District, and of the Department of Ecology of the State of Mexico; personnel of the General Directorate of Research into Urban, Regional and Global Pollution of the INE; of the National Institute of Public Health (INSP) and international experts.

The results expected from the study are the following:

- To improve the methods used to estimate the reductions of emissions and their costs.
- To incorporate the use of simplified atmospheric models.
- To increase the capacity of interpretation of the results generated by models, in order to estimate impacts on health.
- To identify the parameters of atmospheric contamination to be used in the atmospheric models.
- To strengthen the institutional capacity in each of the areas of the project.

- To develop quantitative methods to support decision making.

Once the project is concluded, a technical report will be presented which will give in detail the methods, presuppositions and data used in the analysis; articles will be published on the work carried out and a workshop will be organized to present the results of the study, as well as its weaknesses and uncertainties; and to propose future research activities. The study is funded by the United States Environmental Protection Agency

#### POTENTIAL OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH INTO CLIMATE CHANGE IN MEXICO

The Department of Research and Development of the Coordination of Scientific Research of the UNAM conducted this study for the INE (INE-SEMARNAT, 2002a). It included the preparation of a national census of institutions and specialists that work on the topic of Climate Change in Mexico; a database was prepared with 332 contacts attached to 173 offices in 106 institutions, of which 84 are national institutions. 90% of all formal research into climate change is concentrated in public academic, public-sector and private academic institutions. The Federal District contains 52%, while the remaining 48% are located in the States of Morelos, Chihuahua, Baja California, Baja California Sur, Sonora, State of Mexico, Veracruz, and Yucatan. The participation of international cooperation institutions, private and government organisms is limited, while the NGOs are generally involved in studies and the dissemination of existing knowledge on the subject.

Part of the research and dissemination that is carried out in the country's northern states incorporates a trans-border network of research into Climate Change, in which institutions in the southern United States participate, such as the universities of Arizona, New Mexico and Texas, among others.

About 30 researchers located in different institutions work on observation of the phenomenon, mitigation, Climate Change policy and climate variability. Their number is lesser compared with the 120 who are involved in studies related to vulnerability.

The greater burden of the investment in research into Climate Change falls on government institutions. The importance of international funding is high, because besides constituting 43% of the institutional total, some national offices basically use resources of international origin to finance their projects. This can be explained by the fairly general opinion that the topic of Climate Change is one of the most relevant on the global environmental calendar. The study can be found at the website <http://www.ine.gob.mx/dgicurg/potencial.html>.

## VULNERABILITY AND REGIONAL ADAPTATION TO CLIMATE CHANGE AND ITS ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS

The Intergovernmental Panel on Climate Change (IPCC) published its Third Report on the present state of knowledge about Climate Change in 2001. Work Group II, in charge of the study of Impacts, Vulnerability and Adaptation, presented a detailed revision for North America and Latin America. In both sections, reference is made to aspects of Mexico's vulnerability to variability and to Climate Change.

In addition, there are reviews of different studies into Climate Change in Mexico, in particular the First National Communication to the Framework Convention of the United Nations on Climate Change. The First National Communication is based to a large extent on the results obtained in the Country Study: Mexico, coordinated in the National Institute of Ecology, and in which different research institutes of the UNAM participated (INE-SEMARNAP, 1997). Thus both works present analyses of Mexico's vulnerability conditions in the face of extreme climatic conditions that were carried out in the mid-nineties. Since then changes have taken place that have led to the proposal of new mitigation and adaptation options. Some of these proposals are reflected in the Second National Communication, which was formed by the General Directorate of Research into Urban, Regional and Global Pollution of the INE (INE-SEMARNAT, 2001).

### *Water Resources*

The availability of water would be reduced and competition for this resource could cause social problems, in a scenario of Climate Change (Magaña et al., 2001). The recent conflicts between states for access to the water of certain shared dams begin to show the magnitude of the problem that is ahead. In fact one of the border problems with United States that is causing the greatest concern is that related to water, as reported by the IPCC in its Third Report.

The spatial distribution of water resources in Mexico is far from uniform. 50% of the population has less than 20% of this resource, while in the southeast part of the country, 20% of the population has more than 50% of the country's water. With light precipitation in the north and heavy in the south, Climate Change could be translated, according to the Country Study scenarios, into a shortage of water in the north and excess in the south.

## *Agriculture*

Different strategies exist for evaluating the potential impact of Climate Change on agriculture. One of the most popular consists of the use of agro-climatic models, with yield models such as the CERES Maize used in the Country Study. This work concludes that in the greater part of the country, the effects of Climate Change in different scenarios would be to reduce the yields of corn growing. Thus preliminary estimates indicate that during the drought due to El Niño in the period from 1997 to 1998 in Mexico, more than three million metric tons of corn was lost and damages were caused worth nearly 460 million dollars. If more frequent drought conditions were to occur, the losses in this sector would be greater. The great dependence of agriculture on the fluctuations of the rains can be understood by carrying out a sensitivity analysis. In general, proposing increases in precipitation results in increased yields. However, if the increases in precipitation are high, there could be decreases in the yields due to erosion processes or the washing of nutrients from the soil.

## *Human Settlements*

Human settlements would be vulnerable with regard to the satisfaction of their requirements for water and food, besides possibly requiring a greater consumption of energy for controlling the temperature in houses and industries, and for preserving foods. These extra demands will constitute a challenge to the Mexican energy system. The possible increase in energy demand in the future and the decrease in available water for generating it, in combination with variations in fuel prices, require special consideration.

## *Fisheries*

The Mexican fishing sector is strongly affected by extreme climate conditions. It has been calculated that fishing production fell by 25 to 40% from the effects of the El Niño event in 1997 and 1998, and direct economic losses were of the order of 70 million dollars.

## *Forests / Fires*

Hydric stress in vegetation, the result of the lack of precipitation due to El Niño, was reflected in one of the greatest risk situations for this sector in the last few years. In 1998, it was calculated that in Mexico alone nearly 400 thousand hectares caught fire of which 24% were forests, causing a high level of atmospheric pollution that besides affecting the population of Mesoamerica, affected the population of the neighbouring states of the United States of North America. In this situation,

the traditional practices of cut, slash and burn became the cause of the greatest number of forest fires on record.

### *Adaptation*

The element of water is perhaps the most important one in planning agricultural and environmental activities so that for true adaptation, structural measures for managing this resource must be devised (Magaña et al., 2001).

Since the greatest percentage of available water is used in agricultural activities, it will be necessary to reformulate a substitute for the irrigation mechanisms used up to now by drip irrigation methods. In addition, the forms of reuse of urban water or even of desalinization of sea water are begin to look like real solutions to the problem of the shortage of this resource. The costs of this adaptation strategy have decreased notably in the last few years at the worldwide level, so that adaptation in this direction is beginning to be seriously considered.

Climate changes related to change in land use (deforestation or the expansion of deserts), can even be more striking than those produced by global warming. The models suggest that the change from forests to grazing areas for cattle raising or to crop lands results in a decrease in precipitation. In the case of Mexico, the proposal to reforest corresponds to a situation in which carbon dioxide is captured; this is conducive to more moisture in the soil and possibly more rain, and the country's forests are recovered.

In this regard, it is indispensable to consider, as a structural adaptation measure, the implementation of plans for territorial reorganization; these make it possible to have better control of land use, and also to reduce the vulnerability of populations exposed to hydro-meteorological phenomena stemming from Climate Change.

A second aspect of vital importance in reducing vulnerability, and that constitutes at the same time an adaptation measure to the impacts of Climate Change, is taking non-structural measures. These measures together form systems that permit the correct decision-making and actions necessarily preventive, such as for example the early warning system in the face of El Niño, hurricanes and floods. In this way Mexican institutions will have to participate actively in the early warning system, in order to bring about a decrease in vulnerability.

Finally it is important to establish the danger involved in poor adaptation. Some adaptation strategies that are untested or that are not founded on a profound knowledge of the mechanisms

that control the climate, can result in damages to the environment, thus aggravating the problem of global warming (Magaña et al., 2001). False strategies of rain production (ionizing antennas), poor decisions in the agricultural sector, etc., can have costs greater than those that are already implicit in Climate Change. This study was carried out for the INE by the Centre for Atmospheric Sciences of the UNAM.

## **FEDERAL MINISTRY OF ENERGY**

The activities and studies promoted by the Department of Energy include the following:

### **PROGRAM OF RESEARCH AND TECHNOLOGICAL DEVELOPMENT IN THE ENERGY SECTOR (PIDTSE), 2002-2006**

The introductory part of this document mentions that Mexico allocated 0.40% of its Gross Domestic Product (GDP) in 2000 to research and technological development, a figure that the present administration is seeking to increase substantially (SENER, 2003b). In turn the companies of the Energy Sector should urgently increase the level and effectiveness of their technological and innovative effort in order to become more competitive. To take care of these necessities, the Sub-Department of Energy Policies and Technological Development of the Department of Energy (SENER) formulated the Program of Research and Technological Development in the Energy Sector (PIDTSE), 2002-2006.

The objective of the PIDTSE is to contribute toward organizing a sectoral policy of Research and Development (R+D) and emphasize the characteristics that the research and development activity in the area of energy should have, so that research groups can have access to funds of the Sectoral Fund for Research and Technological Development in Energy, settled down by the Federal Electrical Commission [FCE], Luz y Fuerza del Centro (LFC) [Light and Power of the Centre], Mexican Petroleum [PEMEX], Federal Ministry of Energy and the National Council for Science and Technology. At the same time, and given the great relative importance of this sector in the economy, the strategies that correspond to R&D activity in general are noted. The problem of discrepancy between supply and demand in scientific and technological knowledge is also dealt with (SENER, 2003b).

The diagnosis of the present technological situation in the Mexican companies referred to in this sector begins with the evaluation by scientists and technicians themselves of these companies, of the situation of this activity and what they want to achieve. R&D planning, therefore, is a result of

the diagnosis that the companies themselves make of their productive activity and the technological achievements that arise from this. The strategies of technological development or technological platforms that arise out of this diagnosis, should always be the areas of special attention towards which special efforts are directed in order to achieve the growth proposed in the National Plan 2001-2006, National Development Plan (PND), Sectoral Energy Program (PSE) and Special Science and Technology Program (PECYT) for the present administration.

PIDTSE originates in the National Plan of Development (PND), out of the necessity to find new forms of supplying and using energy for the benefit of society, and affects the PND to the extent that its objectives are achieved, which are namely to produce more with fewer resources, to improve the quality of energy inputs, to predict new energy sources and ensure distribution and marketing at internationally competitive prices. While it was being prepared, with the participation of the scientific community, research institutes, and business people and companies in the sector, the country was observed to be facing a technological backwardness, but at the same time has a critical mass of knowledge in many of its areas which makes it possible to recover lost time; and it was also detected that both in private and public companies, there exist conditions for, and interest in, accelerating technological development in the area of energy.

In the framework of the technological prospect for the sector, for 2025, PIDTSE is logically oriented with respect to the topics that are being researched and developed throughout the world. One must emphasize the great effort that R&D human resources in the sector are making, together with their colleagues in the environmental sector, in attacking the whole problem of greenhouse gas emissions that are causing the phenomenon of Climate Change, both from the point of view of modelling, and of emissions reduction and impact mitigation.

The view of PIDTSE up until 2025 takes into account that new processes are being developed that, depending on the speed of their penetration into the system, which in turn depends on factors such as economic growth or Climate Change, could introduce substantial changes in the energy system.

One important tendency that will apparently continue during this interval of time is the continuous percent increase of the total amount of final energy consumed that corresponds to electricity as secondary energy. At the same time, greater attention will be paid to the measures of energy saving and the administration of energy demand in transport, industry and construction. The use of measures for saving air conditioning through active and passive techniques will grow, as will the degree of automation in the operation of such architectural elements such as external blinds and

mullions, and advanced processes for taking advantage of natural lighting without introducing an excessive thermal load.

Although the phenomenon of Climate Change due to greenhouse gas emissions has caused the great majority of fossil fuels to be considered responsible, new systems of using these fuels (gasification processes and systems based on high-efficiency, supercritical boilers) are already at the demonstration stage in which carbon dioxide sequestering is made more feasible economically. This is important if one considers that the largest proven reservations of a primary fuel are those of coal. The synthetic gas generated, once the CO<sub>2</sub> is removed, is basically hydrogen. The development of commercial processes for inexpensive disposal of CO<sub>2</sub> has already begun, including tests of environmental impact.

To give concrete form to the necessary actions that will lend support to the PIDTSE, ten major areas for research and sectoral development were defined which will be dealt with by research and development efforts and capacities in the sector, according to consultations carried out with experts in the states, companies, CONAE, SENER and INE.

1. Sustainable development of Mexican fields producing hydrocarbons.
2. Improvement of transportation of energy resources.
3. Advanced refinement processes.
4. Optimization of fuels.
5. Increase in the efficiency of systems of generation, transmission and distribution of electric power.
6. Integral systems of energy use in final applications.
7. Alternative sources and renewable sources of energy.
8. Development of productive chains of suppliers in the Energy Sector, with national technology.
9. Applications of nuclear systems and radioactive materials in industry, agriculture, health and transport, and
10. Systems of information and administration of relevant national resources in the Energy Sector

The above topics include ample necessities in the development of forecasting techniques in the behaviour of resources and the market, incorporation of advanced technologies (microscopy and resonance for in-line controls, for example), modernization of laboratories in general, identification and reduction of backwardness and in technological gaps, opportune updating of administrative processes, horizontal and vertical linking, establishment of networks and strategic alliances with national and foreign universities and companies, and rationalization and optimization of developed and developing capacities. In short, it is necessary to undertake an ambitious process of integral strategic planning, in order to identify how the most fortunate connections can be established between the most promising necessities and available capacities.

#### DETERMINING FIREWOOD CONSUMPTION AS FUEL IN THE NATIONAL CONTEXT

The study was conducted by students in the Master's in Energy Engineering program of the UNAM and supervised by personnel of the SENER (SENER, 2002a). In this research work a methodology "by final use" was designed and implemented for the analysis of the structure and evolution of the demand for firewood, based on national and international studies, and which made it possible to estimate in a more itemized way than this present one, firewood consumption in this country for the years 1960, 1970, 1980, 1990 and 2000. The following variables were considered:

- i. The saturation of users separated into urban and rural, provided by population censuses.
- ii. The unit consumption of firewood in the domestic sector both for major users (21 kg person/day), as for mixed, minor ones (1.71 kg person/day).
- iii. The heating power of wood (average value of 15.61 MJ/kg).
- iv. The energy consumption of small industries.

The main results were:

- v It is established that while in 1960 the consumption was 315.9 PJ/year, the following decade saw an increase of 8.4% reaching 342.4 PJ/year. Starting from 1970 the firewood consumption began to fall 0.5% per decade, reaching a national consumption of 338.1 PJ/year in the year 2000. This decrease is mainly due to the decrease in exclusive users in the rural areas.
- v Differences were obtained with regard to the data presented in the National Energy Balance where for the year 2000 a final consumption of firewood was obtained at the national level of 255.8 PJ/year (this is 32.1% higher). This difference arises from the re-estimate both of heating

power and of the unit consumption and saturation, which vary in relation to those used previously.

- ∇ Consumption of firewood per state for the year 2000 is very different. Although Veracruz is the state that consumes the greatest quantity of firewood with a participation of 11%, followed by Chiapas with 10% and Oaxaca with 9%, in Baja California Sur, Baja California Norte, Colima and the Federal District, consumption is practically nil.
- ∇ In a general way it is observed that most of the firewood consumption in our country is concentrated in the south by southeast region. This is due both to the particular socio-economic and cultural conditions, and to the greater importance of the rural factor with respect to the urban in this region of the country. It is also predicted that this consumption will remain at a high level over the next few years. In this respect it is necessary to design and apply energy policies that would, in addition to the immediate replacement of firewood with LP gas or natural gas, promote the use of energetically more efficient cooking utensils as well as the establishment of more transparent firewood markets that would make the control of the forest reserves, a better use of biomass, and monitoring of consumption, all possible.

The differences between the results of this study and the information presented in the National Energy Balance, far from invalidating the existent official information, demonstrate the necessity to conduct studies and more profound discussions that would accurately determine the reasons for these differences (SENER, 2002a).

## NATIONAL INVENTORY OF RENEWABLE ENERGIES

This work was carried out by students of the Master's in Energy Engineering program of the UNAM and supervised by researchers of the same institution and by personnel of the SENER (SENER, 2003a).

The forms of energy considered in the study were solar, aeolian, geothermal, mini-hydraulic, tidal powered and that produced by means of biomass and municipal waste. In this last case sugar cane bagasse and firewood were not included. The cut-off date for the information gathered was December 31st, 2002.

The total installed capacity of the systems that take advantage of renewable energy in our country is 1,032.7 MW, without counting the power exploited in the solar production of salt, which does not require a special system, but rather a place to accumulate sea water during the time that it takes to evaporate.

From this study it turns out that the installed capacity of the photovoltaic systems is 3,570.8 kW, which are distributed in the following way: rural electricity, 3,165.8 kW; rural telephones, 126.5 kW; radio transmission, 40.7 kW and pumping of water 237.8 kW. The ANES indicates an installed capacity to the year 2002 of 14,447 kW, a figure four times greater than that itemized in the present study. The reasons such a difference can exist are that the inventory only contemplated 4 applications of the photovoltaic systems. Uses in booster stations for microwaves and terrestrial and marine signalling were not included. Also, the systems counted were for the most part installed between the years 1991 and 2002, so that those were not included installed outside of this period. On the other hand, the information gathered from each application contemplated only one institution or organization, when others might exist which could not be identified and thus consulted (SENER, 2003a).

The power used in solar production of salt in the salt industry, estimated at 19,345.3 MW, was not taken into consideration in the National Energy Balance. This figure represents the heat required in the process of salt production which, if the solar energy is not used, would have to be supplied by means of some conventional fuel, which shows the importance of this source of renewable energy in the industry in question (SENER, 2003a).

In the case of the aeolian energy, the installed capacity obtained in the inventory is 2.175 MW, a figure that corresponds to the aeolian systems installed by the CFE. The National Energy Balance, with information from the ANES, shows an installed capacity of wind-driven generators different from those supplied by the CFE, so that both figures complement each other when counting the total capacity of aeolian systems.

On the other hand, as for the hybrid systems the installed capacity is 0.3 MW, which is not mentioned in the National Energy Balance because this item was not taken into consideration.

In the case of geothermal energy, four units are not reported that are not considered in the National Energy Balance, with a total capacity of 605 kW, one of which is used for rural electrification and the remaining ones for pumping water, and for heating spaces and water.

As for mini hydraulic energy, the installed capacity obtained from the private power stations is 43.4 MW, which was not taken into consideration in the Balance, since it only took into account those plants operated by the CFE and the LFC. Of the energy that is obtained from biomass and municipal waste, two plants were counted that operate in the state of Nuevo Leon and that provide service for pumping water and drainage. Both plants total a capacity of 10.8 MW.

The results of this inventory show that the technology with greatest installed capacity is solar, greater even than geo-thermal (838.4 MW) and mini-hydraulic (68.8 MW). This result, however, should take with certain reservations, since the main reason is that what is taken into account is the power harnessed in the production of solar salt, which is quite a bit greater than any of the technologies considered, even thermo-solar and photovoltaic technologies. The number of installed flat-plate collectors, though relatively large, does not take into consideration the collectors that have ceased to operate because of the lack of maintenance and other technical or economic reasons (SENER, 2003a).

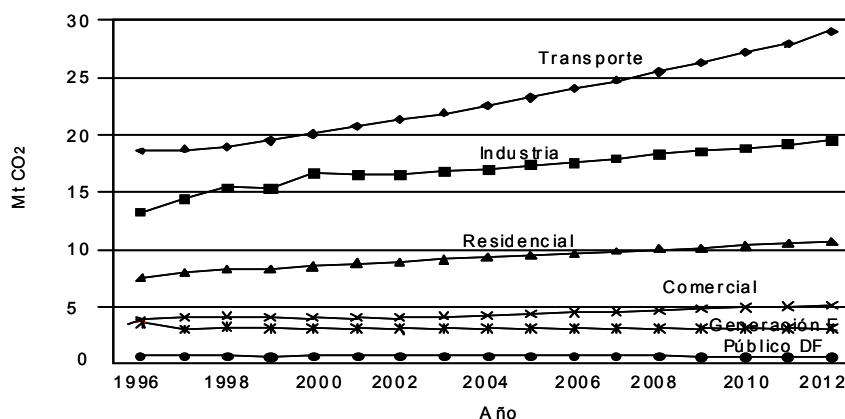
The authors of the study stress the fact that "...programs such as the one carried out by the Shared Risk Fund (FIRCO) is a sample of the way in which the development of renewable energy can be supported in our country. In the second place, although different projects with renewable energy are being established, some of them stop operating quickly when faced with different problems, which include not only technical matters, but also economic, social and political aspects. Renewable energy is not conceived as part of a permanent solution that would allow the diversification of energy sources. It is deplorable to dismantle systems with forms of renewable energy, as has been happening in certain localities. Within the guidelines of the national energy policy is that which concerns the promotion of renewable energy and in this respect it is indispensable for a detailed, regular count to be taken of the installed systems, which would allow the real contribution of the renewable sources of energy in the country to be established more precisely " (SENER, 2003a).

#### **CLIMATE ACTION PLAN IN THE FEDERAL DISTRICT**

The Department of the Environment of the present administration of the Government of the Federal District (D.F.) established a Local Climate Action Plan that includes the definition of a base line of greenhouse gas emissions, scenarios of projection of these and reduction of emissions, besides studies on vulnerability, adaptation, and the estimate of the carbon potential in reservoirs in the area (Vázquez, 2002).

The energy consumption in the MVMA represents approximately 13% of the national consumption, and 17% of the electricity consumption (Sheinbaum et al., 2000). During the year 2000 the seven main energy consumers used 608 PJ for their daily activities: 43% corresponded to the transport; 26% to industry; 14% to homes; 8% to generation of electricity; 7% to trade; 1% to pumping sewage and public lighting; and 1% to the agricultural sector. It is estimated that in the year 2012 this consumption will increase to 867 PJ due to the growth of activities in the city. The CO<sub>2</sub> emissions, for the year 2000, added 51 million tons: 37% corresponded to the transport, 31% to industry; 16% to homes; 6% to generation of electricity; 8% to trade; 1% to pumping water and public lighting, and 1% to agricultural activities (GDF, 2003a). It is predicted that greenhouse gas emissions will amount to 66 million tons in 2012 (figure 3.1).

FIGURE 3.1. PROJECTION FOR CO<sub>2</sub> EMISSIONS BY SECTOR IN THE MVMA, TO 2012



SOURCE: Vázquez, 2002.

By means of the Plan of Climate Action the mitigation of GHG is promoted, through the saving and efficient use of natural resources and equipment, regulation, promotion of alternative fuels, use of new technologies and measures for carbon capture in the forest sector, by means of the promotion of specific projects. It is sought to develop an office of the Government of the Federal District that would develop, manage, concretize and follow up projects that could not be carried out without the support of international mechanisms such as the Clean Development Mechanism and other similar ones, through which their financing and realization would be possible (GDF, 2002a). One must mention that the actions that will be implemented with the Plan for Climate Action, are delineated in the PROAIRE 2002-2010, thereby ensuring complete consistency among the metropolitan programs that cooperate in improving the air quality. Next some specific projects are mentioned:

## Clean Housing

It involves the substitution of high efficiency accessories in showers, basins and sinks of up to 785,000 homes in the period 2002-2005. In a first stage the replacement of conventional shower fixtures and faucets by high efficiency devices will be implemented in 35 thousand homes in housing units in Mexico City. With the substitution of accessories it is hoped to obtain a monthly saving of 7.7 cu m of drinking water; an increase in water availability for the poorest social groups in the City; a reduction of 88.7 Kg CO<sub>2</sub>/month and of other pollutants per home due to the saving in the combustion of LPG from the heating of a smaller volume of water (Vázquez, 2002 and GDF, 2002a).

## Replacement of taxis

In the ZMVM 109,407 there are taxis in circulation, 103,300 of which are registered in the Federal District. 56% of the fleet of taxis corresponds to 1992 and earlier models, which means that they are automobiles without emission control systems. The Government of the Federal District is planning to substitute 80 thousand taxis, pre-1992 models, during the period of 2001 to 2006, for which it will contribute \$15,000.00 pesos in exchange for the old unit and the owners pay the remaining quantity to acquire a new vehicle. The replacement will improve the yield of the fleet of vehicles, diminish the consumption of gasoline and decrease the CO<sub>2</sub> emissions produced by this means of transportation (75 Kg CO<sub>2</sub> per day) by 31% (Vázquez, 2002 and GDF, 2002a).

## Replacement of minibuses

The number of vehicles in the D.F. is 23,000 units and the plan is to replace two minibuses by one new bus, starting from 2001 and continuing until 2006. The Government of the Federal District will contribute \$100,000.00 pesos for each old minibus, so that the proprietors can give the down-payment on a new bus. Each minibus generates 230 Kg CO<sub>2</sub> per day and it is hoped to diminish the consumption of gasoline and to obtain a reduction of 85% in the CO<sub>2</sub> emissions generated (Vázquez, 2002 and GDF, 2002a).

## Use of compressed natural gas in public transportation

Change the consumption of gasoline for compressed natural gas in 800 minibuses (Vázquez, 2002).

## **CENTRE FOR SUSTAINABLE TRANSPORT FOR THE CITY OF MEXICO**

This Centre is operated by the non government organization called the Centre for Interdisciplinary Studies in Biodiversity and the Atmosphere (CEIBA) and began its activities in May of 2002. It promotes the mobility and sustainable transportation in the city of Mexico, to provide a solution for the problems of traffic, regulation and pollution. The actors involved of the Government of the Federal District are: the Department of the Environment; the Department of Transportation and Road Administration; the System of Electrical Transportation; the System of Collective Subway Transportation and the Network of Passenger Transportation. The World Bank, Shell Foundation and World Resources International (WRI), are the international organisms that give funds to the Center (GDF, 2002b and Samaniego, 2002).

The tasks of the Center are the definition of a framework that would facilitate the implementation of strategies for sustainable transportation, provide technical assistance and training so as to incorporate the considerations of Climate Change and air quality in the design and analysis of the strategies for transportation, promote public awareness and dissemination, formulate an alternative model of transportation for the City that would include the creation of exclusive corridors for public transportation; metropolitan corridors; the development of a transportation component for the Historical Centre; financing of transportation projects based on emission permits for industry and a plan for making identified bicycle lanes (Samaniego, 2002).

## **METHANE CAPTURE IN SANITARY LANDFILL, SALINAS VICTORIA, NUEVO LEON**

The project is carried out in the sanitary landfill of the company, Metropolitan System of Solid Waste Processing (SIMEPRODESO), in Saline Victoria, New León. This company is the State Government's decentralized public organization. The "Global Environmental Facility" (GEF) contributes economic resources through the World Bank (World Bank, 2002).

Its specific objectives are: a) to demonstrate the cost-effectiveness of technologies for recovering and using biogas generated in a sanitary landfill; b) to test an institutional framework for implementing this type of project that would include the participation of the private sector; c) to strengthen the regulatory, political and social framework for the introduction of technologies for the capture and use of biogas in Mexico; d) to design a strategy to disseminate the lessons learned in the implementation of the Project in Mexico and Latin America, and) to design a strategy to help to reproduce the Project in other Mexican states.

The facilities that are being built include: i) wells, the network of pipes and ventings for gathering the methane generated in the sanitary landfill and ship it to the electricity generating plant, ii) an electricity generating plant with a treatment plant to remove biogas sludge before combustion, iii) a substation and the electric lines necessary for connection to the Federal Commission of Electricity network; iv) a burner to burn the methane excess that is not used in the electricity generating plant of and thus achieve its maximum destruction still during the temporary suspension of plant activities; v) the construction of support infrastructure such as highways, drainages, water supply, buildings and lighting; and vi) training and supervision of the operators.

The design, construction and operation of the plant are implemented through a public-private society, with shared responsibilities. The Department of Social Development (SEDESOL) will watch the activities of the company SIMEPRODESO, to gather information that would allow them to strengthen their institutional capacity in the future development of a legal framework and modern regulation in the handling of waste, and to promote the adoption of the technology in state and local governments, as well as in private companies. The project had advanced 83% in 2002 and the inauguration of the plant is expected to be in June, 2003.

#### RESEARCH CENTRES AND INSTITUTES OF THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO

During its long history, the National Autonomous University of Mexico (UNAM) has accumulated vast experience through the studies conducted that were associated with the relationship between human activities and their effects on the environment from very diverse focuses. The following is a summary of research related to the topic of Climate Change that at the moment is being conducted in the University's research centres and institutes:

##### CENTRE FOR ATMOSPHERIC SCIENCES

The projects related to Climate Change that are being carried out in the Centre at the moment are (UNAM, 2002a):

- ✓ Integrated evaluation of social vulnerability and adaptation to climate variability and Climate Change among farmers from Mexico and Argentina. Project financed by the "Third World Academy of Sciences", TWAS through their program "Assessments of Impacts and Adaptations to Climate Change in Multiple Regions and Sectors", AIACC.

- ✓ Behaviour of fire and forest fire risk evaluation in wooded areas of Mexico: A study on the La Malinche Volcano. Project financed by the National Council of Science and Technology, CONACYT.
- ✓ Climate variability and its impacts on regions in Mexico, Central America and the Caribbean. Project financed by the Inter-American Institute for Global Change Research, IAI.
- ✓ Analysis to understand climate variability in the Caribbean islands. Project financed by the IAI.
- ✓ Regional climate variability in Mexico. Project financed by CONACYT.
- ✓ Preparation of the inventory of greenhouse gas emissions in the project "Conservation, reforestation, carbon capture and Jaguarundi Ecological Park. Collaboration agreement between the UNAM and PEMEX.

#### INSTITUTE OF ECOLOGY

The Institute of Ecology and the National Commission for Biodiversity (CONABIO) presented the INE with the proposal for a study on "The Use of Forest Biomass for Generating Energy", as an alternative that will make the capture of atmospheric carbon and the replacement of fossil fuels possible (UNAM, 2002b). In countries such as Finland, Sweden and Austria, biomass satisfies 17% of the national energy demand. At the moment there are studies with enough information on species of wood that are preferred as energy sources in the ecological areas of the country.

#### INSTITUTE OF GEOGRAPHY

This Institute has the following research areas:

- ∇ Climate Change. Droughts produce severe effects on the environment, society and the economy; that is why greater attention is paid to this phenomenon at the worldwide level. In this section drought is being studied, both under present conditions and in the context of atmospheric warming associated with the problem of global change (UNAM, 2002c).
- ∇ Bioclimatology. In the long term, climate is what determines the natural vegetation and what decides whether a region is populated or not; in the short term, the safety of different means of transport, and the dispersion or stagnation of atmospheric pollutants, depend on the weather, which enables us to determine the most favourable moment for agricultural activities. For these

reasons, the object of this line of research is to study the relationships between live beings and atmospheric conditions.

- ∇ Synoptic climatology. This is the study of climate systems, their origin, evolution, the frequency of their occurrence, as well as their resultant effects on space, by using remote perception techniques.
- ∇ Agroclimatology. Climate as well as soil are natural resources that are indispensable for agricultural activity. Knowing and evaluating them is of vital importance for the use and management of natural resources, as well as for the planning of agricultural and forestry activities.
- ∇ Hydroclimatology. Through activities related with evaporation processes, evapo-transpiration, dew point and aridity indices, the volume of usable water in hydrological basins will be estimated.

#### INSTITUTE OF ENGINEERING

The Institute of Engineering, at the request of the University Energy Program, is working on consolidating a university network on Climate Change that would serve as a tool for linking and for exchanging information among researchers interested in the topic. This network is made up of Centres, Programs and Institutes of the UNAM (UNAM, 2002d). The Monthly Bulletin on Climate Change is published in the framework of this Network. In addition, the department of Systems Engineering in this Institute is working on the topic of energy and the environment (an analysis of bioclimatic design, the dynamic of the energy sector, inventory of emissions, economic evaluation of the external effects caused by the generation and consumption of energy).

#### UNIVERSITY ENERGY PROGRAM (PUE)

The projects that are developed are aimed at energy efficiency and saving; greenhouse gas emission and Climate Change; the importance of energy in the economy and general well-being, prices and reliability, and sustainable development (UNAM, 2002e).

## UNIVERSITY PROGRAM ON THE ENVIRONMENT (PUMA)

### Jaguarundi Ecological Park

This park occupies an area of 961 hectares in Coatzacoalcos, Veracruz and is the property of PEMEX-Petrochemical. As of June 5, 2002, it is by ordinance the first private reserve recognized by the National Commission of Protected Natural Areas (CONANP), a deconcentrated body of the SEMARNAT (El Universal, 2003). The private-sector company signed an collaboration agreement with the UNAM, and the PUMA has coordinated the "Conservation, reforestation, carbon capture and ecological excursion, Jaguarundi Park" project since May, 2002. Thus the aim is to carry out: 1) an inventory of flora and fauna and forests (Institute of Biology); 2) a study of the soil (Institute of Geology); 3) a study on the presence and reintroduction of the jaguarundi (Institute of Ecology); 4) a study on carbon capture (Institute of Ecology, Morelia Campus); 5) an inventory of greenhouse gas emissions (Centre for Atmospheric Sciences); and 6) a sociological study (Institute of Social Research).

On the other hand, in 2001 PUMA published the book "Mexico: una visión hacia el Siglo XXI. El Cambio Climático en México"; published jointly with the National Institute of Ecology and the Centre for Atmospheric Sciences of the UNAM (UNAM, 2002f).

## MONTERREY TECHNOLOGICAL INSTITUTE AND OF HIGHER STUDIES

In the Institute's centres, the following research related to Climate Change is being conducted:

### CENTRE FOR ENVIRONMENTAL QUALITY

The main areas of the Centre's research are: i) Development of clean technologies, ii) Use of water, iii) Management of natural resources; iv) Transportation and destination of pollutants and v) Pollution prevention and ecological classification (ITESM, 2002).

### CENTRE FOR SOLAR ENERGY

The Centre for Solar Energy promotes the conservation of non-renewable energy resources with the use of solar energy, and conducts studies on solar air conditioning and refrigeration, solar domestic refrigeration and design of internal combustion motors (ITESM, 2002).

## CENTRE FOR ENERGY STUDIES

The activity of this Centre aims at being an agent for change that will lead society to be energetically sustainable by promoting the use of alternative sources of energy. Its main lines of research are: i) Efficient use of electrical energy, with emphasis on the quality of the supply, and ii) Efficient energy use in buildings (ITESM, 2002).

## UNIVERSITY OF THE AMERICAS, PUEBLA

The University is carrying out the study "Economic impact of policies to mitigate Climate Change: effects for Mexico" (UDLA, 2003).

## IV. ACTIVITIES FOR SENSITIZING THE PUBLIC

### FORUMS AND WORKSHOPS

In 2002, different workshops and forums were held to disseminate advances in Climate Change research to the country's educational institutions, non-government organizations, the private enterprise, and other organisms interested in the topic.

#### WORKSHOP: "POTENTIAL OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH"

On May 3rd the National Institute of Ecology presented the results of the inventory of researchers and the diagnosis of Climate Change research conducted by national institutions.

#### WORKSHOP: "JOINT CONTROL OF URBAN ATMOSPHERIC POLLUTION AND GREENHOUSE GAS EMISSIONS IN THE CITY OF MEXICO METROPOLITAN AREA"

The workshop was held August 27th and 28th, organized by the INE, to make known the results of the study by the same name, and to present the second phase corresponding to the co-benefits for the MVMA. There was a total attendance of over eighty people, including in particular representatives of the Environmental Protection Agency (USEPA) and of the National Renewable Energy Laboratory (NREL), both from the United States, as well as representatives from Brazil, Chile and Argentina. In this Workshop there was an exchange of experiences between Mexico and the countries mentioned regarding the problem of local air pollution, greenhouse gas emissions, and the combined solution that can be given to both.

#### FORUM ON INFORMATION AND CONSULTATION ON CLIMATE CHANGE

- 1) The Department of the Environment and Natural Resources, through their Coordinating Unit of Social Participation and Transparency, held the Forum on Information and Consultation on Climate Change on October 15th, in Mexico City (SEMARNAT, 2002). The object of this Forum was to make the relevant aspects on the topic of Climate Change known, and to consult the representatives of academic institutions, non-government organizations, government institutions, civil society and private enterprise with regard to these aspects, before the Eighth Meeting of the Conference of Parties (COP8), of the United Nations Framework Convention on

Climate Change, UNFCCC, held in New Delhi, India, from October 23rd to November 1st, 2002. The topics addressed were the following:

*i) Account of the most important meetings at the Conference of Parties*

The Coordination of Advisors to the Sub-department of Planning and Energy Policy of the SEMARNAT, synthesized the progress in the negotiations of Parties in the United Nations Framework Convention on Climate Change (<http://www.unfccc.int>) and briefly mentioned some aspects related to the Summit on Sustainable Development, held in Johannesburg in August, 2002, in which the Mexican Delegation worked arduously on the topics of attention to the most vulnerable countries on the planet, and to the importance of renewable energy.

*ii) Mexican initiative on the most vulnerable countries on the planet*

The SEMARNAT created the Mexican initiative on vulnerability with the purpose of giving priority on the international agenda to this topic and to adaptation options for Climate Change, and of attending to them as soon as possible.

*iii) Third Report of Evaluation of the Intergovernmental Panel on Climate Change*

The National Institute of Ecology/SEMARNAT presented a summary of the Third Evaluation Report for the Intergovernmental Panel on Climate Change that mentions evidence of anthropogenic interference in the world climate system and the results of different models that show how our Planet could be affected by the year 2100.

*iv) Studies on Climate Change in Mexico, conducted by the INE, from 1993 to date*

Among the studies carried out are the updating of the National Inventory of Greenhouse Gas Emissions; the evaluation of the country's vulnerability; studies on technologies for mitigating Climate Change in the energy-producing and forest areas; scenarios of future emissions; the combined control of urban atmospheric pollution and greenhouse gas emissions; the potential of scientific and technological research on Climate Change in Mexico, etc. These topics can be consulted at the electronic website <http://www.ine.gob.mx>.

*v. Advances in mitigation actions in the energy sector*

The Department of Energy presented the advances in energy efficiency and energy saving achieved through the National Commission on Energy Saving (CONAE), and the Electrical Energy

Saving Fund (FIDE), besides the use of cleaner fuels (natural gas instead of fuel oil) and the promotion of renewable energy. They also mentioned the development of opportunities for the sector, through projects for the Clean Development Mechanism (CDM) of the Kyoto Protocol of the UNFCCC. For more information, consult the following pages: <http://www.energia.gob.mx>; <http://www.conae.gob.mx>; <http://www.fide.org.mx>.

*vi. Civil society and COP 8*

The northwest region of the SEMARNAT underlined the importance of the El Niño phenomenon as part of climate variability, of the fundamental process of information, education, social participation and consensus through consultations.

*vii. Legal implementation of the Clean Development Mechanism*

The Mexican Centre for Environmental Law (CEMDA) addressed the conflict of equity between developed and developing countries, with regard to greenhouse gas emissions, of the common but differentiated responsibilities of countries in the face of Climate Change, and of the historical responsibility of large emitters (countries of the northern hemisphere).

*viii. Position of Mexico before COP 8*

The Coordinating Unit of International Matters of the SEMARNAT mentioned the following: i) vulnerability evaluation and adaptation options of developing countries should be a priority to be dealt with in the technical and political meetings of COP 8, ii) projects for restoring degraded forests should be included within the CDM and not only those of afforestation and reforestation, iii) it is important that there should be agreement among the United Nations conventions: Biological Diversity, Combating Desertification and Climate Change and iv) all countries that have not ratified the Kyoto Protocol should be exhorted to do so in order for it to go into effect as soon as possible.

*ix. Participants' comments*

- 1) The need to have an integrated system of reliable indicators.
- 2) Include topics of desertification in the CDM of the Protocol.
- 3) Improve the quality of lands and their carbon dioxide (CO<sub>2</sub>) content .
- 4) Representatives of the industrial sector mentioned that the verification and certification of mitigation projects in the forest and energy-producing areas should be perfected and that Mexico

should participate in the preparation of the corresponding regulations, under systems validated and accredited by the country and internationally.

5) The different sectors spoke out in favour of the prompt creation of the Climate Change Office.

6) Foster scientific activity in order to solve technological problems and to obtain additional funds, through collaboration between the academy and CONACYT.

7) Concern for pollutant emissions from vehicles that are brought into the country illegally.

8) Concern over who will pay extra funds for vulnerability activities and the adaptation of less developed countries. At present it is already proposed that 2% of the CDM transactions cover these costs by means of an adaptation fund. The other two mechanisms of the Kyoto Protocol do not contemplate this fund.

#### ECOLOGICAL GAZETTE OF THE INE

Gazette number 65, published in December, 2002, contains 4 articles on research and collections on Climate Change (INE-SEMARNAT, 2002b).

#### INFORMATION SYSTEM FOR DECISION MAKING AND PREPARATION OF NATIONAL COMMUNICATIONS ON CLIMATE CHANGE

Through this System it is possible to consult the National Inventory of Greenhouse Gas Emissions for the years 1992, 1994, 1996 and 1998, according to emissions source, type of pollutant, and year (INE-SEMARNAT, 2002c). Access to this information is available at the electronic website <http://www.ine.gob.mx/dgicurg/cclimatico/inventario>.

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## V. INTERNATIONAL COOPERATION

### MEXICO-UNITED STATES

The INE has continued its fruitful collaboration with the United States with regard to Climate Change. The list of joint activities is as follows:

#### VULNERABILITY AND ADAPTATION

##### *Impacts and adaptation options for water resources in Sonora*

The project began at the end of 2001 and will continue until the end of 2003. The study is supported by the United States Environmental Protection Agency (USEPA). Based on analyses of rain tendencies, the northern region of the country was found to have had an increase in precipitation over the last forty years. Although the availability of water in rivers such as the Yaqui in Sonora and the Fuerte in Sinaloa tends to increase, the demand will grow much more quickly given the population increases, irrigation agriculture, and assembly plants. This kind of increase in demand could present a challenge over the long term. Two scenarios for the future were proposed for the particular case of Hermosillo for the 2020's and 2050's (Magaña, 2002).

- i) Scenario A: Higher temperature and frequent droughts (less availability of water).
- ii) Scenario B: Higher temperature and more events of intense precipitation, although not necessarily an increase in water availability, and with possible flooding.

Long term solutions to the current water problem in the region include the following: a) Changes in water culture; b) Use of ideal construction materials in houses, and c) Water management in events of extreme precipitation.

In agriculture, the solutions have been focused on modifying the phenological stage of crops to avoid excessive evapo-transpiration due to the excessive warming of the earth. This action related to the phenological stage has already been carried out in Irrigation District 051 on the Coast of Hermosillo, and what is more, they have been tried to sow varieties of crops with a lower water consumption (information from the National Institute of Forest, Agricultural and Livestock Research,

INIFAP, in the state of Sonora), so that it could be said that the stage of adaptation to Climate Change has begun in advance in that region.

#### INTEGRATED ENVIRONMENTAL STRATEGIES

A study is being conducted for the application of environmental strategies focused on local and general pollution in the Mexico Valley Metropolitan Area. The phase of combined control of emissions of criterion pollutants and of greenhouse gases concluded in 2002, and that same year research began into the health benefits involved in reducing both types of pollutants. The object is to incorporate new options of combined control in the next revision of the Program to Improve Air Quality in the MVMA, PROAIRE 2002-2010. This study is supported by the United States Environmental Protection Agency (SEMARNAT, 2003b).

#### ENERGY

##### *Baseline for emission factors*

The United States International Development Agency (USAID) collaborates with the Association of Technicians and Professionals in Energy Application, A.C. (ATPAE), giving technical assistance in establishing an appropriate baseline emission coefficient (for example tons of CO<sub>2</sub>/MWh) to be used in the estimate of the emission reductions resulting from projects on energy efficiency and/or renewable energy (SEMARNAT, 2003b). As part of this effort, widespread consultations were carried out among decision makers. The project team evaluated different methods for estimating emission coefficients. Specifically, the evaluation of the methods took into consideration the quantitative analysis of the values generated by these, which included simulations with a model of the electrical sector, as well as a quantitative analysis that took into account the availability of data, transparency of the methods, and consistency with other methods developed internationally. The ATPAE proposes to the Mexican government that the results obtained from the analysis and the suggested recommendations be accepted as an official method for developing the coefficients mentioned. The INE participated in the technical group organized by the ATPAE.

##### *Work group on energy and the environment*

In the framework of the Exchange of North American Transport Statistics, a Mexican work group was formed made up of the National Institute of Statistics, Geography and Computer Science (INEGI), the Department of Communications and Transport (SCT), the Department of the Environment (SEMARNAT), the National Institute of Ecology (INE); the Mexican Institute of

Petroleum (IMP), the Mexican Institute of Transport (IMT) and the Department of Energy (SENER). This group prepares environmental indicators related to energy consumption, air pollution, risk, and management of the transport sector. In the 16th Meeting held from April 8-12, 2002 in the City of Mexico, information was exchanged on advances in the environment and energy (including Climate Change). The Parties agreed to present the results of the work carried out, in the trilateral meeting to be held in Washington, on June 10-13, 2003.

## LAND USE AND LAND USE CHANGE

### *Analysis of carbon sequestering*

The object of this project is to complete the analysis of land use and land-use change (LULUCF) for the national forest inventory, establish systems of geographical information, review the LULUCF inventories, project emissions from LULUCF, and analyze emission reductions and sequestration strategies at the regional and national project levels (INE-SEMARNAT, 2003a). In 2001 software was purchased for computer and digital maps, and work meetings were held.

### *Development of baseline for projects on prevented deforestation*

USAID financed the study "Forest projects and land use that mitigate greenhouse gas emissions: Baseline and additionality" (INE-SEMARNAT, 2003b). The area around the Calakmul Biosphere Reserve in Campeche and the Meseta Purepecha in Michoacán were considered. Three methods were used and tested that could be used for calculating regional base lines for land use change, concentrating on the rate of deforestation. The models used to simulate future changes in land use are: the Change in Forest Area (FAC) model; the Land Use and Carbon Sequestering (LUCS) model and Geographical Modelling (GEOMOD). This project will be concluded by mid 2003.

### *Technical assistance for determining rates of deforestation and development of a carbon index*

With the support of USAID, an attempt is being made to strengthen the country's capacities to estimate the quantity of CO<sub>2</sub> in biomass lost or gained with time, based on a consistent methodology (SEMARNAT, 2003b). The INE has participated in the technical meetings.

## ECONOMIC-ENVIRONMENTAL MODELLING

The Metropolitan Autonomous University in collaboration with the INE and with the support of USEPA organized an international workshop on the topic, in November, 2002 (SEMARNAT, 2003b).

## INTER-AMERICAN INSTITUTE FOR GLOBAL CHANGE RESEARCH

The General Directorate for Research into Urban, Regional and Global Pollution of the INE, represents Mexico in the IAI. The National Science Foundation of the United States (NSF) supports the activities of the IAI. Advances in IAI programs and studies in which our country participates are the following:

### THEME 1: UNDERSTANDING CLIMATE VARIABILITY

#### *Climate Variability and its Impacts on Mexico, Central America and the Caribbean Region*

In this study, oceanographic and atmospheric variables are monitored that influence the summer precipitation in Brazil, Colombia, Mexico, Costa Rica, the United States, Cuba and Jamaica (IAI, 2003). At the same time, the impacts of climate variability are examined in different socio-economic sectors of some countries: agriculture (Mexico); generation of hydroelectric energy (Costa Rica); and water resources (Mexico and the United States). A complete report of the second year was presented before the IAI Scientific Council during the meeting that took place in the City of Mexico in May of 2002.

The campaigns are financed with IAI funds and an equivalent of contributions in kind from the participant countries. In particular, the National Autonomous University of Mexico has covered 75% of the cost of navigation time. The Meteorological Service of Mexico has given technical support and additional material. Several Meteorological Services in the region will also make their atmospheric observations available to the participants in this project (IAI, 2002a).

Mesoscale Model 5 (MM5) is an important tool for regional climate modelling. The technical capacity acquired at the UNAM Centre for Atmospheric Sciences in recent years has been transmitted to other participants in the program, "Collaborative Research Network, CRN", and to meteorology groups in Latin America. This Centre also offers post-doctoral studies for conducting research in areas of the IAI's Scientific Agenda. Twenty graduate students are participating actively in the CRN, either preparing their theses or directly, as part of the campaigns.

A regional outline of climate prediction was also implemented to prepare forecasts of precipitation in the agricultural sector in Mexico. The results obtained in the year 2000 were encouraging and this focus has been extended now in order to have climate information for the fishing sector.

### *Climate Variability for the Mitigation of Impacts on Trade Convergence Climate Complex*

The Study gathers participants from Ecuador, Colombia, Chile, Venezuela, Panama, Costa Rica, Mexico, the United States and Canada (IAI, 2003). The scientific results reached up until now include a description of the climate in the region for the period 1961-1990, a description of the inter-seasonal signals in the region, data related to climate effects of the El Niño Southern Oscillation (ENSO) and non-ENSO components of the variability in the eastern equatorial Pacific and a description of precipitation anomalies in Central America.

### *Evaluation of Past, Present and Future Climate Variability*

Scientists from Mexico, Peru, Bolivia, Chile, Canada, Argentina and the United States who have published some preliminary reconstructions of temperature and precipitation patterns in the past (IAI, 2003) are participating. Dendrochronological information for Mexico, Cuba and Bolivia has contributed to the identification and preservation of significant natural areas in these countries. It is of particular interest to point out that the data for Mexico show a period of severe drought during the 16th century to which outbreaks of hemorrhagic fever can be linked that were responsible for the death of millions of natives in central Mexico, after the Spanish colonization.

### *Diagnosis and Prediction of Climate Variability and Impacts on Human Health in Tropical America*

The central objectives of the project are to analyze the relationship between health and climate, to use the research to generate knowledge and to understand the associations between these two variables (IAI, 2002b). The preliminary results obtained from the comparison of El Niño with non-Niño years over a 12 year-old period (1986-2000) show a difference in the number of cases of malaria every month, with significant differences that appear from January to May and in July, September and October. This initial analysis also shows that during the second half of every year, when the precipitation increases, differences can be found in the number of cases of classic dengue fever found in connection with the El Niño and non-Niño periods.

### *Management of ENOS Disaster Risk in Latin America: Proposal for Consolidation of a Regional Network of Comparative Research, Information and Training from a Social Perspective*

There is a complete database of inventories of disasters associated with El Niño, La Niña, neutral years, as well as with other ocean and atmospheric agents of regional climate variability (IAI, 20039). These databases, built with "DesInventar" methodology and software developed by the Network, include the period 1970-2002. In Mexico a very valuable experiment is being carried out

called "Indigenous DesInventar Equipment", a name that is used to indicate a database (under construction), derived from the database "Disasters in communities with an indigenous population", meant to be integrated into "DesInventar".

## TOPIC 2: COMPARATIVE STUDIES OF ECOSYSTEMS, BIODIVERSITY, LAND USE AND WATER RESOURCES

### *Role of Biodiversity and Climate in the Functioning of Ecosystems*

Scientists from Argentina, Uruguay, Chile, Venezuela, Mexico and the United States have commented that the changes in land use will be the decisive factor in the alterations of biodiversity in natural ecosystems during this century (IAI, 2003). It was also estimated that some ecosystems will be more susceptible than others to change, such as for example the prairies, tropical forests and Mediterranean ecosystems, for example.

### *Biogeochemical Cycles with Land Use Changes in Semi-arid Regions in America*

Scientists from Canada, Argentina, Brazil, Venezuela and Mexico, are investigating into how the land use affects the carbon, nitrogen and phosphorus cycles in semi-arid regions (IAI, 2003). Some studies carried out in Brazil and Mexico showed that in those places where the land use has been intensified, there was degradation in its quality, fertility and capacity for storing carbon, and that the replacement rates and loss of organic matter in tropical soils show a greater variation than expected.

## TOPIC 3: CHANGES IN THE COMPOSITION OF THE ATMOSPHERE, OCEANS AND FRESH WATER

### *Eastern Pacific Consortium for Research into Global Change in Coastal and Ocean Regions*

Researchers from Brazil, the United States, Ecuador, Peru, Colombia, Mexico, Jamaica, and Chile are trying to clarify the role of regions of the Pacific, climate variability, and global change, and to anticipate the consequences of these forces for the regional oceanic and coastal ecosystems and the societies that interact reciprocally with these systems (IAI, 2003).

#### TOPIC 4: INTEGRATED EVALUATION, HUMAN DIMENSIONS AND APPLICATIONS

##### *Diagnosis and Prediction of Climate Variability and its Impacts on Tropical Humana Health*

The network of collaborators from Brazil, Venezuela, Colombia, Mexico, United States and Jamaica collected climate and epidemiological data on dengue fever and malaria that will be standardized for incorporation to the System for Information and Data del IAI (DIS).

##### *Risk Management Associated with the ENSO in Amrica Latina*

The study is made up of researchers from Peru, Colombia, Chile, Brazil, Ecuador, Argentina, Costa Rica, Mexico, and United States, who study disaster risk management from a social perspective.

The IAI established the Program for Small Subsidies (SGP, for its initials in Spanish) November 8, 2001, and accepted proposals that involved at least two to three countries that were ratified by members of the IAI (IAI, 2002a). The following proposals are ones in which Mexico will participate.

- Sustainable tropical forests for the future. This research will be guided by Canada and Costa Rica and Mexico will participate.
- The development of an inter-American network for characterizing atmospheric chemistry and the sustainable future. This proposal corresponds to the category of Workshop and Mexico, as leader, Brazil and the United States will all participate.
- Climate variability in Mesoamerica: coffee in Mexico, Guatemala and Honduras. This research will have the participation of Guatemala as leader, Mexico and United States.
- Inter-American comparison of Genetic Erosion of Key Species in Semi-arid Prairies with Overexploitation due to Grazing. In this research Mexico, as leader, Argentina and the United States will participate.
- The Human Dimensions of Biodiversity Conservation and the Sustainable Use of Marine Resources: an integrated evaluation of the lessons based on three administration initiatives in America. This proposal corresponds to the category of Technical Report; Mexico and United States will participate, under the leadership of Chile.

- Inter-hemispheric Comparative Studies of the Effects of ENSO on Populations: mechanisms for inhibition and facilitation that determine restoration after massive events of mortality. Mexico, United States, will participate in this research under the leadership of Chile.

Three annual workshops were held to present the advances in IAI programs:

- Piura, Peru, in 2000.
- Buenos Aires, Argentina, in 2001.
- Mexico D.F., in 2002.

#### **MEXICO-UNITED KINGDOM**

Representatives of the SEMARNAT and of the United Kingdom Department for Environment, Food and Rural Affairs (of Environmental Agency) (DEFRA) expressed their interest in 2002 in advancing toward attaining the goals of the Kyoto Protocol (SENER, 2002b), through the following actions:

- \* Take advantage of opportunities for cooperation, opened up by the Flexible Mechanisms of the Kyoto Protocol.
- \* Collaborate in initiatives that promote sustainable development, in the context of the Protocol.
- \* Carry out activities of joint support that would help consolidate the environmental integrity of the Protocol.
- \* Advance in a new framework of cooperation among developing and developed countries.
- \* Promote sustainable activities in the sector energy.
- \* Establish national and international institutions for the Clean Development Mechanism

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