

THE UNITED MEXICAN STATES

THE STUDY ON THE AIR POLLUTION CONTROL PLAN
OF STATIONARY SOURCES
IN
THE METROPOLITAN AREA OF THE CITY OF MEXICO

FINAL REPORT

SEPTEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the United Mexican States, the Government of Japan decided to conduct a study on the Air Pollution Control Plan of Stationary Sources in the Metropolitan Area of the City of Mexico and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mexico a study team headed by Dr. Akira Uchida, Pacific Consultants International, five times between February 1990 and July 1991.

The team held discussions with the officials concerned of the Government of Mexico, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the United Mexican States for their close cooperation extended to the team.

September 1991



Kensuke Yanagiya

President

Japan International Cooperation Agency

ACRONYMS

- DF : Distrito Federal (Federal District)
- EM : Estado de Mexico (State of Mexico)
- MCEM : Municipios Conurbados del Estado de Mexico (17 cities of the State of Mexico within AMCM)
- AMCM : Area Metropolitana de la Ciudad de Mexico (Metropolitan Area of the City of Mexico = DF + MCEM)
- DDF : Departamento del Distrito Federal (Department of Federal District)
- GEM : Gobierno del Estado de Mexico (Government of the State of Mexico)
- SEDUE : Secretaria de Desarrollo Urbano y Ecologia (Ministry of Urban Development and Ecology)
- SHCP : Secretaria de Hacienda y Credito Publico (Ministry of Finance and Public Credit)
- SPP : Secretaria de Programacion y Presupuesto (Ministry of Planning and Budget)
- SECOFI : Secretaria de Comercio y Fomento Industrial (Ministry of Commerce and Industrial Development)
- SEMIP : Secretaria de Energia, Minas e Industria Paraestatal (Ministry of Energy, Mines and Public Industry)
- PEMEX : Petroleos Mexicanos (Mexican Petroleum)
- CFE : Comision Federal de Electricidad (Federal Commission for Electricity)
- IMP : Instituto Mexicano del Petroleo (Mexican Institute of Petroleum)
- IIE : Instituto de Investigaciones Electricas (Institute of Electrical Investigation)

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ACRONYMS

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CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

The Metropolitan Area of the City of Mexico (Area Metropolitana de la Ciudad de Mexico : AMCM) consists of all the 16 wards (delegaciones) of the Federal District (Distrito Federal : DF) and 17 cities (municipios) of the State of Mexico (Estado de Mexico : EM). AMCM has a population of about 15 million in a total area of about 3,600 km², forming one of the largest megalopolises in the world.

During 1970s, the motorization in the AMCM was highly accelerated and industrial activities were expanded in the same manner. At the same time, the problem of air pollution became serious due to the increased emissions of air pollutants and the unfavorable conditions of the topography and meteorology.

The Mexican Government had been working long against the air pollution problem since the start of monitoring air quality of AMCM in 1960. Activities in pollution control have been intensified from the beginning of 1980s. The Federal Environmental Protection Law was promulgated in 1982. A legal measure was introduced in 1985 in order to promote industrial relocation out of AMCM. A network of automatic air quality monitoring system of 25 measuring stations began its operation in January 1986, thereby giving clearer information on air pollution in AMCM. In February 1986, a Presidential Decree of "21 Concrete Measures for Air Pollution Control" was promulgated and the fight against the air pollution was greatly intensified.

In March 1988, the Federal Environmental Protection Law of 1982 was replaced by the General Law for Ecological Balance and Environmental Protection which defined more clearly the responsibilities of various governmental agencies involved in pollution control activities.

A major aspect of air pollution control of automobiles in Mexico is the establishment of the emission standards. This is to be applied by types and models of automobiles coupled with production and supply of unleaded gasoline. For reduction of air pollutant emissions from factories, measures

such as improvement in fuel quality and increased supply of natural gas have been gradually promoted.

In order to achieve smooth implementation of a wide variety of air pollution control measures including those stated above, serious efforts have been made also in building up social consensus. It was represented by the publication of a report in October 1990 called the "Integrated Program Against Air Pollution in the Metropolitan Area - A Common Agreement". This program of 41 air pollution control measures clarified the significance of each measure, time schedule and the responsible agency for execution of each measure.

Through the development of various programs for air pollution control, it can be said that the programs for air pollution control of automobiles such as emission regulations of new automobiles and introduction of the inspection system of exhaust gas for existing automobiles have provided a long-term prospect of improvement in the automobile air pollution.

On the other hand, regarding stationary sources of air pollution, technical characteristics of a wide variety of the stationary sources in AMCM have not been well understood, and therefore, technological studies for application of effective measures have not been sufficiently conducted. The prospect to abate industrial air pollution is yet to be established.

The purpose of this Study is to provide an assistance for abating air pollution being caused by the stationary sources in AMCM.

The Scope of Work (SW) for the Study was agreed between the authorities concerned in the Government of Mexico (GOM) and Japan International Cooperation Agency (JICA) in August 1989, and the Study was started in February 1990.

1.2 Objective and Scope of the Study

The objective of this Study is to formulate a plan for the control of air pollution caused by stationary sources in the Metropolitan Area of the City of Mexico (AMCM) from both technical and economic points of view.

At the initial stage of the Study, the target pollutants for the Study included sulfur oxides (SOx), as well as nitrogen oxides (NOx) and smoke and soot (or particulate matter, PM). However, shortly after the start of the Study, the Study team was informed that the Mexican Government decided to implement the following programs aiming at reduction of SOx emissions.

- (1) In order to produce heavy oil with the sulfur content at 0.8% which will replace heavy oil of the 3.0% - 3.5% sulfur content currently used in AMCM, a hydro-desulfurization plant is to be constructed in the Tula refinery, and the supply of the desulfurized heavy oil will be started in 1995.
- (2) The two thermoelectric power plants in AMCM are to increase the use of natural gas as the primary fuel until start of supplying the desulfurized heavy oil. The desulfurization of flue gas is not to be employed because of the cost.

Since implementation of these programs is considered to reduce much of the SOx emissions from stationary sources, the scope of the present Study was modified by placing emphasis of the control measure study on NOx and smoke and soot (PM).

1.3 Execution of the Study

1.3.1 Study Organization

(1) General Organization

The executing agencies of the Study in the Mexican Government are as follows:

- 1) Ministry of Urban Development and Ecology (SEDUE), Bureau of Ecology
- 2) Department of Federal District (DDF), General Directorate of Urban Reordination and Ecological Protection
- 3) Government of the State of Mexico (GEM), State Commission of Ecology

The executing agency of Japan is Japan International Cooperation Agency (JICA), which executes the Study in consultation with the Ministry of International Trade and Industry (MITI) and the Ministry of Foreign Affairs (MOFA).

A Japanese Study Team was selected by JICA, and a Mexican counterpart team was organized by the above Mexican agencies.

(2) JICA Study Team

The members of the JICA Study Team are as follows:

Dr. Akira Uchida	Team leader/Air Pollution Control Planning	(PCI)
Mr. Masao Kanekiyo	Deputy team leader/Stationary source control	(JEAC)
Mr. Kihachiro Urushibata	Stationary source control	(PCI)
Mr. Masaaki Noguchi	Oil and gas technology	(IEE)
Mr. Minoru Matsuo	Combustion technology	(MCE)
Mr. Yasuo Hirose	Combustion technology	(TAC)
Mr. Koichi Katayama	Combustion technology	(OGE)
Mr. Minoru Hirao	Flue gas analysis	(JEAC)
Mr. Motoji Katsuta	Flue gas analysis	(JEAC)
Mr. Takashi Sato	Economic analysis	(PCI)
Mr. Shuzo Miyazaki	Technical adviser	(NFK)

Note: PCI : Pacific Consultants International, Ltd.
JEAC : Japan Environmental Assessment Center, Ltd.
IEE : The Institute of Energy Economics, Japan
MCE : Matsuo Consulting Engineer's Office
TAC : Techno-Ace Corporation
OGE : Osaka Gas Engineering Co., Ltd.
NFK : Nippon Furnace Kogyo Kaisha, Ltd.

(3) Mexican Team

The principal members of the Mexican Team are as follows:

Fis. Sergio Reyes R.	Subsecretary for Environment	(SEDUE)
Arq. René Altamirano P.	Overall supervision	(SEDUE)
Ing. Rogelio Gonzalez G.	Team leader	(SEDUE)
Ing. Enrique Campuzano B.	Stationary source investigation and control	(SEDUE)
Ing. Carlos Silva M.	Stationary source measurement and control	(SEDUE)
Ing. Javier Ramos R.	Stationary source investigation /data processing	(SEDUE)
Lic. Raul Guido G.	Laws/Pollution control administration	(SEDUE)
Ing. Patricia Tejeda U.	Stationary source investigation	(GEM)
Ing. Raúl Galván	Stationary source investigation	(GEM)
Ing. Victor J. Gutierrez A.	Energy/Socio-economy /Institution	(DDF)
Ing. César Gálvez	Stationary source data processing	(SEDUE)
Ing. Salvador Orozco	Stationary source data processing	(SEDUE)
Ing. Rigoberto Zamora	Stationary source measurement	(SEDUE)
Ing. Roberto Guerrero R.	Stationary source measurement	(SEDUE)
Ing. Alberto Serrano M.	Stationary source measurement	(SEDUE)
Ing. Cresencio Casas O.	Stationary source measurement	(SEDUE)
Ing. Maria Magdalena C.C.	Stationary source measurement	(DDF)
Ing. Jose Esquivel R.	Stationary source measurement	(GEM)

1.3.2 Study Items and Time Schedule

Since the Study started in February 1990, it was carried out with the time schedule shown in Table 1.3.1.

Table 1.3.1 Major Study Items and Time Schedule

Item	1990												1991									
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
Work in Mexico	Discussion and consultation	□						□					□									
	Collection of relevant existing data	□				□	□	□	□	□												
	On-site survey on 97 establishments				□	□																
	Simplified questionnaires on 1000 establishments and data filing						□	□	□	□												
	Diagnostic survey on selected establishments						□	□	□	□												
	Preliminary combustion test on emulsified heavy oil									□												
	Field test of low-NOx burners										□											
	Study planning	□			□	□																
	Review of existing data			□			□	□	□	□	□											
	Analysis of results of diagnostic and on-site surveys							□	□	□	□											
Work in Japan	Analysis of existing emission data and results of simplified questionnaire							□	□	□	□											
	Study of source control measures								□	□	□	□	□	□								
	Planning of stationary source control program										□	□	□	□	□							
	Submission of Reports *													▲								
																			▲			

* IC/R: inception report, PR/R: progress report, IT/R: interim report, DF/R: draft final report, F/R: final report

**CHAPTER 2 BASIC CONDITIONS CONCERNING STATIONARY AIR
POLLUTION SOURCES IN THE METROPOLITAN AREA**

CHAPTER 2 BASIC CONDITIONS CONCERNING STATIONARY AIR POLLUTION SOURCES IN THE METROPOLITAN AREA

2.1 Geography

Mexico City is located in the Valley of Mexico in the southern corner of the Central Highland. The altitude of the lowest part of the valley is 2,240m above the sea level. The valley stretches toward north and is surrounded by mountain ranges.

The climate is warm and relatively dry. The daily average temperature is between 10°C and 23°C. The highest monthly average temperature is 17.4°C in May, and the lowest one is 12.1°C in January. The annual precipitation is 725mm, most of which concentrates during the period from May to October. During the dry season (or winter season), a higher frequency of forming thermal inversion and a limited precipitation tend to aggravate air pollution.

The Mexico City Metropolitan Area (AMCM) consists of all the sixteen DELEGACIONES of the Federal District (DF) and the seventeen MUNICIPIOS of the State of Mexico (hereinafter referred to as "MCEM", the acronym of MUNICIPIOS CONURBADOS DEL ESTADO DE MEXICO), as shown in Figure 2.1.1. The total area of AMCM is about 3,615km², of which DF is about 1,505km² and MCEM is about 2,110km². The area of Tokyo, for reference, is about 1,758km² excluding its islands. The same area of AMCM is often referred to as "ZMCM" in literature. But in this report, the acronym "AMCM" will be used after the definition given by "PROGRAMA GENERAL DE DESARROLLO URBANO DEL DISTRITO FEDERAL 1987-1988".

**STATE OF MEXICO
MUNICIPIOS CONURBADOS**

17. Atizapán de Zaragoza
18. Coacalco
19. Cuautitlán
20. Cuautitlán Izcalli
21. Chalco
22. Chicolapan
23. Chimalhuacán
24. Ecatepec
25. Huixquilucan
26. Ixtapaluca
27. La Paz
28. Naucalpan de Juárez
29. Nezahualcóyotl
30. Nicolás Romero
31. Tecámac
32. Tlalnepantla
33. Tultitlán

**FEDERAL DISTRICT
DELEGACIONES**

1. Alvaro Obregón
2. Azcapotzalco
3. Benito Juárez
4. Coyoacán
5. Cuajimalpa
6. Cuauhtémoc
7. Gustavo A. Madero
8. Iztacalco
9. Iztapalapa
10. Magdalena Contreras
11. Miguel Hidalgo
12. Milpa Alta
13. Tláhuac
14. Tlalpan
15. Venustiano Carranza
16. Xochimilco

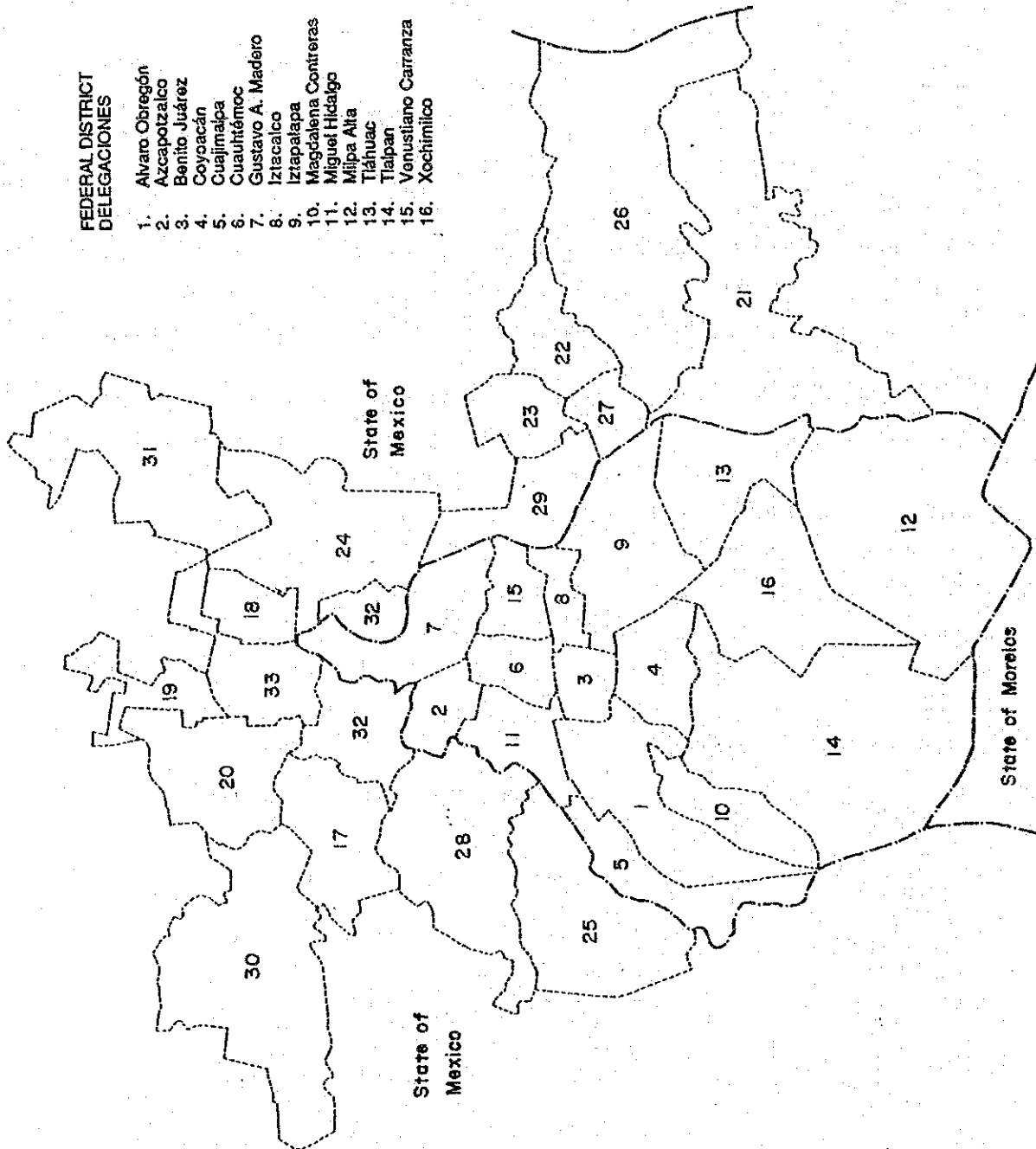


Figure 2.1.1 Mexico City Metropolitan Area (AMCM)

2.2 Population and Urban Planning

2.1.1 Population

(1) Historical Changes in the Population of AMCM

According to the general census published in March 1990, the population of AMCM is about 14,990,000, or 18.4% of the total population of Mexico with about 81,140,000. Of the total population of 14.99 million in AMCM, 8.24 million, or 55% reside in DF, and 6.75 million, or 45% reside in MCEM (17 MUNICIPIOS in the State of Mexico).

Table 2.2.1 shows historical changes in the population of AMCM since 1950. The population of 3.34 million in 1950 increased rapidly to 5.46 million in 1960, 8.99 million in 1970, and 13.36 million in 1980 far exceeding 10 million. The present population of 14.99 million is 4.5 times of that in 1950.

Since 1970, the population of AMCM increased by 6 million, of which 4.6 million or 77% are in MCEM and 1.4 million or 23% are in DF. While the population of DF increased by 1.2 times in the past two decades, the increase in MCEM was 3.2 times in the same period, which indicates remarkable increase of the population in the suburban zones.

The rate of the population growth in AMCM was 5.1% on annual average during 1960-1970, and it decreased to 3.3% during 1970-1980 and to 1.9% during 1980-1990. These trends indicate a further decreased rate of population growth in the future.

While the annual population growth in DF during 1980-1990 was only 0.26%, it maintained a high rate in MCEM at 4.25%. However, the rate for the AMCM total during the same period at 1.85% is slightly below the national average of 1.88%. These figures indicate that the population inflow from other regions, observed significantly during 1960s and 1970s, has been restrained in recent years.

The decrease in population inflow is considered to have been caused by the several factors such as: 1) virtually no new employment during 1980s due to the economic stagnation, 2) higher housing costs and higher commodity prices as compared to other regions, and 3) damages of houses and factories caused by the earthquake in 1985.

Table 2.2.1 Historical Change in the Population of the Metropolitan Area

	1950	1960	1970	1980	1990	Annual Growth Rate(%)		
						1960-1970	1970-1980	1980-1990
Population (person)								
AMCM	3,340,385	5,461,675	8,989,495	12,476,612	14,987,051	5.11	3.33	1.85
DF	3,050,442	4,870,876	6,874,165	8,024,498	8,236,960	3.50	1.56	0.26
MCEM	289,943	590,799	2,115,330	4,452,114	6,750,091	13.60	7.73	4.25
Composition(%)								
AMCM	100.00	100.00	100.00	100.00	100.00			
DF	89.18	76.47	76.47	64.32	54.96			
MCEM	10.82	23.53	23.53	35.68	45.04			
Density (person/km ²)								
AMCM				3,451	4,145			
DF				5,330	5,471			
MCEM				2,110	3,140			

Source: "Senso Población" (INEGI)

Note: 1) AMCM : Mexico City Metropolitan Area = DF + MCEM

2) DF : Federal District

3) MCEM : The 17 MUNICIPIOS in the State of Mexico surrounding DF

(2) Changes in the Geographical Distribution of the Population

Table 2.2.2 shows the population and the population density of AMCM in 1980 and 1990 by DELEGACIONES in DF and MUNICIPIOS in MCEM. A large variation of population increase and decrease has been observed among the administrative areas during the last 10 years.

The population has decreased in the highly urbanized and commercialized six DELEGACIONES in DF: CUAUHEMOC, MIGUEL HIDALGO, BENITO JUAREZ, VENUSTIANO CARRANZA, GUSTAVO A. MADERO, and IZTACALCO.

Meanwhile, the population has more than doubled in the six MUNICIPIOS of the State of Mexico: ATIZAPAN DE ZARAGOZA, CHALCO, CHICOLOAPAN, CHIMALHUACAN, IXTAPALUCA, and TULTITLAN.

As indicated above, inhabitants in AMCM has been moving from the central areas to the surrounding areas.

(3) Future Population in AMCM

The population of AMCM in the future is forecasted by the Government of Mexico (GOM) to increase at an annual rate of 1.4%, and to exceed 20 million in 2010. This means that the population will increase by 5 million in 20 years, and the average population density will be even higher than the present figure of DF.

According to the projections by the Study Team in that the trend of decreasing rate of population growth was taken into account, the population in 2010 is expected to be at about 18 million and it will be close to the saturated population. This is shown in Figure 2.2.1.

Table 2.2.2 Geographical Distribution of Population in AMCM

	AREA (ha)	1980		1990		1990/1980
		POPULATION	DENSITY (MAN/Km2)	POPULATION	DENSITY (MAN/Km2)	RATIO OF POPULATION
AMCM	361,509	12,476,612	3,451.26	14,987,051	4,145.69	1.2012
DF	150,552	8,024,498	5,330.05	8,236,960	5,471.17	1.0265
1 AZCAPOTZALCO	3,451	455,718	13,205.38	474,905	13,761.37	1.0421
2 COYOACAN	5,540	542,591	9,794.05	640,006	11,552.45	1.1795
3 CUAJIMALPA	7,700	82,870	1,076.24	119,720	1,554.81	1.4447
4 GUSTAVO A. MADERO	8,700	1,375,138	15,806.19	1,268,123	14,576.13	0.9222
5 IZTACALCO	2,306	518,282	22,475.37	448,357	19,443.06	0.8651
6 IZTAPALAPA	11,940	1,147,058	9,606.85	1,490,981	12,487.28	1.2998
7 MAGDALENA CONTRERAS, LA	7,004	157,295	2,245.78	195,000	2,784.12	1.2397
8 MILPA ALTA	27,820	48,719	175.12	63,573	228.52	1.3049
9 ALVARO OBREGON	8,586	580,832	6,764.87	643,542	7,495.25	1.1080
10 TLAHUAC	9,300	133,504	1,435.53	206,688	2,222.45	1.5482
11 TLALPAN	31,200	335,274	1,074.60	485,043	1,554.63	1.4467
12 XOCHIMILCO	12,740	197,618	1,551.16	271,020	2,127.32	1.3714
13 BENITO JUAREZ	2,750	495,116	18,004.20	407,731	14,826.58	0.8235
14 CUAUHTEMOC	3,309	740,547	22,379.78	595,972	18,010.64	0.8048
15 MIGUEL HIDALGO	4,764	493,462	1,358.14	406,693	8,536.80	0.8242
16 VENUSTIANO CARRANZA	3,442	629,611	18,292.00	519,606	15,096.05	0.8253
MCEM	210,957	4,452,114	2,110.44	6,750,091	3,199.75	1.5162
1 ATIZAPAN DE ZARAGOSA	9,030	4,982	55.17	353,544	3,915.22	70.9659
2 COACALCO	3,480	95,623	2,747.80	170,902	4,910.99	1.7872
3 CUAUTTLAN	15,028	38,825	258.35	54,811	364.72	1.4117
4 CHALCO	28,820	77,000	267.18	317,298	1,100.96	4.1207
5 CHICOLOAPAN	6,006	26,868	447.35	63,849	1,063.09	2.3764
6 CHIMALHUACAN	3,795	60,718	1,599.94	270,754	7,134.49	4.4592
7 ECATEPEC	15,482	770,569	4,977.19	1,366,634	8,827.25	1.7735
8 HUIXQUILUCAN	14,258	76,761	538.37	148,008	1,038.07	1.9282
9 IXTAPALUCA	28,834	76,479	265.24	154,131	534.54	2.0153
10 NAUCALPAN DE JUAREZ	19,661	717,197	3,647.82	881,036	4,481.13	1.2284
11 NEZAHUALCOYOTL	6,240	1,317,401	21,112.19	1,411,812	22,625.19	1.0717
12 NICOLAS ROMERO	25,967	110,644	426.09	206,625	795.72	1.8675
13 LA PAZ	3,692	97,669	2,645.43	149,553	4,050.73	1.5312
14 TECAMAC	15,541	82,634	531.72	138,185	889.16	1.6722
15 TLANEPANTLA DE BAZ	8,505	764,347	8,987.03	788,169	9,267.12	1.0312
16 TULTILAN	6,618	134,398	2,030.79	274,781	4,152.03	2.0445

Source: "Senso Poblacion" (INEGI) (1980, 1990)

Note: The figures for CUAUTTLAN in MCEM are the totals of CUAUTTLAN and CUAUTTLAN IZCALLI

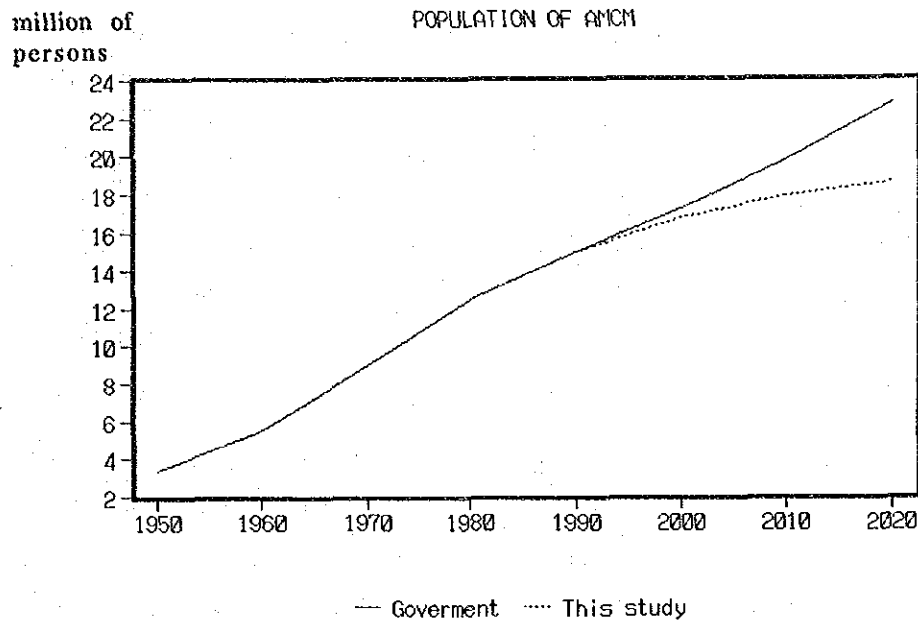


Figure 2.2.1 Forecast of Population in AMCM

2.2.2 Urban Planning

Urban planning for the Metropolitan Area, as well as for other urban areas of the nation, is carried out within the framework of the National Urban Development Program (NUDP) 1990-1994 (PROGRAMA NACIONAL DE DESARROLLO URBANO 1990-1994), which aims to embody the national policies and principles set forth by the National Development Plan (NDP) 1990-1994 (PLAN NACIONAL DE DESARROLLO 1990-1994). The objectives of the National Urban Development Program (NUDP) are to reordinate national land, improve urban services and enhance development, management and operation of urban centers in order to rectify regional differences in the quality of life.

Under the Program, the whole country is geographically divided into 9 Urban-Regional Systems (URS). AMCM belongs to the Central Urban-Regional System (CURS), consisting of two large cities, six medium cities and twenty-two small cities in DF and the States of HIDALGO, MEXICO, MORELOS, PUEBLA and TLAXCALA. The CURS has a population of 26 million making up 32% of the national total.

The themes of urban development in the CURS are:

- 1) control further expansion of AMCM,
- 2) facilitate development of the region in harmony, and
- 3) improve quality of life without adverse effects to environment.

Strategies in land reordination in the Central region aim at migration of population from AMCM to medium cities by regulating development of AMCM and promoting industries in medium cities. Further industrial development will be controlled in AMCM, maintained at present levels in the cities of PUEBLA, PACHUCA, TOLUCA, CUERNAVACA and TLAXCALA/SANTA ANA, and encouraged in APIZACO and TEHUACAN.

These policies are to be implemented, under the guidance of SEDUE, by the Department of Federal District (DDF) and governments of the other states and cities participated by appropriate social and private sectors.

Under such institutional framework, DDF and the government of the State of Mexico (hereinafter referred to as "GEM") make arrangement for development of AMCM through the Metropolitan Council (MC) and other sectorial committees to achieve well-coordinated planning and implementation of developing social infrastructure, land and houses taking into consideration the environmental conditions of AMCM.

2.3 Industry and Economy

This section outlines industrial activities in and around AMCM and presents, in categorized forms, number of factories located in the area in order to understand the background of air pollution contributed by stationary pollution sources.

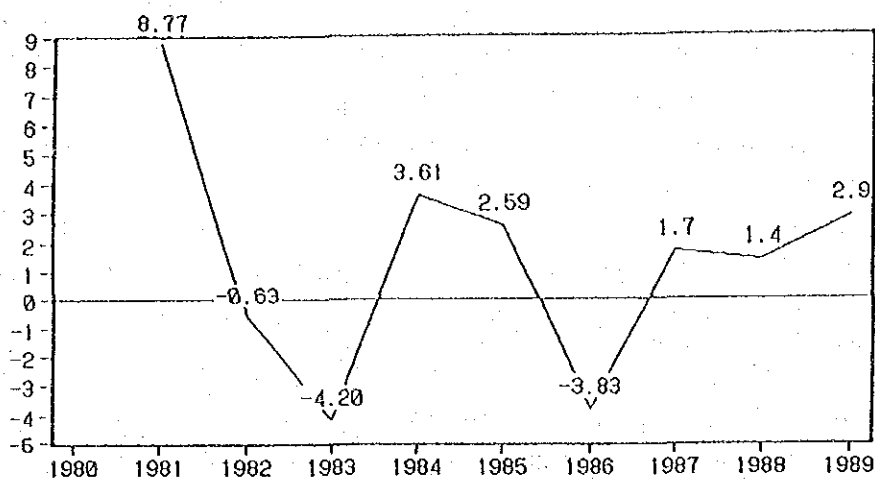
2.3.1 Economic Trend and Activities in the Metropolitan Area

(1) Overview of National Economy

During 1970s, Mexico achieved a high economic growth with annual growth rates exceeding 6%. Income from oil export and a large sum of foreign loans contributed much to this growth.

However, the situation changed drastically during 1980s. Annual changes in real GDP during this period is shown in Figure 2.3.1. A debt crisis was experienced in 1982 as a result of the world-wide economic recession and increase in the debt payments due to high interest rates in the U.S.A. Mexico abided this crisis by the support of international banking circles and by the retrenchment policy adopted by the De la Madrid Administration inaugurated in December 1982. This policy was aimed at reduction in financial deficit, improvement in trade imbalance, and inflation control. As a result, economic recovery was under way in 1984. However, a sharp drop of the international oil price during the last half of 1985 was a severe blow to the Mexican economy which was heavily dependent on the export of oil and its products. The real economic growth rate in 1985 was minus 4%, and the Mexican economy was again fallen into a crisis.

This experience motivated Mexico to join the GATT in 1986, and to shift the economic development policy. The policy of fostering domestic industries aimed at import substituting industrialization was changed to the policy of promoting export of non-petroleum products, thus freeing the country from the heavy dependence on oil exportation. Stringent import restrictions imposed by that time have been gradually removed. The policies in international trade and industry



Source: " Los Indicadores Económicos (Mayo 1990) "
 BANCO DE MEXICO (DIRECCION DE INVESTIGACION ECONOMICA)

Figure 2.3.1 Real Rates of Growth of GDP at 1980 Prices
 Between 1980 and 1989 (Percentages)

have been changing from regulation to deregulation, and from nationalization to privatization.

The trend in the real GDP after 1986 shows economic recovery and stabilization. The growth from the previous year was -3.8% in 1986, 1.7% in 1987, 1.4% in 1988, and 2.9% in 1989. Decrease in per capita GDP experienced for the three consecutive years ceased, and the per capita GDP turned to increase in 1989. Along with this trend, there have been increase of investments from abroad and also refluxes of investment. All these contributed the economic recovery. Investment of private sectors has been activated, and domestic consumption has been gradually increasing. The economic growth in 1990 is expected at 3.5%.

According to the consumer price index (with the December price) published by BANCO DE MEXICO, the annual inflation rate in the recent years reached a peak in 1987 at 159.2%, then turned to decrease to 51.7% in 1988 and 19.7% in 1989, the latest rate being comparable to those during the last half of 1970s when Mexico enjoyed a stable economic expansion.

The burden of the foreign debts over US\$100 billion that was hindering the economic development of Mexico along with inflation has been reduced as the result of financial cooperation of IMF, IBRD and the Export-Import Bank of Japan backed by the governments of the U.S.A., Japan and European countries. An agreement was made on February 4, 1990 with foreign commercial banks to reduce the principal by US\$7 billion and the annual interest payment by US\$1.6 billion.

The Mexican Government has been placing priority on inflation control and foreign debt payment by adopting the policies of freezing wages and prices, and restraining public investments. These policies have resulted in reduction of real wages and repressed development of social infrastructure. Now, with the problems of inflation and foreign debt being self-possessed, the Mexican economy is expected to rise again to retrieve the lagging experienced in the past.

(2) Industry in the Metropolitan Area

1) Economic Scale of AMCM

AMCM is a giant economic sphere occupying about 40% of the national GDP. Table 2.3.1 shows the trend of GDP for the country and AMCM by industrial sectors from 1940 to 1980. The ratio of GDP in AMCM to the national GDP increased during the 1950s from 30.3% in 1950 to 36.2% in 1960, a 5.9 points increase. Economic concentration in AMCM continued with 1.2 points increase in 1960s and 0.8 point in 1970s.

The GDP of Mexico in 1989 was about US\$200 billion according to the temporary report. The economic scale of AMCM is considered to be of US\$80 billion or 40% of the national GDP.

Table 2.3.1 GDP of AMCM and MEXICO by Industrial Sectors
(million pesos of 1950)

	1940		1950		1960		1970		1980		1980/1970 (times)	
	National	AMCM	National	AMCM	National	AMCM	National	AMCM	National	AMCM	National	AMCM
Total	22,869	7,010	41,060	12,427	74,215	28,858	151,760	56,731	301,731	115,338	2.0	2.0
Agriculture	5,170	30	9,242	28	13,917	37	17,643	54	25,198	105	1.4	1.9
Manufacturing	6,789	2,286	12,466	3,378	24,803	10,509	52,009	16,086	112,509	34,618	2.2	2.2
Transport	655	576	1,988	1,038	3,538	2,184	4,778	2,775	13,903	4,788	2.9	1.7
Services	10,965	4,118	17,364	7,983	32,057	14,128	77,330	37,816	150,121	75,826	1.9	2.0
(ZMCM/Nacional)x100)												
Total	100.0	30.6	100.0	30.3	100.0	36.2	100.0	37.4	100.0	38.2		
Agriculture	100.0	0.6	100.0	0.3	100.0	0.3	100.0	0.3	100.0	0.4		
Manufacturing	100.0	33.7	100.0	27.1	100.0	42.7	100.0	30.9	100.0	30.8		
Transport	100.0	66.6	100.0	52.2	100.0	60.0	100.0	58.1	100.0	34.4		
Services	100.0	40.8	100.0	48.0	100.0	44.1	100.0	46.9	100.0	50.5		
(Distribution Ratios)												
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Agriculture	22.6	0.4	22.5	0.2	18.8	0.1	11.6	0.1	8.4	0.1		
Manufacturing	29.7	22.6	30.4	27.2	33.2	39.1	34.3	28.4	37.3	30.0		
Transport	3.8	8.2	4.8	8.4	4.9	8.1	3.1	4.9	4.6	4.2		
Services	44.0	58.7	42.3	64.2	43.2	52.6	51.0	66.7	49.6	55.7		

Source: ATLAS DE LA CIUDAD DE MEXICO, DDF and EL COLEGIO DE MEXICO, November 1987.

2) Industrial Structure

According to the sectoral distribution of GDP in AMCM shown in Table 2.3.1, agriculture constitutes 0.09% of the total, mining, manufacturing, construction and electricity together 30.0%, transportation and communication 3.8%, and services 65.7%. Industrial structure of AMCM, with a large share of the service sector and a very small share of agriculture, is distinctively different from the national average, showing characteristics of major cities.

Numbers of business establishments and employees registered in 1985 in AMCM are shown in Table 2.3.2 by the type of industry. The total number of business establishments in AMCM in 1985 was about 305,000, of which about 217,000 was in DF and 87,000 in MCEM. The sectoral distribution in AMCM was: commerce including hotels and restaurants 178,000 (58.5%), followed by service 89,000 (29.3%) and manufacturing 34,000 (11.4%). About 70% of the manufacturers are located in DF and the rest (about 30%) in MCEM.

The total number of employees in AMCM in 1985 was about 2,181,000, of which 867,000 or 39.8% were engaged in manufacturing, 590,000 (27.1%) in service, and 513,000 (23.5%) in commerce.

Table 2.3.2 Numbers of Business Establishments and Employees in Federal District and State of Mexico by Industrial Sectors (1985)

	Numbers of Establishment			Numbers of Employees		
	DF	MCEM	AMCM	DF	MCEM	AMCM
Minig	32	25	57	7,388	817	8,205
Manufacturing	24,130	9,955	34,085	561,215	306,084	867,299
Construction	1,193	237	1,430	123,962	6,084	130,046
Commerce	121,256	57,106	178,362	380,812	132,019	512,831
Transport	544	819	1,363	56,587	16,251	72,838
Services	70,045	19,331	89,376	442,270	147,613	589,883
Total	217,200	87,473	304,673	1,572,234	608,868	2,181,102
Minig	0.01	0.03	0.02	0.47	0.13	0.38
Manufacturing	11.11	11.38	11.19	35.70	50.27	39.76
Construction	0.55	0.27	0.47	7.88	1.00	5.96
Commerce	55.83	65.28	58.54	24.22	21.68	23.51
Transport	0.25	0.94	0.45	3.60	2.67	3.34
Services	32.25	22.10	29.34	28.13	24.24	27.05
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: ① "Resultados Oportunos del Distrito Federal, Censos Económicos '86"
 ② "Cuaderno de Información para La Planeacion Estado de Mexico"

Although the manufacturers' share in the total number of establishments in AMCM is 11.2%, they absorb 39.8% of the total labor forces, showing their economic importance. Especially in MCEM, more than 50% of all employees are engaged in the manufacturing industry. It can be said that the importance of manufacturing is particularly high in terms of employment.

3) Manufacturing Industry

Table 2.3.3 shows gross output of manufacturing industry in DF and the whole State of Mexico in 1985 by sectors. The gross output in DF was 3,936,900 million pesos. Breakdown by types of industry is : chemicals 17.9%, food 17.0%, transportation equipment 10.0%, electric machinery 7.7%, rubber and plastic 6.1%, metal products 5.8%, publishing and printing 4.8%, textile 4.6%, drinks 4.1%, basic metals 3.8%, and so on.

The gross output in the State of Mexico (EM) was 5,431,700 million pesos in 1985. Breakdown by the type of industry is: chemicals 23.3%, food 12.2%, transportation equipment 10.4%, rubber and plastic 6.8%, electric machinery 6.5%, basic metals 5.9%, textile 5.8%, pulp and paper 5.7%, non-metallic minerals 5.1%, and so on.

As will be shown in Table 2.3.6, MCEM shares 72% of the total number of business establishments in EM, and 77% of the total number of employees in EM. It is considered that the industrial structure of EM as a whole is similar to that of MCEM.

The structure of manufacturing industry in AMCM is characterized by concentration of publishing and printing, rubber and plastic, chemicals, metallic products, paper, and apparel industries. The degrees of concentration of these industries in DF and EM together, in terms of share of total employees of each industry in the country, are 56.0% for publishing and printing, 54.6% for rubber and plastic, 53.7% for chemicals, 50.2% for metallic products, 45.7% for paper, and 39.9% for apparel (see Table 2.3.4).

Table 2.3.3 Gross Output of Manufacturing Industry by Sectors
in the Federal District and the State of Mexico (1985)

Unit: Million Peso

Sector	① Federal District		② State of Mexico (whole state)		① + ②	
		%		%		%
1 Food products	667,117	16.95	664,702	12.24	1,331,819	14.22
2 Drinks	159,302	4.05	153,620	2.83	312,922	3.34
3 Tobacco	31,502	0.80		0.00	31,502	0.34
4 Textile	182,616	4.64	312,676	5.76	495,292	5.29
5 Apparel	143,997	3.66	157,483	2.90	301,480	3.22
6 Leather	27,366	0.70	44,313	0.82	71,679	0.77
7 Timber processing	11,537	0.29	24,816	0.46	36,353	0.39
8 Wooden furniture	50,369	1.28	36,315	0.67	86,684	0.93
9 Pulp, paper	135,519	3.44	308,517	5.68	444,036	4.74
10 Publishing, printing	187,805	4.77	42,785	0.79	230,590	2.46
11 Chemicals	706,408	17.94	1,262,834	23.25	1,969,242	21.02
12 Rubber, plastic	239,977	6.10	369,701	6.81	609,678	6.51
13 Ceramics, stone, clay	110,050	2.80	276,248	5.09	386,298	4.12
14 Basic metals	148,917	3.78	317,639	5.85	466,556	4.98
15 Metal products	226,366	5.75	242,875	4.47	469,241	5.01
16 General machinery	128,658	3.27	209,978	3.87	338,636	3.61
17 Electric machinery	301,904	7.67	350,337	6.45	652,241	6.96
18 Transportation equipment	394,600	10.02	563,989	10.38	958,589	10.23
19 Others	70,810	1.80	92,892	1.71	163,702	1.75
20 Total	3,936,938	100.00	5,431,720	100.00	9,368,658	100.00

Source: (1) Resultados Oportunos del Distrito Federal Censos Economicos '86"
Instituto Nacional de Estadística Geografía e Informática
(2) Cuaderno de Información para La Planeación Estado de México
Instituto Nacional de Estadística Geografía e Informática

Table 2.3.4 The Number of Establishments and Employees in Federal District and State of Mexico by Manufacturing Industrial Sectors (1987)

Number

Name of sectors	Federal District		State of Mexico		National	
	Establishments	Employees	Establishments	Employees	Establishments	Employees
1 Food products	2,247	42,136	1,300	46,691	19,290	211,223
2 Drinks	62	14,325	49	14,019	1,014	107,170
3 Tabacco	5	367	3	1,122	46	18,557
4 Textile	680	23,524	457	43,849	2,691	158,019
5 Apparel	2,959	48,042	877	30,925	8,607	197,937
5 Leather	727	14,085	65	1,570	4,928	111,103
6 Timber processing	180	2,499	106	2,785	2,217	47,000
7 Wooden furniture	696	11,922	354	9,271	3,783	54,036
8 Pulp, paper	165	5,631	156	19,169	732	54,323
9 Publishing, printing	2,009	22,244	542	22,863	5,939	80,629
10 Chemicals	798	25,122	821	77,081	3,260	190,216
11 Petrochemical products	15	226	28	1,310	162	6,553
12 Rubber, plastic	1,156	27,961	731	49,281	3,823	141,454
13 Ceramics, stone, clay	566	11,170	333	22,679	5,012	132,236
14 Basic metals	156	3,770	254	19,161	1,121	93,372
15 Metal products	3,527	55,777	1,993	94,342	16,287	299,315
16 General machinery	1,042	14,029	364	13,199	4,522	73,729
17 Electric machinery	780	24,146	378	45,435	2,618	294,663
18 Transportation equipment	225	23,166	162	14,983	1,246	115,820
19 Others	1,322	27,413	252	5,746	3,817	74,579
20 TOTAL	19,315	397,555	9,227	536,481	91,115	2,208,934

Percentage

Name of sectors	Federal District		State of Mexico		National	
	Establishments	Employees	Establishments	Employees	Establishments	Employees
1 Food products	11.63	10.60	14.09	8.72	21.17	9.56
2 Drinks	0.32	3.60	0.53	2.62	1.11	4.85
3 Tabacco	0.03	0.09	0.03	0.21	0.05	0.84
4 Textile	3.52	5.92	4.95	8.19	2.95	7.15
5 Apparel	15.32	12.08	9.50	5.78	9.45	8.96
5 Leather	3.76	3.54	0.70	0.29	5.41	5.03
6 Timber processing	0.93	0.63	1.15	0.52	2.43	2.13
7 Wooden furniture	3.60	3.00	3.84	1.73	4.15	2.45
8 Pulp, paper	0.85	1.42	1.69	3.58	0.80	2.46
9 Publishing, printing	10.40	5.60	5.87	4.27	6.52	3.65
10 Chemicals	4.13	6.32	8.90	14.39	3.58	8.61
11 Petrochemical products	0.08	0.06	0.30	0.24	0.18	0.30
12 Rubber, plastic	5.98	7.03	7.92	9.20	4.20	6.40
13 Ceramics, stone, clay	2.93	2.81	3.61	4.24	5.50	5.99
14 Basic metals	0.81	0.95	2.75	3.58	1.23	4.23
15 Metal products	18.26	14.03	21.60	17.62	17.88	13.55
16 General machinery	5.39	3.53	3.94	2.46	4.96	3.34
17 Electric machinery	4.04	6.07	4.10	8.48	2.87	13.34
18 Transportation equipment	1.16	5.83	1.76	2.80	1.37	5.24
19 Others	6.84	6.90	2.73	1.07	4.19	3.38
20 TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

Source: "Elaboracion propia de la Direccion General Industrial Mediana Y Pequena con informacion de la Subdireccion de Finanzas del IMSS"

(3) Trend of Manufacturing Industry in Mexico

1) Production

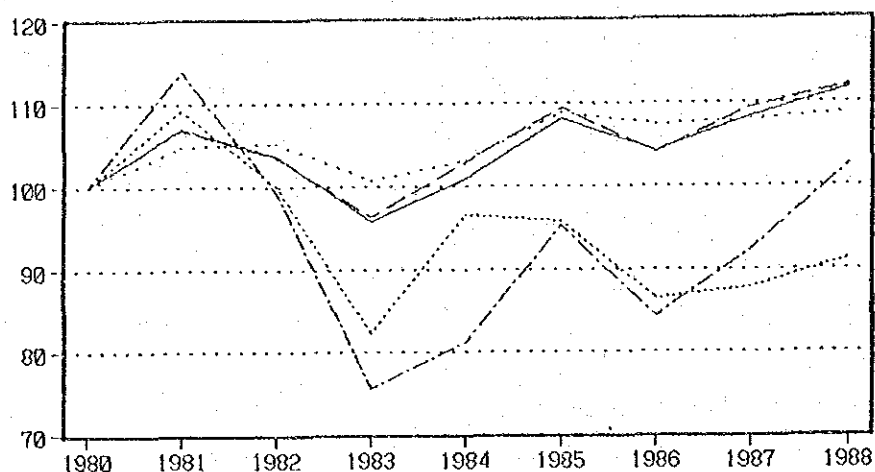
During 1980s, the production of manufacturing industries in Mexico was stagnant due to the economic crises experienced two times. Figure 2.3.2 and Table 2.3.5 show changes in the manufacturing production index during 1980s. The debt crisis of 1982 and the following retrenchment policy caused decrease in the production by 3.1% in 1982 and 7.5% in 1983. The production level was recovering in 1984 and 1985, but it fell again in 1986 by 3.5% because of the economic crisis brought about by the drop of crude oil prices. Since then, the production level showed recovery during two consecutive years. Still, the production index in 1988 was 118.4 as compared with 100 in 1980, a mere increase of 18.4 points in 8 years with an average annual growth of 1.9%.

The trend of manufacturing production as described above can be further examined by looking into types of product. The production of consumer goods, especially of durable consumer goods, were stagnant. The production index (100 in 1980) of the latter in 1988 was 91.2, below the level of 1980. The index for non-durable consumer goods in 1988 was 108.8 and consumer goods as a whole 105.2, a trivial increase.

Production of intermediate goods has been in the upward tendency under the economic recovery since 1986. But the overall increase during the 8 years was only 12.1%.

Production of capital goods was influenced most by the business cycles. The index dropped to 75.5 at the debt crisis of 1983. But it recovered by 1988 to the level of 1980 by the change of economic development policy in 1986.

In contrast to the stagnant production of goods for domestic demand as stated above, production of export oriented goods in MAQUILADORAS had been active. The production in MAQUILADORAS in 1988 was 3.71 times of that in 1980. It is considered that the MAQUILADORAS contributed greatly to the overall growth of manufacturing industry at the annual average rate of 1.9% during the 8 years.



— total durable no durable - - - intermediate - - - capital

Source: " Los Indicadores Económicos (mayo 1990) "
BANCO DE MEXICO (DIRECCION DE INVESTIGACION ECONOMICA)

Figure 2.3.2 Manufacturing Production Between 1980 and 1988
(1980 = 100)

Table 2.3.5 Index of Manufacturing Industrial Product by Types of Goods
Between 1981 and 1988 (base 1980 = 100)

	General index	Consumption goods						Goods of intermediate		Capital goods		MAQUILA for Explotation
		Total		Durable		No durable		(1)	(2)	(1)	(2)	(1)
		(1)	(2)	(1)	(2)	(1)	(2)					
1981	107.0	105.7	106.6	109.3	110.2	104.8	105.6	106.9	110.7	114.0	115.0	108.7
1982	103.7	104.3	104.9	100.0	100.6	105.3	106.0	103.5	104.6	99.4	100.3	118.3
1983	95.9	97.1	97.8	82.1	82.4	100.9	101.2	96.4	96.6	75.5	75.7	154.6
1984	101.0	99.9	100.4	86.5	87.0	103.3	103.7	103.0	103.5	81.0	81.4	186.8
1985	108.1	106.3	107.0	95.9	96.6	108.9	109.6	109.4	109.8	95.3	95.8	201.8
1986	104.3	103.9	103.8	86.5	87.1	107.8	108.0	104.2	104.8	84.2	84.1	266.6
1987	108.4	103.9	104.5	87.7	88.4	108.0	108.5	109.5	110.0	92.3	92.3	323.2
1988	111.7	105.2	105.3	91.2	91.2	108.8	108.9	112.1	111.9	102.6	102.0	371.0

Source: "Los Indicadores Económicos (mayo 1990) "
BANCO DE MEXICO (DIRECCION DE INVESTIGACION ECONOMICA)

According to the National Development Plan (NDP), the real GDP of manufacturing industry in Mexico is expected to grow at annual rates of 3.4% to 4.0% from 1989 to 1991, and 5.7% to 6.3% from 1992 to 1994.

2) Employment

The number of full-time employees in the manufacturing industry in Mexico was 2.42 million in 1980 and 2.36 million in 1984. Figure 2.3.3 shows change in employment index of the manufacturing industry.

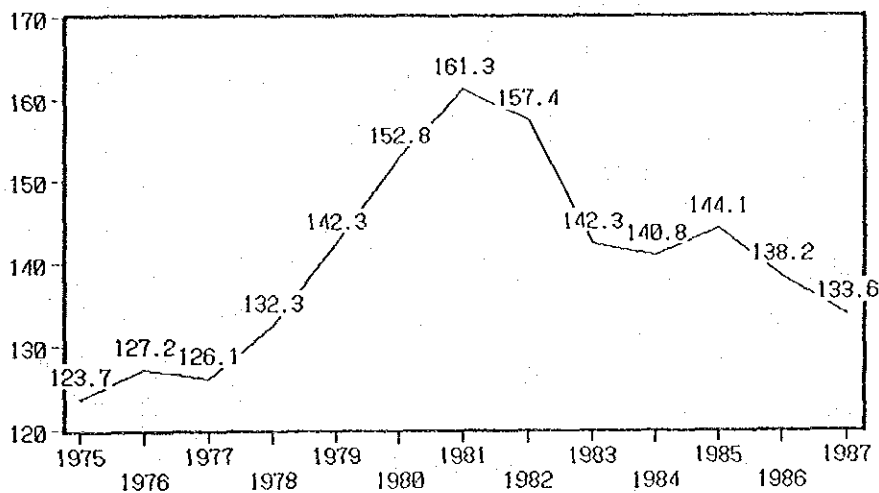


Figure 2.3.3 Employment Index of the Manufacturing Industry (1975 = 100)

During 1970s, the employment steadily expanded. But after the peak of 1981, the downward trend continued until 1987. Since the statistics includes the employees in MAQUILADORAS (210,000 in 1985) where the manufacturing productions were continuously increasing, employment in other domestic manufacturing industries must have been worse than that shown in Figure 2.3.3. The background of this phenomenon was, as discussed already, obviously the stagnation of the manufacturing industry. If an economic recovery brings about a higher operating ratio from now on, a recovery in employment is also expected.

2.3.2 Number of Factories in the Metropolitan Area

(1) Changes in the Number of Factories

Table 2.3.6 shows changes in the number of manufacturing industrial establishments in AMCM during the period from 1960 to 1987. In 1985, the number of the establishments located in AMCM was about 34,000, of which 24,000 were in DF and 10,000 were in MCEM.

Table 2.3.6 Changes in the Number of Manufacturing Industrial Establishments in the Metropolitan Area of the City of Mexico (1960 - 1989)

	1960	1970	1975	1980	1985	1986	1987
AMCM	24,624	33,168	34,404	38,492	34,085	-	-
DF	23,577	29,436	29,654	28,637	24,130	-	19,315
MCEM	1,047	3,732	4,750	9,855	9,955	8,121	-
State of Mexico (Whole State)	-	8,872	10,472	11,706	13,750	-	9,227

Source:

- 1960 ~ 1980 Censos industriales (INEGI)
- 1985 Cuaderno de Información para Planeación Estado de Mexico (INEGI)
Resultados Oportunos del Distrito Federal
- 1986 Government of State of Mexico
- 1987 Elaboracion propia de la Dirección General de Industria Mediana y Pequeña con
información de la Subdirección de Finanzas del IMSS

Although, the numbers shown in Table 2.3.6 may include establishments functioning only as company headquarters, the number of such establishments is considered to be small. Therefore, the word "factory", will be used hereinafter instead of "manufacturing industrial establishment."

The number of factories in DF increased rapidly during 1960s, and reached a peak in 1975 at about 30,000. Then it turned to decrease. During 10 years until 1985, it decreased by 5,000. The decreasing trend is expected to be continuing at present in DF.

On the other hand, the number of factories in MCEM (the 17 MUNICIPIOS in EM) steadily increased from about 1,000 in 1960 to about 10,000 in 1985, ten times in 25 years. According to a survey in 1986 by the government of EM, however, the number in MCEM was about 8,000. This indicates that the number of factories has turned to decrease also in MCEM.

This decreasing trend is presumably caused by the regulations to control the location and operation of factories in the Valley of Mexico enforced after 1975 as a air pollution control measure, and also by the earthquake which struck DF in 1985.

As of 1990, the number of factories located in AMCM may be estimated at about 27,000 considering the past trend.

(2) Distribution of Factories in AMCM

1) Sectoral Distribution

The sectoral distribution of factories in AMCM is shown in Table 2.3.7.

i) DF

Of about 24,000 factories in DF in 1985, food manufacturers occupy 30%, followed by metal products 12%, publishing and printing 10%, apparel 9%, wood products 9%, general machinery 5%, textile 4%, rubber and plastic 4%.

The number of food factories is the largest in DF at about 7,000. Breakdown is: corn flour and TORTILLA making factories count more than half with 3,600, followed by dairies 1,400, and grain milling and agricultural products 1,300. These three sectors occupy 90% of the total.

The factories of metal products stand second in number at about 2,900, of which more than half are engaged in production of steel frames, tanks, and boilers (including cast-iron made).

Table 2.3.7 Number of Manufacturing Industrial Establishments by Sector in the Metropolitan Area of the City of Mexico (DF: 1985, MCEM 1986)

	Number			Percentage		
	DF (1985)	MCEM (1986)	AMCM	DF (1985)	MCEM (1986)	AMCM
1 Food products	7,118	1,233	8,351	29.50	15.1	25.89
2 Drinks	51	53	104	0.21	0.6	0.32
3 Tabacco	9	1	10	0.04	0.0	0.03
4 Textile	852	380	1,232	3.53	4.6	3.82
5 Apparel	2,268	414	2,682	9.40	5.1	8.32
6 Leather	415	51	466	1.72	0.6	1.44
7 Timber processing	465	168	633	1.93	2.0	1.96
8 Wooden furniture	2,262	762	3,024	9.37	9.3	9.38
9 Pulp, paper, paper products	246	119	365	1.02	1.4	1.13
10 Publishing, printing	2,345	282	2,627	9.72	3.4	8.15
11 Chemicals	719	420	1,139	2.98	5.1	3.53
12 Petrochemical products		9	9	0.00	0.1	0.03
13 Petroleum refinery		2	2	0.00	0.0	0.01
14 Coal products	23	28	51	0.10	0.3	0.16
15 Rubber, plastic	858	416	1,274	3.56	5.1	3.95
16 Ceramics, stone, clay	561	518	1,079	2.32	6.3	3.35
17 Basic metal	259	261	520	1.07	3.2	1.61
18 Metal products	2,856	1,668	4,524	11.84	20.5	14.03
19 General machinery	1,253	525	1,778	5.19	6.4	5.51
20 Electric machinery	644	340	984	2.67	4.1	3.05
21 Transportation equipment	326	241	567	1.35	2.9	1.76
22 Precision instruments	167	50	217	0.69	0.6	0.67
23 Other manufactured products	433	72	505	1.79	0.8	1.57
24 Unclassified, etc.	-	108	108	0.00	1.3	0.33
25 Total	24,130	8,121	32,251	100.00	100.00	100.00

Source: Draw up based on following data

"Resultados Oportunos del Distrito Federal" (INEGI)
 "Resultado de la investigación de Edo. MEX" (1986)

ii) MCEM

The number of factories located in MCEM was about 8,100 in 1989. The number of metal products factories is 1,700 occupying 21% of the total, followed by food factories at 15%, wood products at 9%, general machinery at 6%, non-metallic minerals at 6%, chemicals at 5%, apparel at 5%, and rubber and plastic at 5%.

Among the 1,700 metal products factories, the number of factories producing steel frames, tanks and boilers is the largest, as is the case in DF, with about 1,100. Of about 1,200 food factories, dairy factories count for 900 constituting 73%. (In the survey by the State of Mexico, there is a possibility that corn flour and TORTILLA making factories were not included.)

iii) AMCM

In AMCM, food manufacturing factories occupy the highest percentage with 26% of the total. They are followed by metal products factories at 14%, wood products at 9%, apparel at 8%, publishing and printing at 8%, general machinery at 6%, rubber and plastic at 4%, textile at 4%, and electric machinery at 3%.

2) Scale Distribution

The scale of establishments in Mexico is classified into four categories by two factors: 1) number of employees, and 2) ratio of annual sales to general minimum annual wage. As shown below, an establishment employing 251 or more employees, or whose annual sales is 2,011 times or more of the general minimum annual wage is classified as a large establishment.

Scale category	Number of employees		Annual sales / general minimum annual wage
Large	251 or more	or	2011 or more
Medium	101 - 250	or	1116 - 2010
Small	16 - 100	or	111 - 1115
Micro	15 or less	or	110 or less

The number of factories and employees classified by factory scales and the type of industry is shown in Tables 2.3.8 and 2.3.9 for DF and the whole State of Mexico, respectively. These figures were prepared by SECOFI. But, the total number of factories may be slightly less than the actual.

An additional information is available by the Government of EM for MCEM regarding the scale distribution of factories. It is shown in Table 2.3.10.

The following discussion is based on the data mentioned above.

In DF, 1% of the total number of factories are ranked as large, 2% ranked as medium, 20% as small, and remaining 76% as micro. A large number of small or micro scale factories exist in DF. DF has characteristics that such factories as metal products, apparel, publishing and printing, and food are dominant.

In the whole State of Mexico, 5% is ranked as large, 7% as medium, 29% as small, and 41% as micro. The scale distribution in EM, as compared with DF, is characterized by the larger portion of large and medium scale factories.

From these data together, the number of large scale factories in AMCM are estimated to be 600 to 700, medium scale factories estimated to be 900 to 1,100, and large and medium together 1,500 to 1,800. The types of industry in which large scale factories are concentrated and their estimated numbers are shown below.

Chemicals	about 70
Textile	about 60
Rubber and plastic	about 60
Electric machinery	about 50
Metal products	about 50
Food products	about 50
General machinery	about 50

In estimating the above figures, those factories whose scale is categorized as "unknown" in Table 2.3.10 were not taken into account.

Table 2.3.8 Number of Manufacturing Industrial Establishments and Employees by Sector in Federal District (1987)

Number of Establishments

Name of sectors	Micoro	Small	Medium	Large	Total	%
1 Food products	1,810	375	32	30	2,247	11.63
2 Drinks	28	15	5	14	62	0.32
3 Tabacco	2	2	0	1	5	0.03
4 Textile	447	183	29	21	680	3.52
5 Apparel	2,187	709	52	11	2,959	15.32
6 Leather	553	151	16	7	727	3.76
7 Timber processing	150	26	3	1	180	0.93
8 Wooden furniture	518	154	23	1	696	3.60
9 Pulp, paper	108	41	11	5	165	0.85
10 Publishing, printing	1,696	286	20	7	2,009	10.40
11 Chemicals	542	211	23	22	798	4.13
12 Petrochemical products	12	2	1	0	15	0.08
13 Rubber, plastic	765	342	35	14	1,156	5.98
14 Ceramics, stone, clay	437	110	8	11	566	2.93
15 Basic metals	117	31	5	3	156	0.81
16 Metal products	2,784	650	77	16	3,527	18.26
17 General machinery	860	166	9	7	1,042	5.39
18 Electric machinery	553	188	25	14	780	4.04
19 Transportation equipment	155	52	10	8	225	1.16
20 Others	1,046	219	43	14	1,322	6.84
21 TOTAL	14,770	3,911	427	207	19,315	
%	76.47	20.25	2.21	1.07		100.00

Number of Employees

Name of sectors	Micoro	Small	Medium	Large	Total	%
1 Food products	7,386	12,906	4,661	17,183	42,136	10.60
2 Drinks	137	570	935	12,683	14,325	3.60
3 Tabacco	3	30	0	334	367	0.09
4 Textile	2,341	6,434	4,566	10,183	23,524	5.92
5 Apparel	10,627	24,923	7,738	4,754	48,042	12.08
6 Leather	2,237	5,812	2,596	3,440	14,085	3.54
7 Timber processing	668	810	442	579	2,499	0.63
8 Wooden furniture	2,524	5,051	3,342	1,005	11,922	3.00
9 Pulp, paper	604	1,579	1,555	1,893	5,631	1.42
10 Publishing, printing	6,997	9,315	2,985	2,947	22,244	5.60
11 Chemicals	2,996	7,878	3,862	10,386	25,122	6.32
12 Petrochemical products	65	46	115	0	226	0.06
13 Rubber, plastic	4,153	12,162	5,460	6,186	27,961	7.03
14 Ceramics, stone, clay	2,028	3,817	1,337	3,988	11,170	2.81
15 Basic metals	610	1,138	946	1,076	3,770	0.95
16 Metal products	12,693	22,364	11,520	9,200	55,777	14.03
17 General machinery	3,669	5,661	1,418	3,281	14,029	3.53
18 Electric machinery	2,894	6,625	3,946	10,681	24,146	6.07
19 Transportation equipment	726	1,660	1,560	19,220	23,166	5.83
20 Others	4,149	7,912	6,803	8,549	27,413	6.90
21 TOTAL	67,507	136,693	65,787	127,568	397,555	
%	16.98	34.38	16.55	32.09		100.00

Source: "Elaboracion propia de La Direccion General de Industrial Mediana Y Pequena con información de La Subdireccion de Finanzas del IMSS"

Table 2.3.9 Number of Manufacturing Industrial Establishments and Employees by Sector and Scale in the State of Mexico (Whole State, 1987)

Number of Establishments

Name of sectors	Micoro	Small	Medium	Large	Total	%
1 Food products	935	284	45	36	1,300	14.09
2 Drinks	26	16	1	6	49	0.53
3 Tabacco	2	0	0	1	3	0.03
4 Textile	154	179	67	57	457	4.95
5 Apparel	553	248	55	21	877	9.50
6 Leather	50	10	4	1	65	0.70
7 Timber processing	68	33	2	3	106	1.15
8 Wooden furniture	236	97	17	4	354	3.84
9 Pulp, paper	55	54	28	19	156	1.69
10 Publishing, printing	334	156	27	25	542	5.87
11 Chemicals	336	284	116	85	821	8.90
12 Petrochemical products	14	9	4	1	28	0.30
13 Rubber, plastic	338	283	70	40	731	7.92
14 Ceramics, stone, clay	207	91	14	21	333	3.61
15 Basic metals	136	84	20	14	254	2.75
16 Metal products	1,181	593	136	83	1,993	21.60
17 General machinery	238	90	30	6	364	3.94
18 Electric machinery	173	122	37	46	378	4.10
19 Transportation equipment	92	36	14	20	162	1.76
20 Others	206	41	1	4	252	2.73
21 TOTAL	5,334	2,710	690	493	9,227	
%	57.81	29.37	7.48	5.34		100.00

Number of Employees

Name of sectors	Micoro	Small	Medium	Large	Total	%
1 Food products	4,597	11,019	6,684	24,391	46,691	8.72
2 Drinks	147	615	234	13,023	14,019	2.62
3 Tabacco	12			1,110	1,122	0.21
4 Textile	1,013	8,053	11,091	23,692	43,849	8.19
5 Apparel	2,623	9,780	8,680	9,842	30,925	5.78
6 Leather	183	442	693	252	1,570	0.29
7 Timber processing	327	1,272	295	891	2,785	0.52
8 Wooden furniture	1,119	4,080	2,543	1,529	9,271	1.73
9 Pulp, paper	377	2,289	4,326	12,177	19,169	3.58
10 Publishing, printing	1,661	6,440	3,813	10,949	22,863	4.27
11 Chemicals	2,172	12,129	19,040	43,740	77,081	14.39
12 Petrochemical products	100	361	580	269	1,310	0.24
13 Rubber, plastic	2,035	12,652	11,252	23,342	49,281	9.20
14 Ceramics, stone, clay	978	3,756	1,772	16,173	22,679	4.24
15 Basic metals	737	3,037	3,428	11,959	19,161	3.58
16 Metal products	6,206	24,326	22,169	41,641	94,342	17.62
17 General machinery	1,115	4,186	5,141	2,757	13,199	2.46
18 Electric machinery	917	5,233	6,084	33,201	45,435	8.48
19 Transportation equipment	492	1,669	2,425	10,397	14,983	2.80
20 Others	681	2,118	238	2,709	5,746	1.07
21 TOTAL	27,492	113,457	110,488	284,044	535,481	
%	5.13	21.19	20.63	53.04		100.00

Source: "Elaboracion propia de La Direccion General de Industrial Mediana Y Pequena con informacion de La Subdireccion de Finanzas del IMSS"

Table 2.3.10 Number of Manufacturing Industrial Establishments
by Sector and Scale in MCEM of the State of Mexico (1986)

Number

Name of sectors	1	2	3	4	5	6
	LARGE	MEDIUM	SMALL	MICORO	UNKNOWN	TOTAL
1 Food products	17	8	77	1,013	118	1,233
2 Drinks	8	2	6	29	8	53
3 Tabacco	-	-	-	-	1	1
4 Textile	41	25	114	54	146	380
5 Apparel	10	7	64	273	60	414
6 Leather	3	3	18	13	14	51
7 Timber processing	-	-	25	110	33	168
8 Wooden furniture	6	7	75	551	123	762
9 Pulp, paper	9	8	49	14	39	119
10 Publishing, printing	3	2	37	166	74	282
11 Chemicals	44	39	167	26	144	420
12 Petrochemical products	1	1	5	-	2	9
13 Petroleum refinery	-	1	1	-	-	2
14 Coal products	5	4	7	1	11	28
15 Rubber, plastic	44	20	153	66	133	416
16 Ceramics, stone, clay	24	6	131	249	108	518
17 Basic metals	24	11	102	30	94	261
18 Metal products	32	32	255	1,097	252	1,668
19 General machinery	29	22	124	183	167	525
20 Electric machinery	37	17	102	65	119	340
21 Transportation equipment	22	13	60	51	95	241
22 Precision instruments	6	5	12	8	19	50
23 Others	6	6	14	14	32	72
24 Unclassified, etc.	8	8	39	4	49	108
25 TOTAL	379	247	1,637	4,017	1,841	8,121

Composition

Name of sectors	1	2	3	4	5	6
	LARGE	MEDIUM	SMALL	MICORO	UNKNOWN	TOTAL
1 Food products	1.38	.65	6.24	82.16	9.57	100.00
2 Drinks	15.09	3.77	11.32	54.72	15.09	100.00
3 Tabacco	-	-	-	-	100.00	100.00
4 Textile	10.79	6.58	30.00	14.21	38.42	100.00
5 Apparel	2.42	1.69	15.46	65.94	14.49	100.00
6 Leather	5.88	5.88	35.29	25.49	27.45	100.00
7 Timber processing	-	-	14.88	65.48	19.64	100.00
8 Wooden furniture	.79	.92	9.84	72.31	16.14	100.00
9 Pulp, paper	7.56	6.72	41.18	11.76	32.77	100.00
10 Publishing, printing	1.06	.71	13.12	58.87	26.24	100.00
11 Chemicals	10.48	9.29	39.76	6.19	34.29	100.00
12 Petrochemical products	11.11	11.11	55.56	-	22.22	100.00
13 Petroleum refinery	-	50.00	50.00	-	-	100.00
14 Coal products	17.86	14.29	25.00	3.57	39.29	100.00
15 Rubber, plastic	10.58	4.81	36.78	15.87	31.97	100.00
16 Ceramics, stone, clay	4.63	1.16	25.29	48.07	20.85	100.00
17 Basic metals	9.20	4.21	39.08	11.49	36.02	100.00
18 Metal products	1.92	1.92	15.29	65.77	15.11	100.00
19 General machinery	5.52	4.19	23.62	34.86	31.81	100.00
20 Electric machinery	10.88	5.00	30.00	19.12	35.00	100.00
21 Transportation equipment	9.13	5.39	24.90	21.16	39.42	100.00
22 Precision instruments	12.00	10.00	24.00	16.00	38.00	100.00
23 Others	8.33	8.33	19.44	19.44	44.44	100.00
24 Unclassified, etc.	7.41	7.41	36.11	3.70	45.37	100.00
25 TOTAL	4.67	3.04	20.16	49.46	22.67	100.00

Source: Government of State of Mexico (1986)

3) Geographical Distribution

Figure 2.3.4 shows geographical distribution of factories located in AMCM by DELEGACIONES and MUNICIPIOS.

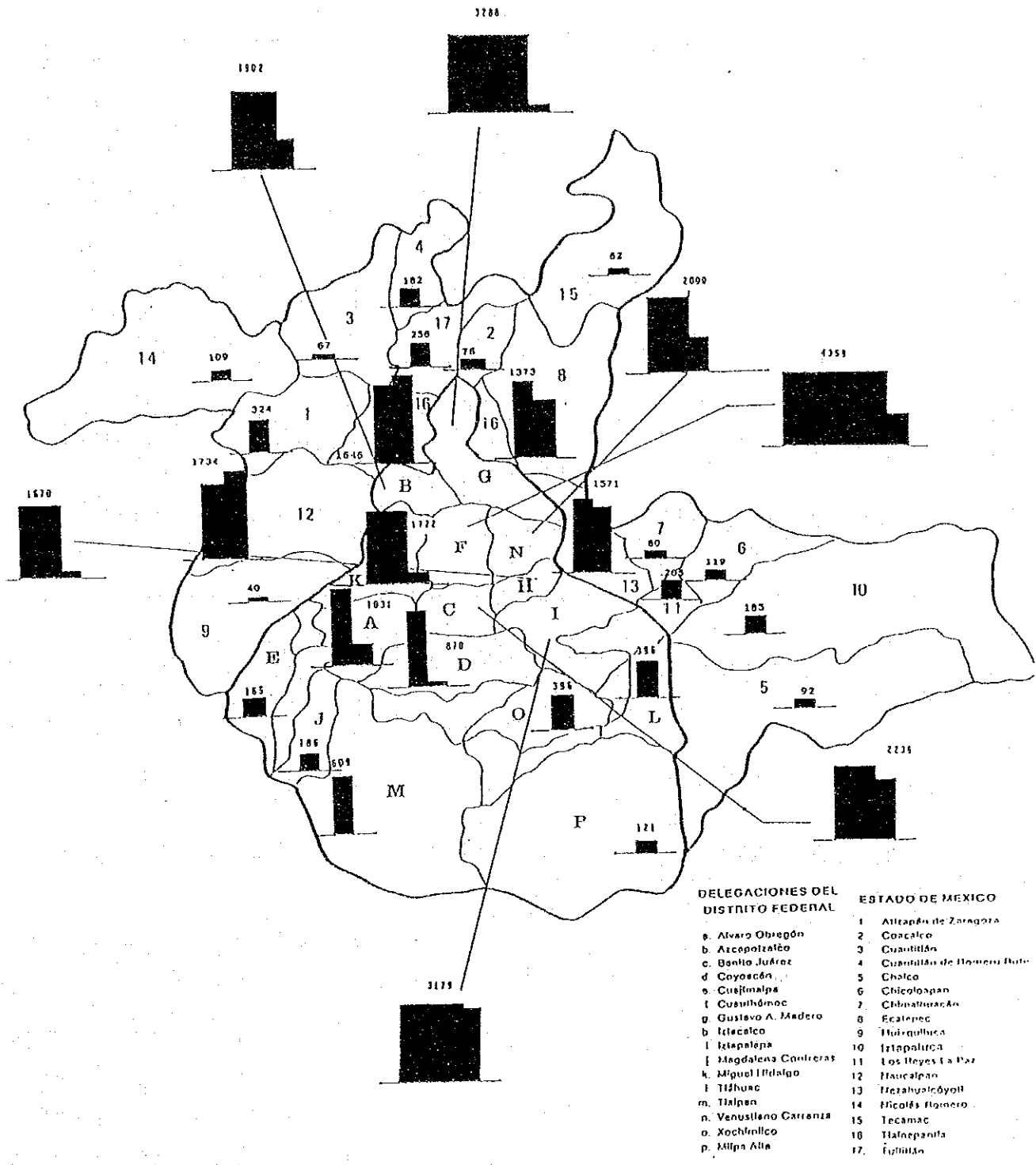
Many factories are concentrated in the northern part of DF, i.e., in and around CUAUHEMOC, GUSTAVO A. MADERO, BENITO JUARES, MIGUEL HIDALGO, and IZTACALCO. In these DELEGACIONES, service and commercial establishments are also concentrated.

In DF, 2,936 hectares of land or 5.3% of the urban development area are used as industrial area. Table 2.3.11 shows the number of factories located in DF by sectors and DELEGACIONES. In CUAUHEMOC where factories are most concentrated, there were 4,360 factories in 1985, while the number was 7,250 in 1980. During the 5 year period, 2,890 factories were moved out or closed. In this area, the most factories are apparel (about 2,000) and publishing and printing (about 1,340).

There are other DELEGACIONES concentrated with factories are GUSTAVO A. MADERO (3,290), IZTAPALAPA (3,180), BENITO JUARES (2,240), VENUSTIANO CARRANZA (2,000), AZCAPOTZALCO (1,900), MIGUEL HIDALGO (1,720), and IZTACALCO (1,670).

The areas with the high ratio of industrial land use, among above DELEGACIONES, are AZCAPOTZALCO (24.7%), IZTACALCO (11.0%), and MIGUEL HIDALGO (8.0%). (See Table 2.3.12.)

The areas with the low ratio of industrial land use are BENITO JUARES (1.8%) and VENUSTIANO CARRANZA (2.0%). It is inferred that in these DELEGACIONES, factories are scattered in urban areas. In BENITO JUARES, factories of food, publishing and printing, wood products, apparel and metal products are located with high percentages. In VENUSTIANO CARRANZA, the percentages of factories of food, wood products, metal products, apparel, and leather products are high.



Source: Drawn up based on Table 2.3.11 and Table 2.3.13

Figure 2.3.4 Geographical Distribution of Factories in AMCM

Table 2.3.11 Number of Factories by Sectors and DELEGACIONES in Federal District (1980, 1985)

	1980										1985
	1 ALVARO OBREGON	2 AZCAPOTZ ALCO	3 BENITO JUARE	4 COYOACAN	5 QUAJIMAL PA	6 CUAUTHEM OC	7 GUSTAVO A. MADER	8 IZTACALC O	9 IZTAPALA PA	10 MAGDALEN A	
1 Food products	445	535	486	370	93	884	1243	486	952	116	
2 Drinks	-	-	7	5	-	12	6	4	-	-	
3 Tobacco	-	3	-	-	-	-	-	-	-	-	
4 Textile	40	52	124	24	3	302	77	122	84	10	
5 Apparel	58	81	354	87	6	1984	240	182	117	10	
6 Leather	3	20	24	3	3	186	48	31	18	-	
7 Timber processing	7	7	48	12	-	79	47	33	38	-	
8 Wooden furniture	114	165	419	99	7	534	416	204	234	15	
9 Pulp, paper	-	38	22	12	-	38	29	25	37	-	
10 Publishing, printing	48	118	426	69	3	1337	230	121	131	-	
11 Chemicals	39	88	145	49	-	109	68	38	86	5	
12 Coal products	-	6	-	-	-	8	5	2	6	-	
13 Rubber, plastic	38	92	76	27	3	125	101	85	128	6	
14 Ceramics, stone, clay	58	58	31	23	13	51	75	32	128	16	
15 Basic metals	3	16	7	-	-	9	22	4	22	-	
16 Metal products	170	336	229	128	22	385	551	309	495	27	
17 General machinery	39	175	126	24	4	380	219	67	152	-	
18 Electric machinery	25	96	90	12	3	192	89	67	36	-	
19 Transportation equipment	15	60	30	6	-	46	69	24	36	-	
20 Precision instruments	-	14	27	11	-	106	18	14	16	-	
21 Others	25	37	44	13	-	460	48	28	39	-	
22 TOTAL	1127	2934	2715	974	180	7247	3601	1905	2799	212	
TOTAL	1031	1902	2236	870	165	4358	3288	1670	3179	186	

	1980						1985	
	11 MIGUEL HIDALGO	12 TLAHUAC	13 TLALPAM	14 VENUSTIA NO CARRA	15 XOCHIMIL CO	16 MILPA ALTA	DF TOTAL	DF TOTAL
1 Food products	544	108	227	760	201	101	7582	7118
2 Drinks	6	-	-	4	-	-	56	9
3 Tobacco	-	-	-	-	-	-	-	-
4 Textile	66	3	15	106	-	-	1028	852
5 Apparel	179	5	11	241	11	3	3580	2268
6 Leather	23	-	3	180	-	-	542	415
7 Timber processing	25	4	4	48	3	-	386	465
8 Wooden furniture	204	18	46	288	23	3	2787	2662
9 Pulp, paper	23	4	6	29	-	-	263	246
10 Publishing, printing	196	7	15	159	4	-	2871	2345
11 Chemicals	73	6	19	30	14	-	769	719
12 Coal products	3	-	-	4	-	-	33	23
13 Rubber, plastic	80	4	15	43	9	-	832	858
14 Ceramics, stone, clay	48	16	6	12	18	-	585	561
15 Basic metals	14	-	4	-	-	-	104	239
16 Metal products	203	37	56	258	40	9	3255	2856
17 General machinery	124	10	8	150	12	-	1515	1853
18 Electric machinery	76	-	9	54	4	-	786	644
19 Transportation equipment	21	-	-	32	-	-	343	326
20 Precision instruments	17	-	-	6	-	-	229	167
21 Others	37	-	6	50	3	-	790	433
22 Total	1962	222	450	2452	345	116	29327	24130
Total	1722	396	609	2000	396	121	24130	

Source:
 "Sensos Industriale 1960, 70, 75, 80"
 "Resultados Oportunos del Distrito
 Federal"
 Instituto Nacional de Estadística
 Geografía e Informática

Table 2.3.12 Land Use (%) by DELEGACIONES in Federal District

	Residence	Urban Facility	Open Area	Industry	Mixed	Ecological Conservation
Alvaro ovregón	52.40	4.20	11.00	1.00	3.90	27.50
Azcapotzalco	48.70	14.50	2.90	24.70	9.20	-
Benito Juárez	71.00	12.60	4.00	1.80	10.60	-
Coyoacán	59.00	3.00	32.00	3.00	3.00	-
Cuajimalpa	6.40	1.90	3.10	-	8.70	79.90
Guahémoc	21.71	11.65	2.83	3.84	59.97	-
Gustavo A. Madero	52.47	7.54	25.87	4.69	9.43	-
Iztacalco	60.00	18.00	3.00	11.0	8.00	-
Iztapalapa	54.10	13.00	6.40	4.20	15.00	7.30
M. Contreras	29.00	1.00	1.50	-	3.50	65.00
M. Hidalgo	49.85	13.31	21.28	7.98	7.58	-
Milpa Alta	3.00	0.40	0.06	-	1.04	95.50
Tláhuac	15.74	0.69	-	1.01	3.52	79.04
Tlátipan	13.30	1.70	1.30	-	2.20	81.50
V. Carranza	43.00	29.50	5.50	2.00	20.00	-
Xochimilco	15.75	0.20	0.77	0.87	2.51	79.90

Source: PROGRAMA GENERAL DE DESARROLLO URBANO DEL DISTRITO FEDERAL 1987 - 1988, DDF

Table 2.3.13 shows the number of factories located in MCEM by the sector. The large numbers are in the 4 MUNICIPIOS of NAUCALPAN (about 1,730), TLALNEPANTLA (1,650), NETZAHUALCOYOTL (1,570), and ECATEPEC (1,370).

Large scale factories are located with the largest number in NAUCALPAN (169), followed by TLALNEPANTLA (106). These two MUNICIPIOS are located adjacent to DF to the north, and they hold 73% of the total number of large factories in MCEM.

In contrast, ECATEPEC holds only 35 large factories among the total 1373 factories located. Small and micro scale factories are concentrated there.

Table 2.3.13 Number of Factories by Sectors and Municipalities in MCEM (1989)

	1 ATIZAPAN ZARAGOZA	2 CHALCO	3 CHICOLOA PAN	4 CHIMALHU ACAN	5 COACALCO	6 CUAUTITL AN	7 CUAUTITL AN-IZCAL	8 HUIXQUIL UCAN	9 IXTAPALU CA	10
1 Food products	43	28	14	24	18	8	21	5	21	21
2 Drinks	-	-	-	-	-	1	2	-	-	1
3 Tobacco	-	-	-	-	-	-	-	-	-	-
4 Textile	8	3	-	3	1	8	10	-	9	9
5 Apparel	6	3	2	7	1	4	2	2	2	2
6 Leather	2	-	-	1	1	1	1	-	-	-
7 Timber processing	4	2	2	1	2	1	3	-	1	4
8 Wooden furniture	37	8	2	3	-	1	12	3	3	3
9 Pulp paper	4	-	-	-	-	7	2	-	7	7
10 Publishing, printing	17	3	1	1	3	6	5	1	4	4
11 Chemicals	-	-	-	-	-	3	14	2	4	4
12 Petrochemical products	-	-	-	-	-	-	-	-	-	-
13 Petroleum refinery	-	-	-	-	-	-	-	-	-	-
14 Coal products	2	-	-	-	1	-	-	-	-	-
15 Rubber, plastic	26	1	1	2	1	1	20	-	4	2
16 Ceramics, stone, clay	28	3	76	5	6	2	2	5	92	92
17 Basic metals	10	1	-	-	-	3	7	-	4	4
18 Metal products	29	29	19	29	22	14	38	19	21	21
19 General machinery	14	4	-	-	7	6	11	-	3	3
20 Electric machinery	17	3	2	3	1	4	17	-	4	4
21 Transportation equipment	19	4	-	-	3	3	11	-	3	3
22 Precision instruments	2	-	-	-	1	1	2	-	1	1
23 Others	1	-	-	-	-	-	1	-	1	1
24 Unclassified, etc	3	-	-	-	-	-	-	-	5	5
25 TOTAL	324	92	119	80	76	67	182	40	1373	185

	11 NAUCALPA N JUAREZ	12 NEZAHUAL COYOTL	13 NICOLAS ROMERO	14 PAZ, LA	15 TECAMAC	16 TLALNEPA NILA	17 TULTITLA	18 TOTAL
1 Food products	154	379	25	43	20	163	33	1233
2 Drinks	3	28	-	4	-	10	1	53
3 Tobacco	-	-	-	-	-	1	-	1
4 Textile	181	26	3	9	3	92	7	380
5 Apparel	126	121	7	12	3	52	6	414
6 Leather	20	9	-	-	1	10	1	51
7 Timber processing	30	47	4	2	-	34	4	168
8 Wooden furniture	116	236	11	13	4	143	16	762
9 Pulp paper	21	3	2	11	1	39	1	119
10 Publishing, printing	73	63	6	6	2	54	2	282
11 Chemicals	143	14	-	9	-	113	14	420
12 Petrochemical products	-	-	-	1	-	3	9	2
13 Petroleum refinery	-	-	-	-	-	-	-	-
14 Coal products	12	1	-	1	-	6	-	28
15 Rubber, plastic	148	51	1	6	5	89	19	416
16 Ceramics, stone, clay	70	55	8	13	2	51	19	518
17 Basic metals	43	11	1	10	2	96	15	261
18 Metal products	213	390	37	40	16	328	67	1668
19 General machinery	136	55	1	9	2	151	21	525
20 Electric machinery	111	37	1	2	1	86	11	340
21 Transportation equipment	44	25	2	8	1	90	6	241
22 Precision instruments	25	5	-	1	-	8	1	50
23 Others	29	11	1	3	-	20	1	72
24 Unclassified, etc	56	4	-	-	-	7	11	108
25 TOTAL	1734	1571	109	205	62	1646	256	8121

Source:
Government of
State of Mexico

2.4 Energy

2.4.1 National Energy Balance

The energy situation in Mexico is briefly described below. Table 2.4.1 shows the national energy balance in production, importation, exportation, transformation and final consumption in Mexico in 1989 by the kind of energy expressed in heat value.

(1) Production, Exportation and Importation

The percentages of production of primary energy by the kind are: 68.6% for crude oil, 18.9% for natural gas, 3.9% for firewood, 3.0% for hydraulic energy, 2.5% for condensates and 1.7% for coal.

Exportation of crude oil is about a half of its production occupying an overwhelming share of the total energy exportation at 94%. Other exporting products include heavy oil (1.9% of the total energy exportation), LPG (1.4%) and diesel (1.0%)

The imported energy makes up 5.2% of the total domestic supply, and virtually all is of the secondary energy. Heavy oil constitutes 58% of the total imported energy, gasoline 19%, LPG 11%, and natural gas 6%.

(2) Energy Transformation

Nearly all of domestically supplied primary energy is used for production of secondary energy in the energy transformation sector including refining, power generation and gas production.

Of the total production of the secondary energy, gas and heavy oil rank the highest with each occupying 22%, followed by gasoline at 18.4%, diesel at 11.2%, electricity at 8.4%, LPG at 7.4%, non-energy products at 5.8% and kerosene at 3.1%.

(3) Final consumption

The total energy supplied to the final consumption sectors is composed of the primary energy at 11.7% and the secondary energy at 88.3%. The breakdown by the kind of energy is as follows: gasoline at 23.2%, gas at 16.9%, diesel at 11.0%, heavy oil at 9.4%, firewood at 8.8%, electricity at 8.3%, LPG at 7.9%, non-energy products at 7.0%, and

Table 2.4.1 National Energy Balance in Mexico in 1989

Unit: 10¹² kcal

	Primary Energy											Secondary Energy										Total		
	Coal	Crude oil	Condensates ¹	Non-associated gas	Associated gas	Nuclear energy ²	Geo-thermal energy ²	Hydraulic energy	Cane-bagasse	Fire-wood	Total	Coke	LPG	Gasoline	Kerosene	Diesel	Heavy oil	Non-energy products ³	Gas ⁴	Electricity	Total			
Supply	Production	35.204	1406.622	46.752	50.514	337.643	0.940	12.033	62.285	19.576	80.381	2051.941	-	-	-	-	-	-	-	-	-	2051.941		
	Importation	0.157	-	-	-	-	-	-	-	-	-	0.157	1.780	7.908	13.354	-	1.468	40.420	-	4.278	0.526	69.743	69.900	
	Inventory variation	0.693	-11.071	-	-	-	-	-	-	-	-	-10.378	0.038	0.386	-2.717	-1.212	-3.710	-0.655	0.005	-0.266	-	-8.141	-18.519	
	Total supply	36.054	1395.551	46.752	50.514	337.643	0.940	12.033	62.285	19.576	80.381	2041.720	1.827	8.294	10.637	-1.212	-2.242	39.755	0.005	4.012	0.526	61.602	2103.322	
	Exportation	-0.236	-714.244	-	-	-	-	-	-	-	-	-714.480	-0.121	-10.977	-2.435	-5.372	-7.622	-14.470	-	-	-1.662	-42.659	-757.139	
	Accidental losses	-	-0.075	-1.653	-0.505	-9.545	-	-	-	-	-0.187	-11.965	-	-	-	-	-	-	-	-	-	-	-11.965	
Gross internal supply	35.818	681.232	45.099	50.009	328.098	0.940	12.033	62.285	19.380	80.381	1315.275	1.706	-2.683	8.202	-6.584	-9.864	25.285	0.005	4.012	-1.136	18.943	1334.218		
Transformation (production and consumption by energy sector)	Total transformation	-34.758	-680.667	-31.747	-40.492	-314.453	-0.940	-12.033	-62.285	-	-	-1177.375	15.279	83.626	207.273	35.092	122.808	88.640	65.297	221.703	94.688	934.406	-242.969	
	Coke production plants	-16.098	-	-	-	-	-	-	-	-	-	-16.098	15.073	-	-	-	-	-	-	-	-	15.073	-1.025	
	Refineries	-	-680.667	-2.980	-	-	-	-	-	-	-	-683.647	0.206	17.136	174.814	35.092	125.678	248.240	23.690	8.277	-	633.133	-50.514	
	Gas production plants	-	-	-28.767	-40.492	-314.453	-	-	-	-	-	-383.712	-	66.490	32.459	-	-	-	41.607	240.426	-	380.982	-2.730	
	Power plants	-18.660	-	-	-	-	-0.940	-12.033	-62.285	-	-	-93.918	-	-	-	-2.870	-159.600	-	-27.000	94.688	-94.782	-188.700		
	Consumption by the sector	-	-	-11.953	-1.515	-11.422	-	-	-	-	-	-24.890	-0.029	-8.472	-2.595	-4.411	-11.770	-27.217	-0.990	-70.278	-4.815	-130.577	-155.467	
	Statistical difference	-1.060	0.842	-	-	-	-	-	-	-	-	-0.218	-0.002	-	-	-	-	-	-	-	-	-0.002	-0.220	
	Losses ⁵	-	-1.407	1.399	-	-2.223	-	-	-	-	-	-5.029	-	-	-	-	-	-	-	-	-	-12.719	-17.748	
Final Consumption	Total final consumption	-	-	-	8.002	-	-	-	-	19.380	80.381	107.763	16.954	72.471	212.880	24.097	101.174	86.708	64.312	155.437	76.018	810.051	917.814	
	Consumption as non-energy	-	-	-	-	-	-	-	-	0.971	-	0.971	0.206	-	21.814	0.135	-	1.764	64.312	29.811	-	118.042	119.013	
	Basic petrochemical	-	-	-	-	-	-	-	-	-	-	-	-	-	21.033	-	-	-	44.730	29.811	-	95.574	95.574	
	Others	-	-	-	-	-	-	-	-	0.971	-	0.971	0.206	-	0.781	0.135	-	1.764	19.582	-	-	22.468	23.439	
	Consumption as energy	-	-	-	8.002	-	-	-	-	-	18.409	80.381	106.792	16.748	72.471	191.066	23.962	101.174	84.944	-	125.625	76.018	692.009	798.801
	Residential, commercial, etc.	-	-	-	0.852	-	-	-	-	-	-	80.381	81.233	-	59.789	-	3.915	0.304	8.533	-	7.361	24.692	104.594	185.827
	Transportation	-	-	-	-	-	-	-	-	-	-	-	-	-	8.696	191.066	16.132	76.589	4.410	-	-	0.661	297.554	297.554
	Agriculture	-	-	-	-	-	-	-	-	-	-	-	-	-	0.362	-	3.132	14.164	-	-	-	6.206	23.864	23.864
	Industry	-	-	-	7.150	-	-	-	-	-	18.409	-	25.559	16.748	3.624	-	0.783	10.117	72.001	-	118.265	44.459	265.997	291.556
	Basic petrochemical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.236	-	56.336	-	58.662	58.662	
Others	-	-	-	7.150	-	-	-	-	-	18.409	-	25.559	16.748	3.624	-	0.783	10.117	69.675	-	61.929	44.459	207.335	232.894	

- Note: 1. includes the condensate recovered in gas ducts
 2. converted with 2574 kcal/kw
 3. asphalts, lubricants, machine oils, paraffine, ethane, butane, butylene, sulfur and primary materials for lamp-black
 4. includes residual gas and dry gas of refineries
 5. losses in transportation, distribution and storage

Gross production of secondary energy

15.279	83.626	207.273	35.092	125.678	248.240	65.297	248.703	94.688	1123.876	1123.876
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Source: Balance Nacional Energia 1989, Secretaria de Energia, Minas e Industria Paraestatal

kerosene at 2.6%. The share of firewood is comparable to those of heavy oil and electricity.

The percentages of consumption by the sector are: 32.4% for the transportation sector, 31.8% for the industrial sector, 20.2% for the residential/commercial/public sector, 13.0% for industrial raw materials, and 2.6% for agriculture.

(4) Crude Oil and Natural Gas

Major reservoirs of crude oil are located in the marine zones in the Gulf of Mexico, CHICONTEPEC zones and the Southeast zones. Natural gas is kept also in these zones, and additionally in the Northeast and the Central zones. Proven reserves and annual production of petroleum crudes are shown in Table 2.4.2.

Table 2.4.2 Proven Reserves and Production of Crude Fuels in Mexico

Kind of Crude	Unit	Proven Reserves as of January					Annual Production				
		1986	1987	1988	1989	1990	1985	1986	1987	1988	1989
Crude oil	10 ⁶ m ³	7729	7637	7500	7343	7194	152.7	141.0	147.4	145.9	145.9
Condensates	10 ⁶ m ³	1110	1087	1103	1086	1070	4.2	4.2	4.4	4.4	4.5
Natural gas	10 ⁹ m ³	2168	2147	2119	2078	2060	37.2	35.5	36.2	36.0	36.9
Ditto (oil equivalent)	10 ⁶ m ³	2433	2404	2367	2318	2300	41.8	39.7	40.4	40.2	41.2
Total (oil equivalent)	10 ⁶ m ³	11272	11128	10970	10747	10564	198.7	184.9	192.2	190.5	191.6

Source: MEMORIA DE LABORES 1985, 1986, 1987, 1988, 1989, PEMEX.

In the latest 5 years, the total proven reserves of the petroleum crudes have been decreasing at about 1.5% annually. The annual production has been maintained largely at a constant level. The reserve/production ratio is about 56 which is larger than the world average of about 30. Mexico has a share of about 5% of the world total production of crude oil, and exporting about a half of its production. PETROLEOS MEXICANOS (PEMEX), a governmental organization, monopolizes production, refining, exportation and importation of

petroleum energy. PEMEX exported $74 \times 10^6 \text{ m}^3$ of crude oil, $4.8 \times 10^6 \text{ m}^3$ of refined liquid fuel, and 450×10^3 ton of basic petrochemicals, and imported $7.0 \times 10^6 \text{ m}^3$ of liquid fuels, $471 \times 10^6 \text{ m}^3$ of natural gas and 55×10^3 ton of basic petrochemicals in 1989. As compared with the previous year, the exportation decreased and importation increased.

After extraction, crude oil and natural gas are transported through pipelines to eight oil refineries and nine gas processing plants where they are refined and separated into various products.

2.4.2 Supply and Consumption of Fuels in the Metropolitan Area

(1) Fuel Supply System

In the Mexico City Metropolitan Area (AMCM), there was one refinery in DELEGACION AZCAPOTZALCO called the 18 de Marzo Refinery, and it was one of the nine oil refining centers in the whole Mexico. This refinery was closed on March 18, 1991, and it will function only as the fuel supply center for AMCM.

This refinery was not capable of producing enough refined products to meet the demand in AMCM. Therefore, pipelines have been installed to supply the balance from other refineries and gas plants. Distillated products, such as diesel and LPG, come from the POZA RICA refinery, 237km apart from the 18 de Marzo refinery, and the TULA refinery, 82km from the 18 de Marzo refinery. Natural gas is piped to the 18 de Marzo refinery from VENTA DE CARPIO, 31km from the refinery, one of the terminals located on the main pipelines connecting gas and oil fields. Heavy oil was the only exception, since it was produced sufficiently in the refinery.

The fuels refined or received in the 18 de Marzo refinery were supplied from here to users in AMCM through various distribution routes.

The distillation products are distributed from the 18 de Marzo refinery by pipeline to three AMCM distribution centers, from where tank cars transport these products to dealers. Major users, such as two power plants, an airport and some large factories, are connected by pipelines from the 18 de Marzo refinery.

Natural gas is supplied through the gas pipeline network shown in Figure 2.4.1 to users in AMCM. This network has 363 control stations beyond which distribution pipes are installed at expense of users. The gas pressure at the control stations is about 13kg/cm². From there the pressure is reduced to about 4kg/cm² in average for distribution to consumers.

(2) Fuel Consumption

According to the Ministry of Energy, Mines and Public Industry (SEMIP), the total consumption of energy in AMCM in 1986 was 121.55 x 10¹²kcal. Its breakdown by sectors and by kinds of energy is shown in Table 2.4.3.

Table 2.4.3 Energy Consumption by Sectors in AMCM (1986)

(Unit: 10¹²kcal)

	Transportation	Electric Generation	(1) Industries	Services	(2) Others	Total
Gasoline	43.35	-	-	-	-	43.35
Diesel	10.12	0.03	6.34	0.48	-	16.97
Heavy oil	-	9.88	1.90	0.42	-	12.21
LPG	-	-	-	1.01	11.06	12.07
Natural gas	-	6.83	16.94	-	0.62	24.40
Electricity	0.60	-	5.81	2.02	4.12	12.55
Total	54.07	16.74	30.99	3.93	15.80	121.55

Source : PROGRAMA INTEGRAL DE LUCHA CONTRA LA CONTAMINACION ATMOSFERICA EN LA ZONA METROPOLITANA DE LA CIUDAD DE MEXICO, SEDUE, PEMEX, Edo. Mex, DDF, CFE, September 1989.

Note : (1) Includes PEMEX
(2) Residential and public facilities

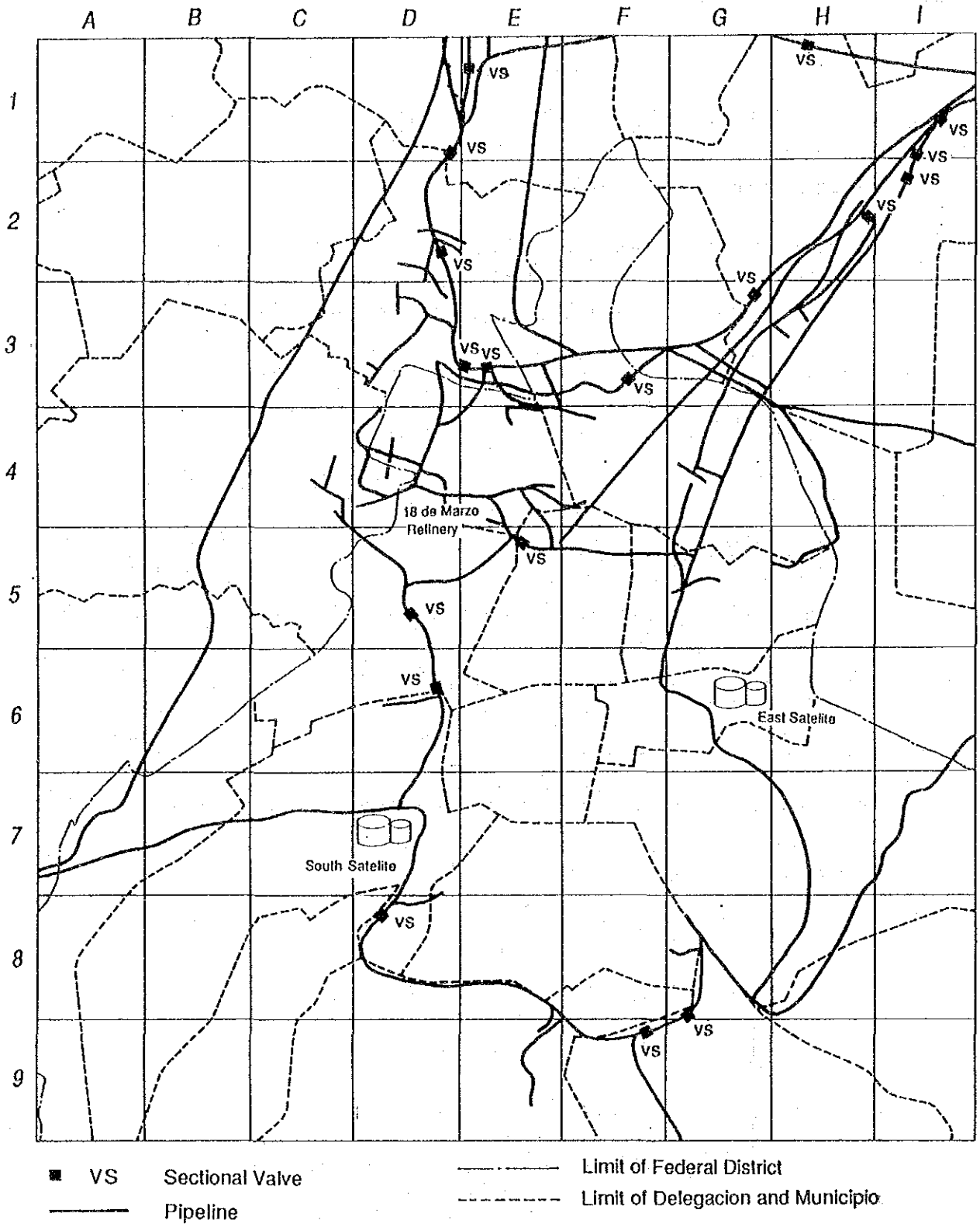
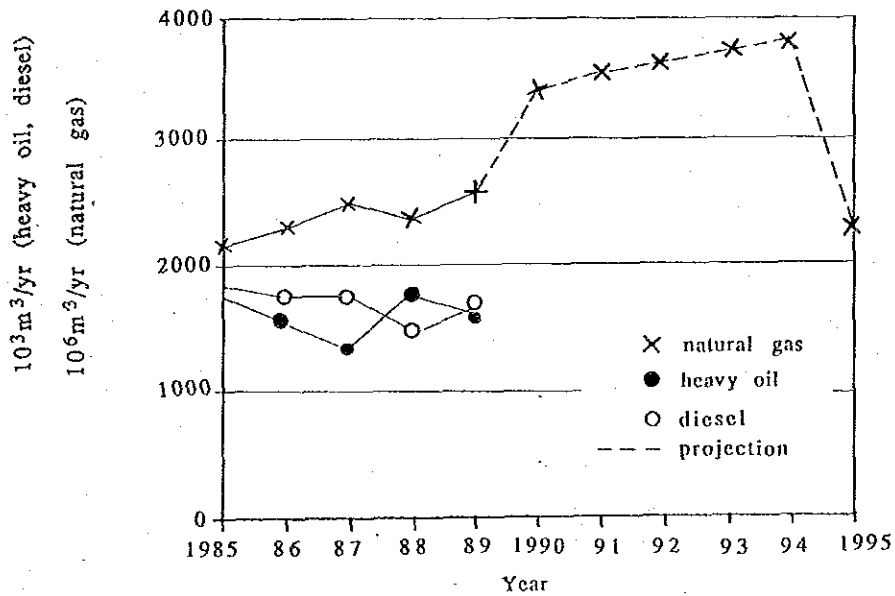


Figure 2.4.1 Natural Gas Pipeline Network in AMCM

When the energy consumption figures shown in Table 2.4.3 are summed up for stationary and mobile sectors, the stationary sector makes up 55.5% and the mobile sector (transportation) makes up 45.5% of the total consumption. The kind of energy whose consumption is the largest in the stationary sector is natural gas at about 20% of the total energy consumption in AMCM. It is followed by heavy oil (10%), LPG (9.9%), electricity (9.8%) and diesel (5.7%).

Table 2.4.4 shows the annual actual quantity and projected quantity of supply of major fuels in AMCM informed by PEMEX. Figure 2.4.2 shows the same for natural gas, heavy oil and diesel.



Source: PEMEX, 1990

Figure 2.4.2 Annual Supply of Major Fuels in AMCM

Table 2.4.4 Annual Supply of Major Fuels in AMCM

Kind of Fuel	Unit	Actual Amount of Supply							Projected Amount of Supply						
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995			
Heavy oil	10 ³ m ³	1,747	1,567	1,329	1,776	1,607									
Natural gas	10 ⁶ m ³	2,155	2,304	2,506	2,371	2,584	3,411	3,541	3,627	3,721	3,824	2,274			
Diesel	10 ³ m ³	1,838	1,752	1,753	1,453	1,654									
Gasoline	10 ³ m ³					5,524									

Source : PEMEX, March 8, October 24 and 26, 1990.

Note : (1) Original units were converted to the metric units.

(2) In 1995, low sulfur heavy oil will be available by 1.306 x 10³m³/yr (22,500 BPCD). This amount is equivalent to 1,550 x 10⁶m³ of natural gas. From that year on, supply of natural gas will be increased again towards the present level.

The supply of natural gas has been increased in the recent years mainly for two thermo-electric power plants in AMCM as a measure for air pollution mitigation. Towards several years ahead, the supply of natural gas will be further increased to be used in large-scale factories. At present, a project is going on to construct a plant in TULA for hydro-desulfurization of heavy oil. The capacity of the plant to produce desulfurized heavy oil is $2650 \times 10^3 \text{m}^3/\text{yr}$ (45700 barrels per day). PEMEX expects to supply this fuel in 1995 by about $1300 \times 10^6 \text{m}^3$, and therefore to reduce supply of natural gas by equivalent amount. From that year on, PEMEX intends to increase supply of natural gas towards the present level, but there is no fixed time schedule.

There are two kinds of diesel supplied in AMCM: diesel No.1 and special diesel. Diesel No.1 is exclusively used by automobiles and the special diesel both by automobiles and stationary users. The amount shown in Table 2.4.4 is the total of these two kinds. The exact amount of special diesel consumed by stationary users in AMCM is not evaluated by PEMEX.

There are two kinds of heavy oil supplied to users in AMCM: PESADO (heavy) and ECOLOGICO (ecological). There is another kind of heavy oil LIGERO (light) which is produced in the 18 DE MARZO refinery but not supposed to be used in AMCM. PESADO is used in the two thermo-electric power plants (VALLE DE MEXICO and JORGE LUQUE) and the 18 de Marzo refinery, and ECOLOGICO is used in other factories and establishments.

(3) Consumption of Fuels by Stationary Sources by Kinds

The consumption amount of major fuels in 1989 at stationary sources in AMCM are described below. It is reasonable to assume that virtually all of heavy oil and natural gas supplied in AMCM are consumed at stationary sources. As described above, however, the amount of diesel consumed at stationary sources is not known exactly. Therefore, it has to be estimated.

The consumption of diesel by the final consumption sectors in the whole country in 1989 was $101.174 \times 10^{12} \text{kcal}$ as shown in Table 2.4.1.

When the consumption of diesel by the energy sector is added, the total becomes 115.814×10^{12} kcal. Of this total, the consumption at stationary sources (energy sector, industries, residential, commercial and public facilities together) makes up 21.6%, agriculture sector makes up 12.2%, and transportation sector 66.1%. When the consumption by the agricultural sector, which is very small in AMCM, is excluded, the national shares for stationary users and transportation are 24.6% and 75.4%, respectively.

According to the SEMIP's data for AMCM in 1986 shown in Table 2.4.3, the consumption of diesel by the stationary users makes up 40.4% and the transportation sector 59.6%.

From the information given above, it is expected that the consumption of diesel by the stationary users in AMCM in 1989 was between 25% - 40% of the total of $1654 \times 10^3 \text{m}^3$, i.e., between $410 \times 10^3 \text{m}^3$ and $660 \times 10^3 \text{m}^3$.

Table 2.4.5 summarizes the quantity of heavy oil, natural gas and diesel consumed at stationary sources in AMCM in 1989.

Table 2.4.5 Consumption of Major Fuels in Stationary Sources in AMCM (1989)

Kinds of Fuel		Unit	Consumption	Users
Heavy oil	Heavy	10^3m^3	702(1)	power plants, 18 de Marzo refinery
	Ecological	10^3m^3	905	factories, service and commercial establishments
	Sub-total	10^3m^3	1,607	
Natural gas		10^6m^3	2,584	power plants, refinery, factories, etc.
Diesel	Special	10^3m^3	410 - 660(2)	factories, service and commercial establishments

Note: (1) Breakdown of this amount is as follows (unit: 10^3m^3):

Valle de Mexico power plant : 496.8
 Jorge Luque power plant : 163.6
 18 de Marzo refinery : 41.4

(2) Estimated amount

(4) Fuel Quality

The specifications and quality of major fuels used in stationary sources in AMCM are described below.

1) Heavy Oil

There have been three kinds of heavy oils distributed from the 18 DE MARZO refinery: PESADO (heavy), LIGERO (light) and ECOLOGICO (ecological). However, only PESADO and ECOLOGICO are supplied to the users in AMCM: the former to the power plants, and the 18 de Marzo refinery, and the latter to other users.

Table 2.4.6 shows the specifications and the typical analytical results for heavy oil "ecological" and "light", and Table 2.4.7 for heavy oil "heavy".

Table 2.4.6 Specifications and Analytical Results for Heavy Oil "Ecological" and "Light"

Item	Unit	Specification (1)	Analyses	
			Ecological (2)	Light (3)
Specific gravity, 20/4°C		-	0.962	0.981
Viscosity, S.Furol, 50°C	sec	150 - 200	72	191
Total sulfur	%wt	3.0	3.0	3.02
Water & sediment	%vol	2.0	0.64	0.2
Flash point	°C	min. 66	48	89
Pour point	°C	max. 15	-4	-
Conradson carbon	%wt	-	-	13
Ash	%wt	-	-	0.08
Net calorific value	kcal/kg	-	-	10400

Note : (1) Specification No. 508/86 for heavy oil "special light".

(2) Average of 5 samples of ecological heavy oil in 18 de Marzo refinery, October 10, 1990, PEMEX.

(3) Data supplied by IMP to JICA in July 1987 as typical analysis of heavy oil "light".

Table 2.4.7 Specifications and Analytical Results for Heavy Oil "Heavy"

Item	Unit	(1) Specification	Analyses	
			A (2)	B (3)
Specific gravity, 20/4°C		-	0.982	0.999
Flash point	°C	min. 66	103	86.0
Pour point	°C	max. 15	-	-
Water distilled	%vol	-	-	<0.10
Water & sediment	%vol	max. 2.0	0.11	0.10
Viscosity, S.F., 50°C	sec	475 - 550	510	-
Viscosity, S.F., 60°C	sec	-	-	486
Viscosity, S.F., 82.2°C	sec	-	-	123
Viscosity, S.F., 98.9°C	sec	-	-	58
Conradson carbon	%wt	-	12.4	14.61
Ash	%wt	-	0.32	0.071
Total sulfur	%wt	-	3.3	3.8
Asphaltenes in nC ₅	%wt	-	-	17.26
Gross carolific value	kcal/kg	-	-	10142
Net carolific value	kcal/kg	-	10400	9661
H	%wt	-	-	10.35
C	%wt	-	-	84.1
N	%wt	-	-	0.47
O	%wt	-	-	1.28

Note : (1) Specification No. 503/79 for heavy oil "heavy".

(2) Data supplied by IMP to JICA in July 1987 as typical analysis of heavy oil "heavy".

(3) Result of analysis by IIE for a sample of heavy oil supplied by 18 de Marzo refinery, November 1990.

2) Natural Gas

Table 2.4.8 shows the specifications and the analytical results for natural gas.

Table 2.4.8 Specifications and Analytical Results for Natural Gas

Item	Unit	Specification ⁽¹⁾	Analyses	
			A (2)	B (3)
Specific gravity (air=1)		-	0.6121	0.602
Methane	%vol	-	88.3	92.3
Ethane	%vol	-	11.0	6.3
Propane	%vol	-	0.7	1.4
Humidity	kg/10 ⁶ m ³	max.16	-	-
Molecular weight		-	17.78	17
Net calorific value (15.6°C, 760mmHg)	kcal/m ³	8455	8840	8540
Total sulfur	mg/m ³	23	-	-
H ₂ S	ppm	15 (vol)	1.5 (wt)	35 (vol)
Mercaptan sulfur	ppm	-	2.2 (wt)	-
CO ₂	%vol	max. 3	-	-

Note : (1) Specification supplied by IMP to JICA in July 1987.

(2) Supplied by PEMEX in October 26, 1990.

(3) Data supplied by IMP to JICA in July 1987 as typical analysis.

3) Diesel

Table 2.4.9 shows the specifications and the analytical result for diesel "special" which is used in stationary sources in AMCM.

Table 2.4.9 Specifications and Analytical Results for Diesel "Special"

Item	Unit	Specification (1)	Analyses (2)
Flash point	°C	min. 52	74
Pour point	°C	Note (3)	3
Water & sediment	%vol	trace	trace
Ramsbottom carbon (in 10% of residue)	%wt	max. 0.35	0.09
Ash	%wt	max. 0.02	-
Total sulfur	%wt	max. 0.5	0.40
Corrosion (3hrs, 50°C)		max. std. 2	std. 1-A
Cetane index		max. 45	52
Viscosity, SU, 37.8°C	sec	32 - 40	38
Distillation at 760mmHg			
Initial boiling point	°C	-	189
10% distillation	°C	max. 200	208
50% distillation	°C	-	260
90% distillation	°C	-	315
95% distillation	°C	max. 360	-
End point	°C	-	350
Color		max. 3	0.5
Aniline point	°C	max. 60	66
Specific gravity, 20/4°C		-	0.824
Net calorific value	kcal/kg	-	10680

Note : (1) Specification No. 414/88 for diesel "special".

(2) Data supplied by IMP to JICA in July 1987 as typical analysis.

(3) From January to October: 0°C, and from November to February: -5°C.

2.5 Present Status of Pollution Control of Stationary Sources

2.5.1 Economic Policy Stimulating Air Pollution Control of Stationary Sources

The investments for equipment or plant relocation aimed at pollution control usually do not contribute directly to revenue increase, and they are not usually given a high priority in management of manufacturing industries. Therefore, it is desirable to adopt the policy that will stimulate such investments.

In this section, economic policies stimulating air pollution control adopted by the Mexican Government are reviewed with a particular reference to the Metropolitan Area.

(1) Policy Under the Previous Administration (1983 - 1988)

1) Position of the Metropolitan Area in the Industrial Development Policy

i) Outlines of Industrial Development Policy in Mexico

As shown in Figure 2.5.1, the industrial development policy of the De la Madrid Administration was formulated based on the National Development Plan (NDP) and the National Plan for Development of Commerce and Industry (NPDCI). Purposes of the policy were :

- to promote an expansion of employment and import substituting industrialization and to increase Mexican capital assets along with fostering international competitiveness by encouraging investments in preferential industrial sectors
- to promote development of small-scale industries
- to promote balanced regional development

Incentives of tax or energy supply are applied most favorably when an industry of the preferential sector is located in the national preferential zone of I-A.

ii) Regional Preference and the Metropolitan Area

AMCM is categorized as Zone III-A where the industrial development is tightly controlled. Stimulative benefits such as favorable taxation applicable to other zones in facility investment are not applied to Zone III-A at all. Tax favor is applied when a factory in this zone is relocated to other zones.

2) Stimulative Measures for Relocation of Factories Out of the Metropolitan Area

i) Outline of Stimulative Measures

On January 22, 1985, a decree to promote industrial relocation out of Zone III-A was published in the official diary. An outline of this decree is shown in Figure 2.5.2. This decree may be regarded as a measure to promote implementation of the Plan for Promoting Dispersion of Industrial Activities (PDIA) and the Plan for Development of AMCM and the Central Region (PDACR) in parallel with the National Plan for Development of Commerce and Industry (NPDCI) and the National Fund Plan (NFP). The former two plans have their roots in the National Urban Development Program (NUDP) which embodies urban development principles provided by the National Development Plan (NDP).

Industrial relocation is promoted through reduction of the federal tax considering the total value of relocated fixed assets, income gained by selling fixed assets, transportation costs for relocation, facility installation costs, and new facility investment.

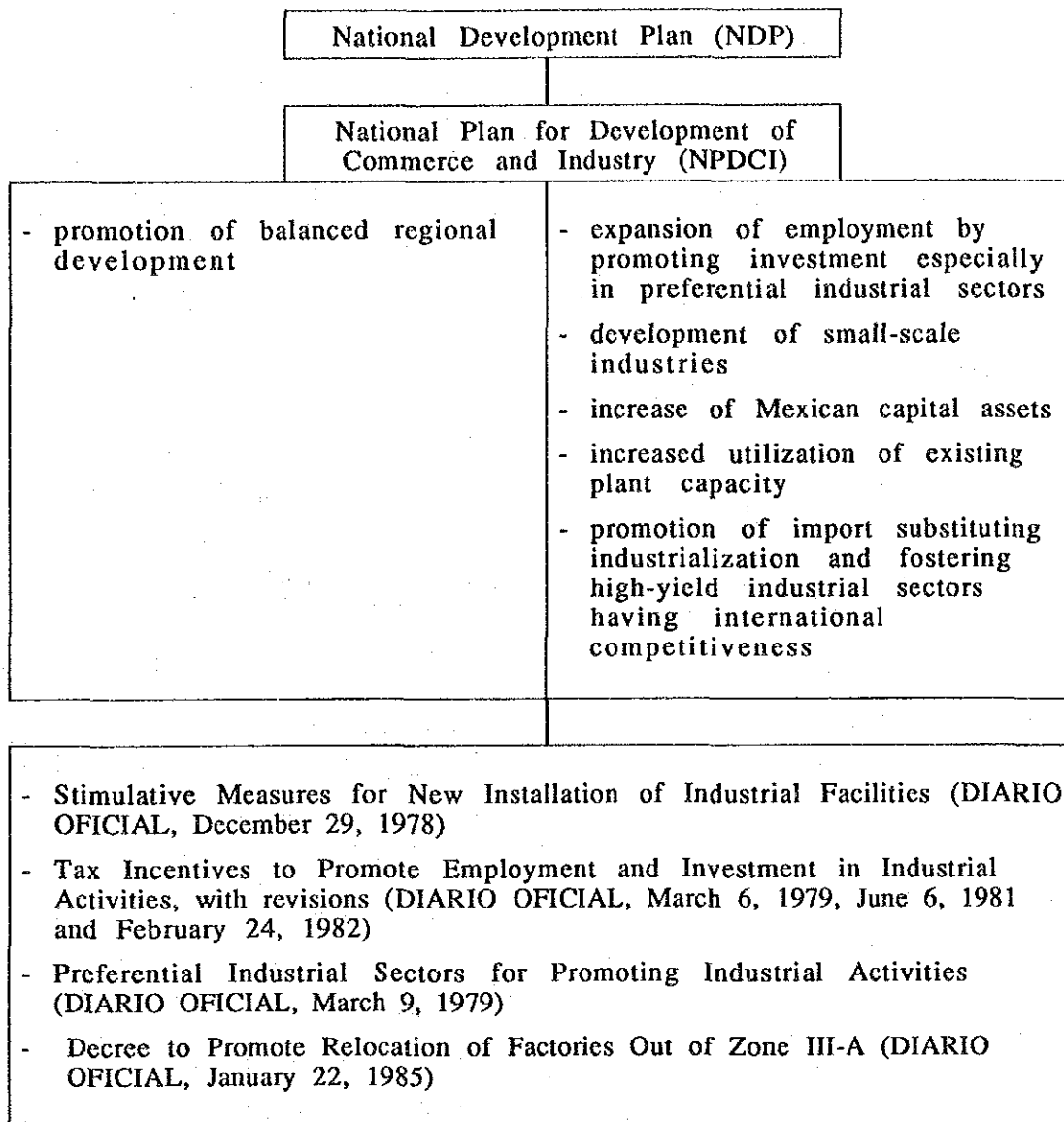


Figure 2.5.1 Outline of Industrial Development Policy of the Previous Administration

To implement this policy, as shown in Table 2.5.1, the industrial sectors were categorized into three, i.e., preferential, non-preferential and small-scale, while the regions were categorized into national preferential zones (Zone I-A and Zone I-B), state preferential zones (Zone II), and controlled zones (Zone III-A and Zone III-B).

Table 2.5.1 Outline of Industrial Development Promotion Measures During the Previous Administration

		Tax Incentives to Promote Employment and Investment in Industrial Activities (Reduction of federal tax)				
		Applicable when a judicial person or an individual having Mexican nationality is to invest in productive activity to create employment or to purchase Mexican-made machinery or equipment				
		Preferential Industrial Sector		Small-Scale Industry	Non-Preferential Industrial Sector	
Category 1 agro-industry, capital goods production	Category 2 production of basic consumption goods, production of raw materials					
Incentives for Industries to Locate in Preferential Regions to Promote Regional Dispersion of Industry	National Preferential Region	Zone I-A Coastal industrial zones: 4 large industrial ports (Lazaro Cardenas, Tampico, Coatzacoalcos, Salina Cruz)	<ul style="list-style-type: none"> 30% reduction of domestic sales prices of natural gas, petroleum fuels and electricity for industries operating newly installed industrial facilities additional 30% reduction of prices of basic petrochemicals when the newly installed facilities have exported 25% or more of products for 3 years or more exemption of contract fee of electricity for newly located factories 20% tax reduction for investment for newly located factories or facility enlargement, and 20% tax reduction for employment for newly located factories (for 2 years) additional 5-10% tax reduction for investment and by 10% for employment when investment was made for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 80% tax reduction for newly located factories for employment when the investment tax reduction is abandoned (for 2-3 years) 	Same as Category 1	Same as Category 1	Same as Category 1
	National Preferential Region	Zone I-B Other cities with industrial development potential	<ul style="list-style-type: none"> 30% reduction of prices of two industrial consumption goods among natural gas, petroleum fuels, electricity and basic petrochemicals for new industrial facilities located in the states of Tabasco and Chiapas 10% reduction of price of natural gas in the area heaving gas pipeline or 10% reduction of prices of petroleum fuels in other areas for newly installed facilities exemption of contract fee of electricity for newly located factories 20% tax reduction for investment for newly located factories or facility enlargement, and 20% tax reduction for employment for newly located factories (for 2 years) additional 5-10% tax reduction for investment and by 10% for employment when investment was made for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 80% tax reduction for newly located factories for employment when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 30% reduction of prices of two industrial consumption goods among natural gas, petroleum fuels, electricity and basic petrochemicals for new industrial facilities located in the states of Tabasco and Chiapas 10% reduction of price of natural gas in the area heaving gas pipeline or 10% reduction of prices of petroleum fuels in other areas for newly installed facilities exemption of contract fee of electricity for newly located factories 10% tax reduction for investment for newly located factories or facility enlargement 5-10% tax reduction for investment for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 60% tax reduction for employment for newly located factories when the investment tax reduction is abandoned (for 2 years) 	<ul style="list-style-type: none"> 30% reduction of prices of two industrial consumption goods among natural gas, petroleum fuels, electricity and basic petrochemicals for new industrial facilities located in the states of Tabasco and Chiapas 10% reduction of price of natural gas in the area heaving gas pipeline or 10% reduction of prices of petroleum fuels in other areas for newly installed facilities exemption of contract fee of electricity for newly located factories 25% tax reduction for investment for newly located factories or facility enlargement additional 5-10% tax reduction for investment for improving productivity and international competitiveness 80% tax reduction for employment for newly located factories when the investment tax reduction is abandoned (for 2 years) 	<ul style="list-style-type: none"> 30% reduction of prices of two industrial consumption goods among natural gas, petroleum fuels, electricity and basic petrochemicals for new industrial facilities located in the states of Tabasco and Chiapas 10% reduction of price of natural gas in the area heaving gas pipeline or 10% reduction of prices of petroleum fuels in other areas for newly installed facilities exemption of contract fee of electricity for newly located factories 15% tax reduction for investment for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 60% tax reduction for employment for newly located factories when the investment tax reduction is abandoned (for 2 years)
	State Preferential Region	Zone II Cities designated by relevant authorities as industrial centers of states	<ul style="list-style-type: none"> 20% tax reduction for investment for newly located factories or facility enlargement, and 20% tax reduction for employment for newly located factories (for 2 years) additional 5-10% tax reduction for investment and by 10% for employment when investment was made for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 80% tax reduction for newly located factories for employment when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 20% tax reduction for investment for newly located factories or facility enlargement 5-10% tax reduction for investment for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 40% tax reduction for employment for newly located factories when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 25% tax reduction for investment for newly located factories or facility enlargement 5-10% tax reduction for investment for improving productivity and international competitiveness 80% tax reduction for newly located factories for employment when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 15% tax reduction for investment for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 40% tax reduction for employment for newly located factories when the investment tax reduction is abandoned (for 2-3 years)
	Controlled Region	Zone III-A Area composed of DF and peripheral cities				<ul style="list-style-type: none"> 10% tax reduction for investment for improving productivity and international competitiveness
Controlled Region	Zone III-B Densely populated regions under influence of Zone III-A (States of Hidalgo, Mexico, Morelos, Puebla and Tlaxcala)	<ul style="list-style-type: none"> 20% tax reduction for investment in facility enlargement 5-10% tax reduction for investment for improving productivity and international competitiveness 20% tax reduction of employment when worker-shift is associated (for 2 years) 80% tax reduction for employment for facility enlargement when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 10% tax reduction for investment in facility enlargement 5-10% tax reduction for investment for improving productivity and international competitiveness 40% tax reduction for employment for facility enlargement when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 25% tax reduction for investment in facility enlargement 5-10% tax reduction for investment for improving productivity and international competitiveness 80% tax reduction for employment for facility enlargement when the investment tax reduction is abandoned (for 2-3 years) 	<ul style="list-style-type: none"> 10% tax reduction for investment for improving productivity and international competitiveness 40% tax reduction for employment for facility enlargement when the investment tax reduction is abandoned (for 2-3 years) 	

Note: Price reductions for industrial fuels and basic petrochemicals are valid until December 31, 1988.

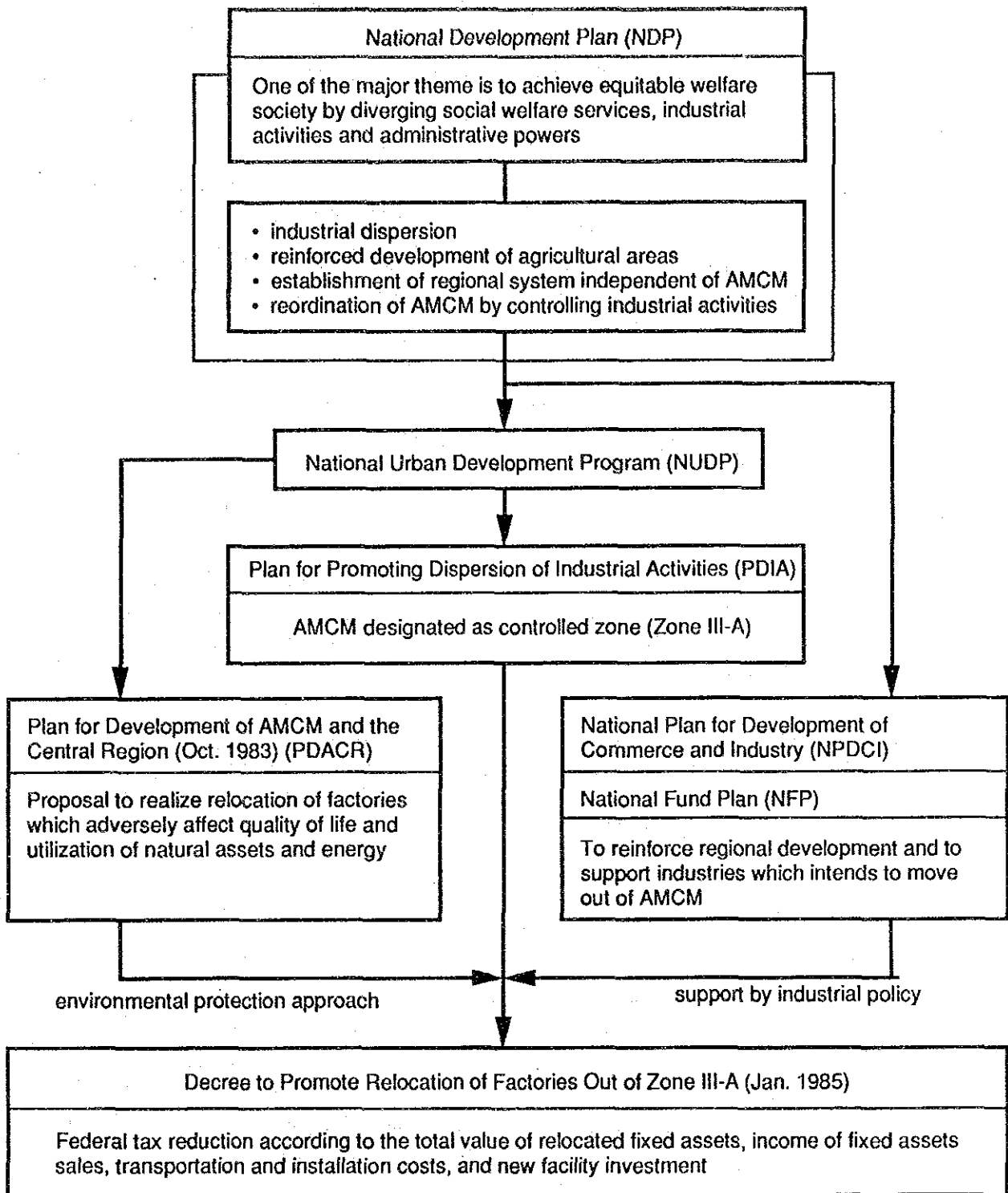


Figure 2.5.2 Framework to Promote Relocation of Factories Out of Zone III-A

The executing agency for the decree is the Ministry of Commerce and Industrial Development (SECOFI). Figure 2.5.3 shows roles of relevant agencies in the execution of the decree. When an application is made, SECOFI calls for comments of SEDUE and makes decision. Depending on contents of the application, the approval by the inter-ministerial committee is required. The committee is composed of SECOFI, Ministry of Finance and Public Credit (SHCP), SEDUE, Ministry of Planning and Budget (SPP), and DDF or GEM in the case of the Metropolitan Area. Upon approval, SHCP issues a tax reduction certificated to the applicant.

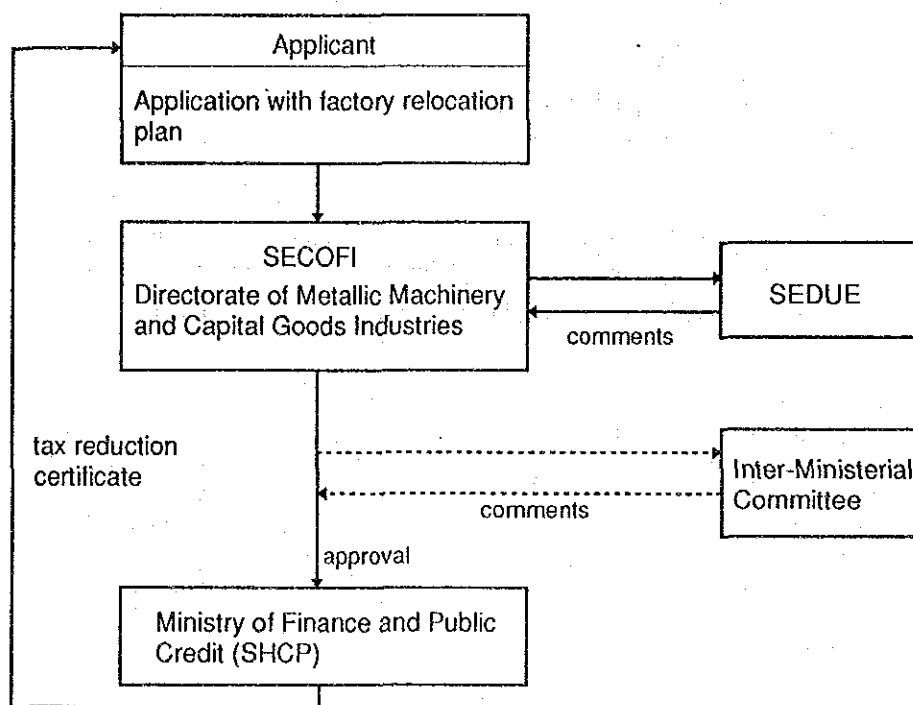


Figure 2.5.3 Roles of Relevant Agencies for Execution of the Decree to Promote Relocation of Factories Out of Zone III-A

The rates of federal tax reduction are determined depending on the industrial category to which the applicant belongs and the zone category to which the factory is relocated.

The types of industry whose relocation from Zone III-A is recommended by the Plan for Development of AMCM and the Central Region and cited in the decree are listed in Table 2.5.2.

Table 2.5.2 Types of Industries Desirable to Move Out of Zone III-A

Code	Type of Industry
202	processing of cereals and other grains and flour milling
204	butchery, meet dressing, storage and packing of meet
205	production and processing of dairy product
207	production of flour-based product
209	production of miscellaneous foods
211	production of alcoholic drinks
212	production of malt and beer
213	production of refreshing drinks
231	preparation, spinning, weaving and finishing of soft textile fabrics
233	preparation, spinning, weaving and finishing of hard textile fabrics
239	production of other textile products
252	hides, skins and substitute materials industry
281	production of pulp, paper and cardboad
282	production of paper, cardboad and pulp based products
301	production of chemicals and basic chemical industry
302	production of fertilizer and pesticide
303	production of synthetic or artificial resin
304	production of paint and vanish, lacquer and alikes
305	production of medicaments and pharmaceuticals
306	production of soap, detergents, perfumes and cosmetics
307	production of non-vegetable, non-animal oil and grease for industry
309	production of chemical products
311	refinement of petroleum crude and its derivatives and basic petrochemicals
312	production of coal derivatives and asphalt mixture
321	production of rubber product
322	production of materials and articles of plastic
331	production of articles of clay, china and porcelain
332	production of glass and glass product
333	production of construction material of clay
334	production of cement, lime and gypsum
335	production of other non-metal mineral product
341	basic industry of iron and steel
342	basic industry of non-ferrous metals
359	production of other metallic products except machinery and equipment
381	production and assemblage of automobiles, buses, trucks and their parts

ii) Status of Implementation

The decree to promote the industrial relocation out of Zone-III-A was abolished in August 1988, because the highest priority had to be placed on the wage and price control urged by the Economic Solidarity Pact (ESP) to calm down the hyper-inflation of 1987 and 1988 with the annual rate exceeding 100%.

There were 17 establishments moved out of the Metropolitan Area under the favorable taxation provided by the decree before it was abolished. Nine of them were relocated in Zone I, one in Zone II, and six in Zone III-B.

3) Fiscal Stimulation to Promote Pollution Control Measures

On August 3, 1987, a decree that established fiscal stimulation to promote activities for prevention and control of environmental pollution was promulgated. The contents of the decree and the situation in its execution are outlined below.

i) Outline of the Decree

This decree was applicable to the following types of industry or facility

- A. Mining
- B. Manufacturing
- C. Factories having equipment for measurement and diagnosis of environmental pollution
- D. Baker, laundry, hospital, recreation center, public bathhouse, hotel, and other similar types of industry
- E. Mobile emergency electric generator, mobile concrete plant, automobile vehicle having internal combustion engine used exclusively for transport of passenger or cargo, and aircraft for fumigation.

An establishment who has invested in acquiring facility, machinery, equipment or instrument that is useful to prevent or control environmental pollution is treated favorably in taxation subject to technical judgement by SEDUE.

Twenty-five percent (25%) of the total amount of investment for such acquisition excluding taxes, fees, interests, insurance and transportation costs is deductible in federal taxes for 5 years.

An applicant for this tax reduction system is to submit necessary documents to SEDUE, who judges appropriateness of the application from the technical view point, and if judged positively, issues a technical certificate which is transferred to SHCP. SHCP then issues a tax reduction certificate to the applicant.

ii) State of Implementation

This decree was abolished as of the end of December 1987 by the same reason for the abolishment of the decree of promoting industrial relocation. However, being unaware of the abolishment, submission of the application continued beyond the effective period; at a total of 159 by the end of August 1988. Table 2.5.3 shows the situation in application and issuance of the technical certificate.

Table 2.5.3 State of Application for Technical Certificate for Pollution Control Investment

Period	Applications Submitted	Applications Accepted	Certificates Issued
Aug. 3, 1987 - Dec. 31, 1987	51	51	51
Jan. 1, 1988 - Aug. 31, 1988	159	140	89
Total	210	191	140

The technical certificates with a total of 140 were issued by the end of August 1988. The fact that a total of 210 applications were submitted in one year indicates that a considerable number of establishment are interested in tax favor for investment in protection and control of environmental pollution.

(2) Policy Under the Present Administration (1989 - present)

1) Industrial Development Policy and the Metropolitan Area

Since the present administration was established in December 1988, the framework of basic industrial policy has not been changed significantly from that of the previous administration.

Economic recovery coupled with stabilization of prices is the major theme in the economic policy of the present administration, namely:

- continuing economic stability
- increase of investment
- modernization of economic structure
- creation of new employment
- inflation control

Industrial development policy in Mexico is being shifted from import substituting industrialization to export-oriented industrialization. Control of import volume has been totally abolished, tariffs have been lowered drastically, and Mexican industries are more exposed than before to international competition.

At the same time, subsidies and fiscal incentives to industries have been reduced and some of them were abolished because of the heavy fiscal burden.

Industrial development is controlled as before in the Metropolitan Area. However, there is almost no tax incentive for industries to move out of the area but for a part of tax reduction measures for employment.

2) Low Interest Credit for Pollution Control Measures

i) Credit System

NAFINSA, a national bank, started in August 1990 a credit system that was once adopted by the World Bank and suspended since economic crisis of 1982.

The credit is applicable to investments in all aspects of pollution control activities such as design, factory construction, relocation,

equipment acquisition, and training. Interest rates are at the same level as government bonds. The grace period is 3 years and the period for repayment is 10 years.

When an application for the credit is judged technically sound by SEDUE, a technical certificate issued by SEDUE is submitted to NAFINSA. Eighty percent (80%) of the investment amount is financed by NAFINSA, 10% by the applicant, and 10% by a managing bank.

ii) Status of Implementation

As the project started just recently, SEDUE is emphasizing the advertisement of the project, especially in the cast-iron industry.

3) Future Outlook

SEDUE is negotiating with SHCP for resuming tax incentive measures for factory relocation and pollution control activities of industrial sectors.

Since the inflation has been calmed down and the national economy is in the upward direction, there is a possibility to resume tax incentive measures if the fiscal conditions of Mexico are further improved.

2.5.2 Emission Standards for Stationary Sources

The basic law for the protection of the environment in the United Mexican States is the General Law for Ecological Balance and Environmental Protection (LEY GENERAL DEL EQUILIBRIO ECOLOGICO Y LA PROTECCION AL AMBIENTE: LGEEPA) which became effective in March 1988. The rules and regulations for enforcement of LGEEPA for prevention and control of air pollution were also promulgated in November 1988. As required by LGEEPA, the emission standards for air pollution sources have been developed by SEDUE.

Table 2.5.4 lists the emission standards applicable to stationary air pollutant sources presently effective or soon to become effective. Tables 2.5.5 through 2.5.13 show the summarized contents of these standards.

The presently effective emission standards for general combustion facilities are laid down according to the kind of fuel used (NTE-CCAT-005/88, 007/88 and 008/88). Since these standards are rather lenient, SEDUE is currently preparing new standards to replace them. The new standards will consist of two sets (the last two in Table 2.5.4). Either one of these is to be applied to any combustion equipment depending on its capacity. A threshold capacity that separates application of these two standards is soon to be determined.

Since these standards rest on the basis of quality of fuels presently supplied in Mexico and existing practicable emission control technologies, they may be revised when fuels of better quality or more efficient practicable control technologies become available.

In addition to the emission standards shown in the tables, standards for the following emissions are under preparation by SEDUE.

- Emission of volatile hydrocarbons in fuel distribution centers
- Emission of asbestos particles through manufacture of asbestos products
- Emissions from combustion equipment in sugar factories

Also, control of the following emissions are being considered by SEDUE for the future.

- Emissions of ammonia through production of ammonia and fertilizers.
- Emissions of sulfuric acid through petroleum refining, sulfur production and pulp digestion
- Emissions from incinerators

Table 2.5.4 Emission Standards for Stationary Air Pollution Sources

NO.	Standards	Date published in DIARIO OFICIAL	Remark
NTE-CCAT-001/88	Maximum permissible levels of emission of SO ₂ , SO ₃ and mist of H ₂ SO ₄ for plants producing sulfuric acid	June 6 1988	to be revised
NTE-CCAT-002/90	Maximum permissible levels of emission of particulates from cement factories	to be published	to replace 002/88
NTE-CCAT-005/88	Maximum permissible levels of emission of particulates, CO, SO ₂ and NO _x through combustion of diesel	October 18 1988	to be replaced by 014/91 and xxx/91
NTE-CCAT-006/88	Maximum permissible levels of emission of particulates, CO, SO ₂ and NO _x through combustion of coal at thermal power plants	December 14 1988	
NTE-CCAT-007/88	Maximum permissible levels of emission of particulates, CO, SO ₂ and NO _x through combustion of heavy oil	October 18 1988	to be replaced by 014/91 and xxx/91
NTE-CCAT-008/88	Maximum permissible levels of emission of particulates, CO, SO ₂ and NO _x through combustion of natural gas	December 14 1988	to be replaced by 014/91 and xxx/91
NTE-CCAT-009/90	Maximum permissible levels of emission of solid particulates from processes other than combustion of fuels	to be published	to replace 009/88
NTE-CCAT-012/88	Maximum permissible levels of emission of SO ₂ and mist of SO ₃ and H ₂ SO ₄ through production of dodecylbenzene sulfonic acid	December 14 1988	
NTE-CCAT-014/91	Maximum permissible levels of emission of particulates, CO, SO ₂ , NO _x and soot and operational requirement for combustion equipment of small to medium capacity	under preparation	to replace 005/88 007/88 008/88
NTE-CCAT-xxx/91 (tentative)	Emission standards for combustion equipment of the capacity greater than that applicable to NTE-CCAT-014/91	under preparation	to replace 005/88 007/88 008/88

Table 2.5.5 Maximum Permissible Levels of Emission of SO₂, SO₃ and Mist of H₂SO₄ for Plants Producing Sulfuric Acid (NTE-CCAT-001/88)

Plant Category	Plant Capacity (ton/day)	Maximum Permissible Emission (kg of SO ₂ /ton of 100% H ₂ SO ₄)	
		Critical Zones	Other Regions
Existing plants	1 - 500	17.5	28.0
	501 - 700	13.0	20.0
	701 - 1000	9.0	14.0
	1000 -	4.0	7.0
New plants	1 - 500	13.0	
	500 -	3.0	

Table 2.5.6 Maximum Permissible levels of Emission of Particulates From Cement Factories (NTE-CCAT-002/90)

(1) For Calcination

Rate of Processing (ton/hr)	Maximum Permissible Emission of Particulates (kg/hr)	Opacity (%)
< 300	0.6319 (C) 0.7502	< 20
≥ 300	0.15 (C)	

Note: C = Amount of raw material fed into calcinator (ton/hr)

(2) For Crushing, Milling and Clinker Cooler

Operation	Maximum Permissible Emission of Particulates (mg/m ³ N)*	Opacity (%)
Crushing	80	< 15
Milling of primary material w/o drying	80	
Milling of primary material with dryer using fossil fuel	380	
Clinker cooling	150	

Note: * Milligram of particulates per cubic meter of gas at 25°C, 1 atm.

Table 2.5.7 Maximum Permissible Levels of Emission of Particulates, CO, SO₂ and NO_x through Combustion of Diesel (NTE-CCAT-005/88)

Pollutant	Maximum Permissible Emission (kg/m ³) *	
	Critical zones	Other regions
Particulates	0.260	0.300
CO	0.600	0.665
SO ₂	17.0	34.0
NO _x **	2.70	3.00

Note: * Kilogram of pollutant per cubic meter of diesel at 25°C

** Expressed as NO₂

Table 2.5.8 Maximum Permissible Levels of Emission of Particulates, CO, SO₂ and NO_x Through Combustion of Coal at Thermal Power Plants (NTE-CCAT-006/88)

Pollutant	Maximum Permissible Emission (kg/m ³) *
Particulates	3.600
CO	0.270
SO ₂	51.300
NO _x **	10.000

Note: * Kilogram of pollutant per cubic meter of coal on dry base

** Expressed as NO₂

Table 2.5.9 Maximum Permissible Levels of Emission of Particulates, CO, SO₂ and NO_x Through Combustion of Heavy Oil (NTE-CCAT-007/88)

Pollutant	Maximum Permissible Emission (kg/m ³) *	
	Critical zones	Other regions
Particulates	4.240	6.740
CO	0.600	0.660
SO ₂	57.00	95.00
NO _x **	(a) 6.6 (b) 8.0	(a) 6.6 (b) 8.0

Note: * Kilogram of pollutant per cubic meter of heavy oil at 25°C

** Expressed as NO₂

(a) For combustion equipment of the capacity up to 106 x 10⁹ joules/hr.

(b) For combustion equipment of the capacity greater than 106 x 10⁹ joules/hr.

Table 2.5.10 Maximum Permissible Levels of Emission of Particulates, CO, SO₂ and NO_x for Combustion of Natural Gas (NTE-CCAT-008/88)

Pollutant	Maximum Permissible Emission (kg/10 ⁶ m ³) *
Particulates	100
CO	(a) 500 (b) 640
SO ₂	10
NO _x **	(a) 2250 (b) 9000

Note: * Kilogram of pollutant per each million cubic meter of natural gas at 20°C, 1 atm.

** Expressed as NO₂

(a) For combustion equipment of the capacity up to 106 x 10⁹ joules/hr.

(b) For combustion equipment of the capacity greater than 106 x 10⁹ joules/hr.

Table 2.5.11 Maximum Permissible Levels of Emission of Solid Particulates From Stationary Sources (NTE-CCAT-009/90)

(1) Concentration Standard

Quantity of Exhaust Gas G _v (m ³ N*/min.)	Maximum Permissible Concentration of Solid Particulates (mg/m ³ N*)
not greater than 1,000	300 G _v ^{-0.21}
greater than 1,000	44 G _v 0.067

Note: * Cubic meter of exhaust gas at 25°C, 1 atm.

(2) Weight Standard

Production, P (kg/hr)	Maximum Permissible Emission of Solid Particulates (kg/hr)
not greater than 45,000	0.0047 P ^{0.727}
greater than 45,000	1.782 P 0.173

Table 2.5.12 Maximum Permissible Levels of Emission of SO₂ and Mist of SO₃ and H₂SO₄ Through Production of Dodecylbenzene Sulfonic Acid (NTE-CCAT-012/88)

Pollutant	Maximum Permissible Emission (g/kg of product in 100%)	
	Existing Plants	New Plants
SO ₂	3.0	2.0
Mist of SO ₃ and H ₂ SO ₄ (Expressed as dodecylbenzene sulfonic acid)	1.2	1.2

Table 2.5.13 Maximum Permissible Levels of Emission of Particulates, CO, SO₂, NO_x and Soot and Operational Requirement for Combustion Equipment of Small to Medium Capacity (NTE-CCAT-014/90, under preparation)

- (1) Equipment of the Capacity Not Greater Than 2,120 m-j/hr (506,500 kcal/hr)

Soot	Minimum CO ₂ Concentration (% in volume)	
No.4	liquid fuel	10
	gas fuel	8

- (2) Equipment of the Capacity Greater Than 2,120 m-j/hr (506,500 kcal/hr) ^a

Particulates (mg/m ³ N) ^b		SO ₂ (mg/m ³ N) ^b		CO (% vol)	NO _x ^c (mg/m ³ N) ^b	
Critical Zone	Other Zone	Critical Zone	Other Zone		Installed by Dec. 31, 1992	Installed after Dec. 31, 1992
165	250	4.5	6.0	0.1	470	320

Note: a. The upper limit of the capacity is soon to be determined.

b. Milligram of pollutant per cubic meter of exhaust gas at 25°C, 1 atm.

c. Expressed as NO₂

2.5.3 Integrated Program Against Air Pollution in the Metropolitan Area

(1) Evolution of the Program

In February 1986, the Government of Mexico promulgated a presidential decree of "Twenty-one Control Measures" against air pollution in AMCM specifying responsible governmental bodies and time limits for implementation of these measures. In addition, the Government made public "Ecology - 100 Necessary Actions" in January 1987, among which thirty-six actions were aimed at mitigation of air pollution in AMCM. This development prompted a wide range of activities involving a number of public and private bodies.

After the formation of the present Administration in December 1988, progress of the on-going activities was comprehensively reviewed. As a result, a new program entitled "Integrated Program to Fight Against the Atmospheric Pollution in the Mexico City Metropolitan Zone" was established in September 1989. This program contained twenty-eight concrete short-term air pollution control measures for which the responsible agencies and implementation periods were specified. Of these, thirteen measures were intended to control stationary pollution sources.

In 1990, the progress of implementation of the above program was thoroughly reviewed and the program was strengthened by adding new projects and giving more concrete shapes to existing projects. Then, a revised program entitled "Integrated Program Against Atmospheric Pollution in the Mexico City Metropolitan Zone, A Common Agreement" (hereinafter, referred to as "the Program") was established in October 1990. The Program was worked out by the inter-governmental technical secretariat composed of SEDUE, SHCP, SPP, SECOFI, Ministry of Communication and Transport, SEMIP, Ministry of Agriculture and Water Resources, Ministry of Health, DDF, GEM, municipal governments of MCEM, PEMEX, CFE, and IMP.

The strategy of the Program is to integrate air pollution control activities in the following sectors.

1. Petroleum industry
2. Transportation
3. Private industries and service establishments
4. Thermoelectric power generation
5. Reforestation and ecological restoration
6. Investigation, environmental education and social communication

The Program contains a total of 41 concrete air pollution control measures involving the above sectors. Executing organization(s) are specified for each of these measures.

(2) Stationary Source Control Measures in the Program

Among the total forty-one (41) concrete measures contained in the Program, seventeen (17) measures are aimed to control stationary sources of air pollution. They are outlined below.

Measure No.3 Production of low-sulfur heavy oil

Executor : PEMEX

Period : 48 months from March 1991

Investment : US\$ 484 million

Contents : A hydro-desulfurization plant of the capacity of 45,700 barrels per day is to be constructed in the Tula refinery to reduce sulfur content of heavy oil from 4% to 0.8%.

Measure No.7 Sulfur recovery in the 18 de Marzo refinery

Executor : PEMEX

Period : 36 months from March 1991

Investment : US\$ 9.1 million

Contents : Modernization of an existing sulfur recovery plant and installation of a new recovery plant

Measure No.8 Recovery of hydrocarbon vapor and replacement of burners in the 18 de Marzo refinery

Executor : PEMEX
Investment : US\$ 5.1 million
Contents : Construction of a hydrocarbon vapor recovery plant and installation of low-NOx burners in combustion equipment with subsequent test run.

Measure No.9 Installation of continuous monitoring devices for stack gas in the 18 de Marzo refinery

Executor : IMP, PEMEX, SEDUE
Period : On-going
Investment : US\$ 3.0 million
Contents : Measurement of exhaust gas flowrate and concentration of SOx, NOx, HC and O2, and measurement of environmental concentration of SO2, NOx, CO, CO2, HC and PM.

Measure No.10 Installation of floating roofs in fuel storage tanks

Executor : PEMEX
Period : 2 years
Investment : US\$ 1.6 million
Contents : Floating roofs are installed in 23 storage tanks for crude oil and gasoline to prevent evaporation by 98%.

Measure No.11 Installation of vapor recovery systems at fuel terminals and gasoline stations

Executor : PEMEX and private sector
Period : 18 months for PEMEX storage tanks
From June 1991 for gasoline stations
Investment : US\$ 16.9 million
Contents : Repair of fuel injection systems of distribution terminals, installation of floating roofs in storage tanks, and installation of vapor recovery systems in gasoline stations.

Measure No.22 Substitution of natural gas for heavy oil in factories
Executor : SEDUE, private sector and PEMEX
Investment : US\$ 1.8 million (for SEDUE's part)
Contents : Factories with high SO₂ emission located within the network of natural gas distribution pipeline are to substitute natural gas for heavy oil. PEMEX is responsible for supplying 7 million m³/day of natural gas.

Measure No.23 Agreement between SEDUE and industries on emission control
Executor : SEDUE, DDF and private sector
Period : Within 36 months from November 15, 1990 for implementation of agreed control measures
Investment : By industries
Contents : 1550 large to medium size factories are to take necessary measures to meet the emission standards. The factory not meeting the standard is closed temporarily or permanently, or to move out of the Mexico Valley. Progress of implementation of the agreed measures has to be reported every three months. The Federal Government takes necessary arrangements to facilitate implementation of control measures such as : to let private sectors participate in establishment of the standards, to facilitate procedures for reconversion and relocation of factories, to facilitate credits for technological modernization and acquisition of control equipment.

Measure No.24 Prohibition of new installation of factory and expansion of processes with high consumption of water or fuels
Executor : DDF and GEM
Contents : Installation of new plants and expansion of industrial processes with high consumption of water or fuels are prohibited. The Government is to

establish criteria for judging consumption of water and fuels.

Measure No.26 Emission control and relocation of foundries

Executor : DDF and private sector

Period : On-going

Investment : US\$ 52.5 million

Contents : There are about 100 unregistered foundries in the Metropolitan Area in addition to 216 registered foundries and forges. SEDUE, DDF and GEM concluded agreements with CANACINTRA, CANACERO and the Mexican Foundry Association for the following purposes.

- 1) installation of flue gass emission control devices in foundries remaining in the Metropolitan Area
- 2) identification of unregistered foundries and their closure
- 3) closure of foundries not controlling emissions even though they are registered
- 4) financing foundries for their relocation through NAFINSA

So far, 36 foundries out of 38 inspected have been closed because of absence of emission control devices. Another 80 foundries are to be inspected.

Measure No.27 Installation of continuous exhaust gas monitoring devices in factories with high pollutant emission

Executor : SEDUE and private sector

Period : On-going

Investment : US\$ 5.0 million

Contents : So far, 25 large factories are said to have installed monitoring devices for PM, SO₂, NO_x and HC. Others with high consumption of fuels are scheduled to install such devices. Monitored data are to be transmitted automatically to the SEDUE's operation

center of RAMA (Automatic Atmospheric Monitoring Network) in the near future.

Measure No.28 Improvement of combustion processes and installation of emission control devices in service establishments

Executor : Private sector

Investment : US\$ 30 million

Contents : Public bathhouses

Not operating on one day per week since August 1990. Control measures to reduce emission by 10% are to be applied from November 1990 under the supervision of UNAM. At least 40 bathhouses are to be modernized within 6 months. Others are to install devices to improve combustion process and to control pollutant emissions.

Bakers

Fuel change from heavy oil and diesel to others such as LPG is being made at 350 bakers. Another 270 bakers are to do the same in 1991.

Laundries

Following measures are to be implemented starting from November 1990.

- large-scale laundries to strengthen maintenance and cleaning with higher frequency and to reduce operation hours from 12 hrs to 10 hrs per day.
- dry cleaners to collect and distribute cloths only one time per day instead of 2 times, and 80 dry cleaners to change fuel to LPG
- self-service laundries to reduce service hours by 2 hrs.
- pressing operation reduced by one hour

Restaurants, hotels and hospitals

Use of firewood has been reduced by 50% or more.

Boiler operators

A training program for boiler operators has started focussing on appropriate operational methods to reduce pollutant emissions under cooperation of the Ministry of Labor.

Measure No.29 Use of natural gas in the thermoelectric power plants until low-sulfur heavy oil is supplied

Executor : CFE, PEMEX

Period : Until when Measure No.3 has been completed

Investment : US\$ 8.9 million

Contents : Substitution of natural gas for heavy oil in the power plants has been gradually increased since 1986. At present, Valle de Mexico Plant uses natural gas at 84%, and Jorge Luque Plant 78%.

Measure No.30 Suspension of operation of power generation units at the two power plants in winter

Executor : CFE

Period : Winter of 1990/91 and thereafter until when Measure 3 has been completed

Contents : Operation of one unit out of four generators in each power plants is suspended during the winter of 1990/91, and the suspension continues also in other seasons until low-sulfur heavy oil becomes available.

Measure No.31 Installation of continuous exhaust gas monitoring devices in the power plants

Executor : CFE

Period : By the winter of 1990/91

Investment : US\$ 2.0 million

Contents : Monitoring of SO₂ and NO_x in stack gas is to be carried out in the two power plants starting from the winter of 1990/91.

Measure No.32 Reforestation of urban area

Executor : DDF

Period : From June 1990

Investment : US\$ 56.5 million

Contents : During June to August of 1990, 1.8 million trees were planted in the urban area through the "one tree for one family plan" of DDF.

Measure No.33 Reforestation of rural areas of the Mexico Valley and ecologically influenced areas

Executor : DDF, GEM, State of Morelos

Period : 4 years from the summer of 1991

Investment : US\$ 349 million

Contents : 100 million trees are to be planted in the total area of 364,000 hectares in 4 years.

2.5.4 Recent Development

(1) Pollution Control Measures for the Winter of 1990/91

The status of air pollution in AMCM in the winter of 1990/91 became severer than normal years, particularly since the middle of December. Major causes for this outcome are believed to be increased traffic volume and traffic jam, and the status of atmospheric thermal inversion which was observed to be more intense than in normal years.

Against this situation, SEDUE, DDF and GEM collaborated to work out the following measures which were publicly announced by the Head of DDF on January 9, 1991.

1) 300 factories that are considered as major pollution sources take one of the following two measures during the period from January 15 to February 28:

i) to substitute natural gas or diesel for heavy oil

ii) to cut plant operation by 30%

- 2) The best solution to air pollutant emissions from the 18 de Marzo refinery is determined within 10 months
- 3) All the schools in AMCM are closed on the days when the air pollution has reach to a high level.
- 4) Traffic of large-size trucks in the central area of AMCM is allowed only at night.
- 5) Operation of taxis and combis on Saturdays is cut by 50% beginning from January 19.
- 6) The "No Car Day" program is applied also to the automobiles for group tours and airport services.
- 7) All the city buses will have a new engine before March 1.

To meet the requirement of 1) above, the 82 factories have changed heavy oil to diesel as of the end of January. Among the factories located on the network of natural gas pipeline, the 16 factories applied for the use of natural gas.

(2) Closure of the 18 de Marzo Refinery

After the announcement of the above measures, SEDUE and PEMEX worked together to elaborate on the permanent solution against pollutant emissions from the 18 de Marzo refinery.

The refinery began its operation in 1933, and many of their oil refining facilities are of old age. Therefore, implementation of the permanent air pollution control measures requires a large amount of capital investment and a long period of time.

It was finally decided by the President of Mexico that the refinery should be closed. All refining operation was stopped as of March 18, 1991.

The 18 de Marzo refinery has been functioning, besides as a refinery, as the sole base of fuel supply for AMCM by distributing distillate fuels transported by pipelines from other refineries. This function is expected to continue. However, the closure of oil refining operation

will affect the fuel supply system of AMCM to a considerable extent. Prompt reorganization of the fuel supply system for AMCM is needed.

**CHAPTER 3 FUEL CONSUMPTION AND AIR POLLUTANT EMISSIONS
FROM STATIONARY SOURCES IN THE METROPOLITAN AREA**

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3.1 Objects and Method of Investigation

3.1.1 Types of Sources and Method of Investigation

The object sources for the investigation of fuel consumption and pollutant emissions are desirably all the establishments in AMCM having a combustion facility emitting air pollutants. The sources actually considered in this Study are shown in Table 3.1.1 by the method of investigation and by the type of sources. The amounts of fuel consumption and pollutants emissions were estimated for these sources.

Table 3.1.1 Types of Object Sources and Method of Investigation

Category by method of investigation	Type of sources	Number of establishments
1) Establishments previously investigated by SEDUE	Factories	about 600
2) Establishments visited with detailed questionnaire in this Study	Mainly large factories and mostly included in 1)	97
3) Establishments diagnosed in this Study	Mainly large factories selected from 2) considering types of facility	25
4) Establishments investigated by SEDUE in this Study	Mainly factories with partial duplication with 1) and 2)	about 1,000
5) Establishments previously investigated by DDF	Service and commercial establishments in DF	6,302
6) Establishments previously investigated by CANAIBAL	Public bathhouses mostly in DF and included in 5)	203
Total		about 8,000

The establishments categorised in 2) and 3) were investigated with a particular emphasis in this Study. The establishments of the category 2)