Preface

In February 1995, the Greek Government announced its National Action Programme for Climate Change, whose aim was the achievement of a 10% reduction in the expected national emissions of CO_2 over the next 5 years. This effort was undertaken in the scope of the obligation of the Framework Convention for Climate Change and in the spirit of the Rio Earth Summit as regards the seriousness of the danger and the urgentneed of world-wide action.

In the intervening two years, the implementation of this Programme has started and already the trajectory of emissions levels is solidly within the bounds set in the Programme.

A lot of work remains to be accomplished in adhering to the final Programme but we remain confident that it will be reached. This becomes especially important given the desire of Greece to proceed with even larger reduction efforts in view of recent climatic indications of the urgency for action and the emerging consensus expressed in the Berlin mandate for the additional policies and measures in the time period past 2000.

June 1997

Theodoros Koliopanos

Deputy Minister for the Environment,
Physical Planning and Public Works

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

GDP	Gross Domestic Product
LPG	Liquified Petroleum Gas
IPCC	Intergovernmental Panel on Climate Change
FCCC	Framework Convention on Climate Change
GWP	Global Warming Potential
OPE	Operational Programme for Energy
RES	Renewable Energy Sources
GRT	Gross Tonnage
PPC	Public Power Corporation
CORINAIR	Co-ordination of Information on Air Pollution
EUROSTAT	European Statistical Service
CHP	Combined Heat and Power
NG	Natural Gas
PGC	Public Gas Corporation
HPTS	High Pressure Transmission System
LPDS	Low Pressure Distribution System
LNG	Liquified Natural Gas
ECC	Energy Control Centre
MD	Ministry for Development
OPRT	Operational Programme for Research and Technology
ECC	Exhaust Control Card
TPF	Third Party Financing
ESCO	Energy Services Company
PAM	Policies and Measures
BAU	Business-As-Usual
CW	Conventional Wisdom
FO	Forum
CT	Current Trends
ECSF	Effects of the Community Support Framework
CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
NO_x	Nitrogen oxides
CO	Carbon dioxide
NMVOCs	Non-methane volatile organic compounds

0. EXECUTIVE SUMMARY

This report constitutes the 2nd National Communication of Greece to the United Nations Framework Convention on Climate Change.

0.1. National conditions

0.1.1. General

Greece has a total area of 13,195,740 ha and is located at the southern part of the Balkan region. It is divided into 52 counties that in turn are grouped into 13 administrative regions. Greece is primarily a mountainous country. Agricultural land covers 30% of the total land, while urban areas, industrial areas and internal waterways represent only 8% of the total.

0.1.2. Population

The total population of the country is approximately 10.35 million inhabitants, presenting an increase of 6.5% during the last decade. Urban centres concentrate around 60% of the total population, half of which lives at the greater Athens area. The active population represents 38% of the total, while unemployment is reported to around 10%.

0.1.3. Finances

Greece is one of the four cohesion countries of the European Union with an estimated gross domestic product in 1996 of 29,576 billion GRD or 122.9 billion USD (exchange rate: 1 USD = 240.7 GRD). Currently, it has a rate of inflation of 5.4%, which is declining, a general government deficit-to GDP ratio of 7.4%, which is also declining, and an outstanding general government debt-to GDP ratio of 111.8%. Economic policy focuses on meeting the convergence criteria for joining the European Monetary Union by 2001.

0.1.4. The Energy system in Greece

0.1.4.1.Energy supply

The total energy supply in Greece has been continuously increasing, reaching a total of approximately 23.7 Mtoe in 1995. Despite this general rapid increase, however, the average annual growth rate in the first five years of the 90s was reduced to approximately 1.4% per year, compared to 3.3% in the 80s. Although the energy system relies heavily on the use of petroleum products, their relative contribution to the energy system has fallen from 72.5% in 1980 to 60% in 1995, because of a gradual increase in the use of indigenous brown coal (lignite). The partial replacement of oil by lignite had a marked effect on the import dependency of energy, which dropped from 85.6% in 1980 to 78.1% in 1995.

Renewable energies currently cover approximately 5% of the total energy supply, but - apart from large hydropower and solar power - they have not been exploited to their full potential (less than 0.2% of total energy supply in 1995). Natural gas similarly covers approximately 0.2% of the total energy supply, although this

situation will rapidly change after the summer of 1997 when the first natural gas power station is expected to operate.

The electricity generation system in Greece consists of thermal and hydroelectric units, as well as a very small percentage of other renewables. The percentage contribution of coal products, and more specifically lignite, has steadily increased since 1980, because of the commissioning of 3,663 MW of lignite-fired power stations from 1980-1989. In 1995, the installed capacity of the Public Power Corporation (PPC) generating system was 9,198 MW. Electricity generation has been steadily increasing at an average annual rate of approximately 3.5% in the 1990-1995 period, reaching 42.3 TWh in 1995. Of that, 68% and 21% came from the combustion of coal and petroleum products, respectively, 9% from hydropower and 2% from gas and imports.

0.1.4.2.Energy use

Final energy demand in Greece in 1995 totalled 14.4 Mtoe, of which 26% was used in industry, 44% for transportation and 30% by the domestic and tertiary sector. In the 1970-1995 period, the only sector that has reduced its energy demand is the industrial sector that has been mostly affected by the energy crises of the last two decades and the recession of the last 5 years. The other two sectors have increased their energy use, thus resulting in a total increase of 36.5% between 1980 and 1995.

In *industry*, during the 1980-1995 period, there was a gradual replacement of petroleum products by coal products, a trend almost solely attributable to the increased use of steam coal by the cement industry. In 1995, oil products accounted for approximately 50% of the total energy needs of the sector compared to 69% in 1980. Electricity consumption has steadily increased in the last two decades, representing 27% of the total energy use of the sector in 1995.

Regarding the *domestic and tertiary sector*, the improving standards of living resulted in higher levels of heating and recently of cooling, while the increase in the number of dwelling units in a rise in the ownership of home electric appliances. Energy demand for ventilation, lighting and other office equipment in the tertiary sector has also increased. However, there is a number of factors helping to reduce the rate of increase in energy consumption (e.g. installation of thermal insulation in private residences and apartment buildings, installation of solar water heating units in residences and hotels, the installation of double glazing in new and in some cases in older buildings, replacement or modernisation of older electric and heating appliances etc.). The general upward trend of the energy demand is mostly the result of an increased demand for electricity (37% of the total energy consumption in 1995, compared to 26% in 1980) and to a smaller extent of petroleum products. At the same time, the relative contribution of solid fuels and biomass is decreasing.

In the *transportation sector*, energy use has almost doubled during the 1980-1995 period, increasing at a growth rate slightly larger than either of the other two economic sectors. Oil products accounted for 99.7% of the final energy use, while electricity and coal accounted for the remaining 0.3%. The energy use is mainly gasoline consumption by automobiles, while other uses include diesel oil for trucking, maritime transport and railroads, jet fuel for aircraft and smaller amounts

of LPG and diesel oil used by taxis. Steam coal is solely used by railroads, while electricity covers the needs of the electric buses (trolleys) that operate in the central Athens area.

0.2. Emissions of greenhouse and other gases

The emissions estimates reported here were calculated using the *IPCC Guidelines for National Greenhouse Gas Inventories* to ensure inventory consistency and comparability across sectors with other nations. An overview of the emissions of the greenhouse gases for the years 1990 to 1995 are presented in Table 0-1.

Table 0-1 Greenhouse and other gases emissions (in Kt) for the period 1990-1995

	1990	1991	1992	1993	1994†	1995†
Carbon dioxide	**84,575**	**84,303**	**86,429**	**86,946**	**89,005**	**90,492**
Energy	76,834	76,642	78,722	79,015	81,289	82,426
Industrial Processes	7,398	7,315	7,358	7,581	7,364	7,713
Waste	343	346	349	350	352	353
Methane	**443.027**	**443.985**	**444.544**	**447.597**	**456.628**	**455.608**
Agriculture	272.795	272.201	270.071	271.833	278.236	275.988
Waste	111.696	112.662	113.492	114.106	114.674	114.936
Energy	58.536	59.122	60.981	61.658	63.718	64.684
Nitrous oxide	**17.286**	**16.827**	**16.893**	**16.602**	**16.685**	**16.884**
Agriculture	8.392	8.438	8.442	8.341	8.378	8.333
Energy	6.594	6.493	6.468	6.378	6.476	6.591
Industrial Processes	2.300	1.896	1.983	1.883	1.831	1.960
Carbon monoxide	**1,280.010**	**1,359.601**	**1,359.124**	**1,391.640**	**1,427.042**	**1,447.921**
Nitrogen oxides	**344.081**	**358.113**	**360.989**	**358.940**	**367.436**	**372.603**
NMVOCs	**262.693**	**274.424**	**288.363**	**303.201**	**331.970**	**338.536**

† Provisional figures

Following the FCCC guidelines for the preparation of national communications, emissions from international air transport and marine bunkers have not been included in the national totals and are reported separately in Table 0-2. Emissions from these activities arise from the use of diesel and fuel oil by marine vessels and jet fuel by airline carriers. Furthermore, CO_2 emissions from the use of biomass are not included in the national totals.

Table 0-2: Emissions (in Kt) from the use of bunker fuels for the period 1990-1995

	1990	1991	1992	1993	1994†	1995†
Carbon dioxide	**10,423**	**9,446**	**10,582**	**12,711**	**13,026**	**13,623**
Methane	**0.206**	**0.185**	**0.205**	**0.244**	**0.256**	**0.264**
Nitrous oxide	**0.515**	**0.472**	**0.542**	**0.632**	**0.672**	**0.721**
Carbon monoxide	**32.468**	**30.160**	**35.205**	**39.537**	**41.924**	**42.547**
Oxides of nitrogen	**173.759**	**158.496**	**179.567**	**213.921**	**222.424**	**237.737**
NMVOCs	**27.104**	**24.645**	**27.922**	**32.261**	**33.522**	**33.234**

† Provisional figures

Since 1990, overall greenhouse gases emissions have increased by approximately 4.6%, and it is estimated that the equivalent increase in 1995 was about 6.1%. Carbon dioxide emissions account for the majority of these emissions (Figure 0.1), since they were responsible for approximately 86% of the total emissions in Greece, while methane and nitrous oxide accounted for 9% and 5%, respectively.

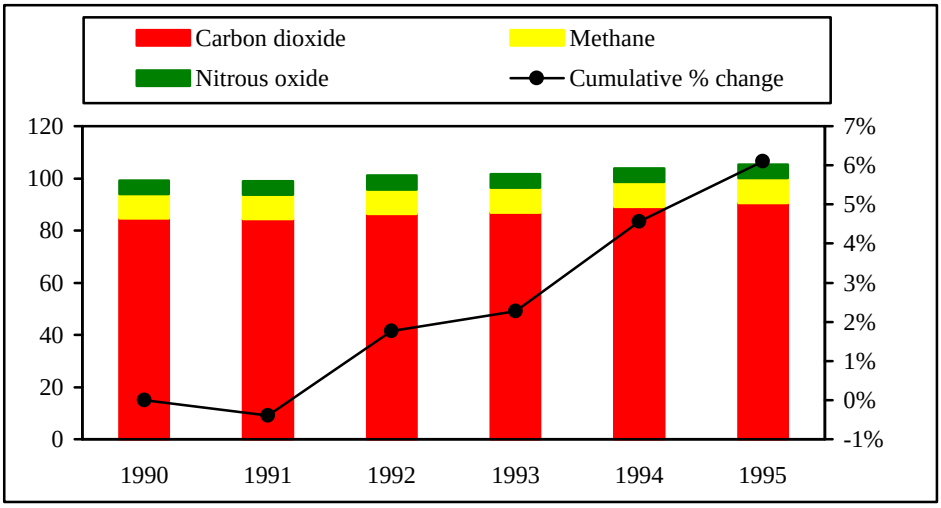

Figure 0.1: Emissions of greenhouse gases (in Mt of CO_2 equivalent), weighted by the GWP values for the 100-years horizon

Carbon dioxide. Combustion of fossil fuel accounts for 92% of total CO_2 emissions, while the remaining 8% result from cement and lime production and the incineration of solid waste. Energy related activities include the generation of electricity, the industry sector, heating in commercial, domestic and public buildings and fossil fuels consumption in automobiles and other vehicles.

Methane. The agricultural sector (enteric fermentation in domestic livestock and manure management) is the largest anthropogenic source of methane emissions in Greece, accounting for approximately 61% of total in 1995. Landfills and wastewater treatment are the second largest anthropogenic sources of methane emissions accounting for approximately 25% of total. Fuel combustion, coal mining, the production and processing of natural gas and oil, accounted for the remaining 14% of the national total.

Nitrous oxide. While actual emissions of nitrous oxide are much smaller than carbon dioxide emissions, N_2O is approximately 270 times more effective than carbon dioxide at trapping heat in the atmosphere over a 100-year time horizon. The major sources of N_2O emissions are fertiliser use (49%), fossil fuel combustion(39%) and production of nitric acid (12%).

Other gases. Carbon monoxide (CO), oxides of nitrogen (NOx) and non-methane volatile compounds (NMVOCs) are important for their role as precursors of tropospheric ozone. In this role, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. These gases are generated through a variety of anthropogenic activities, including fossil fuel combustion, solid waste incineration, oil and gas production and processing, industrial processes and solvent use and agricultural crop waste burning. Their respective emissions have remained relatively constant from 1990 to 1995.

0.3. The National Action Plan

Based on projections for the year 2000, in Greece, a "business-as-usual" course of events (in the absence, in other words, of abatement measures) would lead to an ***increase in emissions in the order of 27%*** or 22 million tonnes CO_2 by the year 2000 (increase from 82 to 104 million tonnes). After an exhaustive study of the technology options available and realistic timetables and penetration targets, as well as the specific development programmes that have been elaborated for the energy (Public Power Corporation, Public Gas Corporation, etc.), transport, residential sector etc., the Greek government has accepted as a ***realistic objective for its national programme the restriction of the total increase in CO_2 emissions during the 1990-2000 period to 15%±3%*** (or 12.4 million tonnes). The detailed study of Greece's specific problems revealed that, by exclusively technological criteria, it would be theoretically possible to achieve a much greater abatement of CO_2 and other gas emissions. In practical terms, however, this was not easy because of the limited time available, restricted financial resources, inflexibility of the production system and consumer inertia.

The Greek National Action Plan for the reduction of CO_2 and other greenhouse gases was elaborated under the responsibility and supervision of the Ministry for the Environment, Physical Planning and Public Works, in collaboration with the Ministry for Development. Other competent Ministries, bodies of the wider public sector and experts from the private sector participated in the elaboration of the Plan. Abatement measures included refer to *supply-side*, as well as *demand-side* interventions. Regarding the former, the most important measures concern the sector of electricity generation and are the introduction of natural gas, the

modernisation of the existing system, the development of cogeneration units in existing and planned power stations and the large-scale exploitation of renewable energy sources. *Demand-side* interventions are focused primarily on the introduction of natural gas in the industrial, tertiary and residential sector, energy conservation measures in buildings and manufacturing units - especially the ones with a high energy consumption - as well as measures affecting energy consumption in the transport sector.

Finally, the Plan comprises a range of measures for the management of biological resources, namely support for the utilisation of agricultural by-products, protection of soils from erosion, control of forest resources, rational use of farmlands and acceleration of the reforestation programme.

0.4. Progress of implementation of national policies and measures

0.4.1. Progress in legal and fiscal instruments

Among the various existing policy instruments for the reduction of greenhouse gases, particular emphasis should be paid to the recent law for the exploitation of RES in electricity generation and the promotion of cogeneration, the Operational Programme for Energy (OPE) developed by the Ministry of Development and co-financed by the new Community Support Framework and the up-coming legislative framework for energy conservation in the building sector. These three instruments, together with the ones already available, are expected to change significantly the energy profile of the country up to the year 2000, taking also into account the future penetration of natural gas.

Law 2244 on electricity generation came in effect in 1994 and eliminated the major drawbacks of the previous legislative framework, which was not successful in attracting investors in the exploitation of renewable energy sources. This new legislation makes available favourable electricity tariffs to self-producers and independent producers of electricity and combined electricity/heat. These tariffs are particularly advantageous in autonomous island grids, where the potential of renewables such as wind is significant. Furthermore, the law extends cogeneration investment opportunities to manufacturing units and enterprises of the tertiary sector. It should be noted that since the introduction of this law, a large number of projects was submitted for approval, while in many cases the capacity of RES installations proposed exceeds by far maximum penetration limits set mainly for safety reasons in the independent grid.

The *Operational Programme for Energy (OPE)* of the Ministry for Development has a total budget of 946 MECU, out of which 37.5% derive from the European Fund for Regional Development, 29.5% from national public funds and 33% from private funds. OPE covers the time period 1994-1999 and comprises four sub-programmes. Sub-Programme 1 (total budget: 350 MECU) concerns electricity generation facilities construction and upgrading of the Public Power Corporation. Sub-Programme 2 (total budget : 375 MECU) supports energy conservation, mainly in industry and tertiary sector. Sub-Programme 3 (total budget : 191 MECU) concerns actions in the field of renewable energies, while Sub-Programme

4 (total budget : 30 MECU) supports the systematic research and investigation of the possibilities for the exploitation of mineral resources. The total annual energy conservation gained by the implementation of the programme is estimated at 700 Ktoe. After the first call for proposals, 57 projects have been approved, out of which 31 refer to energy conservation/cogeneration/substitution of conventional fuels by natural gas (total budget : 17.2 billion GRD), while the rest 26 refer to the renewable energies' exploitation (total budget : 22.7 billion GRD).

The third important instrument towards energy conservation in the building sector is the *Action Plan "Energy 2001"* developed by the Ministry for the Environment, Physical Planning and Public Works. The plan includes measures for the promotion of RES use and energy conservation in existing and new buildings. The programme will come into force in September 1997 through the issuance of a Common Ministerial Decision (Ministry for the Environment, Physical Planning and Public Works/Ministry for Development/Ministry for National Economy/ Ministry for the Interior) and is in accordance with the provisions of the SAVE Directive (93/76/EC) on the "*stabilisation of carbon dioxide emissions and the efficient energy use in buildings*", and the subsequent specification of subsidies for the whole building sector. The system is expected to be in full operation in 1998.

0.4.2. Progress in implementation of actions

In the energy sector, the reduction of greenhouse emissions will be achieved through both supply and demand side measures. The progress of implementation of the various measures for the reduction of greenhouse gases emissions is summarised in Table 0-3.

In the supply side, the major intervention is the *introduction of natural gas* to the Greek energy system, at first in the electricity generation sector and large industrial units and next - by slower rates - in the residential and commercial sectors. The construction of the main transmission pipeline was completed in July 1995, while the construction of secondary pipelines is progressing. The supply of natural gas to the first PPC gas-fired power station will begin in the summer of 1997, while the second part of the pipeline that will supply natural gas to two more power stations at South Attica is scheduled to be completed in the spring of 1998. Furthermore, another natural gas fired station in Northern Greece is expected to come on-line by the year 2001. In the industrial sector, the Public Gas Corporation has already formulated a pricing policy and the general terms of gas supply to industrial customers and is aggressively pursuing contracts with the industrial customers. Nine contracts have already been signed for sale of more than 0.3 billion Nm^3/yr and a few large industrial units are already connected to the distribution network, while negotiations with other industries are in progress. City networks are presently under construction and will be completed by the year 2000.

Furthermore, *improvements in the conventional power generation system* are in progress and comprise of efficiency improvements in lignite-fired power stations, limitation of distribution losses and development of cogeneration units, combined with district heating installations for space-heating purposes in the nearest towns. Up to now, two district heating networks have been developed, while two more are planned to be constructed in the next few years.

Table 0-3: Greenhouse gases abatement measures in the energy sector

Measures	*Status in 1995*		*Status in 1997*	
	Degree of implementation	*Administrative planning*	*Degree of implementation*	*Administrative planning*
PENETRATION OF NATURAL GAS				
Electricity generation	Starting	I	In progress	I
Industry	Starting	PD	In progress	D
Residences - Commerce - Services	Starting	PD	In progress	D
IMPROVEMENTS IN THE CONVENTIONAL POWER GENERATION SYSTEM				
Efficiency improvements Limitation of distribution losses	In progress	PD	In progress	PD
Combined Heat and Power Systems	In progress	PD	In progress	PD
RENEWABLE ENERGY SOURCES				
Wind energy (300 MW)	In progress	D PD	In progress	D D
Small hydroelectric Works (34 MW)	In progress	I	In progress	I
Solar systems : • *conventional systems* • *new technology systems*	 In progress Under elaboration	 PD P	 In progress Starting	 I D
Geothermal Energy	In progress	PD	In progress	D
Biomass : • *District heating (50 MWth)* • *Electricity generation (80 MWe)* • *Biofuels (50 kt/y*	 In progress Under elaboration Under elaboration	 PD PD PD	 In progress Starting Under elaboration	 I I PD
Research & Development	Under elaboration	P	Starting	D
ENERGY EFFICIENCY IMPROVEMENTS IN INDUSTRY				
Cogeneration	In progress	PD	In progress	D
Improvements in auxiliary operations	In progress	P	In progress	D
Interventions in energy intensive sectors	In progress	P	In progress	D
Environmental Energy Listings	Under elaboration	P	Under elaboration	P
INTERVENTIONS IN THE DOMESTIC AND TERTIARY SECTORS				
Cogeneration	Under elaboration	P	Starting	D
Lighting	Under elaboration	P	Starting	I/D
Road-lighting	In progress	P	In progress	P
Central boiler maintenance	In progress	P	In progress	P
INTERVENTIONS IN THE TRANSPORTATION SECTOR				
Fuel-related interventions	In progress	PD	In progress	PD
Vehicle-related interventions	In progress	PD	In progress	PD
Interventions in the transport system	In progress	PD	In progress	I/D
Interventions in Public Transports	In progress	PD	In progress	I/D

Administrative planning : ***I***: Under implementation, ***D***: Decided,
PD: Planned/Pending Decision, ***P***: Proposed

As regards *exploitation of Renewable Energy Sources* (RES), significant progress has been made and 47 investment projects have been within the framework of the Operational Programme for Energy (OPE), the law 2244/94 and the development law 1892/90. Projects submitted refer mainly to the exploitation of wind, small hydroelectric works and use of agricultural by-products for the substitution of liquid fuels in manufacturing units.

Interventions concerning *energy conservation* in industry and tertiary sector are also in progress. Within the existing policy framework, 27 projects have been approved, while the implementation of the Action Plan "Energy 2001", mentioned before, will greatly stimulate investments in this field and is expected to change substantially the consumers' behaviour on energy issues.

The reduction of greenhouse gases in the transport sector is expected to be achieved through indirect measures, namely the improvement of the existing road network and traffic conditions in large urban centres. Major transport works, already under construction, will significantly reduce the distance between major cities and ports and consequently the required energy consumption and resulting carbon dioxide emissions. Further improvement in the public transports sector is expected by the construction of the two additional metro lines in the town of Athens, work which is in progress. The extension of the metro network will be completed by the year 2001 and it is expected that a significant shift from the use of private cars towards public transport means will be achieved. Additional measures improving traffic conditions in the two largest towns in Greece (Athens and Thessaloniki) are in progress within the framework of two Action Plans, "Attica SOS" and "Thessaloniki SOS" developed by the Ministry for the Environment, Physical Planning and Public Works.

In the forestry sector, the reduction of greenhouse gases emissions and the sequestration of CO_2 progresses with much slower rates. Measures are mainly focused on reforestation and control of fires, while there has been also some progress on the protection of soils from erosion. The implementation of the EU Directive 91/676 on the reduction of nitrogen pollution of underground and surface waters will reduce the use of nitrous fertilisers and consequently the emissions of N_2O. The progress of implementation of the various measures for the reduction of greenhouse gases emissions are summarised in Table 0-4.

Table 0-4: Greenhouse gases abatement measures in forestry

Measures	*Status in 1995*		*Status in 1997*	
	Degree of implementation	*Administrative planning*	*Degree of implementation*	*Administrative planning*
Acceleration of Reforestation programmes	In progress	PD	In progress	D
Reinforcement of the Forest Resource Control Programme	In progress	PD	In progress	D
Protection of soils from erosion	In progress	PD	In progress	PD
Study on the rational use of forest resources	Starting	PD	Starting	PD
Rational use of farmlands	Starting	PD	Starting	PD
Support for the utilisation of agricultural by-products	In progress	PD	In progress	PD
Support for the promotion of energy cultivations	Under elaboration	P	Under elaboration	P
«The role of forests and agriculture in the CO_2 balance»	Under elaboration	P	Under elaboration	P

Administrative planning : ***I***: Under implementation, ***D***: Decided, ***PD***: Planned/Pending Decision, ***P***: Proposed

0.5. Emissions projections

For the period 1991-1995, CO_2 emissions are within the limits set by the National Action Plan. In 1995, the cumulative increase compared to the 1990 levels, was estimated at 7% against 8.6% and 5.8% for the pessimistic and optimistic scenarios, respectively. Provided that the implementation process of the National Action Plan follows closely the time schedule set for the period 1997-2000, for all sectors concerned, the final increase is expected to be approximately 16% compared to 1990 levels, a level well within the target set by the Greek government, which was 15% ± 3%.

For the period after 2000, the Greek Government has reaffirmed its desire to continue its efforts to curtail further greenhouse emissions. Having considered that the adopted targets should be demonstrably reachable from the financial-technical point of view, acceptable socially and in step with overall national constraints and international obligations, the Greek Government stated its intention to restrict the national increases of CO_2 emissions between 2000 and 2010 to a level of 13%. The major instruments to be applied towards this goal include:

a) increased use of natural gas in electricity generation,
b) modification of existing power plants to include topping cycles and introduction of new clean coal technologies,
c) energy conservation measures in the transport sector,
d) increased energy conservation in the building sector, and
e) continuing emphasis on renewable energy sources utilisation.

1. INTRODUCTION

1.1. General

The United Nations Framework Convention on Climate Change (FCCC), established as a target for the industrialised/developed countries of the world the return of greenhouse gases emissions by the year 2000 at 1990 levels. Greece, a member state of the EU, in the context of fulfilling this requirement jointly by the EU as a whole, has - bearing in mind its economic and social capabilities and needs - put into effect a National Action Plan aiming at restricting the increase of carbon dioxide emissions to 15%±3% by the year 2000 compared to 1990 levels.

The Greek National Action Plan for the abatement of CO_2 and other greenhouse gases emissions was approved by the Greek Government in February 1995 and subsequently submitted as the 1st National communication to the FCCC. The National Action Plan constitutes a programme focusing on the implementation of a number of policies and measures that are expected to curtail the forecast CO_2 emissions in Greece. These policies and measures cover a wide range of anthropogenic sources/sinks of greenhouse gases.

This report has been prepared in fulfilment of the obligations under the provisions of the FCCC that request the submission of a 2nd National Communication, which provides a full account of the progress in implementing national policies and measured and their expected results by the year 2000.

The report was elaborated under the responsibility and supervision of the Ministry for the Environment, Physical Planning and Public Works in collaboration primarily with the Ministry for Development. In addition, other competent Ministries (Ministry of Internal Affairs, Ministry of Foreign Affairs, Ministry of National Economy, Ministry of Finance, Ministry of Agriculture, Ministry of Merchant Marine, Ministry of Transportation) and organisations in the public sector (Public Power Corporation, Public Natural Gas Corporation) participated in the preparation of the report. The scientific support was provided by the National Observatory of Athens.

1.2. Structure of the report

This report consists of 8 chapters. Chapter 2 gives general background information related to national circumstances and past trends of the energy supply and demand. Chapter 3 presents emission estimates for greenhouse and other gases for the years 1990-1995. Chapter 4 gives a brief description of the National Action Plan. Chapter 5 offers an analytical description of the current status of implementation of the policies and measures defined in the National Action Plan. Chapters 6 and 7 provide information on adaptation measures and on education, information, and public awareness. Finally, chapter 8 gives an overview of emission projections up to and beyond the year 2000.

2. NATIONAL CONDITIONS

This chapter includes a short description of the geographical, population, and economic profiles of Greece. In addition, the basic elements constituting the actual energy profile of the country are presented, together with a brief analysis of the past trends in energy supply and especially demand.

2.1. General

Greece has a total area of 13,195,740 ha and occupies the southernmost extension of the Balkan peninsula. It is divided into 52 counties, which in turn are grouped into 13 administrative regions, the boundaries of which are shown in Figure 2.1.

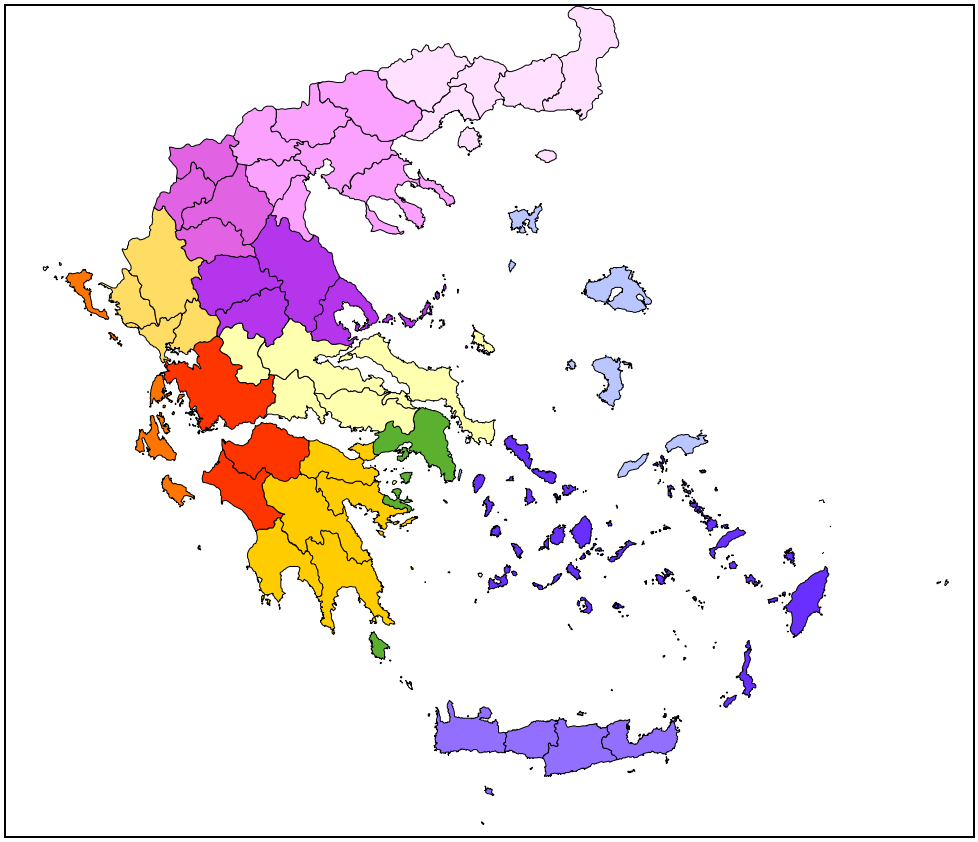

Figure 2.1: Major administrative regions of Greece

As shown in Figure 2.2, approximately, 26% of the total area of Greece is covered by forests of coniferous and broadleaf trees. Important conifers are fir, black pine, Aleppo and Brutia pines, Scots pine, and spruce, and of the broadleaves there are various species of deciduous oaks and beech especially in the north [23], [24]. Partly-forested areas and grasslands cover 4.6 Mha (or 35%), mostly used for grazing by sheep, goats and cattle. Agricultural land occupies about 31% of the

total area while other uses - including urban areas, industrial areas and internal waterways - make up the remaining 8%.

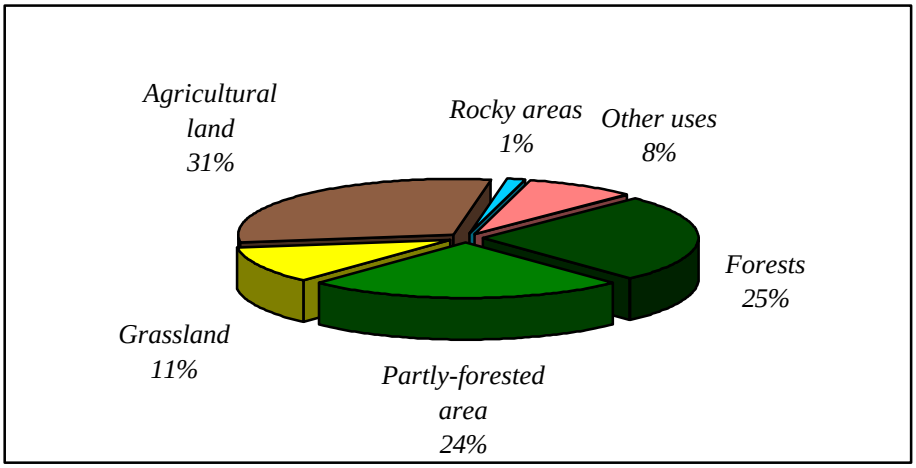

Figure 2.2: Distribution of the area of Greece by land cover category

The Greek landscape, with its islands occupying a fifth of its territory and its mainland coastline exceeding 1400 km in length, is closely linked with the sea, since only a small region in the Northwest is further than 80 km from the sea. Approximately 25% of it is lowland, particularly the coastal plains along the Aegean sea and the valleys and small plains that lie near the river mouths.

2.2. Population

The total population of the country is approximately 10.35 million inhabitants and the population density is 78 inhabitants per km^2. Currently, the annual growth rate is approximately 0.9/1000 inhabitants. During the period 1981-1993, the total population increased by 6.5%.

Urban centres concentrate approximately 60% of the total population, while approximately 50% of that lives in the Greater Athens area. The active population represents 38% of the total, while unemployment is reported to be around 10%.

2.3. Finances

Greece is one of the four cohesion countries of the European Union with an estimated gross domestic product in 1996 of 29,576 billion GRD or 122.9 billion USD (exchange rate: 1 USD = 240.7 GRD). Currently, it has a rate of inflation of 5.4% (May 1997), which is declining, a general government deficit-to GDP ratio of 7.4% (in 1996), which is also declining, and an outstanding general government debt-to GDP ratio of 111.8% (in 1996).

Economic policy focuses on meeting the convergence criteria for joining the European Monetary Union. It is the aim of the Greek government to join the

monetary union by 2001 at the latest, one year before the common currency, Euro, is introduced in physical form and stage III of the unification is completed.

2.3.1. Development of the Gross Domestic Product

Although the annual growth of the GDP is much higher than that of the population, Greece is still one of the countries with the smallest GDP per capita in the EU. The annual rate of increase of the GDP during the time period 1970-1980 was approximately 5%, while it has dropped to 2% during 1981-1994 (calculated in 1970 prices) [21] , but since then it has started to increase gradually reaching 2.6% in 1996. The contribution of primary, secondary and tertiary sectors to the total GDP is shown in Figure 2.3. The tertiary sector represented 59.4% of the total GDP in 1994 (53% in 1980), while during 1980-1994 the contribution of primary and secondary sector has dropped (12.4% in 1994 versus 14.5% in 1980 and 28% in 1993 versus 32.5% in 1980 respectively).

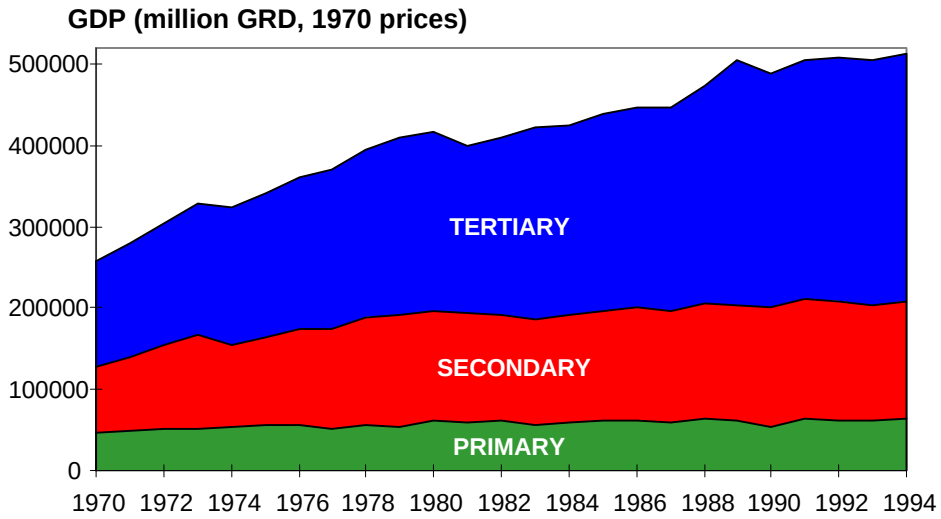

Figure 2.3: Contribution of economic sectors to GDP (1970-1994)

The annual rate of change in agriculture, industry and construction recorded during 1970-1980 (2.5%, 6.1% and 1.4% respectively) was significantly decreased during 1980-1994 (0.5%, -0.3% and 0.3% respectively). During the same time period, electricity/gas/water supply, transport/communications, residence/ insurance, rest services and mining follow an annual rate of increase higher than that of the total GDP (Figure 2.4). It should be noted that “rest services” include public administration, defence, health, education and miscellaneous services.

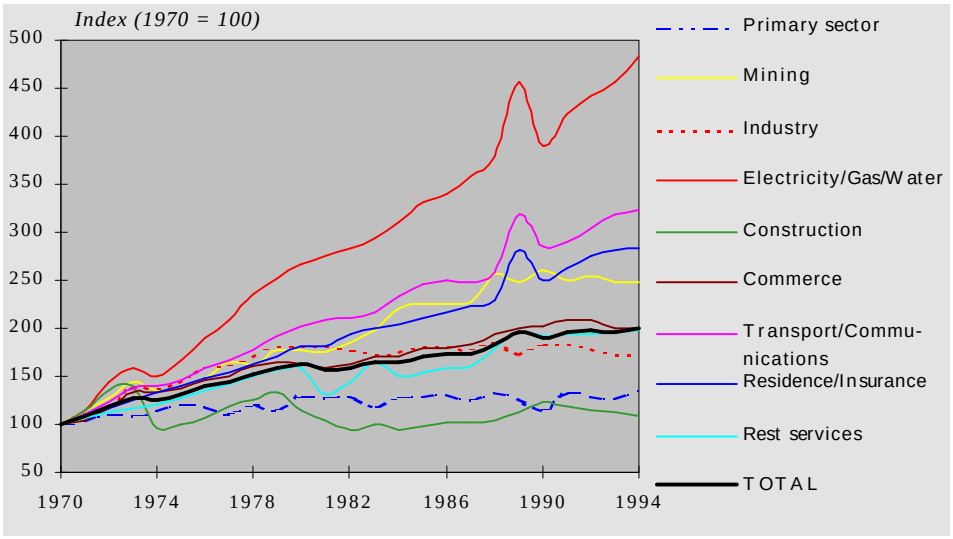

Figure 2.4: Development of GDP (in 1970 prices)

2.3.2. Agriculture and forestry

The total agricultural area in Greece is approximately 3.9 million ha, more than half of which is on relatively steep slopes where cultivation is carried out without protection against soil erosion. No significant changes took place during the last decade [20], regarding the cultivated, irrigated and fallow land (Figure 2.5). In 1994, irrigated land represented about 38% of the total cultivated land and more than 70% of the cultivated land suitable for irrigation.

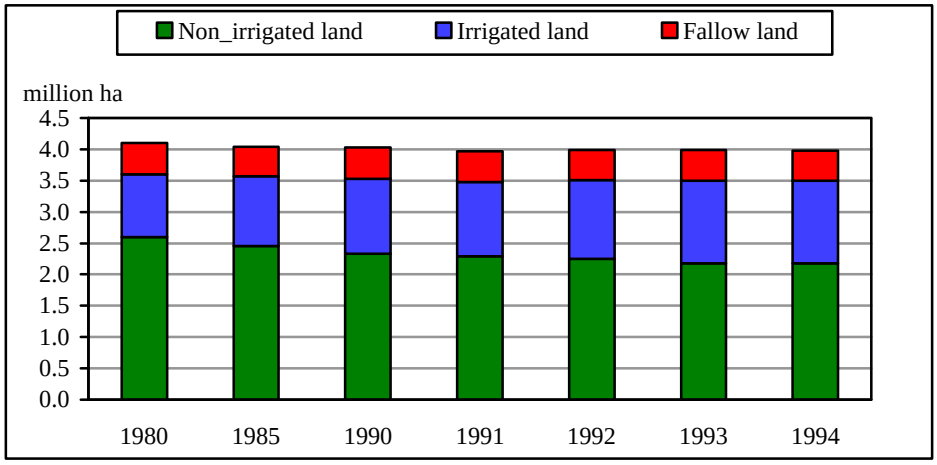

Figure 2.5: Total agricultural and irrigated land (1980-1994)

In terms of acreage, the most important crops of the country are field crops (65%), horticulture (22%) and industrial crops (13%). Modest amounts of N-fertilisers are used in Greek agriculture and rates vary with the type of crop (field crops: 50-240 kg N/ha, vegetables: 200-400 kg N/ha and industrial crops: 80-160 kg N/ha).

During the decade 1980-1990 the total amount of N-fertilisers applied to crops was 400,000 tonnes of N.

Agriculture involves approximately 25% of the total active population of the country. The GDP from agriculture remained almost stable during the last decade, and private investment in the sector is decreasing. Among the major problems of the Greek agriculture are land fragmentation into small and scattered fields and high production costs.

In 1994, livestock population comprised approximately 16 million animals (cattle : 4%, sheep: 54%, goats : 33%, horses/mules/ashes : 1%, pigs : 8%) and 40 million laying hens and other poultry.

Closed forests cover less than 25% of the area of the country, a relatively small percentage considering that more than 70% of the land in Greece is mountainous and hilly. Sparsely forested steep slopes are overgrazed by goats and sheep inducing serious problems of soil erosion and landslides. Extensive forest fires and low rates of planting also contribute to soil erosion and desertification.

2.3.3. Industry

"Major Industry" (i.e. industries with more than 10 employees) comprises approximately 8,100 manufacturing units with around 290,000 employees (average size : 36 employees per unit). Between 1980 and 1992, the number of industries and handicrafts decreased by 2%, while the number of employees decreased by 18%. The average size was 42.4 employees per unit in 1980. The majority of industrial units are located in the prefectures of Athens and Thessaloniki.

Between the years 1980 and 1992, the contribution of industry to the total GDP dropped from 21.3% to 16.8% (calculated on 1970 prices). During 1970-1980, the gross domestic product from industry increased by a higher rate than that of the total GDP, mainly because of the influence of the high investments carried out during the sixties. Since then, investments in the sector present a decreasing trend. Investments decreased up to 1985, increased up to 1989 and then decreased again. Between 1991 and 1994, the annual rate of increase of the GDP in industry was negative.

During the eighties, industrial sectors presenting a higher annual rate of increase of GDP than that of the total GDP were primary metal, plastic/rubber, chemicals, petroleum/coal products, fabricated metal products, food/beverage and paper/pulp, while non-mineral products, clothing and wood/furniture lost their comparative advantages [16] .

An indicative distribution of the number of industrial units between the various product sectors is shown in Figure 2.6.

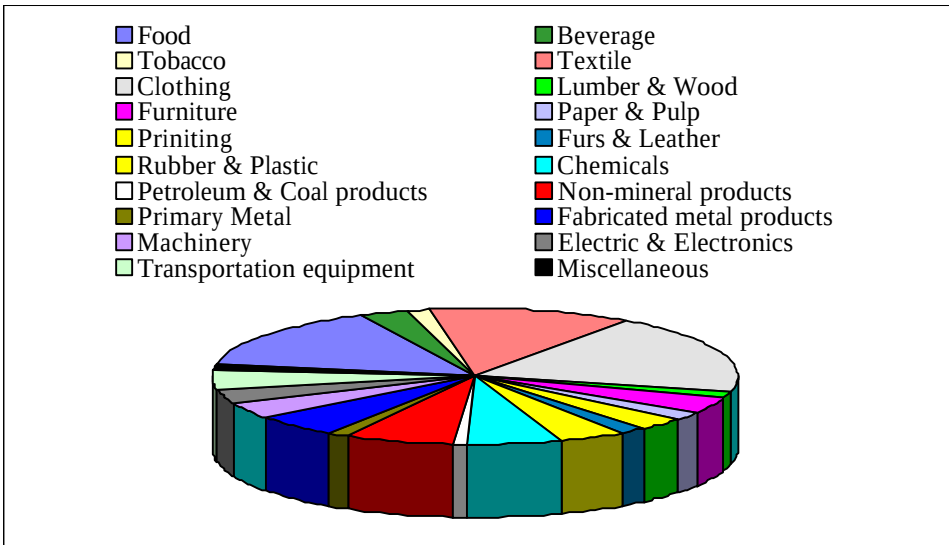

Figure 2.6: Structure of major industry

A significant decrease in the number of units and employees was observed in the tobacco, textile and lumber, and wood industry, while the respective figures increased in primary metal industry, petroleum and coal products, paper and pulp, and furniture industry.

2.3.4. Tourism

Tourism is one of the better developed economic sectors in Greece. Since 1980, the number of foreign tourists visiting Greece has almost doubled, reaching 10.5 million visitors per year. This number is approximately the same as the total indigenous population and adds to the demand on natural resources and for service facilities. It is not surprising, therefore, that during the same period the total hotel capacity (including hotels, motels and bungalows, suites, guest rooms, inns and boarding houses) increased by about 90%. In 1996, the number of hotel beds was approximately 552,000, while there was an additional 715,000 beds in rooms for rent. About 60% of the total bed capacity is located on the islands.

2.3.5. Transportation

2.3.5.1.Road Transport

The improving economic conditions in Greece over the last 15 years had a significant impact on the ownership of road vehicles, as shown in Figure 2.7. The number of passenger cars in 1994 was almost 10 times that in 1970, while similar increases have also occurred in the number of trucks, buses and motorcycles. In 1980, the number of passenger cars was 1.3 million cars, or 1 car per 11 inhabitants, while in 1994 this figure became 2.9 million cars, or 1 car per 5 inhabitants. Despite these drastic changes, however, Greece still has one of the lowest ownership rates in Europe.

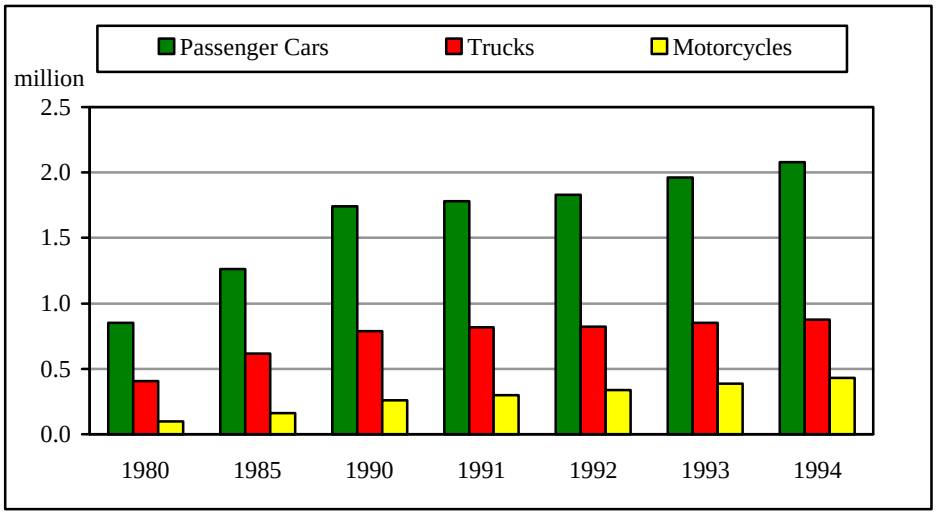

Figure 2.7: The Road Vehicles Market in Greece

The increase of motorcycles in Greece is the result of a number of different factors, such as the introduction of restrictive measures in Athens in the form of an inner and outer "ring" inside which cars can only circulate on alternating days, lack of sufficient parking places, traffic congestion and public transport problems. In addition to the number presented in Figure 2.7, it should be noted that an even larger number of mopeds are currently in operation. According to provisional data, in 1994, their number was estimated to have reached 1.2 million. More than 50% of these were in circulation in the large cities in Greece, where the above mentioned problems make them an affordable and convenient alternative.

Up to 1992, Greece was the only country in Europe that prohibited the use of passenger cars running on diesel oil, except for taxis. The reason for the introducing such a measure was the increasing atmospheric pollution in Athens, caused mainly by smoke and dust emitted by older technology and improperly serviced buses, lorries and taxis. In 1992, the Greek government introduced the Law 2052/92 which allowed the use of diesel powered passenger cars of up to 3.5 tons in Greece, except for the areas of Athens, Piraeus and Thessaloniki.

2.3.5.2.Shipping

The Greek maritime fleet is one of the largest in the world accounting for 8% of the global number of vessels and 14.8% of the global dead-weight tonnage [25]. Approximately 45% of these vessels carry the Greek flag, which, in 1996, amounted to about 2,160 vessels of 100 GRT and over. Merchant (dry cargo) ships represent 40% of this total, 24% are passenger ships, 20% tankers and 16% other type of vessels. The merchant fleet is composed by ships of average age and specialises in "*tramping*" or going anywhere in the world on a single trip, rather than in travelling regular routes. Passenger ships (including ferries and cruise ships) are primarily used for transporting both goods and passengers to and from the numerous islands in the Aegean and Ionean Seas and to countries in the Mediterranean Sea.

Greek shipping makes a significant contribution to the country's balance of payments and provides about one-third of the national income derived from services.

2.3.5.3.Railways

The total length of the railway network in Greece is 2,497 km. Greece was the last European country to develop a railway system that dates only from the 1880s. Over the last 10 years, the railway network has undergone an extensive modernisation, the aims of which are the improvement of the existing tracks, the standardisation of metric gauges, the connection to the western European network and the co-ordination of the development with that of the roads. Both the modernisation and the extension of the system have been proved costly and difficult mainly due to the complex topography that is characterised by a mountainous region (Pindos mountains) that divides the western and eastern parts of Greece.

2.4. The Energy System in Greece

2.4.1. Energy supply

The total domestic energy supply in Greece has been continuously increasing, despite the two energy crises that characterised the first halves of the last two decades and the economic recession that followed. In 1995, the total domestic energy supplied reached a total of approximately 23.7 Mtoe, an increase of approximately 48% compared to 1980 level. Despite this general rapid increase, however, the average annual growth rate in the first five years of the 90s was reduced to approximately 1.4% per year, compared to 3.3% in the 80s.

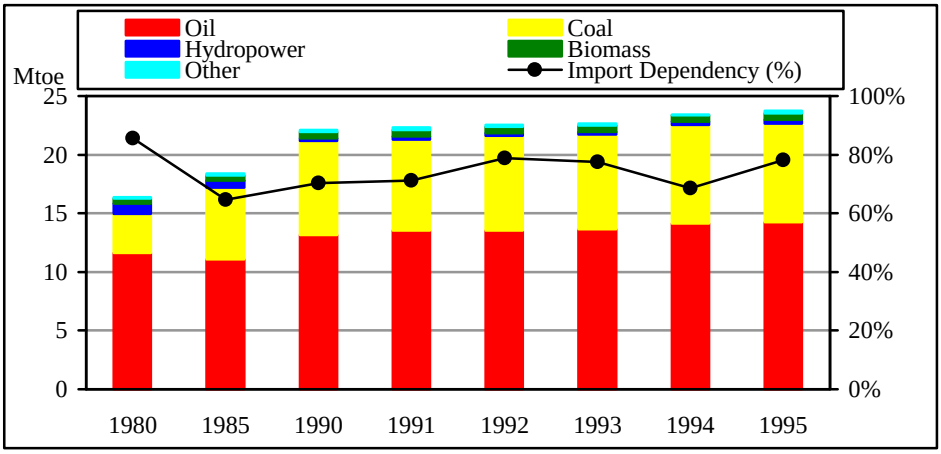

Figure 2.8: Energy supply in Greece by energy carrier[1]

[1] The category Other includes gas, renewable energy (except for large hydropower and biomass) and net imports of electricity

The composition of the energy carriers (Figure 2.8) manifests the major weakness of the Greek energy system, which is the absence of alternative solutions for covering the country's energy demands. During the period 1980-1995, oil and coal products have retained the lion's share of the total energy supply, while the relative contribution of other energy sources has gradually decreased.

Despite the reliance of the energy system on oil products, their relative contribution has fallen from 72.5% in 1980 to 60% in 1995. This change in trend was the result of a gradual tendency of the general energy balance towards indigenous coal products, in particular brown coal (lignite), that accounted for 32% of the total energy supply in 1995, compared to 19% in 1980.

The partial replacement of oil by lignite had a marked effect on the import dependency of energy, which is solely attributed to imports of crude oil and other oil products. During the 80s import dependency gradually fell, and in 1994 it reached its lowest ever value of approximately 59%, a decrease that though was not sustained in the following year.

Renewable energies currently cover approximately 4% of the total energy supply. Apart from large hydropower, other forms of renewable energy (solar power, wind energy, geothermal energy and biomass) have not been exploited to their full potential resulting in a contribution of less than 3% in 1995. Similarly, natural gas and gas works cover approximately 0.2% of the total energy supply, although this situation will rapidly change after the summer of 1997 when the first natural gas power station is expected to operate.

The electricity generation system in Greece consists of thermal and hydroelectric units as well as a very small percentage of other renewables. The percentage contribution of coal products, and more specifically lignite, has steadily increased since 1980, due to the commissioning of 3,663 MW of lignite-fired stations from 1980-1989 compared to 650 MW of fuel oil fired ones in the same period. In 1995, the installed capacity of the Public Power Corporation (PPC) generating system was 9,198 MW (Table 2-1) corresponding to 98% of the total installed capacity in Greece, while, an additional 221 MW from autoproducers was also in operation.

Table 2-1. Installed capacity (in MW) in 1995

	PPC	**Auto-producers**
Coal-fired	4,533	-
Oil-fired	2,114	131
Hydroelectric	2,524	-
Renewables	26	3
Natural gas	-	40
Other fuels	-	47

Electricity generation has been steadily increasing at an average annual rate of approximately 3.5% in the 1990-1995 period. The total amount of electricity supplied in 1995 totalled 42.3 TWh, of which 68% and 21% came from the

combustion of coal and petroleum products, respectively, 9% from hydropower and 2% from gas and imports.

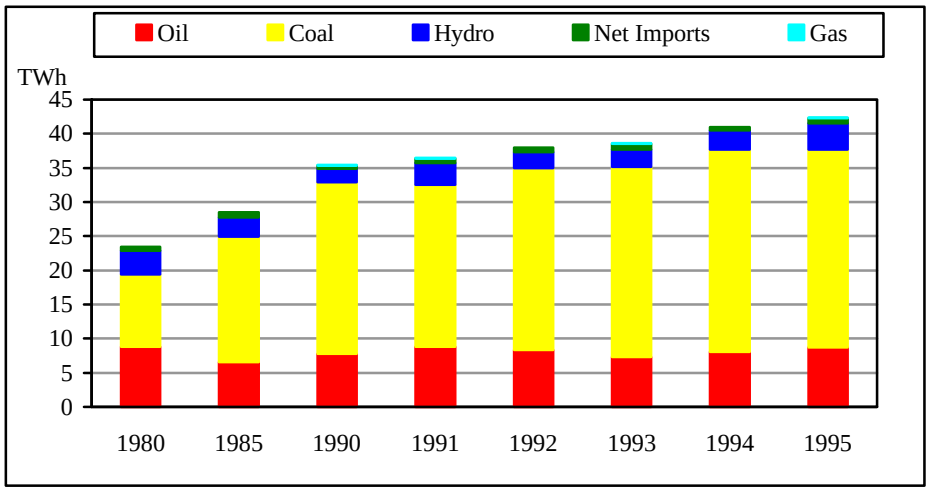

Figure 2.9: Total Electricity Supply in Greece

The tendency towards lignite electricity generation has decreased the average thermal efficiency, which dropped from approximately 34% in 1980 to 32.4% in 1990. However, this trend was reversed in the 1990-1995 period (Figure 2.10) with the thermal efficiency reaching 34.4% in 1994, because of a number of improvements in the power plants and the distribution system. Despite a small lessening of this trend in 1995, it is expected that the overall efficiency of the electricity generation system will be further improved with the introduction of new combined-cycle power plants in 1997.

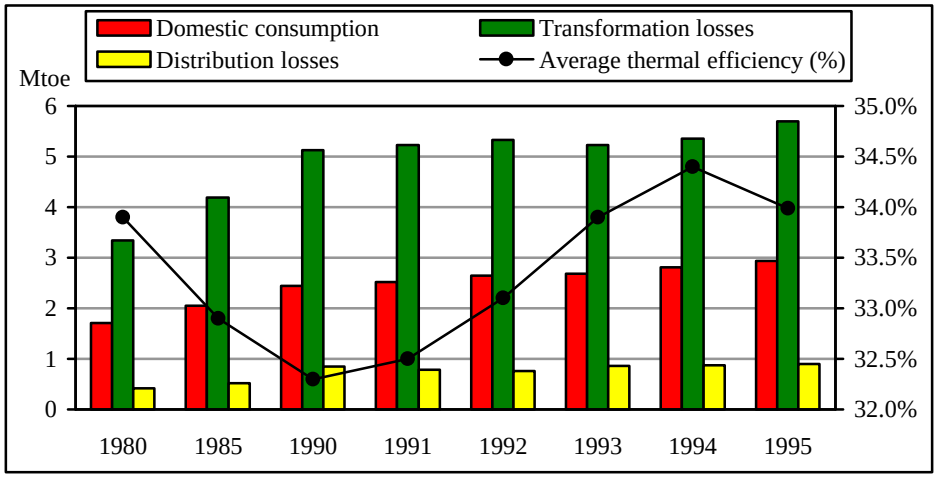

Figure 2.10: Domestic consumption and related losses of electricity

Out of the total of electricity production, only approximately 1/3 is finally supplied for domestic consumption.

2.4.2. Energy use in Greece

Final energy demand in Greece in 1995 totalled 14.4 Mtoe, of which 26% was used in industry, 44% for transportation and 30% by the domestic and tertiary sector.

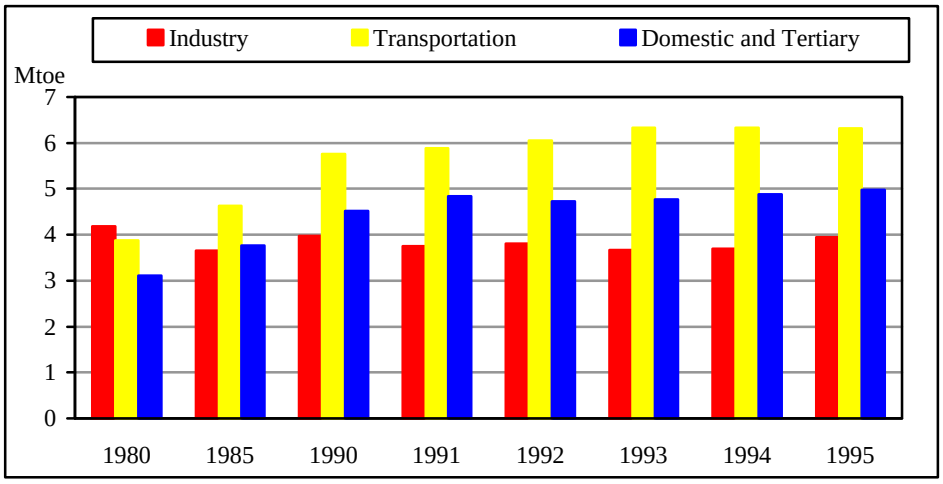

Figure 2.11: Final energy demand by economic sector

In the 1980-1995 period, the only sector that has reduced its energy demand is the industrial sector that has been mostly affected by the energy crises of the last two decades and the recession of the last 5 years. The other two sectors have increased their energy use thus resulting in a total increase of 36.5% between 1980 and 1995.

2.4.2.1.Energy use in Industry

In 1995, the total energy consumption of the industrial sector totalled 3.9 Mtoe that corresponds to the 26% of the total energy demand in Greece. Although, energy use in industry follows the variations of the industrial output, as shown in Figure 2.12, it has to be noted that energy demand is also affected by factors such as changes in the products produced, fuel substitution, energy prices and technical innovations and developments. After the energy crisis of the 80s, industrial output is characterised by a stagnation that is only interrupted by a short-lived recovery in the latter part of last decade. After 1990, the output level falls again as the economic recession of the last five years caused the shutdown of a number of manufacturing firms.

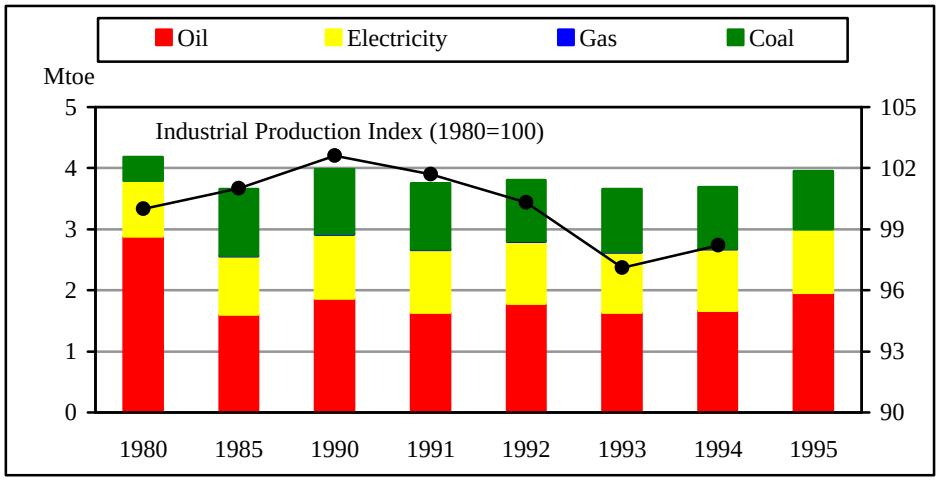

Figure 2.12: Final energy demand in industry by energy carrier

The evolution of the industrial sector has a direct effect on the relative contribution of different types of fuel. During the 1980-1995 period, the only noticeable change is a gradual replacement of petroleum products by coal products, a trend almost solely attributable to the increased use of steam coal by the cement industry. In 1995, oil products accounted for approximately 50% of the total energy needs of the sector, compared to 69% in 1980. Electricity consumption has steadily increased, reaching a total of 1.0 Mtoe or 27% of the total energy use of the sector.

2.4.2.2.Energy use in the Domestic and Tertiary sectors

In 1995, the energy use in this sector totalled 4.4 Mtoe or 30% of the total energy demand in Greece. This energy was primarily used for space heating and cooling, and domestic hot water production in residential and public buildings and commercial premises. Other energy uses were in the form of electricity for domestic purposes and for the operation of building services systems in residential, public and commercial premises. The figure also includes energy use for the agricultural and public sectors, which in 1995 contributed for approximately 30% and 15% of the total, respectively.

The changes in the energy consumption of the sector reflect both the improving standards of living of the Greek society and the increase in the number of dwelling units. These two factors have resulted in improved levels of heating and recently of cooling as well as in a rise in the ownership of home electric appliances. The floor area of commercial premises has also increased substantially, thus contributing to increasing the demand for electricity for ventilation, lighting and other office equipment.

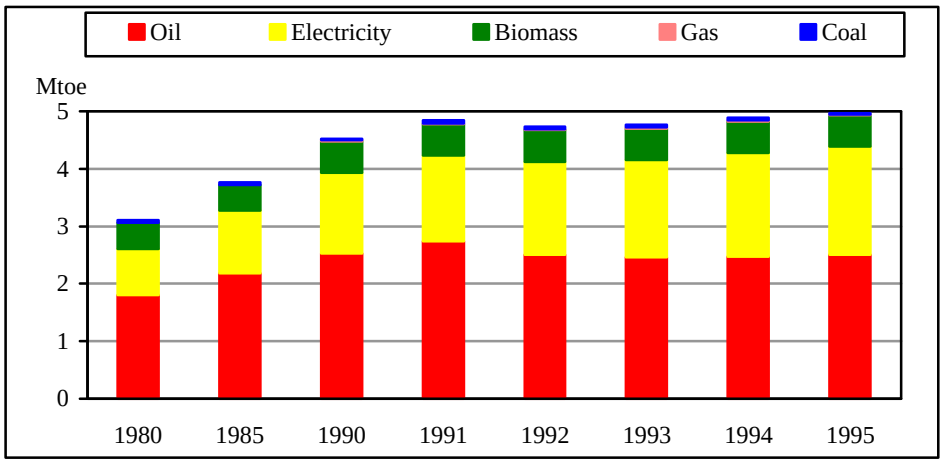

Figure 2.13: Final energy demand in the Domestic and Tertiary sectors

The factors that have helped to reduce the rate of increase in the energy use of the sector are the installation of thermal insulation in private residences and apartment buildings, the installation of solar heating units in private residences and some large hotels, the installation of double-glazing in new and in some cases in older buildings, and the replacement or modernisation of older electric and heating appliances.

The general upward trend of the energy demand, as illustrated in Figure 2.12, is mostly the result of an increased demand for electricity and to a smaller extent of petroleum products. In 1995, the contribution of the latter fell to 51% compared to 58% in 1980, while electricity use has increased to 37% compared to 26% in 1980. Although, in absolute figures, the use of solid fuels and biomass has remained relatively stable in the last twenty five years, their relative contribution has dropped to 12% compared to 16% in 1980. Up to 1985, most of the biomass was used in the countryside to meet the heating requirements of households and holiday homes. Since then, however, the market indicates that there is a gradual shift of their use from the country side to large urban areas. This change is the result of both the increasing population of the large cities in Greece and the renewed demand for the installation of fire-places in both private residences and apartment buildings.

2.4.2.3.Energy use for Transportation

The energy use of the transportation sector has almost doubled during the 1980-1995 period. The growth rate is slightly larger than either of the other two economic sectors. In 1995, transportation accounted for 6.3 Mtoe or 44% of the total final energy demand in Greece. Oil products accounted for 99.7% of the final energy use, while electricity and coal accounted for the remaining 0.3%. The energy use is in the form of gasoline consumption by automobiles, while other uses include diesel oil for trucking, maritime transport and railroads, jet fuel for aircraft and smaller amounts of LPG and diesel oil used by taxis. Steam coal is solely used by railroads, while electricity covers the needs of the electric buses (trolleys) that operate in the central Athens area.

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3. EMISSIONS OF GREENHOUSE AND OTHER GASES

This section presents emissions estimates for the period 1990-1995 for three major greenhouse gases, i.e. carbon dioxide (CO_2), methane (CH_4) and nitrous oxide(N_2O) and three photochemically important gases, namely, carbon dioxide (CO), oxides of nitrogen (NOx) and non-methane volatile organic compounds (NMVOC). It should be noted that emissions for other greenhouse gases such as HFCs, PFCs and SF_6 are not currently estimated but will be reported in future inventory updates.

3.1. Methodology

3.1.1. Activity data

For the completion of the present inventory, the energy statistics of IEA have been used together with the annual energy balance sheets of the Ministry for Development, in order to calculate the emissions from fuel combustion and other energy-related activities. The only exception is for the case of emissions of gases from the transportation sector, where additional data relating to the condition of the fleet of road vehicles in Greece were necessary and have been obtained from the Association of Greek Car Importers and the Insurance Companies Statistical Service of Greece.

For the other areas, the necessary data have been obtained from the National Statistical Service of Greece and the Ministry for the Environment, Physical Planning and Public Works.

Note that for the activity areas of Solvents and Other Products use and Land Use Change and Forestry, there are not sufficient official inventory data to allow the estimation of NMVOCs production and to account for CO_2 sinks, respectively.

3.1.2. Emission factors

Following the specifications defined by the FCCC, all emissions estimates were calculated following the IPCC inventory compilation guidelines. For most activity areas and sectors, the emission factors used were the ones proposed by the IPCC [1]. For cases where such factors were not available, corresponding emission factors suggested by the CORINAIR programme [3] were used. For both the IPCC and CORINAIR factors, attention was paid to selecting (where possible) values that reflected the preferred practices and climatic conditions in Greece. On a very limited number of occasions, it was possible to utilise specific factors that arise from measurements or estimations for particular activity sectors in Greece.

For some categories, the emissions reported here are different from those presented in the *National Inventory of Greenhouse and Other Gases* [26] because of the use, here, of updated emission factors.

3.1.3. Radiative forcing effect

Emissions from anthropogenic activities affect the concentration and distribution of greenhouse gases in the atmosphere. These changes can potentially produce a radiative forcing of the Earth's surface and lower atmosphere, by changing either the reflection or absorption of solar radiation or the emission and absorption of long-wave radiation. IPCC, [27], has reviewed information on the radiative forcing of greenhouse gases and the role of aerosols and their incorporation in climate models.

According to the reporting guidelines, emissions of greenhouse gases must be reported in absolute figures for each gas as well as in tonnes of carbon (or carbon dioxide) equivalent by using appropriate values for their global warming potential (GWP). For the present report, GWP values for three time horizons, presented in Table 3-1, have been taken from the IPCC Climate Change 1995 report [27].

Table 3-1: GWP values of methane and nitrous oxide relative to 1 kg of carbon dioxide for three time horizons

	20 years	100 years	500 years
Carbon dioxide	1	1	1
Methane[2]	56	21	6.5
Nitrous oxide	280	310	170

3.2. Overview of emissions for the period 1990-1995

Summary emissions estimates for the years 1990-1995 are given in Table 3-2. It must be noted that these emission figures will be further revised once more detailed data for sectors such as Land Use Change and Forestry and Solvents and Other Products Use become available.

Following the FCCC guidelines for the preparation of national communications, emissions from international air transport and marine bunkers have not been included in the national totals and are reported separately in Table 3-3. Emissions from these activities arise from the use of diesel and fuel oil by marine vessels and jet fuel by airline carriers. Furthermore, CO_2 emissions from the use of biomass are not included in the national totals.

[2] The GWP value for methane also includes indirect (cooling) effects

Table 3-2: Greenhouse and other gases emissions (in Kt) for the period 1990-1995

	1990	1991	1992	1993	1994†	1995†
Carbon dioxide	**84,575**	**84,303**	**86,429**	**86,946**	**89,005**	**90,492**
Energy	76,834	76,642	78,722	79,015	81,289	82,426
Industrial Processes	7,398	7,315	7,358	7,581	7,364	7,713
Waste	343	346	349	350	352	353
Methane	**443.027**	**443.985**	**444.544**	**447.597**	**456.628**	**455.608**
Agriculture	272.795	272.201	270.071	271.833	278.236	275.988
Waste	111.696	112.662	113.492	114.106	114.674	114.936
Energy	58.536	59.122	60.981	61.658	63.718	64.684
Nitrous oxide	**17.286**	**16.827**	**16.893**	**16.602**	**16.685**	**16.884**
Agriculture	8.392	8.438	8.442	8.341	8.378	8.333
Energy	6.594	6.493	6.468	6.378	6.476	6.591
Industrial Processes	2.300	1.896	1.983	1.883	1.831	1.960
Carbon monoxide	**1,280.010**	**1,359.601**	**1,359.124**	**1,391.640**	**1,427.042**	**1,447.921**
Nitrogen oxides	**344.081**	**358.113**	**360.989**	**358.940**	**367.436**	**372.603**
NMVOCs	**262.693**	**274.424**	**288.363**	**303.201**	**331.970**	**338.536**

NA Not available
† Provisional figures

Table 3-3: Emissions (in Kt) from the use of bunker fuels for the period 1990-1995

	1990	1991	1992	1993	1994†	1995†
Carbon dioxide	**10,423**	**9,446**	**10,582**	**12,711**	**13,026**	**13,623**
Methane	**0.206**	**0.185**	**0.205**	**0.244**	**0.256**	**0.264**
Nitrous oxide	**0.515**	**0.472**	**0.542**	**0.632**	**0.672**	**0.721**
Carbon monoxide	**32.468**	**30.160**	**35.205**	**39.537**	**41.924**	**42.547**
Oxides of nitrogen	**173.759**	**158.496**	**179.567**	**213.921**	**222.424**	**237.737**
NMVOCs	**27.104**	**24.645**	**27.922**	**32.261**	**33.522**	**33.234**

† Provisional figures

The year 1990 has been set as the base year for the emission limitation objectives for Greece. The technical report [5] accompanying the 1st National Communication, published in February 1995, described the calculation details of the first collective attempt to create an inventory of greenhouse and other gases for the base year 1990. Since then, emission estimates have been recalculated on the basis of more reliable data for some activity sectors and the update of the methodology used. The revised emission data for 1990 are reported in Table 3-4.

Emissions figures by activity sector and corresponding emissions from bunker fuels use for the years 1991-1995 are presented in Table 3-5-Table 3-9.

Table 3-4: Emission estimates (in Kt) for the 1990 base year

SOURCE AND SINK CATEGORIES	EMISSION ESTIMATES					
	CO2 (Kt)	CH4 (Kt)	N2O (Kt)	NOx (Kt)	CO (Kt)	NMVOC (Kt)
NATIONAL TOTALS	**84,575**	**443.027**	**17.286**	**344.081**	**1,280.01**	**262.693**
1 All Energy	**76,834**	**58.536**	**6.594**	**306.17**	**1,114.262**	**201.543**
A Fuel Combustion	76,834	14.628	6.594	304.609	1,114.168	181.069
1 Energy and Transformation Ind.	43,661	0.676	1.403	72.228	6.619	2.61
2 Industry (ISIC)	9,820	1.5	1.418	19.812	4.563	2.25
3 Transport	15,193	2.649	1.556	165.395	849.821	152.371
4 Commercial, Residential etc	8,159	9.803	2.218	47.174	253.164	23.845
B Fugitive Emissions from Fuels	0	43.908	0	1.751	0.094	20.468
1 Solid Fuels	0	43.489	0	0	0	0
2 Oil and Natural Gas Fuels	0	0.419	0	1.751	0.094	20.468
2 Industrial Processes	**7,398**	**0**	**2.3**	**31.506**	**30.499**	**2.599**
3 Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**NE**
4 Agriculture	**0**	**272.795**	**8.392**	**4.552**	**111.885**	**50.211**
A Enteric Fermentation	0	141.792	0	0	0	0
B Manure Management	0	23.746	0	0	0	0
C Rice Cultivation	0	4.936	0.038	0	0	0
D Agricultural Soils	0	96.994	8.228	0	0	29.651
E Prescribed Burning of Savannas	0	0	0	0	0	0
F Field Burning of Agricultural Residues	0	5.328	0.127	4.552	111.885	20.56
G Other Agriculture Activities	0	0	0	0	0	0
5 Land Use Change & Forestry	**0**	**0**	**0**	**0**	**0**	**0**
A Wood & Woody Biomass Stock Change	0	0	0	0	0	0
B Forest and Grassland Conversion	0	0	0	0	0	0
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other Land Use Change Activities	0	0	0	0	0	0
6 Waste	**343**	**111.696**	**0**	**1.663**	**23.365**	**8.339**
A Solid Waste Disposal on Land	343	101.992	0	0	0	0
B Wastewater Treatment	0	6.094	0	0	0	0
C Waste Incineration	0	3.61	0	1.663	23.365	8.339
D Other Waste	0	0	0	0	0	0
7 Other	**0**	**0**	**0**	**0**	**0**	**0**
International Aviation and Marine (not included in national totals)	10,423	0.206	0.515	173.759	32.468	27.104

NE Not estimated

Table 3-5: Emission estimates (in Kt) for the year 1991

SOURCE AND SINK CATEGORIES	EMISSION ESTIMATES					
	CO2 (Kt)	**CH4** (Kt)	**N2O** (Kt)	**NOx** (Kt)	**CO** (Kt)	**NMVOC** (Kt)
NATIONAL TOTALS	**84,303**	**443.984**	**16.828**	**358.113**	**1,359.601**	**274.424**
1 All Energy	**76,642**	**59.122**	**6.493**	**318.976**	**1,150.558**	**213.145**
A Fuel Combustion	76,642	14.579	6.493	316.995	1,150.452	193.608
1 Energy and Transformation Ind.	42,530	0.69	1.392	74.717	6.356	3.044
2 Industry (ISIC)	9,679	1.199	1.406	19.46	4.577	1.765
3 Transport	15,999	2.79	1.426	174.453	882.226	164.576
4 Commercial, Residential, etc.	8,435	9.899	2.269	48.365	257.293	24.224
B Fugitive Emissions from Fuels	0	44.543	0	1.981	0.106	19.536
1 Solid Fuels	0	44.158	0	0	0	0
2 Oil and Natural Gas Fuels	0	0.384	0	1.981	0.106	19.536
2 Industrial Processes	**7,315**	**0**	**1.896**	**31.071**	**23.644**	**2.248**
3 Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**NE**
4 Agriculture	**0**	**272.201**	**8.438**	**6.391**	**161.875**	**50.635**
A Enteric Fermentation	0	140.109	0	0	0	0
B Manure Management	0	23.39	0	0	0	0
C Rice Cultivation	0	4.428	0.034	0	0	0
D Agricultural Soils	0	96.566	8.228	0	0	29.738
E Prescribed Burning of Savannas	0	0	0	0	0	0
F Field Burning of Agricultural Residues	0	7.708	0.177	6.391	161.875	20.897
G Other Agriculture Activities	0	0	0	0	0	0
5 Land Use Change & Forestry	**0**	**0**	**0**	**0**	**0**	**0**
A Wood & Woody Biomass Stock Change	0	0	0	0	0	0
B Forest and Grassland Conversion	0	0	0	0	0	0
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other Land Use Change Activities	0	0	0	0	0	0
6 Waste	**346**	**112.662**	**0**	**1.675**	**23.524**	**8.396**
A Solid Waste Disposal on Land	346	102.867	0	0	0	0
B Wastewater Treatment	0	6.16	0	0	0	0
C Waste Incineration	0	3.635	0	1.675	23.524	8.396
D Other Waste	0	0	0	0	0	0
7 Other	**0**	**0**	**0**	**0**	**0**	**0**
International Aviation and Marine (not included in national totals)	9,446	0.185	0.472	158.496	30.16	24.645

NE Not estimated

Table 3-6: Emission estimates (in Kt) for the year 1992

SOURCE AND SINK CATEGORIES	EMISSION ESTIMATES					
	CO2 (Kt)	CH4 (Kt)	N2O (Kt)	NOx (Kt)	CO (Kt)	NMVOC (Kt)
NATIONAL TOTALS	**86,428**	**444.545**	**16.893**	**360.989**	**1,359.124**	**288.362**
1 All Energy	**78,722**	**60.981**	**6.468**	**322.641**	**1,182.194**	**228.212**
A Fuel Combustion	78,722	14.466	6.274	320.458	1,182.077	207.794
1 Energy and Transformation Ind.	44,906	0.701	1.438	78.271	6.7	2.849
2 Industry (ISIC)	9,294	0.902	1.351	18.909	4.434	1.34
3 Transport	16,418	2.999	1.519	177.991	917.611	179.976
4 Commercial, Residential, etc.	8,104	9.863	2.16	45.288	253.331	23.628
B Fugitive Emissions from Fuels	0	46.515	0	2.183	0.117	20.419
1 Solid Fuels	0	46.133	0	0	0	0
2 Oil and Natural Gas Fuels	0	0.383	0	2.183	0.117	20.419
2 Industrial Processes	**7,358**	**0**	**1.983**	**31.435**	**23.557**	**2.347**
3 Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**NE**
4 Agriculture	**0**	**270.071**	**8.442**	**5.223**	**129.635**	**49.331**
A Enteric Fermentation	0	139.233	0	0	0	0
B Manure Management	0	23.246	0	0	0	0
C Rice Cultivation	0	4.409	0.034	0	0	0
D Agricultural Soils	0	97.009	8.264	0	0	29.651
E Prescribed Burning of Savannas	0	0	0	0	0	0
F Field Burning of Agricultural Residues	0	6.173	0.144	5.223	129.635	19.68
G Other Agriculture Activities	0	0	0	0	0	0
5 Land Use Change & Forestry	**0**	**0**	**0**	**0**	**0**	**0**
A Wood & Woody Biomass Stock Change	0	0	0	0	0	0
B Forest and Grassland Conversion	0	0	0	0	0	0
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other Land Use Change Activities	0	0	0	0	0	0
6 Waste	**349**	**113.492**	**0**	**1.69**	**23.738**	**8.472**
A Solid Waste Disposal on Land	349	103.62	0	0	0	0
B Wastewater Treatment	0	6.204	0	0	0	0
C Waste Incineration	0	3.668	0	1.69	23.738	8.472
D Other Waste	0	0	0	0	0	0
7 Other	**0**	**0**	**0**	**0**	**0**	**0**
Inernational Aviation and Marine (not included in national totals)	10,582	0.205	0.542	179.567	35.205	27.922

NE Not estimated

Table 3-7: Emission estimates (in Kt) for the year 1993

SOURCE AND SINK CATEGORIES	EMISSION ESTIMATES					
	CO2 (Kt)	**CH4** (Kt)	**N2O** (Kt)	**NOx** (Kt)	**CO** (Kt)	**NMVOC** (Kt)
NATIONAL TOTALS	**86,945**	**447.598**	**16.602**	**358.94**	**1,391.64**	**303.201**
1 All Energy	**79,015**	**61.658**	**6.378**	**320.15**	**1,220.178**	**243.524**
A Fuel Combustion	79,015	15.418	6.378	317.659	1,220.044	224.208
1 Energy and Transformation Ind.	45,325	0.703	1.398	78.116	6.638	2.917
2 Industry (ISIC)	9,101	1.638	1.234	18.649	14.239	2.457
3 Transport	16,624	3.215	1.614	176.399	946.065	195.307
4 Commercial, Residential etc.	7,964	9.861	2.131	44.495	253.103	23.527
B Fugitive Emissions from Fuels	0	46.241	0	2.491	0.133	19.316
1 Solid Fuels	0	45.922	0	0	0	0
2 Oil and Natural Gas Fuels	0	0.318	0	2.491	0.133	19.316
2 Industrial Processes	**7,581**	**0**	**1.883**	**32.087**	**24.398**	**2.544**
3 Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**NE**
4 Agriculture	**0**	**271.833**	**8.341**	**5.004**	**123.196**	**48.614**
A Enteric Fermentation	0	139.445	0	0	0	0
B Manure Management	0	24.517	0	0	0	0
C Rice Cultivation	0	6.068	0.047	0	0	0
D Agricultural Soils	0	95.937	8.156	0	0	29.381
E Prescribed Burning of Savannas	0	0	0	0	0	0
F Field Burning of Agricultural Residues	0	5.866	0.139	5.004	123.196	19.233
G Other Agriculture Activities	0	0	0	0	0	0
5 Land Use Change & Forestry	**0**	**0**	**0**	**0**	**0**	**0**
A Wood & Woody Biomass Stock Change	0	0	0	0	0	0
B Forest and Grassland Conversion	0	0	0	0	0	0
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other Land Use Change Activities	0	0	0	0	0	0
6 Waste	**350**	**114.106**	**0**	**1.699**	**23.869**	**8.519**
A Solid Waste Disposal on Land	350	104.192	0	0	0	0
B Wastewater Treatment	0	6.226	0	0	0	0
C Waste Incineration	0	3.688	0	1.699	23.869	8.519
D Other Waste	0	0	0	0	0	0
7 Other	**0**	**0**	**0**	**0**	**0**	**0**
International Aviation and Marine (not included in national totals)	12,711	0.244	0.632	213.921	39.537	32.261

NE Not estimated

Table 3-8: Emission estimates (in Kt) for the year 1994 (provisional figures)

SOURCE AND SINK CATEGORIES	EMISSION ESTIMATES					
	CO2 (Kt)	CH4 (Kt)	N2O (Kt)	NOx (Kt)	CO (Kt)	NMVOC (Kt)
NATIONAL TOTALS	**89,005**	**456.628**	**16.684**	**367.436**	**1,427.042**	**331.97**
1 All Energy	**81,289**	**63.718**	**6.476**	**329.228**	**1,243.777**	**272.164**
A Fuel Combustion	81,289	15.164	6.476	327.14	1,243.665	250.913
1 Energy and Transformation Ind.	47,106	0.721	1.442	83.709	6.935	2.921
2 Industry (ISIC)	9,236	1.566	1.218	19.941	14.749	2.341
3 Transport	16,925	3.573	1.669	178.748	978.569	222.914
4 Commercial, Residential etc.	8,022	9.305	2.147	44.742	243.413	22.736
B Fugitive Emissions from Fuels	0	48.554	0	2.087	0.112	21.251
1 Solid Fuels	0	48.171	0	0	0	0
2 Oil and Natural Gas Fuels	0	0.382	0	2.087	0.112	21.251
2 Industrial Processes	**7,364**	**0**	**1.831**	**31.098**	**24.398**	**2.653**
3 Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**NE**
4 Agriculture	**0**	**278.236**	**8.378**	**5.404**	**134.883**	**48.593**
A Enteric Fermentation	0	142.578	0	0	0	0
B Manure Management	0	26.227	0	0	0	0
C Rice Cultivation	0	6.966	0.053	0	0	0
D Agricultural Soils	0	96.044	8.175	0	0	29.419
E Prescribed Burning of Savannas	0	0	0	0	0	0
F Field Burning of Agricultural Residues	0	6.423	0.149	5.404	134.883	19.174
G Other Agriculture Activities	0	0	0	0	0	0
5 Land Use Change & Forestry	**0**	**0**	**0**	**0**	**0**	**0**
A Wood & Woody Biomass Stock Change	0	0	0	0	0	0
B Forest and Grassland Conversion	0	0	0	0	0	0
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other Land Use Change Activities	0	0	0	0	0	0
6 Waste	**352**	**114.674**	**0**	**1.707**	**23.984**	**8.56**
A Solid Waste Disposal on Land	352	104.698	0	0	0	0
B Wastewater Treatment	0	6.27	0	0	0	0
C Waste Incineration	0	3.706	0	1.707	23.984	8.56
D Other Waste	0	0	0	0	0	0
7 Other	**0**	**0**	**0**	**0**	**0**	**0**
International Aviation and Marine (not included in national totals)	13,026	0.256	0.672	222.424	41.924	33.522

NE Not estimated

Table 3-9: Emission estimates (in Kt) for the year 1995 (provisional figures)

SOURCE AND SINK CATEGORIES	EMISSION ESTIMATES					
	CO2 (Kt)	CH4 (Kt)	N2O (Kt)	NOx (Kt)	CO (Kt)	NMVOC (Kt)
NATIONAL TOTALS	**90,747**	**455.609**	**16.885**	**372.603**	**1,447.921**	**338.536**
1 All Energy	**82,426**	**64.686**	**6.591**	**333.132**	**1,272.352**	**279.886**
A Fuel Combustion	82,426	15.282	6.591	330.726	1,272.223	257.119
1 Energy and Transformation Ind.	46,899	0.727	1.474	79.492	6.968	2.67
2 Industry (ISIC)	10,173	1.594	1.341	22.383	15.136	2.357
3 Transport	17,255	3.671	1.601	183.38	1006.529	229.265
4 Commercial, Residential etc.	8,099	9.289	2.175	45.472	243.59	22.826
B Fugitive Emissions from Fuels	0	49.404	0	2.406	0.129	22.768
1 Solid Fuels	0	49.013	0	0	0	0
2 Oil and Natural Gas Fuels	0	0.391	0	2.406	0.129	22.768
2 Industrial Processes	**7,713**	**0**	**1.96**	**32.711**	**24.398**	**2.653**
3 Solvent and Other Product Use	**0**	**0**	**0**	**0**	**0**	**NE**
4 Agriculture	**0**	**275.988**	**8.333**	**5.049**	**127.13**	**47.416**
A Enteric Fermentation	0	138.907	0	0	0	0
B Manure Management	0	27.73	0	0	0	0
C Rice Cultivation	0	7.68	0.059	0	0	0
D Agricultural Soils	0	95.617	8.135	0	0	29.264
E Prescribed Burning of Savannas	0	0	0	0	0	0
F Field Burning of Agricultural Residues	0	6.054	0.14	5.049	127.13	18.152
G Other Agriculture Activities	0	0	0	0	0	0
5 Land Use Change & Forestry	**0**	**0**	**0**	**0**	**0**	**0**
A Wood & Woody Biomass Stock Change	0	0	0	0	0	0
B Forest and Grassland Conversion	0	0	0	0	0	0
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other Land Use Change Activities	0	0	0	0	0	0
6 Waste	**353**	**114.936**	**0**	**1.711**	**24.041**	**8.58**
A Solid Waste Disposal on Land	353	104.929	0	0	0	0
B Wastewater Treatment	0	6.292	0	0	0	0
C Waste Incineration	0	3.715	0	1.711	24.041	8.58
D Other Waste	0	0	0	0	0	0
7 Other	**0**	**0**	**0**	**0**	**0**	**0**
International Aviation and Marine (not included in national totals)	13,623	0.264	0.721	237.737	42.547	33.234

NE Not estimated

The long-range integrated effect of all greenhouse gas emissions is shown in Table 3.10. Three time horizons are examined with the cumulative equivalence computed with the assistance of the coefficients of Table 3-1.

Table 3-10: Total emissions (in Mt of carbon dioxide equivalent) for the period 1990-1995

	1990	***1991***	***1992***	***1993***	***1994†***	***1995†***
20-year horizon						
Carbon dioxide (CO_2)	84.58	84.30	86.43	86.95	89.01	90.49
Methane (CH_4)	24.81	24.86	24.89	25.07	25.57	25.51
Nitrous oxide (N_2O)	4.84	4.71	4.73	4.65	4.67	4.73
Total	**114.22**	**113.88**	**116.05**	**116.66**	**119.25**	**120.73**
100-year horizon						
Carbon dioxide (CO_2)	84.58	84.30	86.43	86.95	89.01	90.49
Methane (CH_4)	9.30	9.32	9.34	9.40	9.59	9.57
Nitrous oxide (N_2O)	5.36	5.22	5.24	5.15	5.17	5.23
Total	**99.24**	**98.84**	**101.00**	**101.49**	**103.77**	**105.29**
500-year horizon						
Carbon dioxide (CO_2)	84.58	84.30	86.43	86.95	89.01	90.49
Methane (CH_4)	2.88	2.89	2.89	2.91	2.97	2.96
Nitrous oxide (N_2O)	2.94	2.86	2.87	2.82	2.84	2.87
Total	**90.39**	**90.05**	**92.19**	**92.68**	**94.81**	**96.32**

† Provisional figures
NA Not available

Carbon dioxide emissions account for the majority of the total greenhouse gases emissions for all three time horizons considered. Considering the 100-year horizon, CO_2 emissions were responsible for approximately 86% of the total emissions in Greece, while methane and nitrous oxide accounted for 9% and 5%, respectively.

As far as the sectoral contributions are concerned (Figure 3.1), energy-related activities are the largest source (approximately 84%) of all greenhouse gases emissions. These include primarily CO_2 emissions from the combustion of fossil fuels (96%) and smaller amounts of methane (both from combustion and the production, transmission, storage and distribution of fossil fuels) and nitrous oxide that account for 1.7% and 1.6%, respectively. The other sectors, i.e. Agriculture (6.4%), Industrial processes (7.3%) and Waste (2.4%) account for the remaining 16% of all greenhouse gases emissions. Emissions from Agriculture mainly comprise of methane emissions from the breeding of animals and rice cultivation, while methane emissions from Waste come from the management of the solid waste and wastewater. For Industrial processes, the main contributor is CO_2 emissions from the production of non-mineral products and particularly cement and lime.

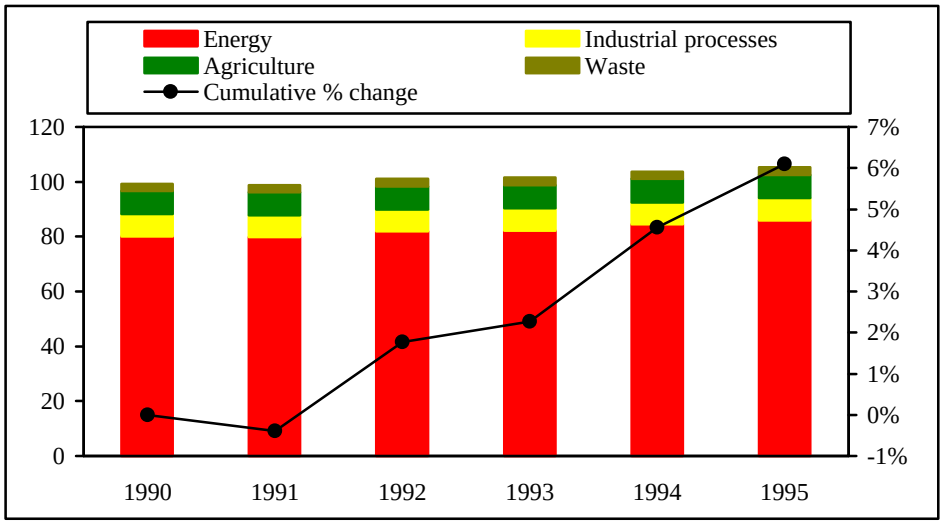

Figure 3.1: Total greenhouse gases emissions (in Mt of CO_2 equivalent for the 100-year horizon) by activity sector

3.3. Carbon dioxide

As shown in Figure 3.2, the combustion of fossil fuels accounts for approximately 92% of total CO_2 emissions, while the remaining 8% result from industrial processes (mainly the production of cement and lime) and the incineration of solid waste. Since 1990 (except for 1991), the amount of carbon dioxide emitted has steadily increased. In 1994, CO_2 emissions totalled 89 Mt compared with 84.58 Mt in 1990, a change of approximately 5.2%. According to provisional data, the equivalent increase for 1995 compared with 1990 is estimated to be 7%.

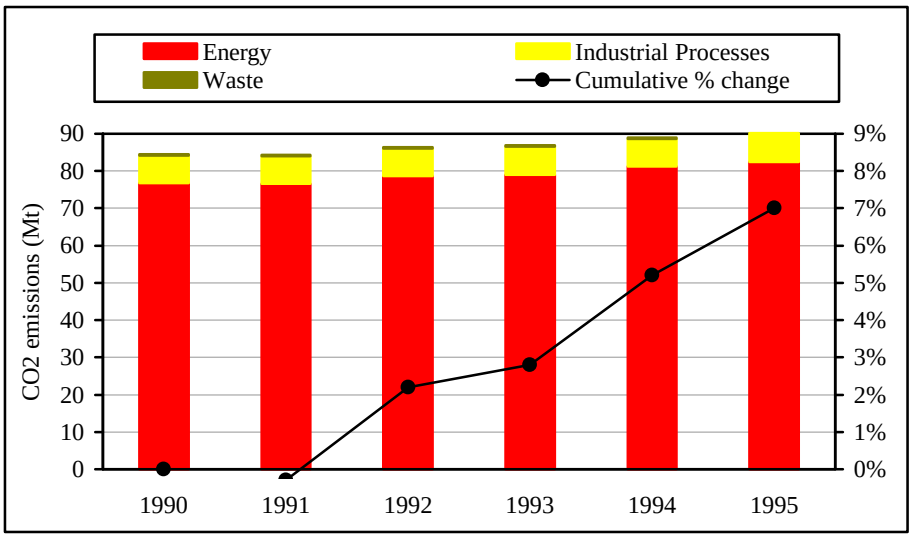

Figure 3.2: Carbon dioxide emissions by activity area

3.4. Methane

After carbon dioxide, methane is the second most important anthropogenic gas in the process of the greenhouse effect. From Figure 3.3, it is clear that the agricultural sector, which includes enteric fermentation in domestic livestock and manure management, is the largest anthropogenic source of methane emissions in Greece, accounting for approximately 61% of total methane emissions in 1995.

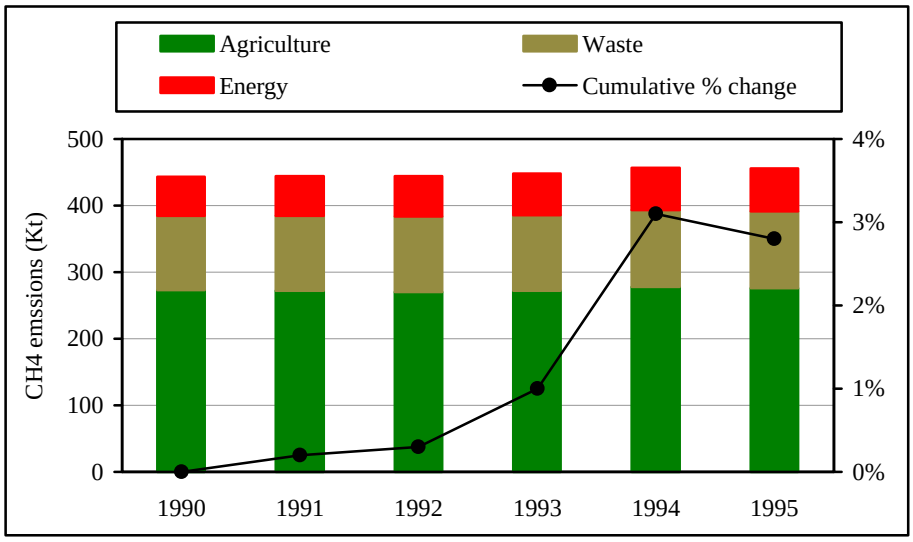

Figure 3.3: Methane emissions by activity area

Landfills and wastewater treatment is the second largest anthropogenic source of methane emissions, accounting for approximately 25% of total Greek methane emissions, while coal mining activities are responsible for 11%.

3.5. Nitrous oxide

Nitrous oxide (N_2O) is a chemically and radiatively active greenhouse gas that is produced naturally from biological sources in soil and water. As depicted in Figure 3.4, the agricultural sector is the primary anthropogenic source of nitrous oxide emissions in Greece. It accounted approximately for 49% of total Greek nitrous oxide emissions in 1994.

Nitrous oxide is also a product of the reaction that occurs between nitrogen and oxygen during fossil fuel combustion. This source accounted for 39% of total nitrous oxide emissions. Production of nitric acid is the major industrial source of nitrous oxide emissions, accounting approximately for 12% of total nitrous oxide emissions.

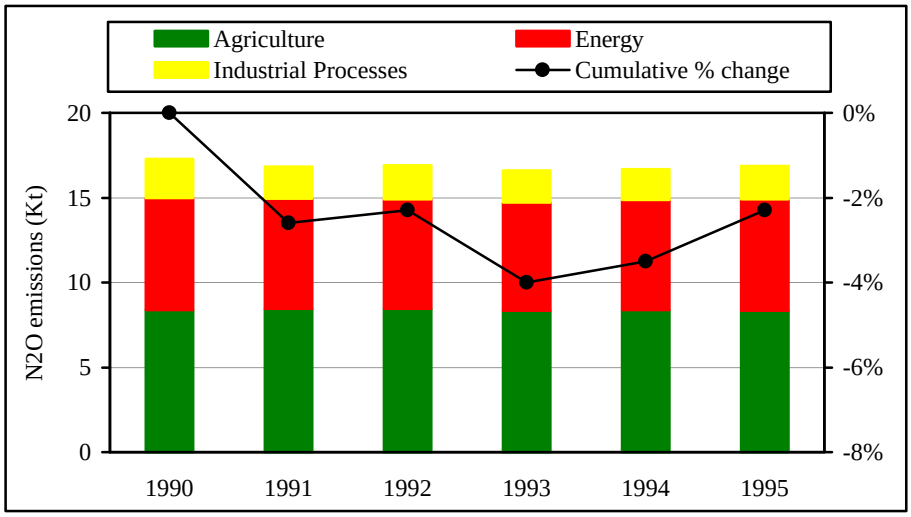

Figure 3.4: Nitrous oxide emissions by activity area

The marked reduction observed from 1990-1993 was solely due to a temporary reduction in the production of nitric acid from a manufacturing unit, which resumed its operation in 1994. In 1994 and 1995 emissions grew further because of a larger contribution from the energy sector.

3.6. Other gases

Anthropogenic activities also emit carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs) that are commonly referred to as "criteria pollutants". They are not greenhouse gases, *per se*, but play an important role in the greenhouse effect by reacting with other compounds, thus affecting the concentration of greenhouse gases in the atmosphere.

Carbon monoxide is created when carbon-containing fuels are burned incompletely. The principal anthropogenic sources of oxides of nitrogen, NO and NO_2, are fossil fuel combustion activities and biomass fires, while emissions also arise from other natural phenomena such as lightning and, in the stratosphere, from nitrous oxide. Non-methane volatile organic compounds are emitted primarily from transportation and industrial processes, biomass burning and non-industrial consumption of organic solvents.

Total emissions of these pollutants are presented in Figure 3.5. It should be noted that NMVOCs from use of solvents have not been included, as there was not available reliable information on their uses in Greece for any of the years considered.

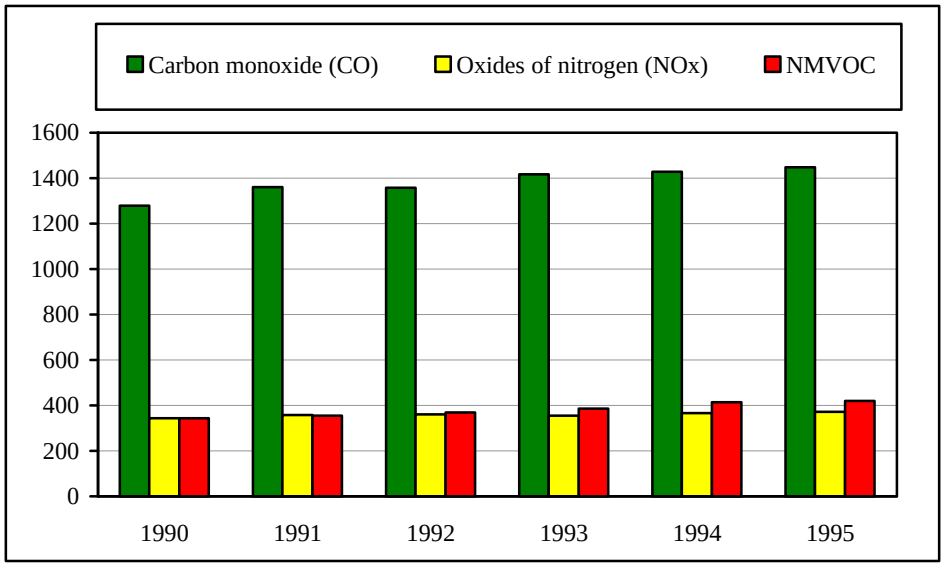

Figure 3.5: Emissions (in Kt) of carbon monoxide, oxides of nitrogen and non-methane volatile organic compounds

4. SUMMARY PRESENTATION OF THE NATIONAL ACTION PLAN

The Greek National Action Plan for the reduction of CO_2 and other greenhouse gases [4] was elaborated under the responsibility and supervision of the Ministry for the Environment, Physical Planning and Public Works, in collaboration with the Ministry for Development. The preparation of the Plan was however completed with the participation and contribution of other competent Ministries, bodies of the wider public sector and experts from the private sector.

The target set by the European Union as a whole is to achieve stabilisation, i.e. to return CO_2 emissions in the year 2000 to 1990 levels. In Greece, a "business-as-usual" course of development actions (in the absence, in other words, of planned and specific abatement measures) would lead to an ***increase in emissions in the order of 27%*** or 22 million tonnes CO_2 by the year 2000 (increase from 82 to 104 million tonnes). The inventory data compiled for 1990 were the result of an extensive and complex study based on OECD and EUROSTAT emission data and factors. The projections for the year 2000 were established with the use of the Midas model, which integrated the international estimates of future energy prices, as well as the impact of technologies which have already penetrated the market and of policies that were first implemented prior to 1992.

The programme of actions for the abatement of CO_2 and other greenhouse gas emissions was based on the specific development programmes planned or elaborated for the energy sector (Public Power Corporation, Public Gas Corporation, etc.), transport, residences, etc. The complementary measures which were adopted aimed at achieving an additional and reasonable improvement in the means by which energy was either produced or used. Having co-assessed all existing data, the Greek government considered that a ***realistic objective for its national programme consists in restricting the total increase in CO_2 emissions during the 1990-2000 period to 15%*** (or 12.4 Mt). Discrepancies of ±3% were allowed for, due to unpredictable internal and international parameters and to possible revisions of the European Union's relevant policy. In comparison with the business-as-usual scenario, the specific objective adopted in the programme implied that ***a decrease in emissions in the order of 9.6 million tonnes CO_2*** was expected to be achieved by the year 2000.

The detailed study of Greece's specific problems revealed that, with solely technological criteria, it would be theoretically possible to achieve a greater abatement of CO_2 and other gas emissions by the year 2000. The addition, however, of other unavoidable factors such as the limited availability of financial resources, the inflexibility of the production system and the inertia displayed by consumers, quickly showed this to be unrealistic.

The abatement of CO_2 and other greenhouse gas emissions was to be achieved by the implementation of :

(a) a drastic energy conservation policy in all sectors of final consumption (domestic-commercial-services, industry, transports) aimed at rationalising

energy consumption without affecting the population's standard of living, and

(b) a bold investment policy in order to promote new energy generation means (involving natural gas at an initial stage and renewable energy sources in the longer term) in an attempt to substitute for conventional fuels without altering the basic characteristics of the energy system (safety, stability and reasonable operating costs).

The various interventions for the reduction of CO_2 and other greenhouse gases emissions included in the Greek Action Plan are summarised in Table 4-1and Table 4-2. A more detailed presentation of these interventions is given below.

4.1. Supply-side interventions

Approximately 50% of Greece's CO_2 emissions are caused by the production of electricity, as the national power generation system is based on the combustion of a thermally poor lignite. Consequently, the success of any policy for the abatement of CO_2 emissions depends largely upon decisions affecting the power generation sector. Measures considered include :

4.1.1. Modernisation of the existing system.

This measure includes efficiency improvements in lignite-fired stations, reduction of losses in the transmission and distribution system and introduction of new and "cleaner" lignite combustion technologies (e.g. Liquefied Bed Units, Integrated Gasification Combined Cycle).

4.1.2. Development of combined heat and power (CHP) generation systems.

CHP systems will allow for a reduction of energy consumption in : a) urban districts located close to the Public Power Corporation's plants (Ptolemaida, Kozani, Amynteo, Florina) by the development of district-heating networks and b) highly energy consuming units in industrial zones and even in small-scale systems and non-industrial facilities (hospitals, public buildings, etc.). The introduction of natural gas will facilitate the development of co-generation systems.

4.1.3. Introduction of Natural Gas.

On the horizon of the year 2000, the abatement of CO_2 emissions will be mainly achieved by the introduction of natural gas in the national energy system, i.e. through one of the greatest investments ever carried out in Greece. Plans to use natural gas (NG) for electricity generation have been finalised and incorporated in the Public Power Corporation's programme, as decisions have been taken to switch certain existing plants over to NG and to construct new gas-fired power stations, of some 1100 MW by the year 2000. Once in operation, these power plants alone are expected to enable the PPC to meet its NG absorption commitments, while yielding an annual production of approx. 5300 GWh. The CO_2 savings, ensuing from the

substitution of more polluting fuels and primarily of lignite, are also expected to be significant. Furthermore, the completion of the central pipeline will accelerate the penetration of NG in the industrial sector. Of the total industrial NG consumption of 1.0 billion Nm^3 anticipated for the year 2000, approx. 80% will be absorbed by a limited number of large industrial units. Smaller manufacturing units will also draw multiple economic benefits from the use of NG and it is certain that their connection to the network will be carried out as soon as realistically possible.

Natural gas penetration will be slower in the other sectors, because of the long time periods necessary for the construction of the distribution networks in residential areas and the inertia characteristic of current consumer behaviour. The larger part of this NG will be used for space-heating purposes, as a substitute for diesel. Substitution of electricity (for cooking and water-heating purposes) will remain limited, since the significant expenses necessary to switch existing installations over to NG will only prove profitable in cases where the use of NG is substantially more energy-efficient. The substitution of NG for electricity has, however, been envisaged in air-conditioning applications with the use of new types of equipment, mainly in the commercial and services sector.

4.1.4. Exploitation of Renewable Energy Sources.

Renewable energy sources (RES) exploitation is also expected to make a marked contribution to the abatement of CO_2 emissions by the year 2000. Until recently, the specific legal framework did not allow for a significant acceleration of investments in this field. This has been reversed by the establishment of the favourable new Law 2244/94. Regarding *wind energy*, it is estimated that the total installed generating capacity will reach some 300 MW by the year 2000. *Solar energy* applications are expected to be considerably expanded for the heating of usage water (with the additional installation of approx. 1.3 million m^2 of solar collectors from 1990 to 2000) and to be extended to both new technologies (e.g. void heating) and new uses (e.g. space-heating). In the case of *biomass*, prospects are particularly interesting, concerning mainly new techniques and systems such as district-heating, new technologies for the production of industrial heat and/or bioelectricity, and production of biofuels. The exploitation of the remaining RES is expected to be of smaller importance. As far as the construction of *small hydroelectric* works is concerned, it is estimated that total installations will reach 34 MW in the year 2000. As for *geothermal energy*, applications for the exploitation of low enthalpy geothermal fluids are likely to be promoted, primarily in agricultural uses.

4.2. Demand-side interventions

Even though the CO_2 problem in Greece is basically a "supply side" issue, energy conservation nevertheless constitutes a high priority task which can substantially improve the system's energy and economic efficiency and reduce the emissions of CO_2 (and other greenhouse gases). In all sectors of activity, there are still numerous possibilities for profitable investments in technologies and/or products which contribute decisively to energy conservation. Previously acquired experience will serve as an additional asset and ensure the greater effectiveness of the adopted measures and elaborated policies.

4.2.1. Domestic-commercial and public sector.

Measures are focused on: (a) reduction of energy requirements by the incorporation of "passive systems" in new buildings, increase of insulation requirements in new constructions and improvement of the situation in the existing building reserve (b) rational use of all available energy sources with the introduction of new fuels and primarily of NG and (c) introduction of new technologies (increased efficiency equipment and appliances) and proper maintenance of existing ones. The realisation of all of these interventions is expected to lead to a considerable reduction in the emissions of CO_2 by the year 2000. This reduction will essentially derive from the penetration of NG in fields such as space/ water heating and even air-conditioning, as well as from the extensive use of solar heat pumps. Furthermore, drastic interventions will be carried out in the lighting sector. Finally, the maintenance of central heating boiler systems is another measure of significance.

4.2.2. Industrial sector.

The introduction of NG constitutes the most effective CO_2 abatement measure. Other previously mentioned measures, such as the reintroduction of "new technology" solar systems and the promotion of co-generation - although indubitably beneficial - will have a less tangible impact. A wide range of what are usually considered "minor improvements" can be made in the auxiliary operations of industrial units. The most important of these interventions involve the supply of steam and compressed air or even the lighting of industrial premises. Other measures, such as the improvement of space/water heating, are expected to have a smaller impact. Furthermore, there are also numerous technological interventions which can be carried out in the production procedure of all of the industrial sectors. Industries presenting the greatest abatement potential are, of course, the more energy-consuming ones, such as cement industry, metallurgy (steel and non-ferrous metals), fertilisers and sugar industry.

4.2.3. Transport

Possible interventions for reducing the CO_2 emissions can be either direct or indirect in nature. The first category includes measures targeted in priority at restricting CO_2 emissions. In the indirect measure group, the reduction in emissions, on the contrary, results from the pursuit of other objectives, mainly related to the improvement of transport services. Direct measures focus on : (a) the fuel types in use, through the promotion of more effective fuels (diesel) and the use of biofuels, (b) the vehicles in circulation, through the promotion of their systematic maintenance and the use of more economical vehicle-types. Indirect measures involve : (a) the rational management of the entire transport system (improved road network and signalling, restructuring and combined use of transport modes, changes in driver mentality and behaviour), (b) the modernisation of public transports (metro, tram, improvements in urban bus routes, etc.).

4.3. Management of biological resources.

The effective management of biological resources and systems can make a very decisive contribution to the abatement of anthropogenic CO_2 emissions. Emissions reductions can be achieved through the implementation of proposed measures such as the substitution of conventional fuels (up-grading of old and advancement of new uses for bioenergy) and the increase of the terrestrial ecosystems' annual CO_2 fixation capacity by increasing the resource reserve in existence or by reducing its rate of depletion.

4.4. Other greenhouse gases

As far as the other greenhouse gases are concerned, reductions in their emission levels are, depending on the case, to be achieved either through the same measures or through specifically devised complementary actions. Particular attention has been paid to reducing the emissions of methane, other volatile hydrocarbons and carbon monoxide. In the case of nitrous oxide and nitrogen oxides - for which accurate estimates are difficult to establish - a slight increase in emissions is anticipated, although this increase will be proportionally smaller than the one to be normally induced by the increase in vehicle numbers.

Table 4-1: Greek Action Plan - Measures in the energy sector

Measures	*Measure typology*	*Responsible organisation*	*Emission Abatement Potential up to 2000 (kt CO_2)*	*Public Expenditure (MECU)*	*Status in 1995*	
					Degree of implementation	*Administrative planning*
ELECTRICITY GENERATION			**4570**			
Natural Gas Penetration	PPC investment	Ministry for Development/PPC	4200	184	Starting	I
Co-generation/District heating	PPC investment	Ministry for Development/PPC/ Local Authorities	70		In progress	PD
Improved efficiency of Lignite	PPC investment	Ministry for Development/PPC	300		In progress	PD
RENEWABLE ENERGY SOURCES			**3267**			
Wind energy 300 MW	PPC investment Incentives to private investors	Ministry for Development/PPC Ministry for Development	1000	52	In progress In progress	D PD
Small hydroelectric Works 34 MW	Subsidies granted	Ministry for Development/PPC/ Local Authorities	221	3.5	In progress	I
Solar systems : – *conventional systems 1,300,000 m^2* – *new technology systems 200,000 m^2*	 Tax exemption Subsidies granted	 Ministry for Economics Ministry for Environment, Physical Planning & Public Works/ Ministry for Development	 939 37	 34.5	 In progress Under elaboration	 PD P
Geothermal Energy	Subsidies granted	Ministry for Development	60	3.5	In progress	PD
Biomass : – *District heating 50 MW_{th}* – *Electricity generation 80 MW_e* – *Biofuels 50 kt/y*	 Subsidies granted Subsidies granted Incentives	 Local Authorities Ministry for Development Ministry for Transportation	 60 750 100	 10 40 10	 Starting Under elaboration Under elaboration	 PD PD PD
Research and Development	Pilot projects	Ministry for Development/ General Secretariat for Energy and Technology	100	50	Under elaboration	P
INDUSTRY			**2088**	**> 153**		
Natural Gas Penetration	Incentives	Ministry for Development	720		Starting	PD
Co-generation 37.5 MW_e	Incentives	Ministry for Development	80		In progress	PD
Improvement in auxiliary operations (industrial premises, steam production, compressed air)	Regulating interventions, Information, Training	Ministry for Development/ Ministry for Environment, Physical Planning & Public Works	430		In progress	P
Interventions in energy intensive sectors	Regulating interventions, Incentives	Ministry for Development	808		In progress	P
Environmental Energy Listings	Legislative regulation	Ministry for Environment, Physical Planning & Public Works	50		Under elaboration	P

Table 4.1 : Greek Action Plan - Measures in the energy sector (continued)

Measures	*Measure typology*	*Responsible organisation*	*Emission Abatement Potential up to 2000 (kt CO_2)*	*Public Expenditure (MECU)*	*Status in 1995* *Degree of implementation*	*Administrative planning*
RESIDENCES - COMMERCE - SERVICES			**2195**			
Natural Gas Penetration	Incentives	Ministry for Development/ Ministry for Environment, Physical Planning & Public Works	1092		Starting	PD
Co-generation 11.2 MW_e	Incentives	Ministry for Development	51		Under elaboration	P
Lighting	Subsidies granted	Ministry for Development/ Ministry for Environment, Physical Planning & Public Works	470		Under elaboration	P
Street lighting	Investment	Local Authorities	239	13	In progress	P
Central boiler maintenance	Regulating interventions, Training	Ministry for Development	343		In progress	P
TRANSPORTS			**1263**			
Fuel-related interventions	Regulating interventions, Incentives		56		In progress	PD
Vehicle-related interventions	Regulating interventions, Incentives		300		In progress	PD
Interventions in the transport system	Investment, Information		470		In progress	PD
Interventions in Public Transports	Investment		437		In progress	PD
GENERAL TOTAL			**13383**			
Anticipated result			**9600**			

Administrative planning : ***I:*** Under implementation, ***D:*** Decided, ***PD:*** Planned/Pending Decision, ***P:*** Proposed

Table 4-2: Greek Action Plan - Measures for the management of biological resources and systems

Measures	*Measure typology*	*Responsible organisation*	*Emission Abatement Potential up to 2000 (kt CO_2)*	*Public Expenditure (MECU)*	*Status in 1995* *Degree of implementation*	*Administrative planning*
Acceleration of Reforestation programmes	Investment	Ministry for Agriculture	20	36	In progress	PD
Reinforcement of the Forest Resource Control Programme	Investment	Ministry for Agriculture	100	104	In progress	PD
Protection of soils from erosion	Investment	Ministry for Environment, Physical Planning & Public Works	200	130	In progress	PD
Study on the rational use of forest resources	Research	Ministry for Agriculture	10 *	150	Starting	PD
Rational use of farmlands	Information, Training	Ministry for Agriculture	100	80	Starting	PD
Support for the utilisation of agricultural by-products	Investment	Ministry for Agriculture	1470	75	In progress	PD
Support for the promotion of energy cultivations	Investment	Ministry for Agriculture	-	25	Under elaboration	P
«The role of forests and agriculture in the CO_2 balance»	Research	Ministry for Agriculture/Ministry for Development	-	15	Under elaboration	P
TOTAL			**1900**	**615**		

Administrative planning : ***I:*** Under implementation, ***D:*** Decided, ***PD:*** Planned

5. PROGRESS OF IMPLEMENTATION OF NATIONAL POLICIES AND MEASURES

5.1 Progress in legal and fiscal instruments

5.1.1. Legal and pricing policy instruments

5.1.1.1.Promotion of Renewable Energy Sources

The possibility for the exploitation of RES for electricity generation was established for the first time by ***Law 1559/85***. According to the provisions of the law, self-producers (including local authorities) consumed the greatest part of the electricity produced, while the surplus was sold to the PPC. The results obtained through the implementation of this law were not encouraging, mainly due to the following reasons :

(a) Tariffs provided by PPC for the surplus of electricity were too low (equal approximately to 1/3 of the current KWh price).
(b) The law was applicable only to self-producers and not to independent producers

These major drawbacks were altered by the establishment of ***Law 2244/94,*** which was approved in 1994, and a number of mandated complementary decrees to assist its implementation signed in 1995-1996. The main differences between this law and Law 1559/85 are [8] :

(a) Apart from “self-producers”, “independent producers” can also benefit from the provisions of the law. The electricity produced is exclusively sold to PPC.
(b) Tariffs are now favourable, especially in the non-connected grid.
(c) Long-term contracts (10-years period with the possibility of expansion) are provided.
(d) In the case of “self-producers”, the electricity produced can be transported from the production to the consumption site, via the existing PPC grid.
(e) Maximum capacity limits - affecting significantly the possibility for RES penetration, especially in the case of wind and small-hydros- are now increased.
(f) Possibility of production of electricity from small-hydros (no limitations up to 2 MW, as well as for installations up to 5 MW, provided that the latter are not included in the PPC’s 10-years Development Plan).
(g) Bureaucratic procedures are reduced.

5.1.1.2.Promotion of Cogeneration

Apart from electricity generation by the exploitation of RES, the previously mentioned Law 1559/85 and Law 2244/94 regulate issues concerning cogeneration either from RES or conventional fuels. According to the new Law 2244/94, the term "cogeneration" includes the following processes :

(A) Production of electricity and heating/cooling from conventional fuels
(B) Production of electricity by the exploitation of by-products
(C) Production of electricity by exploitation of recovered waste heat

According to the law, the capacity of CHP units of type (A) and (B) must not exceed the thermal and cooling capacity of the producer's installations. For CHP units of type (C) such a limitation does not exist. As in the case of renewable energies, the surplus of electricity produced must be sold exclusively to PPC. "Self-producers" or "independent producers" can benefit from the provisions of the law, which includes :

- More favourable tariffs.
- Withdrawal of prohibition for CHP installations in the prefecture of Attica (a region with an important potential for CHP installations) set by the Presidential Decree 84/94.
- Simpler licence procedures than the ones provided by the former Law 1559/85.
- Apart from industrial units, enterprises in the commercial sector and services (e.g. hotels, hospitals etc.) are now able to carry out investments in cogeneration.

Furthermore, specific regulations for *central CHP units* are set by the ***Ministerial Decision 8907/96*** for the bilateral agreement between PPC and third interested parties for the establishment of cogeneration stations. The provisions of the Decision include:

- lifting of limitations in the electrical and thermal capacity of such cogeneration stations
- minimum setting efficiency standards of the stations are 65% regarding electrical and thermal capacities (theoretical potentials), 60% regarding actual electrical and thermal loads on a monthly basis
- guaranteed supply of the agreed amount of electricity and power to the PPC
- provisions for the setting of prices of electricity and power sold to PPC bilaterally agreed by the two sides in each particular agreement, under a common structure of cost analysis, and
- obligation for selling all the electricity produced exclusively to PPC, while thermal energy can be sold to anyone third.

5.1.1.3.Promotion of energy efficient appliances

Legislative instruments for the promotion of energy efficient appliances can be divided in two main categories: (a) legislation setting minimum standards for energy efficiency and (b) legislation concerning energy labelling of domestic appliances.

(a) *Minimum Energy Efficiency Standards*. Such standards were set by the EU for non-industrial boilers (Directive 92/42/EC) and refrigerators and freezers (Directive 96/57/EC). Regarding the former, a harmonisation of the Greek

legislation was accomplished through the ***Presidential Decree 335/1993***, while the harmonisation to the latter is under way.

(b) *Energy Labelling of domestic appliances*. The general obligations are set by the Directive 92/75/EC (harmonisation by the ***Presidential Decree 180/1994***), while particular provisions are set for refrigerators/freezers (Directive 94/2/EC - harmonisation by the ***Ministerial Decision 26810/1994***), washing machines (Directive 95/12/EC - harmonisation by the ***Ministerial Decision 3971/96***), driers (Directive 95/13/EC - harmonisation by the ***Ministerial Decision 3971/96***) and combined washer-driers (Directive 96/60/EC - harmonisation is under way).

It should be noted that the Ministry for Development formulates specific measures regarding the safe operation and fire-protection of natural gas, LPG, cogeneration and RES installations, the promotion of energy efficient appliances/equipment and the development of a certification system for Energy Laboratories.

5.1.1.4.Reduction of energy consumption in the building sector

Recently, the Ministry for the Environment, Physical Planning and Public Works prepared an Action Plan entitled " ***Energy 2001*** ", which aims to promote the use of RES and the application of energy efficiency technologies in the building sector. The Plan was carried out in order to set the measures for the reduction of greenhouse gases emissions in the building sector - as stated in the National Action Plan - and was completed in 1995, with the participation of competent authorities, research and academic institutes, experts etc. Action focuses on five broad fields [17], namely : a) interventions in existing residential buildings b) interventions in public buildings c) interventions in traditional buildings and settlements, d) implementation of the bioclimatic design principles in new buildings and urban settlements, and e) energy installations. In particular:

1. *Existing buildings*. The following measures are foreseen :
   a) Residential dwellings : Reduction of energy losses through interventions concerning the building's components, installation of passive solar systems for space heating, installation of active solar systems for hot water purposes, space heating and cooling, interventions concerning the improvement of buildings' insulation.
   b) Public buildings and buildings of the broader public sector : Measures for the reduction of energy consumption for space heating, cooling and lighting, through insulation improvements, installation of active solar systems etc. Proposed implementation means include the mandatory establishment of bodies responsible for energy management, energy audits and studies etc.
   c) Traditional settlements : Measures such as double-glaze windows and insulation improvements will be mandatory in case of general repair. Furthermore, subsidies will be given for the installation of active solar systems for space heating, cooling and hot water.
2. *New buildings*. Among the most important interventions is the requirement for a mandatory study on the energy performance of every new building according to a number of specifications. The energy study will be combined with the issue of an "*environmental-energy identity card*", the latter forming a necessary document during the licence procedure or for selling, purchasing or renting this building. The inspection of the provisions of the above will be guaranteed by the

procedure of the "*Energy-Environmental Labelling*" of buildings, according to which every new building will be placed in a specific performance category, according to the study carried out and the results of on-site measurements and controls.

3. *Energy installations* (central heating, space heating, cooling, lighting). Measures include the mandatory control of central heating boilers in public buildings, the mandatory control of central air-conditioning systems in public buildings, offices, hotels, hospitals etc., tax exemptions for the retrofit of central heating boilers in residential dwellings in order to use natural gas, controlling devices for central heating installations, replacement of incandescent with fluorescent lamps etc.

The programme will come into force in July 1997 through a Common Ministerial Decision (Ministry for the Environment, Physical Planning and Public Works/Ministry for Development/Ministry of National Economy/ Ministry of the Interior) in agreement with the provisions of the SAVE Directive (93/76/EC) for the "*stabilisation of carbon dioxide emissions and the efficient energy use in buildings*" A Presidential Decree will follow, regulating the provision of subsidies for the whole building sector. The system will be in full operation in 1998 and it is expected that it will change significantly the energy consumers' behaviour.

5.1.2. Provision for investment subsidies

5.1.2.1.Development Law 1892/90

The Law 1892/90, (as amended by Laws 2234/94 and 2324/95) replaced the previous development law 1262/82. It foresees *inter alia* the subsidisation of industrial activities relative to energy saving, exploitation of agricultural, industrial and municipal wastes and effluents, the creation of mechanisms for energy saving, the use of solid fuels in the form of biomass and the production of energy by annual or perennial plants (energy plantations). The law also foresees the subsidisation of industries or companies for the production of electricity through the exploitation of indigenous renewable energy sources. It was the first step towards recognising the fact that this kind of investments should be subsidised as productive. Investment subsidies range from 40-55%, depending on the geographical location of the investment, while loans at reduced interest rates, tax credits and increased depreciation rates are provided.

5.1.2.2.The Operational Programme for Energy of the Ministry for Development

An Operational Programme for Energy (OPE) has been put in operation in 1996, in which funds for investments on RES and rational energy use become available. The Programme has a total budget of 946 MECU, out of which 37.5% derive from the European Commission, 29.5% from national public funds and 33% from private funds. OPE covers the time period 1994-1999 and comprises four sub-programmes:

- ***Sub-Programme 1 - Electricity generation***. The total budget is approximately 350 MECU and covers the production of electricity by lignite (measure 1.1) and

natural gas (measure 1.2). The works currently financed by this sub-programme are: a) fuel switching of two fossil-fired units of 360 MW in Keratsini by the introduction of natural gas, and b) construction of three combined-cycle gas-fired power stations in Lavrio (177 MW and 560 MW) and in Thraki (370-480 MW) .

- ***Sub-Programme 2 - Energy conservation***. This sub-programme aims at the implementation of an integrated plan for energy conservation in various sectors, mainly in the industrial and the tertiary sectors with interventions in three basic levels :
  - *Institutional, organisational and regulative level* (measure 2.1), including the improvement of the existing legal framework on the finance of investments, the organisation of the National Energy Council, the organisation of appropriate mechanisms for the inspection of energy conservation applications etc.
  - *Financial level* (measure 2.2), focusing on the provision of the necessary subsidies for the motivation of investors, as well as to other financial mechanisms, such as Third Party Financing, Technology Performance Financing and Voluntary Agreements.
  - *Technology level* (measure 2.3), including energy-audits, promotion and demonstration of new technologies for energy conservation and efficient energy use in final user groups. This measure is expected to promote significantly energy conservation measures in small and medium-size enterprises.

The implementation of the actions under this sub-programmes will result in an energy conservation of 700 ktoe on an annual basis.

- ***Sub-Programme 3 - Renewable Energies***. The sub-programme has four main targets : development of a consistent, modern and flexible legal, institutional and administrative framework (measure 3.1), the provision of appropriate financial incentives for the development of RES applications (measure 3.2), the promotion of the required technical infrastructure for the development of a local industry for RES (measure 3.3) and the assessment of the technical and economic RES potential (measure 3.4). Through this action, it is expected that the energy production from RES will reach approximately 200 ktoe yearly. It should be noted that measures 3.1, 3.3 and 3.4, as well as the measures 2.1 and 2.3 of Sub-Programme 2, aim at the development of mechanisms which will remain economic viable even after the end of OPE.
- ***Sub-Programme 4 - Support of the research activities of the Institute for Geological and Mineral Research***. This sub-programme supports the systematic research and investigation of the possibilities for the exploitation of natural resources for energy purposes and refers to four main fields : energy raw materials (measure 4.1), water resources (measure 4.2), equipment required for the implementation of measures 4.1 and 4.2 (measure 4.3) and programme for technical support and monitoring (measure 4.4).

Presently, 31 projects on energy conservation/cogeneration/substitution of conventional fuels by natural gas and 26 projects on the exploitation of renewable energies have been approved after the first call for proposals for measures 2.2 and 3.2. It is estimated that the realisation of these projects will result in an annual energy conservation of 140 Ktoe, accompanied by a respective reduction of

atmospheric pollutants emissions (1050 Kt of CO_2, 9102 Kt of SO_2 and 2087 Kt of NO_x). A call for proposals referring to measure 2.3 on the technical support of small and medium-size enterprises is expected to take place in the near future.

5.1.3. Tax exemptions

Law 2364/95, which was approved by the Parliament in 1995, promotes the distribution of natural gas that is recently being implemented in Greece. The law provides a tax exemption of 75% from the end-user purchase and installation expenses of household appliances or systems using RES or natural gas, thus re-instating previous tax exemptions for users of solar collector systems, which had lapsed.

5.1.4. Other fiscal instruments

The mechanism of Third Party Financing (TPF) - through which the economic risk of investments in the field of renewable energies, rational energy use and energy conservation is undertaken by a third party (mainly the Energy Services Company/ESCO) instead of the end-user - promotes significantly the dissemination of environmentally friendly technologies and the realisation of energy investments leading to a reduction of the consumption of conventional energy forms. An appropriate legal framework is being formulated by the Ministry for Development, while a favourable evaluation is foreseen for proposals comprising TPF schemes, which are submitted for approval within the OPE framework. Furthermore, it is planned to extend the TPF mechanism on the environmental and energy projects supported by Laws 1892/90 and 2234/94.

5.1.5. Support of R&D

According to the ***Operational Programme for Research and Technology*** (OPRT) of the Ministry for Development, a number of RES demonstration projects aiming at the application and promotion of new products are financed up to 50% of the investment.

5.2. Progress in implementation of actions

The national policies and measures (PAMs), analytically described in the 1st National communication to the FCCC, concern mainly the restriction of CO_2 emissions from the energy sector (both the supply and demand side). Measures aiming at the increase of CO_2 sequestration from the rational management of the biological resources and systems in Greece, although part of the National Action Plan, will not have any visible effects by the year 2000 given the fact that the energy sector is responsible for over 90% of greenhouse gases emissions. All national PAMs can be categorised in the following general areas:

- **Energy sector**

  - *Fuel switching*
  - *Improvements in the conventional power generation system*
  - *Promotion of renewable energy sources*
  - *Energy efficiency improvements*
  - *Transport sector interventions*

- **Forestry sector**

  - *Reforestation*
  - *Rational use of land resources*
  - *Protection of soils*

5.2.1. Energy sector

The measures for the reduction of greenhouses gases emissions in the energy sector, as stated in the Greek National Action Plan, together with their actual degree of implementation are summarised in Table 5-1. Details on the progress of each specific measure are given below.

The most important measures for the reduction of greenhouse gas emissions in the energy sector are the introduction of natural gas - that will substitute significant amounts of lignite and petroleum products in the electricity generation sector and end-use sectors - and the exploitation of renewable energies. The anticipated benefit provided from the implementation of measures in these two areas represents 70% of the overall CO_2 emissions reduction goal (i.e. 13.38 Mt CO_2) or 97% of the realistic goal (i.e. 9.6 Mt CO_2) set for up to the year 2000.

Table 5-1: Greenhouse gases abatement measures in the energy sector

Measures	*Status in 1995*		*Status in 1997*	
	Degree of implementation	*Administrative planning*	*Degree of implementation*	*Administrative planning*
PENETRATION OF NATURAL GAS				
Electricity generation	Starting	I	In progress	I
Industry	Starting	PD	In progress	D
Residences - Commerce - Services	Starting	PD	In progress	D
IMPROVEMENTS IN THE CONVENTIONAL POWER GENERATION SYSTEM				
Efficiency improvements Limitation of distribution losses	In progress	PD	In progress	PD
Combined Heat and Power Systems	In progress	PD	In progress	PD
RENEWABLE ENERGY SOURCES				
Wind energy (300 MW)	In progress	D/PD	In progress	D
Small hydroelectric Works (34 MW)	In progress	I	In progress	I
Solar systems : • *conventional systems* • *new technology systems*	 In progress Under elaboration	 PD P	 In progress Starting	 I D
Geothermal Energy	In progress	PD	In progress	D
Biomass : • *District heating (50 MWth)* • *Electricity generation (80 MWe)* • *Biofuels (50 kt/y)*	 In progress Under elaboration Under elaboration	 PD PD PD	 In progress Starting Under elaboration	 I I PD
Research & Development	Under elaboration	P	Starting	D
ENERGY EFFICIENCY IMPROVEMENTS IN INDUSTRY				
Cogeneration	In progress	PD	In progress	D
Improvements in auxiliary operations	In progress	P	In progress	D
Interventions in energy intensive sectors	In progress	P	In progress	D
Environmental Energy Listings	Under elaboration	P	Under elaboration	P
INTERVENTIONS IN THE DOMESTIC AND TERTIARY SECTORS				
Cogeneration	Under elaboration	P	Starting	D
Lighting	Under elaboration	P	Starting	I/D
Road-lighting	In progress	P	In progress	P
Central boiler maintenance	In progress	P	In progress	P
INTERVENTIONS IN THE TRANSPORTATION SECTOR				
Fuel-related interventions	In progress	PD	In progress	PD
Vehicle-related interventions	In progress	PD	In progress	PD
Interventions in the transport system	In progress	PD	In progress	I/D
Interventions in Public Transports	In progress	PD	In progress	I/D

Administrative planning : ***I***: Under implementation ***D***: Decided
PD: Planned/Pending Decision ***P***: Proposed

5.2.1.1.Penetration of natural gas

The introduction of natural gas in the national energy system is one of the largest investments to have ever been carried out in Greece. The actual cost for the NG penetration is estimated at 2 billion ECU and will be largely financed by the European Investment Bank.

According to the programme of the Public Gas Corporation (PGC), the total absorption of natural gas will reach 3.5 billion Nm^3 per year by the year 2005. Approximately 85% of this total will be imported from Russia, via Bulgaria, by pipeline, while the remaining 15% will be imported from Algeria in liquefied form.

An extended infrastructure system has been designed and is now near completion in order to carry the imported natural gas to the main consumption areas. The project consists of the following parts [11] :

1. *High Pressure Transmission System (HPTS)*
   - Main transmission pipeline (total length : 511 km)
   - High pressure branch lines (total length : 400 km)
   - Above ground installations (border station, metering and pressure regulation stations, operation and control buildings, and -in the future- a compression station)
   - LNG receiving terminal on Revithoussa island (comprising two LNG tanks 65,000 m^3 each and installations for regasification, dispatch and control)
   - Remote control and communication facilities
2. *Medium Pressure Network* (total length : about 500 km), connecting the HPTS directly to industrial customers
3. *Low Pressure Distribution System (LPDS)* in the cities of Athens, Thessaloniki, Larissa and Volos, comprising 6,500 km of pipes and the necessary metering and pressure regulation stations.

In the future, the national gas system will be extended to feed other cities as well.

The construction of the main transmission pipeline was completed in July 1995, together with the three operation and maintenance buildings. The border station and the metering/regulating stations are under construction, as well as the LNG tanks. The medium pressure network is in good construction progress in all the four consumption areas. The construction of the high pressure branch lines and the cryogenic installations on Revithoussa island has already started. Furthermore, PGC - in collaboration of SOFREGAZ - produced the basic design of the LPDSs in the cities of Athens, Thessaloniki, Larissa and Volos and has started the procedures for the construction.

Regarding the electricity generation sector, the initial tests with NG at the first PPC gas-fired power station (Keratsini) took place in May 1997 and the power plant is expected to go into operation in the summer of 1997. The second part of the pipeline that will supply natural gas to two more power stations at Lavrio (South Attica) is scheduled to be completed by the end of 1998. Furthermore, another natural gas fired station in Thraki (Northern Greece) is also expected to come on-line by the end of the year 2000. Depending on the decision on the size of the power plant in Thraki and provided that all of these projects will be completed

according to the specified timetable, it is estimated that the PPC will be in a position to absorb approximately 1.1 billion Nm^3 of natural gas by the year 2000 and 1.5 billion Nm^3 by the year 2001 [10]. The total cost - as estimated by PPC - for all the necessary infrastructure works related to the penetration of natural gas in the sector of electricity generation is 184 MECU.

Regarding industry, PGC has already formulated a pricing policy and the general terms of gas supply to industrial customers, while it started intensive contracts with the industrial sectors. Up to now, nine contracts have been signed for sale of more than 0.3 billion Nm^3/yr [11]. Negotiations with other industries are in progress. The construction of network to ensure the connection of other user categories is progressing at a satisfactory rate and a few large industrial units are already connected to the distribution network. Furthermore, 15 projects for the substitution of petroleum fuels by natural gas have been submitted for approval within the framework of law 1892/90. The investments concern pottery, steel and aluminium industry, fabricated metal products, food and paper products industry. For half of these projects, the financing procedure at the Ministry of National Economy has been completed, while for the rest is in progress.

The secondary pipelines and the city networks are to be completed by the year 2000, at which time utilisation of natural gas will be gradually extended to the numerous small users of the domestic sector. Annual consumption is expected to reach 1.0 billion Nm^3 in the industrial sector and 1.0 billion Nm^3 in the domestic and tertiary sector. 7

5.2.1.2.Improvements in the conventional power generation system

The basic principle underlying the policy in this field consists of :

- Efficiency improvements of the existing lignite fired power stations - Energy conservation
- Limitation of distribution losses by :
  - the gradual replacement of normal loss distribution transformers by limited loss transformers,
  - the construction of a third line (400 KV) between the northern and southern electric systems, and
- Promotion of CHP systems

Efficiency improvements and energy conservation

The merits of different efficiency improvement measures are currently being evaluated by PPC, including the enhancement of the operation of the cooling towers and the installation of new lignite mills for the coal-fired stations. Other technologies considered are pressurised combustion of lignite in liquefied bed units and the more promising Integrated Gasification Combined Cycle.

Furthermore, 3 energy conservation projects in PPC power stations of a total budget of 0.6 billion GRD have been approved after the first call for proposals within the framework of the Operational Programme for Energy (OPE) of the Ministry for Development.

Limitation of distribution losses

The replacement of normal loss distribution transformers and the incorporation of the new distribution line is gradually being completed. By 1995, approximately 46% of the transformers had been replaced, while the work on the remaining 54% is expected to be completed by the year 2000. The construction of the third trunk line has been delayed because of local planning difficulties that will hopefully be resolved soon with the co-ordinated action from both the Ministry for the Environment, Physical Planning and Public Works and the Ministry for Development.

Combined Heat and Power systems

PPC has initiated the implementation of a cogeneration programme in its lignite-fired plants by setting up a district-heating network in Northern Greece. Specifically :

- Medium pressure steam from the lignite-fired power station of Agios Demetrios in Northern Greece is already used for the district-heating of a part of the nearest town of Kozani (i.e. the part presenting the highest heat demand). The thermal capacity of the installation is 67 MW_{th}. With the construction of a new power unit in Agios Demetrios, the network will be expanded to 70 MW_{th} in order to cover the entire town.
- Medium pressure steam from the lignite-fired power station of Ptolemais is used for the district-heating of approximately 45% of the nearest town of Ptolemais. The thermal capacity of the installation is 50 MW_{th}.
- There is a provision for the development of a district-heating network in the town of Florina, exploiting the medium pressure heat from the lignite-fired power station of Florina that will be constructed in the near future.
- A framework has been set up for the supply of heat in the town of Amyntaio and its neighbouring communities.

Other activities

Two additional activities related to the PPC's commitments for the upgrade and improvement of the electricity system in Greece are:

1. *The undertaking of an extensive maintenance programme for all coal-fired units*. The result of this programme has been a drastic increase of the average thermal efficiency for electricity generation from 32.2% in 1990 to 34% in 1995. This figure is expected to increase further as some of the older lignite-fired units will be replaced by new units of higher efficiency, and
2. *The completion of the Energy Control Centre (ECC).* The ECC is a fully operational control room that aims at optimal utilisation of all available output from the power stations and the elimination of blackout occurrences especially during high demand periods.

5.2.1.3.Renewable energy sources

The Ministry for Development (MD) has placed the exploitation of renewable energies amongst its energy policy priorities. As was mentioned above, the Law 2244/94 and OPE promote the use of RES for the generation of electricity. These

initiatives are expected to substantially increase RES development in Greece during the next five years.

Since the publication of law 2244/94 and up to March 1997, the MD had received 135 applications for the installation of RES in Greece [13] . As shown in Table 5-2, the majority of these applications refer to the installation of wind turbines and small hydroelectric units, while there is also a smaller number of applications for biomass installations. So far, 11 installation permits have been granted for a total of 38.5 MW.

Table 5-2: Summary of applications status under Law 2244/94 by March 1997

	Applications received		***Permits granted***	
	Number	MW	Number	MW
Wind	86	520	6	35.9
Hydroelectric	42	63	3	2.2
Biomass	7	28	2	0.4

The capacity of wind and small hydropower applications submitted for approval exceeds by far the goals set by the National Action Plan for the abatement of greenhouse gases. Although the evaluation procedure is still in progress, it is clear that the enactment of the new Law on RES exploitation and cogeneration greatly stimulated the interest of private investors, especially for the most commercially mature renewable technologies.

Wind power

Following a delay in obtaining a contract with the PPC for buying the electricity produced from the exploitation of wind energy, the first installation permits according to Law 2244/94 were issued in September 1996 and it is expected that deployment will continue without further delays. Although the additional rated wind energy capacity (35.9 MW) will more than double the current electricity production figures (approximately 34 GWh in 1995) from wind power in Greece, much higher penetration rates is hoped for 2000 with a more rigorous implementation of the law. In addition, 5 projects concerning wind farm installations were approved within the framework of OPE, after the first call for proposals.

Biomass

Regarding biomass, combustion installations burning wood residues for heat production purposes were operating in 21 manufacturing units (wood industries, paper mills and lime industries) in 1995. The total amount of residues burned was 79,515 tons and the total heat production was 1166 TJ. In addition, there were 9 cotton ginning factories burning residues for heat production (18,050 tons of cotton residues, 257 TJ heat produced) [9]. Within the framework of Law 1892/90, 20 projects concerning the substitution of liquid fuels by cotton and wood residues have been submitted for approval. For half of these, the financing procedure in the Ministry of National Economy has been completed, while the for the rest is in

progress. In addition, 5 projects concerning biomass exploitation were approved within the framework of OPE, after the first call for proposals.

Thermal solar and photovoltaics

In 1995, approximately 30% of the total number of households in Greece use flat plate collectors for thermal water heating purposes, amounting to a total of 2.0 million m^2 of installed solar systems. It should be noted that this figure represents the 57% of the total surface area of solar collectors installed in the whole European Union, while the local industry accounts for 50% of the total European market. The annual energy production from these units reaches 1.2 TWh, thus reducing CO_2 emissions by approximately 1.5 Mt per annum. The internal market is estimated to grow by 120,000 m^2 per year, resulting to a total installed area of approximately 2.5 million m^2 by the year 2000.

Within the framework of OPE, 6 projects concerning the installation of central solar systems in hotels, 1 project concerning the installation of a passive solar systems in a school and 3 projects concerning PVs installations were approved, after the first call for proposals.

Regarding PVs, it should be noted that one out of the three projects approved consists of a 5 MW solar photovoltaic plant, which - when completed - will be one of the largest in Europe. The realisation of the three PV projects approved will promote the penetration of solar photovoltaic plants, that currently amount to only 235 KWp, providing 216 MWh of net electricity power [9] .

Hydropower

Apart from projects approved within the framework of Law 2244/94 (Table 5-2), 6 additional projects concerning the development of small hydroelectric works were approved within the framework of OPE, after the first call for proposals. Further substantial CO_2 reductions are also to be expected from the incorporation in the PPC programme of new hydroelectric works of more than 600 MW capacity by the year 2000. Financing for these units has been secured and, as shown in Table 5-3, their construction will be completed by the year 2000 [22] .

Table 5-3: New hydropower stations of the PPC

Plant/Unit	***Installed Capacity (MW)***	***Year of Commissioning***
Thissavros	300.0	1997
Pournari II	31.5	1997
Smokovo	10.5	1999
Platanovrissi	100.0	1999
Messohora	161.6	1999
Agia Varvara	0.6	2000

Research and development

During the period 1994-1999, the basic instrument for the formulation and implementation of the research and technology policy will be the 2nd Operational Programme for Research and Technology (OPRT II). Action for reduction of CO_2 emissions is incorporated mainly in the following programmes :

(a) *Programme EKVAN* (Research Consortia for Improving the Industrial Competitiveness) : Introduced in 1993, this programme supports collaborations between the academic and production sectors via long-term projects with substantial budget and aims.

(b) *PEPER* (Programme of Demonstration Projects) : Launched in 1995, the programme supports the promotion and implementation in Greek enterprises of new techniques and processes or the manufacturing of new products for which the research and development stage is almost completed.

(c) *The Technology Brokerage Programme* : Conceived in 1995, it aims to enhance the flow of technology between suppliers and users of technology, as well as to develop the technology market in the country and the profession of technology brokers.

Up to now, 17 projects related to RES exploitation have been included in these three Programmes and they are in progress. Furthermore, several institutes/ organisations involved in the field of RES development and energy use are currently receiving funds for improvement of their laboratories and other facilities.

5.2.1.4.Energy efficiency improvements in industry

Energy efficiency improvements in various areas of the industry sector are being promoted under the provisions of laws 1892/90 and Law 2244/94. Combined heat and power (CHP) generation has been particularly popular for application in several energy-consuming units of the industry sector, public buildings and other areas, such as the ceramics, food and textile industries. According to the latest data from PPC and the Greek Organisation for the promotion of Combined Heat and Power, industrial CHP units in Greece have reached an output of about 3% of the total electricity supply, whilst it is estimated that this figure could increase to 4% in the near future without the need for any further investments. The existing CHP units in industry [12] are shown in Table 5-4.

Table 5-4: **Existing CHP units in industry**

Industrial sector	***Installed Capacity (MW)***	***Production (1995)***	
		Electricity *(GWh)*	***Steam*** *(TJ)*
Sugar industry (5 units)	56.0	64.3	1127.5
Textile industry	13.1	39.0	820.0
Petroleum refineries (2 units)	73.0	484.3	2154.3
Petroleum extraction	16.5	70.9	513.0
Production of fertilizer	47.8	97.0	1583.2
Aluminum production	11.6	63.3	59.0
TOTAL	***218***	***818.8***	***6257***

Other activities being promoted include fuel switching from fuels with high carbon content to other less carbon intensive energy forms (natural gas, biomass) and production and combustion of biogas from landfills. Within the framework of the law 1892/90, 2 projects concerning the installation/expansion of CHP units in petroleum refineries have been approved and will be financed by the Ministry of National Economy. Within the same legal framework, 6 projects concerning energy conservation and use of exhaust gas heat in sectors such as cement and glass industry, pottery and dryers have been submitted for approval. For half of these, the financing procedure at the Ministry of National Economy has been completed, while for the rest is in progress.

In addition, within the framework of the Operational Programme for Energy (OPE), 24 projects on energy conservation, cogeneration and substitution of fossil fuels by natural gas in refineries, dryers, cement, sugar, food, electric and mechanical equipment, glass, aluminium and paper / pulp industry (total budget : 16 billion GRD) have been approved after the first call for proposals.

5.2.1.5.Interventions in the domestic and tertiary sectors

Apart from the introduction of natural gas, a major intervention in the domestic and tertiary sector in order to reduce greenhouse gases emissions is energy conservation. Increased energy conservation in the building sector will specifically result from the implementation of new legislature currently under preparation, which is expected to come into force after 1997. As mentioned above, the Ministry for the Environment, Physical Planning and Public Works has pushed forward an action plan, titled “Energy 2001” (to be introduced as a Presidential Decree) concerning policies, measures, new techniques, and incentives for energy conservation and promotion of renewable energy sources in the building construction sector. Some of the highlights of the action plan are:

- Measures for :
  - energy saving techniques
  - improvement of the efficiency and operation of the existing central heating installations
  - introduction of the principles of environmental/energy planning and promotion of the principles of bioclimatic architecture in the planning process of new buildings
- Measures for the technology dissemination and education of technicians, engineers and the general public
- Technical advise, regulations and suggestions for the promotion of certification of construction material and of new technology products
- Planning regulations related to environmental/bioclimatic planning of buildings
- Energy audits in buildings

Regarding energy conservation in the domestic and commercial sector, a programme for the replacement of incandescent by fluorescent lamps was carried out by PPC in the island of Crete in 1996. It should be noted that in Crete, as well as in many other Greek islands with a high tourist activity, electricity demand

presents a much higher rate of increase compared to the mainland. By the completion of the programme, approximately 55,000 lamps were replaced, while the initiative will be repeated this year. In addition, 3 energy conservation projects in hospitals and public services have been approved after the first call for proposals within the framework of the Operational Programme for Energy.

An important intervention for the reduction of greenhouse gas emissions in the tertiary sector is the promotion of cogeneration. Two recently commissioned pilot-demonstration CHP projects are the "Solar Village" near Athens (67 KW_e/72 KW_{th}) and a private school in Athens (320 KW_e) with combined space heating during winter and cooling during summer [12] .

5.2.1.6.Interventions in the transportation sector

Up to 2000, policies and measures in the transportation sector comprise mainly further promotion of mass transport, improvements in the road network and continuous renewal of the fleet. Although these activities are not directly related to CO_2 reductions, they are expected to have an impact on fuel consumption and engine efficiency of road vehicles.

Interventions in the transport system

The efforts of the Ministry for the Environment, Physical Planning and Public Works for the enhancement of the existing infrastructure have primarily focused on the following targets [19] :

(a) *Road grid improvements in the large urban centers*. The major part of these improvements refer to the broader Athens area. During the last three years (1994-1996), significant infrastructure works in the existing road network were carried out, while an additional 50 MECU will be spent in road grid improvements during the time period 1998-2000.

(b) *Reconstruction of the major highway road arteries*. A number of significant infrastructure works in the national highway grid is actually in progress. These works will significantly decrease energy consumption - and consequently the emissions of carbon dioxide - in the transportation sector, as they will greatly reduce the distance to several important destinations. Specifically :

- *Construction of the highway linking Patras-Athens-Thessaloniki* (total length: 730 km, total budget : 2433 MECU). This work is very important, as it will cross the country North to South and will link 5 administrative regions, 10 prefectures, 14 towns and 5 ports. Up to now, 202 km are completed, with 310 additional km to be completed by the year 2000.
- *Construction of the Egnatia highway* in Northern Greece (total length : 680 km, total budget : 2333 MECU). The work is very important for the transportation sector, as it will permit a direct access to 19 large towns in Northern Greece, 5 ports (Igoumenitsa, Thessaloniki, Volos, Kavala and Alexandroupoli), 8 airports, 10 important industrial areas. Up to now, 122 km have been completed, while 280 km are under construction.

- *Construction of the Rio-Antirrio bridge* (total budget : 733 MECU). The work will be completed by the year 2004. The work will significantly reduce the distance for transportation from Peloponnese to Central and Northern Greece. It should be noted that on an annual basis, approximately 2 million vehicles - out of which 25% are buses and trucks - and 6 million passengers cross this sea-channel. The average time for crossing the channel (now around 45 minutes) will be reduced to 5 minutes at most.
- *Undersea highway of Maliakos Gulf* (total budget : 333 MECU). The new highway will reduce the traveling distance by 44 km, compared to the existing road grid. The work will be completed by the year 2002.
- *Construction of the Stavros-Elefsina highway* (total length : 70 km, total budget : 1667 MECU). The work will be completed by the year 2002 and will link the west part of Attica with the new airport of Spata, which is under construction, without the need to cross the town of Athens.

(c) *Improvements in the traffic-lights system*. Within the framework of the programme «Attica SOS» (an on-going programme developed in 1994 by the Ministry for the Environment, Physical Planning and Public Works in order to tackle the serious environmental problems in the Attica region), improvement works in four major road arteries of Athens have been carried out. In addition, a computerized system for the control of the traffic-lights system in the center of Pireus area has been completed. Additional works are in progress in the town of Thessaloniki, within the framework of the programme «Thessaloniki SOS» (an initiative similar to the one for the region of Attica).

Interventions in Public Transport

Interventions in Public Transports include mainly the following measures [14,15,18] :

(a) *Construction of metro lines*. Two new metro lines will supplement the already existing Athens underground service. Up to now, approximately 60% of the work has been completed and full operation is expected by the year 2001.

(b) *Improvements in the existing Athens' metro-line*. Additional wagons have been included in the existing traffic lines, increasing the transportation capacity during peak hours by 15%, to reduce car traffic.

(c) *Efficiency improvements of buses*. In Athens, up to 1995, old buses were replaced by 614 new low-polluting ones. It is expected that by 1998, approximately 1000 more new buses will be purchased.

(d) *Interventions in the traffic network of buses*. In the greater Athens area, a re-organisation of the bus traffic network has started by the development of five main central-lines and subsequent local lines. By these intervention measures, the number of vehicle-km has been reduced. Further works will be carried out within the next years. Furthermore, bus lanes in major road arteries in Athens are already in operation, while additional works are also in progress. The bus traffic network will be further improved by the re-design of traffic lines. Relevant technical studies are in progress.

(e) *Restrictions in the use of private cars in urban areas*. The entrance of private cars in the commercial centre of Athens is now prohibited. This measure resulted in a significant improvement of traffic conditions and - in combination with the circulation of flexible mini-buses - promoted the use of public transportation means. In combination to the existing and planned interventions in the field of parking policy, it is expected that the use of private cars in urban centres will be further discouraged.

(f) *Improvements in the Athens' suburban railway network*. This measure includes the improvement of railway stations, the provision of vehicles, the renewal of traffic-lights and the development of park-and-ride stations. Required funds will be supplied by the Ministry for the Environment, Physical Planning and Public Works, the National Railway Organisation and the Regional Operational Programme for Attica. The work is in progress.

(g) *Reconstruction of the national railway network*. The "Railway" Operational Plan is financed by the Community Support Framework 1994-1999 with a total budget of 490.1 MECU. The Plan includes the following sub-programmes:

- Improvements in the railway line of Athens-Thessaloniki-Edomeni (this line has been included in the High Speed European Network)
- Provision of railway material and maintenance installations
- Improvements in the rest of the railway lines grid
- Connection with the port of Kavala, in Northern Greece

During the time period 1994-1995, the progress of the work was very satisfactory.

Furthermore, additional works are financed by the Cohesion Fund with a total budget of 497.4 MECU, including the construction of two supplementary railway lines, enlargement of existing railway lines, electrification of the Pireus-Athens-Thessaloniki railway line. The above mentioned works will facilitate a shift of goods and passengers transportation from gasoline and diesel vehicles to railway.

Interventions in vehicles

Measures taken by the Ministry for Transportation include mandatory periodic overall check controls (every 2 years) and annual renewal of the Exhaust Control Card (ECC) for all road vehicles [15] . The establishment of the ECC leads to a reduction of exhaust emissions, higher performance of the engine and fuel conservation.

5.2.2. Agriculture and Forestry

The measures for the reduction of greenhouse gases emissions from agriculture and forestry, as stated in the National Action Plan, together with their actual degree of implementation, are summarised in Table 5-5. Details on specific measure are given below.

Table 5-5: Greenhouse gases abatement measures in agriculture and forestry

Measures	*Status in 1995*		*Status in 1997*	
	Degree of implementation	*Administrative planning*	*Degree of implementation*	*Administrative planning*
Acceleration of Reforestation programmes	In progress	PD	In progress	D
Reinforcement of the Forest Resource Control Programme	In progress	PD	In progress	D
Protection of soils from erosion	In progress	PD	In progress	PD
Study on the rational use of forest resources	Starting	PD	Starting	PD
Rational use of farmlands	Starting	PD	Starting	PD
Support for the utilisation of agricultural by-products	In progress	PD	In progress	PD
Support for the promotion of energy cultivations	Under elaboration	P	Under elaboration	P
«The role of forests and agriculture in the CO_2 balance»	Under elaboration	P	Under elaboration	P

Administrative planning : ***D***: Decided,
PD: Planned/Pending Decision, ***P***: Proposed

Although no significant progress is discernible in this very important sector, a number of structural changes and improvements in the Forestry Service have been put in place which are necessary for the implementation of the reforestation programme. Actions to be carried out comprise :

a) reforestation with coniferous and deciduous species, giving priority to species resistant in forest fires,
b) construction and improvement of forest roads,
c) construction of small-size works in mountainous areas facilitating access to forests, and
d) construction and improvement of buildings used by the Forestry Service for the inspection of forest fires.

Regarding the reinforcement of the Forest Resource Control Programme (i.e. the control of forest fires), the implementation of this measure is in progress and it is expected that the trend observed during the last years (i.e. every 3-4 years, forest fires are more than triple the annual average), resulting in a significant loss of forest land will be altered.

As for the protection of soils from erosion, there has been some progress in works carried out, especially in areas where forest fires occurred during the period 1992-1995. Regarding the rational use of farmlands (i.e. setting-aside of arable land for non-agricultural use), it is expected that by the implementation of the EU Directive

92/2078 more than 2500 ha of agricultural land will be set-aside. Finally, as for N_2O, it is expected that the implementation of the EU Directive 91/676 on the reduction of pollution of surface and ground water from nitrates will lead to the decrease of N-fertilisers used in agriculture.

6. ADAPTATION MEASURES

6.1. Nature conservation

Within the context of the EU Directive 92/43 "Natura 2000", an integrated programme on the management and conservation of natural ecosystems has been developed by the Ministry for the Environment. The programme is included in the Operational Plan for the Environment (OPENV) and financed by the 2nd Community Support Framework. It comprises the formulation and establishment of management plans in important biotopes and protected areas (areas protected under the Ramsar Convention, National Forests, Marine Parks, other biotopes included in the "Natura 2000" network), as well as the necessary works for the creation of infrastructure for environmental protection in the areas in question. Plans include the definition of the spatial limits for each protected area, the formulation of a consistent set of management actions and operational rules, as well as the determination of the appropriate management body for each area.

Actually, 27 similar projects in marine parks, waterlands and mountainous areas, of a total budget of approximately 32 MECU are financed under measures 3.2 (Development of infrastructure for the conservation and protection of important national biotopes) and 3.3 (Development of infrastructure for the management and protection of biotopes, natural systems and soils - Implementation of the sustainable development principle) of OPENV. It should be noted also under the latter measure 3.3, a project concerning the protection of soils from erosion in three coastal areas is being financed.

6.2. Coastal Zone Management and Water Management

According to the national environmental policy on the environmentally sound development of sensitive zones (coastal areas, biotopes, forests etc.), rules and restrictions regarding the possible land uses within these zones are determined by Specific Planning Studies, which are implemented through relevant Presidential Decrees. Within the context of the ENVIREG Programme for the protection and development of coastal areas, 13 similar studies concerning coastal areas in islands, as well as in the mainland, were financed. Actually, these studies are at the final stage of completion. Furthermore, within the context of OPENV (measure 4.1 on spatial planning), additional Specific Planning Studies, as well as the development of a national regulative framework for coastal areas, are currently being financed.

In addition, within the context of OPENV, a project concerning the installation of Gaw stations and stations for the measurement of sea level changes, is being financed.

6.3. Research

The Ministry for the Environment, Physical Planning and Public Works supported (under the 2nd Community Support Framework of the EU) :

a) a research study entitled "Assessment of the impact of emissions of CO_2 and other greenhouse gases to climatic changes". The main objective of this work was to define the requirements for the development of a network, which by monitoring a wide range of climatic parameters will allow the recognition of the impacts of climate change onto the natural and anthropogenic environment in Greece

b) a research study for the development of monitoring stations GAW (Global Atmospheric Watch) and stations for monitoring sea level changes.

7. EDUCATION, TRAINING AND PUBLIC AWARENESS

7.1. Education

Greece participates in the GLOBE Programme (Global Learning and Observations to Benefit the Environment). GLOBE is implemented in Greece under the auspices of the Ministry for the Environment, Physical Planning and Public Works and the Ministry of National Education, while the University of Athens has the scientific and technical responsibility for the Programme. During the first year of implementation of the Programme in Greece (which was given the name GLOBE/ALEXANDROS), 24 schools were included in the network. These schools reflect a wide geographic coverage of Greece and all levels of education.

Within GLOBE/ALEXANDROS students can enhance their education through involvement in scientifically valid research. The goals of the Programme are:

- to enhance the environmental awareness of individuals at national and international level,
- to contribute to the scientific understanding of the Earth's environment and
- to help all students reach higher levels of achievement in science and mathematics.

A first assessment of the progress showed that the Programme succeeded in motivating teachers and students. The programme's success resulted in several schools to apply for becoming members of the GLOBE/ALEXANDROS network.

7.2. Environmental information

The access to environmental information in Greece will be significantly facilitated through the development of the National Network of Environmental Information (NNEI), a project which is financed by the 2nd Community Support Framework for the Environment. The target of the project is to support the formulation of national environmental policy and to promptly provide reliable data on the environmental quality in Greece to the European Environmental Agency (EEA). Within this general framework, a computer network connecting the central administration with regions and including environmental information provided by the major Greek environmental organisations is actually under development. The network will also be connected to the EEA network.

During the first phase of the project, 3 regions and 5 prefectures were connected with central computer stations in Athens. Databases and a GIS system have been incorporated to the network, while certain pilot software programmes for data input have been developed. The second phase of the project, at the end of which the network will be expanded to cover all regions and prefectures in Greece, is financed by OPENV with a total budget of approximately 9.2 MECU.

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8. EMISSIONS PROJECTIONS

Growth rate variations in societal and economic sectors are closely related to the energy demand and supply. As discussed in Chapter 3, in Greece, energy related activities are responsible for 84% of the global greenhouse gases emitted each year. In 1995, carbon dioxide emissions from the energy sector accounted for approximately 96% of this total, thus making this gas the largest contributor to the greenhouse effect. It is clear, therefore, that the development of energy policy is of paramount importance in the trend of future emissions of greenhouse gases.

This chapter gives an overview of emissions estimates for Greece up to and beyond the year 2000. These estimates are primarily based on the forecast of energy demand that in turn is related to societal and economic trends and macro-economic prospects.

8.1. Emissions for the year 2000

As shown in Figure 8.1, for the period 1991-1995, CO_2 emissions are within the limits set by the National Action Plan. In 1995, the cumulative increase compared to the 1990 levels, was 7% against 8.6% and 5.8% of the pessimistic and optimistic scenarios, respectively. This, however, is not principally the result of the national PAMs described in the previous chapters, but is primarily attributed to:

a) past efforts of the PPC for the improvement of the combustion efficiency of its lignite-fired stations and
b) the decrease in the energy demand of manufacturing units due to the recession of the industrial sector in the first five years of the 90s.

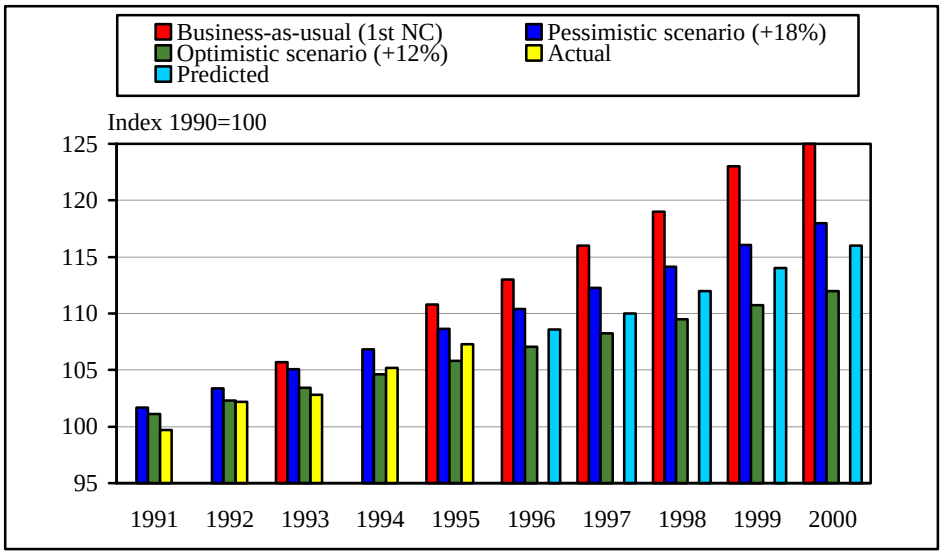

Figure 8.1: Trends of CO_2 emissions up to the year 2000

The upward tendency of the CO_2 emissions in the following years is expected to remain relatively unchanged mostly because of the following reasons:

a) very high increases in electricity demand (estimated to be 4% per annum up to 2000),
b) increased energy needs of the industrial sector, whose output has exhibited encouraging signs of recovery during the latter part of 1996, and
c) expected increase, at current rates, of the energy demand by the other economic sectors, without any tendency for stabilisation before the year 2000.

Despite these developments for future energy demand, it should be emphasised that the implementation of the PAMs discussed in the previous chapter (particularly natural gas penetration, energy efficiency improvements and augmented use of renewables), will significantly curtail the emissions up to the year 2000. As far as electricity demand is concerned, the actual amount of CO_2 increase will depend on the means for meeting this demand. It is expected that the utilisation of the lignite units will be maximal, given their substantially lower operating cost. Still, the projected intense use of natural gas, which will be utilised for electricity generation in 1997/1998, will keep the cumulative increase within bounds. Provided that the implementation process of the National Action Plan will follow closely the time schedule set for the period 1997-2000, for all sectors concerned, the final increase is expected to be approximately 16% compared to 1990 levels, a level well within the target set by the Greek government.

8.2. Emissions up to the year 2010

A number of forecasts for the period after 2000 are available for Greece. We focus here on the prediction of final energy demand as the means to compute the emissions of CO_2 from the energy sector, since they typically account for over 90% of the total emissions both in Greece and in the EU as a whole. The estimates presented in this section refer to the following five scenarios:

1. Business-As-Usual (BAU)
2. Conventional Wisdom (CW)
3. Forum (FO)
4. Current Trends (CT)
5. Effects of the Community Support Framework (ECSF)

The first three scenarios were extracted from the work of Kapros et al. [6] utilising MIDAS 5.1, (the scenarios were developed by the EC DG-XVII for the prediction of future energy and economic trends in all EU member states). The fourth scenario is based on current trends of energy demand and the anticipated GDP growth according to the provisions of the cohesion programme and the official predictions of the Greek government. The last scenario, [7], emphasises the macroeconomic approach resulting in final energy demand from which the expected emissions have been computed. This latter model takes into account the effects that the 2nd Community Support Framework is likely to have on the Greek economy.

Forecasts of the final energy demand and CO_2 emissions for all five scenarios are presented in Table 8-1. It should be emphasised that in order to enable the comparison between all five scenarios, the emissions for BAU, CW and FO have

been recalculated by using the same emission factors as those for the other two scenarios. Therefore, the figures presented in Table 8-1 may be different than those reported in [6].

Table 8-1: Final energy demand and CO_2 emissions for the five scenarios

	2000	2005	2010
Final Energy Demand (in Mtoe)			
BAU		19.35	21.69
CW	16.46	17.41	18.65
FO	15.41	16.08	17.49
CT	17.64	18.73	19.60
ECSF	17.20	19.71	22.89
CO_2 Emissions (in Mt)			
BAU	95.90	102.49	113.42
CW	89.12	92.09	97.68
FO	81.00	83.00	80.16
CT	101.31	121.82	145.18
ECSF	95.59	110.20	127.80

A comparison of the final energy demand and CO_2 emissions for the five models is presented in Figure 8.2 and Figure 8.3.

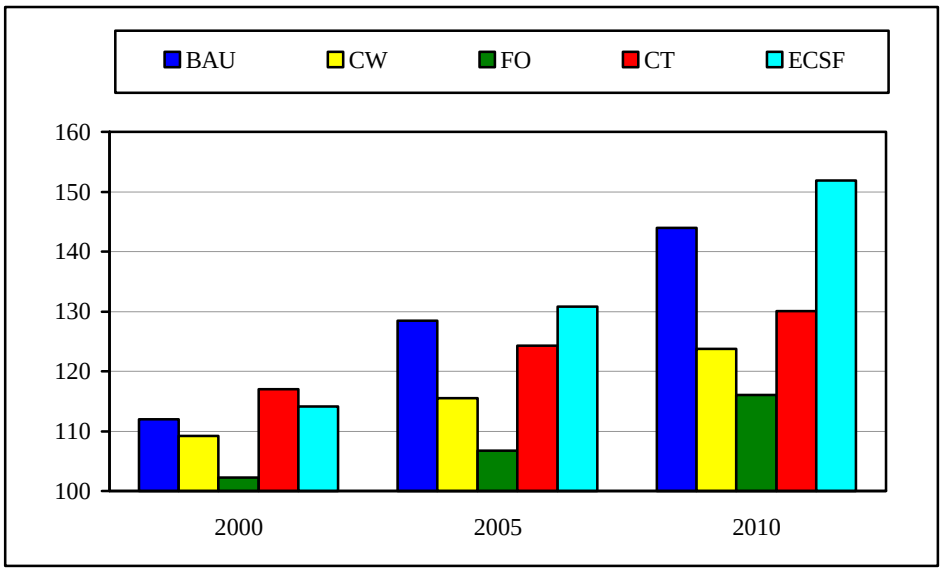

Figure 8.2: Index of final energy demand for the five scenarios (1990=100)

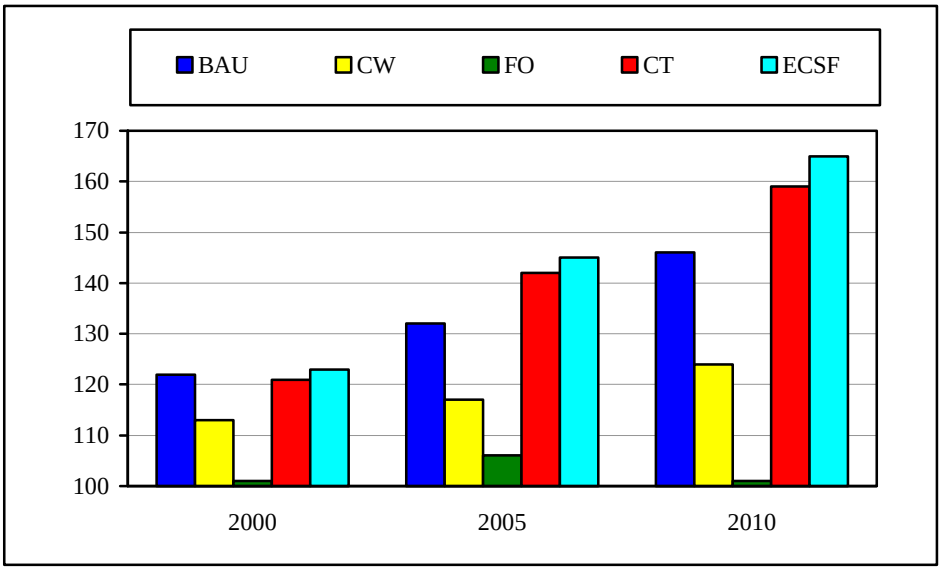

Figure 8.3: Index of CO_2 emissions for the five scenarios (1990=100)

As shown in the above figures, there is a large discrepancy between the forecasts of the five scenarios, which, for the CO_2 emissions in 2010, range from +65% to +2% compared to 1990 levels. These arise from the differing assumptions for the growth of the economy, the energy system developments and the fuel mix used for the meeting of the energy demand.

For the period after 2000, the Greek Government has reaffirmed its desire to continue its efforts to curtail further greenhouse emissions. Having considered that the adopted targets should be demonstrably reachable from the financial-technical point of view, acceptable socially and in step with overall national constraints and international obligations, the Greek Government has stated its intention to restrict the national increases of CO_2 emissions between 2000 and 2010 to a level of 13%. This level is considerably lower than the no-action option and of the same level as the Conventional Wisdom scenario, which incorporates a number of current programs and policies such as: natural gas penetration, efficiency improvements and use of all available clean technologies.

The major instruments to be applied towards this goal are the following (in order of priority):

1. Increased use of natural gas in electricity generation with the construction of at least 2 new power stations in northern Greece, modification of existing power plants to include topping cycles and introduction of new clean coal technologies.
2. Energy conservation measures in the transport sector focusing on mass transport, improved road grid, continuous renewal of the fleet and improvements in communications assisting decentralization of private and especially state services.
3. Increased energy conservation in the building sector specifically resulting from the implementation of new legislature currently under preparation.
4. Continuing emphasis on renewable energy sources utilisation

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