# FOREWORD

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# TABLE OF CONTENTS

## FIGURES

# TABLES

# 0 EXECUTIVE SUMMARY

## 0.1 National Circumstances

### *0.1.1 Government structure*

The Constitution of 1975, as revised in 1986 and in 2000, defines the political system of Greece as a Parliamentary Democracy with the President being the head of state. The legislative power is vested in the national parliament, comprising 300 members, elected by direct, secret, universal ballot and its term is four years. Parliament deals with legislative work (i.e. the right to propose legislation lies within the Parliament and the Government), while it controls the Government and administration in general.

At the top administrative level is the national government, with ministers appointed by the prime minister. The ministries mainly prepare and implement national laws. The Ministry for the Environment, Physical Planning and Public Works (MEPPPW) is main body concerned with the development and implementation of environmental policy in Greece. MEPPPW is responsible for the co-ordination of climate change activities, while other ministries are responsible for integrating environmental policy targets and the National Action Plan on Climate Change (NAPCC) within their respective fields. The Council of Ministers is responsible for the final approval of policies and measures related to climate change mitigation.

### *0.1.2 Population*

According to the preliminary results of the Census of March 2001, as provided by the National Statistical Service of Greece, the total population of the country is approximately 10.96 million inhabitants, with 35% of total population living in the greater Athens area. Compared to the 1991 Census results, the total population increased by 6.6%. Population density, estimated at 84 inhabitants/km$^2$, is one of the lowest in the European Union.

### *0.1.3 Geographic and climate profile*

Greece has a total area of 131,957 km$^2$ and occupies the southernmost extension of the Balkan Peninsula. The mainland accounts for 80% of the land area, with the remaining 20% divided among nearly 3,000 islands. The Greek landscape, with its extensive coastline, exceeding 15,000 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.

Greece has a Mediterranean climate, with mild, wet winters and hot, dry summers. The average temperature during summer is approximately 28°C in Athens and southern Greece, while lower in the north. In general, temperatures are higher in the southern part of the country. Except for a few thunderstorms, rainfall is rare from June to August, and days are dry and sunny, a typical characteristic of the Mediterranean climate. Summers in the lowlands are hot and dry with clear skies. Dry hot days are often relieved by a system of seasonal breezes. The average annual temperature, as measured in the various meteorological stations of the country, presents an increase in 1998 compared with both the average annual temperature for the time period 1981 – 1990, as well as with the average annual temperature in 1997. In general, the 1990s was the warmest decade of the 20$^{th}$ century in Greece.

### 0.1.4 Economic profile

In January 1st, 2001, Greece became the 12th member of the Euro-zone. In 2002, the Gross Domestic Product (GDP) increased by 3.8% compared to 2001 (the respective increase at EU-15 level was 0.9%) and amounted to 140,249 million €. Inflation (on a 12-month basis) reached 3.6% in 2001, percentage that deviates by 1.4% from the average figure of the Euro-zone. In 2001, the balance of the general government, for the first time, became a surplus, being equal to 0.1% of the GDP and it further increased to 0.4% in 2002. The ratio of public debt to GDP decreased continuously during the recent years and reached to 99.6% in 2001.

Due to the implementation of the Stability and Growth Programme, the Geek economy has presented a strong growth performance that has outpaced that of the EU as a whole. As a result, the GDP per capita in Greece reached 68.2% of the EU average in 2002, while the labour productivity increased from 73.6% of the EU average in 1994 to 84.9% of the EU average in 2002.

### 0.1.5 The Greek energy system

The total gross inland consumption in Greece has been continuously increasing, during the period 1990 – 2000, with only exception the years, 1993 and 1999. In 2000, gross inland consumption reached a total of approximately 28.5 Mtoe, presenting an increase of approximately 27% compared to 1990 level. Despite this increase, however, the average annual growth rate in the period 1990 -2000 was reduced to approximately 2.4% per year, compared to 3.3% in the 80s.

During the period 1990-2000, oil and coal products have retained the lion's share of the total energy supply. The only significant change in the Greek energy system recorded in the last decade was the introduction of natural gas in 1997, which represents the 6% of gross inland consumption in 2000. The contribution of renewable energy sources (RES), including large hydro, varies from 4.5% to 6.3% following the fluctuations of large hydropower plants. Excluding large hydro, the share of renewable energy sources increases from 3.7% in 1990 to 4.1% in 2000.

The electricity generation system in Greece consists of thermal and hydroelectric units as well as a very small percentage of other renewables. In 2000, the total installed capacity of the Public Power Corporation (PPC) generating system was 11.1 GW, resulting in an increase of 27% approximately compared to 1990 levels, while the net electrical capacity of auto-producers in 1999 was 282 MW. Electricity generation has been steadily increasing at an average annual rate of approximately 4.4% in the period 1990-2000. Gross electricity production in 2000 totalled in 53.7 TWh, of which 64% and 17% came from the combustion of coal and petroleum products, respectively, 8% from hydropower, 11% from natural gas and 1% from other (except large hydro) renewable energy sources.

Final energy demand in Greece in 2000 totalled 18.9 Mtoe, of which 24% was used in industry, 39% for transportation and 37% by the residential and tertiary sector. The mean annual increase rate for the period 1990-2000 is estimated at 2.5%. The per capita final energy consumption has increased by 20% from 1990 to 2000 (1.45 and 1.74 toe/cap respectively), while the respective figure at EU-level is estimated at 9% (from 2.54 toe/cap in 1990 to 2.78 toe/cap in 2000).

All three sectors have increased their energy use from 1990 to 2000, with residential and tertiary presenting the most significant increase by 44% in 2000 compared to 1990, followed by

transportation with an increase of 24% and industry with 16%. This resulted in a total increase of 28% between 1990 and 2000.

### *0.1.6 Waste*

For the time period 1990-2000, the total produced wastes show a consecutive increase, while only minor changes are recorded regarding the composition of wastes. While in 1990 the total produced wastes were approximately 3.1 Mt, in 2000 this amount became 4.4 Mt. In 2000, managed waste disposal on land represented 52.4% of the total, while the respective percentage for 1990 was 41.7%. The total recycled wastes show an increasing trend (290 thousand tones in 1990 to 330 thousand tones in 2000), while the recycling percentage for managed waste reduced from 9.4% in 1990 to 7.6% in 2000.

## 0.2 Greenhouse gas inventory information

Emissions estimates were calculated according to the CORINAIR methodology and the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The implementation of the IPCC Good Practice Guidance is in progress. Base year emissions are calculated using 1990 as the base year for carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$), and 1995 for fluorinated gases (F-gases-Hydrofluorocarbns, HFCs / Perfluorocarbns, PFCs / Sulphur hexafluoride, $SF_6$).

An overview of GHG emissions for the time period 1990–2000 is presented in **Table 0.1**.

**Table 0.1** Greenhouse gases emissions for the period 1990–2000 (in kt CO2 eq)

| Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 85586 | 84610 | 87672 | 87268 | 88627 | 87273 | 90045 | 94380 | 101784 | 98698 | 107818 |
| $CH_4$ | 8743 | 8705 | 9007 | 9106 | 9362 | 9494 | 9811 | 9922 | 10439 | 10410 | 10562 |
| $N_2O$ | 10622 | 10520 | 10468 | 10144 | 10258 | 9899 | 10338 | 10625 | 10634 | 10418 | 10979 |
| F-gases | 1193 | 1364 | 1161 | 1791 | 2303 | 3452 | 3988 | 4360 | 4257 | 4288 | 4429 |
| **Total** | **106143** | **105199** | **108307** | **108308** | **110550** | **110119** | **114182** | **119287** | **127113** | **123814** | **133788** |
| Index (Base year = 100) | 97.9 | 97.0 | 99.9 | 99.9 | 102.0 | 101.6 | 105.3 | 110.0 | 117.3 | 114.2 | 123.4 |

- Carbon dioxide, methane and nitrous oxide emissions had increased by 23% over the time period 1990–2000, and as a result the target set in the "Hellenic Action Plan for the Abatement of CO2 and other Greenhouse Gas Emissions" was not achieved.
- The total increase of emissions regarding the 6 greenhouse gases covered by the Kyoto Protocol to the UNFCCC was 23.4% compared to base year emissions. This increase is mainly attributed to the large number of forest fires in 2000, which was three times above the average of the period 1990–1999.
- Carbon dioxide emissions accounted for 80.6% of total GHG emissions in Greece in 2000, while CH4 and N2O emissions accounted for 7.9% and 8.2% of total emissions respectively. F-gases emissions were still low (3.3%) but are expected to grow rapidly over the next few years.

- As far as the sectoral contributions are concerned, energy-related activities were the largest source of GHG emissions for the year 2000 (77.9%). These include CO2 emissions from the combustion of fossil fuels (95%), CH4 from production, storage, distribution and combustion of fossil fuels (1.5%), and N2O (3.5%). The other sectors, namely, agriculture (7.9%), industrial processes (9.9%), waste (4.1%) and solvent use (0.1%) accounted for the remaining 22.1% of emissions.

GHG emissions trends are mainly driven by economic development (**Figure 0.1**). Moreover, and given the fact that energy is the main source of GHG emissions for the period 1990 - 2000, gross inland consumption (GIC) and emissions follow the same pattern, with emissions showing a slightly lower mean annual rate of increase.

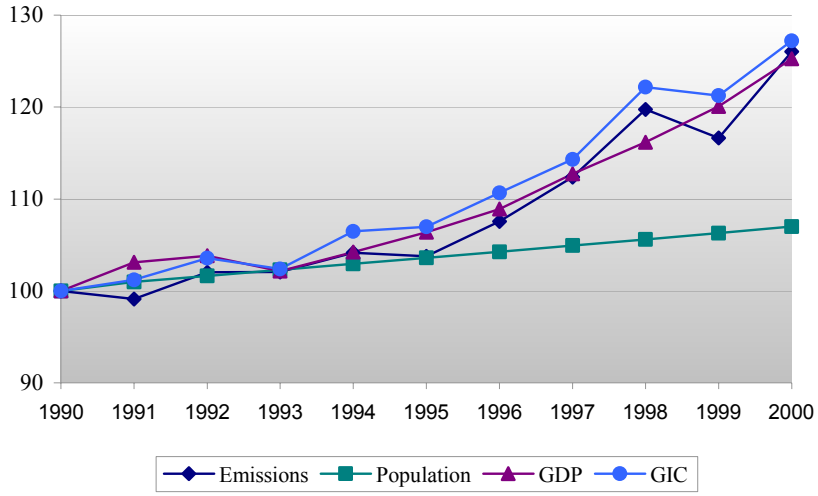


**Figure 0.1** Factors underlying GHG emissions trends

## 0.3 Policies and Measures

The Ministry for the Environment, Physical Planning and Public Works is initially responsible for environmental legislation and policy development, while other ministries are responsible for integrating environmental policy targets and the National Action Plan on Climate Change (NAPCC) within their respective fields. Final approval of policies and measures related to climate change mitigation rests with the Council of Ministers.

In 1995 Greece developed the "Hellenic Action Plan for the Abatement of $CO_2$ and other Greenhouse Gas Emissions". The plan's objective was to restrict the increase of emissions, regarding a basket of three GHG ($CO_2$, $N_2O$ and $CH_4$) from all sources**,** of 2000 to no more than 15%±3% from 1990 level. The margin of 3% was adopted to allow for unpredictable domestic or international developments and relevant EU policy actions. Measures defined in this Plan, as well as policies introduced since 1995 and until 1997, are described in the 2nd National Communication to the UNFCCC. The above-mentioned policies and measures together with those included in the "with measures" scenario are considered as either implemented or adopted.

The effect of these policies and measures on GHG emissions is estimated at 5.3 Mt $CO_2$ eq in 2000 and 16.4 Mt $CO_2$ eq in 2005.

Although policies and measures related to Land Use change and Forestry are considered as implemented or adopted, the quantification of their effects is not possible. As a result, and in relation to the projection of GHG emissions, it is assumed that forest fires will remain at the levels observed in the 1990s.

The second national climate change programme, adopted in May 2002, defines the additional policies and measures to be undertaken in order to ensure compliance with the target set in the framework of the Kyoto Protocol. The implementation of this plan presupposes that all necessary arrangements in the legislative and administrative frameworks will be in place and the infrastructure needed will be ready. The operational programmes formulated within the 3rd Community Support Framework (CSF) are expected to provide the basis upon which the climate change action plan will be implemented, since sustainability and compliance with all international commitments are some of the guiding principles adopted for their formulation.

The main actions foreseen in the programme include:

- Further penetration of natural gas in all final demand sectors including cogeneration
- Promotion of renewable energy sources for electricity generation and heat production
- Energy conservation in the industrial and residential–tertiary sectors
- Promotion of energy-efficient appliances/equipment in the residential–tertiary sectors
- Structural changes in agriculture and the chemical industry
- Transport and waste-management options

The effect of the planned policies and measures on GHG emissions is estimated at 3.4 Mt $CO_2$ eq in 2005 and 12.3 Mt $CO_2$ eq in 2010.

## 0.4 Projection of emissions

The "with measures" scenario indicates that emissions will be 35.8% and 56.4% above base-year levels[1] (108.4 Mt $CO_2$ eq) by 2010 and 2020, respectively. The energy sector accounts for more than 75% of total greenhouse-gases emissions while carbon dioxide emissions account for more than 80% of total emissions (**Table 0.2**). However, f-gases emissions are estimated to increase with a mean annual rate more than 4 times higher than that of total emissions for the time period 2000–2020 (5.1% for the f-gases compared to 1.2% for total emissions).

As a result of additional policies and measures set out in the 2nd climate change national programme, the increase of GHG emissions in Greece could be restricted to 24.5% by 2010, compared to base-year levels (**Table 0.3**).

[1] 1990 has been used as the base year for $CO_2$, $CH_4$ and $N_2O$. 1995 has been used as the base year for HFCs, PFCs and $SF_6$.

**Table 0.2** Projections of greenhouse gases emissions in the "with measures" scenario, disaggregated by gas, kt CO2 eq

| Gas | Base year | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Carbon dioxide | 85586 | 85586 | 87273 | 107818 | 111961 | 120817 | 128947 | 136834 |
| Methane | 8743 | 8743 | 9493 | 10562 | 9395 | 7936 | 8040 | 9283 |
| Nitrous oxide | 10624 | 10624 | 9900 | 10979 | 10909 | 11148 | 11285 | 11430 |
| HFCs | 3369 | 935 | 3369 | 4281 | 5022 | 7158 | 9626 | 11842 |
| PFCs | 83 | 258 | 83 | 148 | 148 | 148 | 148 | 148 |
| SF6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Σύνολο** | **108405** | **106146** | **110118** | **133788** | **137436** | **147207** | **158046** | **169537** |
| Change from base year levels | ***100*** | ***97.9*** | ***101.6*** | ***123.4*** | ***126.8*** | ***135.8*** | ***145.8*** | ***156.4*** |

**Table 0.3** Projections of greenhouse gases emissions in the "with measures" and the "with additional measures" scenarios, disaggregated by sector, kt CO2 eq

| Sources / Sinks | 1990 | 1995 | 2000 | 2005 | | 2010 | |
|---|---|---|---|---|---|---|---|
| | | | | With measures | With additional measures | With measures | With additional measures |
| Energy | 80789 | 84386 | 101062 | 107787 | *104441* | 116890 | *109404* |
| Industrial processes | 9591 | 11725 | 12874 | 13667 | *13667* | 15899 | *11248* |
| Solvents | 177 | 156 | 169 | 173 | *173* | 177 | *177* |
| Agriculture | 10448 | 9737 | 10227 | 9736 | *9702* | 9668 | *9604* |
| LUCF | 1391 | -307 | 4138 | 2030 | *2030* | 2030 | *2030* |
| Waste | 3749 | 4422 | 5319 | 4042 | *4016* | 2542 | *2473* |
| **Total** | **106145** | **110120** | **133789** | **137435** | ***134029*** | **147206** | ***134936*** |
| Change from base-year levels | ***97.9*** | ***101.6*** | ***123.4*** | ***126.8*** | ***123.6*** | ***135.8*** | ***124.5*** |

Two main model types/procedures have been used for scenarios development and projections.

- Economic-technical model (ENPEP) for the energy sector (energy supply and use—fugitive emissions).
- Spreadsheet models for the non-energy sectors, in which future changes in activity data are mainly derived from statistical analysis, while emission factors are derived from expert assessments based on the IPCC/CORINAIR methodology.

The main assumptions made for the projection of energy consumption and associated GHG emissions in the "with measures" scenario are presented in **Table 0.4.**

**Table 0.4** Main assumptions in the "with measures scenario"

| | Historic | | | Projected | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 1995 | 2000 | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2020 |
| Population (mio) | 10.16 | 10.53 | 10.87 | 0.5% | 0.4% | 0.3% | 0.2% |
| Household size (cap/hh) | 3.21 | 3.14 | 3.06 | 2.97 | 2.87 | 2.78 | 2.68 |
| GDP (bil. Euro 2000) | 96.6 | 102.8 | 121.0 | 4.4% | 3.4% | 3.0% | 2.9% |
| International fuel prices | | | | | | | |
| Coal ($90/t) | *51.3* | *40.6* | *28.5* | | *31.2* | | |
| Oil ($90/bbl) | *22.2* | *17.2* | *22.8* | *-7.7%* | *0.0%* | *0.8%* | *3.1%* |
| Natural gas ($90/toe) | *119.1* | *92.5* | *90.1* | *-7.7%* | *0.0%* | *0.8%* | *3.1%* |
| Transport activity | | | | | | | |
| Passenger transport (bil. p-km) | 96.5 | 124.3 | 151.4 | 3.3% | 2.3% | 1.7% | 1.0% |
| Goods transport (bil. t-km) | 84.8 | 94.3 | 106.0 | 2.6% | 2.3% | 2.1% | 1.9% |

## 0.5 Vulnerability assessment, climate change impacts and adaptation measures

### *0.5.1 Climate change impacts*

According to the records of several stations in Greece and Eastern Mediterranean, it seems that there was not a gradually warming during the 20th century, which may be correlated to the general warming observed in the globe as well as in Europe. The particularly rapid warming observed since 1977 constitutes an exception to the general trend. There is, however, a distinct negative trend in precipitation appeared up to the early 1990's in southeastern Mediterranean and Greece in contrast to positive trend observed in north Europe. In conclusion, climate change in the area of Greece tends to be harmonized, even if it is partially differentiated, with the general globally warming trends

The long-term predictions of climatic models for Mediterranean region are alarming. All model simulations agree that the temperature in Greece will increase in the range of 1°C to 2°C by the year 2030, despite the conflicting estimations of the magnitude of this increase. Concerning the future precipitation regime most of model estimations offer conflicting evidence over how precipitation may change over the area. There are serious indications, however, for a remarkably decline in summer precipitation over the Mediterranean region as a whole.

### *0.5.2 Adaptation measures*

Combating climate change is one of the priorities of the National Strategy for Sustainable Development. Other issues included in the National Strategy are:

- Reduction of air pollution
- Waste management
- Rational use of water resources

- Prevention of desertification
- Protection of biodiversity and natural ecosystems

## 0.6 Financial Resources and transfer of technology

Greece contributed US$5.5 million to the 2nd replenishment of the GEF covering the time period 1998–2001, while the contribution of Greece to the 3rd replenishment, covering the period 2003–2006, will be US$4.50 million (5.73 million €).

Greek contributions to multilateral financial institutions are given as regular payments and as support for specific projects or programmes. Funding supplied to these institutions totalled US$27.65 million over the time period 1997–2000 (**Table 0.5**). Funding on an annual basis is more or less consistent but one has to bear in mind that the time period coincided with a period in which Greece was pursuing tight macro-economic policies in order to meet the conditions for joining the Euro-zone.

**Table 0.5** Financial contributions to multilateral institutions and programmes

| Institution or Programme | Contributions (millions US dollars) | | | |
|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 |
| World Bank | 4.23 | 3.00 | 3.36 | 3.20 |
| International Finance Corporation | 0.00 | 0.00 | 1.00 | 0.00 |
| European Bank for Reconstruction and Development | 1.20 | 2.05 | 2.40 | 2.06 |
| United Nations Development Programme | 0.26 | 0.47 | 0.23 | 0.19 |
| United Nations Environment Programme | 0.05 | 0.03 | 0.21 | 0.49 |
| UNFCCC | 0.06 | 0.03 | 0.08 | 0.08 |
| Other | 0.56 | 1.30 | 0.59 | 0.52 |

Since 1996, Greece's net bilateral ODA disbursements have quadrupled, from US$27 million to US$99 million. In 2000, Greece's total net ODA disbursements were US$226 million, or 0.20% of its gross national income (GNI), almost reaching the DAC average of 0.22%. The Ministry for Environment, Physical Planning and Public Works is responsible for bilateral assistance in environmental issues. Since 1999 (starting date of the bilateral development programme of the ministry), 7 projects in the field of climate change have been funded. Six of them are related to capacity building for climate change mitigation in Balkan counties (see Chapter 7.3), while the 7th one is related to the development of technological infrastructure for the protection of water resources due to climate change oriented pressures in Cyprus. The total budget of these projects is €1.2 million.

## 0.7 Research and systematic observation

### *0.7.1 Research*

Research in Greece is carried out at research centers and universities, and in industry. Its monies come from public funds provided by the Greek government and the European Commission and from private funds in industry, foundations and other business enterprises. In 1999 (the last official data available), the overall amount spent for research was 0.68% of GDP (0.52% Greek state funds, 0.16% private funds).

Climate-related research is carried out in 2 of the national research centers, the National Observatory of Athens (NOA) and the National Center for Marine Research. (NCMR). In addition, the majority of Greek universities conduct meteorological and climatological research covering a wide range of subjects, as does a small group in the Academy of Athens. Finally, the National Agricultural Research Foundation of the Ministry of Agriculture carries out research on the impact of climate change to agricultural activity.

Recently, in 2001, the GSRT provided funds to the National Observatory of Athens for improving its modelling capability for both short-term prediction capability (3–5 days) and longer-term climatic forecasts (3–6 months). NOA is currently running, in an operational mode, 2 mesoscale models for weather forecasting, which are being altered for medium-length climatic forecasts (6 month). NOA has also implemented and is currently evaluating 2 additional regional climate models.

### *0.7.2 Systematic observation*

Systematic observations of parameters that register or affect climate and its change are carried out by a number of ministries and agencies, research centers, academic institutions and private enterprises. Chief amongst them are the Hellenic National Meteorological Service (HNMS), services of the Greek Armed Forces, the Ministry of Environment, Physical Planning and Public Works and the Ministry of Agriculture. The networks cover all areas of Greece, including a number of islands in the Aegean, Ionian and eastern Mediterranean seas. In addition, the Public Power Corporation of Greece operates 8 air quality stations near its power plants that monitor all standard air pollutants (SO2, NOx, O3, TSP) but also CO2 and meteorological parameters. The National Center for Marine Research (NCMR) is the chief organization charged with the collection of marine data from the seas surrounding Greece.

The National Observatory of Athens has recently installed a station in a remote location on top of Mount Helmos (2,350m above MSL), which has no local sources nearby, to initiate measurements of $CO_2$ and other greenhouse gases as well as climatological parameters.

Greece is a member EUMETSAT, the consortium that operates the meteorological monitoring satellite METEOSAT. It is also a member of and an active personnel supplier to the ECMWF effort. In both these international efforts, Greece is represented by the HNMS.

## 0.8 Education and public awareness

It is irrefutable that action on climate change will have a favourable outcome only when it becomes known and understood by the public. This can be accomplished with intensive programmes of education, awareness and training at all levels. Greece has proceeded in a series of actions concerning education and information.

Greece participates in several international programmes concerning environmental education for students, while environmental education has been introduced as a specific course mainly to the Educational Faculties of universities. Moreover, the Ministry of Education and Religious Affairs has incorporated into its planning the establishment of 20 Centres of Environmental Education situated all over the country. To date, 17 Centres of Environmental Education are in operation. Services at these centres include: (a) offering special programmes of environmental education to groups of students, (b) organizing training seminars to teachers and other interested population groups, (c) publishing tutorial material, (d) coordinating networks of Environmental Education and (e) cooperating with the regional administration, universities and environmental organisations at the national and international level.

Although climate change issues have been a concern to non-governmental organisations (NGOs) since the 1980s, it is only in the mid-1990s, when the Greek government ratified the UNFCCC and began enforcing laws for the promotion of RES, that NGOs became more actively involved.

However, in most cases the involvement of NGOs on climate change issues and especially those issues related to energy policy is not of a systematic nature (long term involvement, the undertaking of campaigns, submissions of proposals, etc.), and it is restricted to the provision of basic information to a small audience.

The National Centre for Environment and Sustainable Development (NCESD) was established in 2000, under the supervision of the Ministry of Environment, Physical Planning and Public Works, with the intended purpose of assisting the processing of environmental policies. In general the involvement of NCESD in environmental-policy issues is related to (a) the collection, evaluation, diffusion and updating of environmental information, (b) the development of a network of all entities involved in environmental awareness (c) the fulfilment of Greece's international commitments concerning issues of environmental awareness and education (RIO+10, Olympic games, etc.) and (d) the submission of specific proposals to decisions centers, aiming to the promotion of environmental awareness and education and consolidation of their positive results.

Finally, the completion of the National Network of Environmental Information (NNEI), funded by the 2nd CSF, is expected to facilitate the access to information concerning environmental quality.

# 1 NATIONAL CIRCUMSTANCES

This chapter includes a short description of Greece's government structure, and geographical, climate, population, and economic profiles of the country. In addition, this chapter presents the basic elements constituting Greece's actual energy profile, together with a brief analysis of past trends in energy supply and demand.

## 1.1 Government structure

The Constitution of 1975, as revised in 1986 and in 2000, defines the political system of Greece as a parliamentary democracy with the president being the head of state. Legislative power is vested in the national parliament, which comprises 300 members, each elected by direct, secret, and universal ballot. The parliament's term is four years. The parliament deals with legislative work (i.e. the right to propose legislation lies within the parliament and the government), while it controls the government and national administration in general. At the top administrative level is the national government, with ministers appointed by the prime minister. The ministries mainly prepare and implement national laws.

At the next level are 13 administrative regions (**Figure 1.1**), each headed by a secretary general who is appointed by the Council of Ministers and who reports to the minister of the interior. The primary responsibility of the regional authorities is the development and implementation of regional economic-development plans. Such plans are financed by the Ministry of Economy and Finance. Below the 13 administrative regions, are 50 prefectures. Regional authorities coordinate the activities of the prefectures in its jurisdiction. A prefect directly elected for a four-year term, heads each of the 50 prefectures.

An additional administrative level, below the prefectures, comprises local authorities: 900 municipalities (with population greater than 10,000 people) and 133 communities, each governed by a directly elected mayor and council. A 1997 major reform of municipalities (**Law 2539/97**) resulted in a reduction of the number of municipalities and communities from 6,350 to its current total of 1,033. This reform was accompanied by the decentralisation of certain government responsibilities, including some environmental management duties (licensing procedures, waste management, etc.).

The Ministry for the Environment, Physical Planning and Public Works (MEPPPW) is the main governmental body concerned with the development and implementation of environmental policy in Greece. To this end, the ministry works in collaboration with the regions, prefectures and local authorities. The ministry's responsibilities include developing government guidelines and policies concerning the environment, and then managing and coordinating their implementation and enforcement.

MEPPPW is responsible for the coordination of climate change activities, while other ministries are responsible for integrating environmental policy targets and the National Action Plan on Climate Change (NAPCC) within their respective fields. The Council of Ministers is responsible for the final approval of all policies and measures related to climate change mitigation.

Policies and measures, as well as all other issues and actions regarding mitigation are discussed within the framework of an inter-ministerial committee, comprising representatives from the following ministries/organisations:

- Ministry for the Environment, Physical Planning and Public Works
- Ministry of Foreign Affairs
- Ministry of the Interior, Public Administration and Decentralisation
- Ministry of Economy and Finance
- Ministry for Development
- Ministry of Mercantile Marine
- Ministry of Transport and Communications
- Ministry of Agriculture
- Public Power Corporation

This committee is responsible for the initial formulation of policy, as well as for the monitoring, evaluation and modification/completion of the NAPCC.

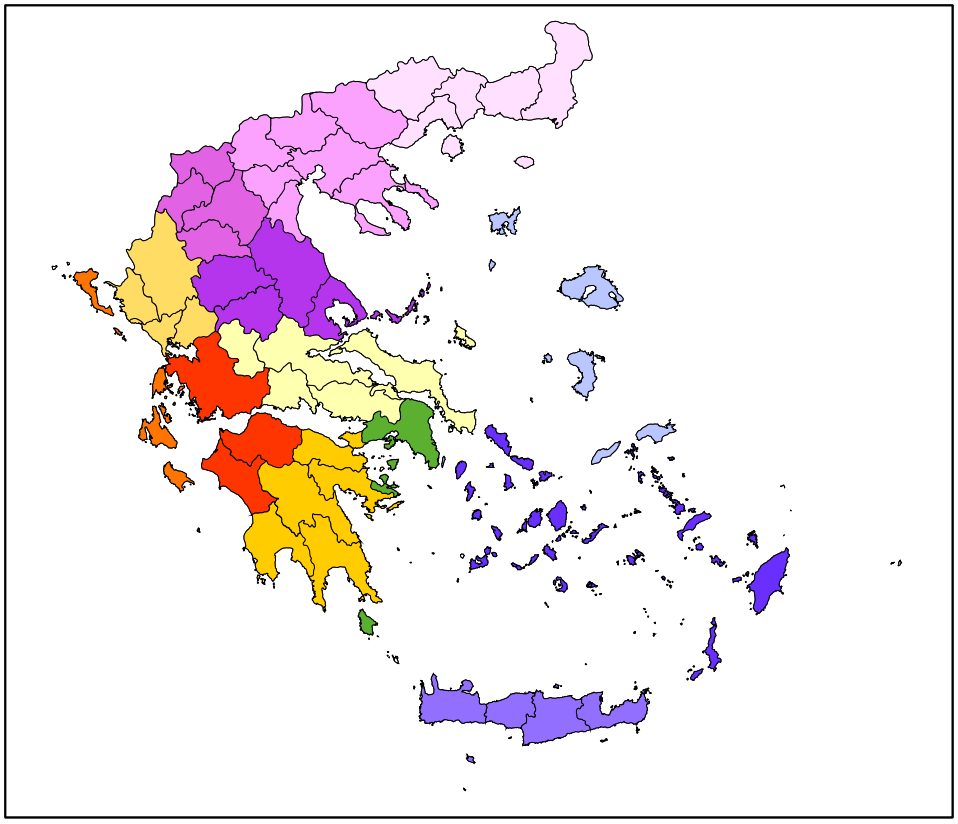

**Figure 1.1** Major administrative regions of Greece

## 1.2 Population

In 1998, the total population of Greece was approximately 10.51 million. According to the preliminary results of the Census of March 2001, as provided by the National Statistical Service of Greece [1], the total population is approximately 10.96 million, with 35% of total population living in the greater Athens area. Compared to the 1991 Census results, the total population increased by 6.6%. The population of Greece according to the census from 1920 to 2001 is presented in **Figure 1.2.**

Population density in Greece is estimated to be 84 inhabitants/km$^2$, one of the lowest in the European Union (EU).

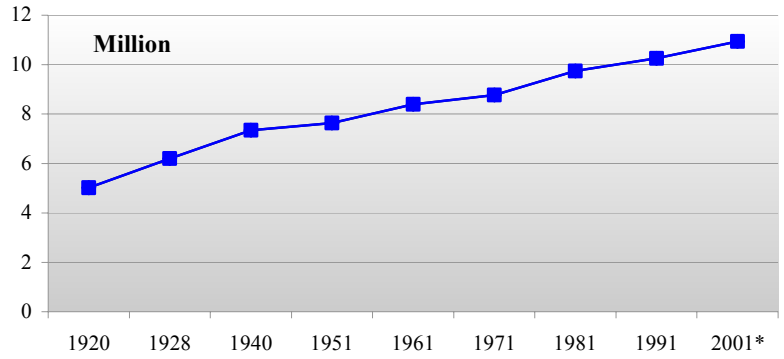


**Figure 1.2** Population of Greece (*: *preliminary results*)

## 1.3 Geographic profile

Greece has a total area of 131,957 km$^2$ and occupies the southernmost extension of the Balkan Peninsula. The mainland accounts for 80% of the land area, with the remaining 20% divided among nearly 3,000 islands. The Greek geography is closely linked with the sea. Its extensive coastline exceeds 15,000 km in length, and 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 river mouths.

According to the data provided by the Forestry Service and the National Statistical Service, forests of coniferous and broadleaf trees cover approximately 19% of the total area of Greece (**Figure 1.3).**

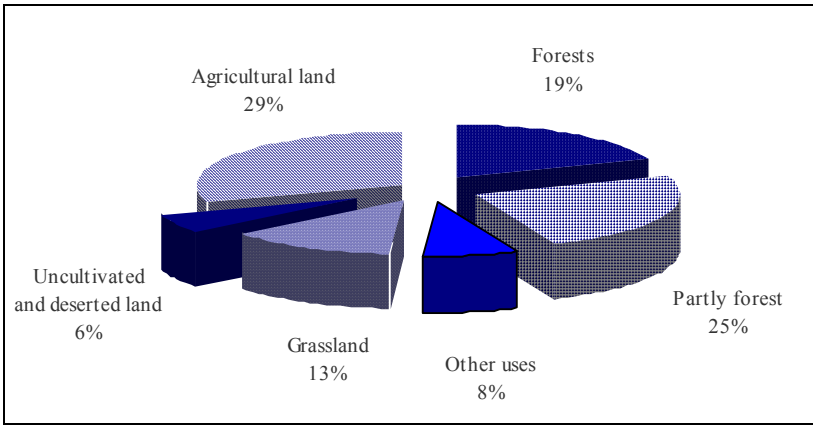


**Figure 1.3** Distribution of the area of Greece by land cover category

Partly forested areas and grasslands important conifers are fir, black pine, Aleppo and Brutia pines, Scots pine, and spruce. Important broadleaves include various species of deciduous oaks and beech, especially in the north, cover 38% of the total area (4.9 Mha) and are mostly used for grazing by sheep, goats and cattle. Agricultural land occupies approximately 30% of the total area. Other uses account for 8% of the total area, including in areas occupied by brushwood, alpine areas and internal waterways. Uncultivated and deserted land makes up the remaining 6%.

## 1.4 Climate profile

Greece has a Mediterranean climate, with mild, wet winters and hot, dry summers. In general, temperatures are higher in the southern part of the country. The average summer temperature in Athens and southern Greece is roughly 28°C, while lower in the north. Summers in the lowlands are hot and dry with clear skies. Except for a few thunderstorms, rainfall is rare from June to August. The dry, hot weather is often relieved by a system of seasonal breezes.

As shown in **Figure 1.4,** the average annual temperature, as measured at the various meteorological stations of the country, increased in 1998 compared to both the average annual temperature for the time period 1981–1990, as well as with the average annual temperature in 1997 [2]. In general, the 1990s was the warmest decade of the 20th century in Greece.

Winters are mild in the south, much colder in the north. The average winter temperature in Athens and southern Greece is approximately 11°C, while lower in the north. January is generally the coldest month. Below-freezing temperatures and snow occur mainly in the mountains. Winters are mild in the lowlands with rare frost and snow. Rainfall occurs mostly between October and March. **Figure 1.5** presents total precipitation (in mm), as measured from various meteorological stations of Greece, for the time period 1981–1990 and for the years 1997 and 1998 [2].

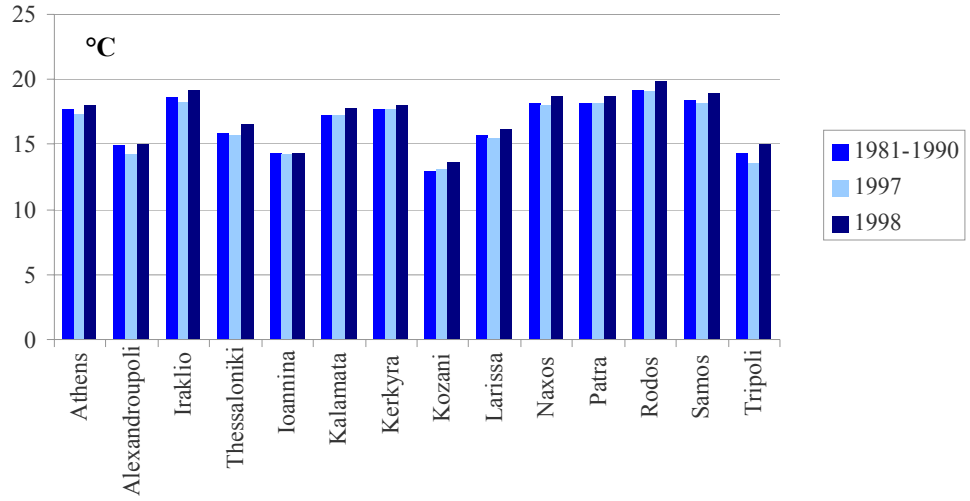


**Figure 1.4** Mean annual temperature (in ˚C) at various meteorological stations

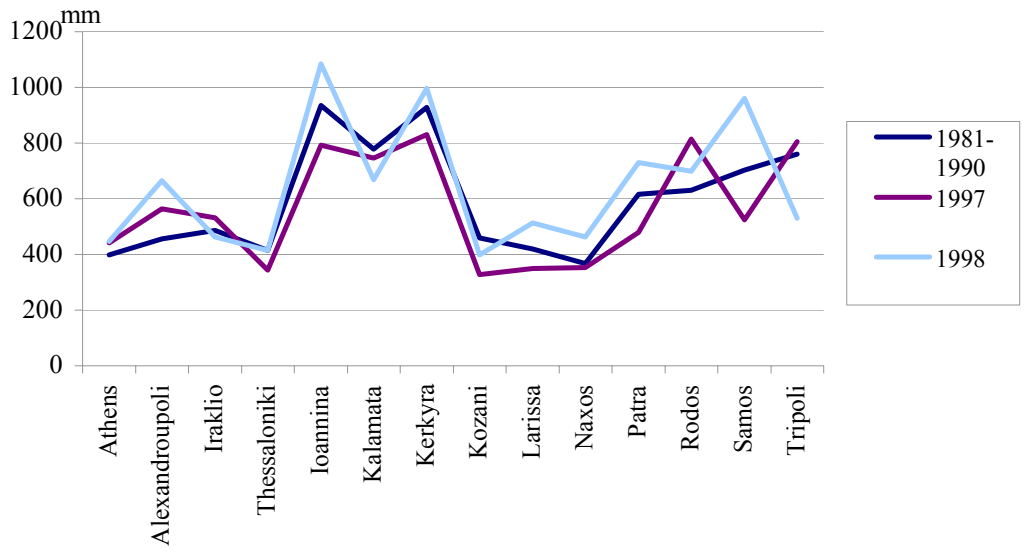


**Figure 1.5** Total precipitation height (mm) at various meteorological stations

## 1.5 Economic profile

In January 1st, 2001, Greece became the 12th member of the Euro-zone. In 2002, the Gross Domestic Product (GDP) increased by 3.8% compared to 2001 (the respective increase at EU-15 level was 0.9%) and amounted to 140,249 million €. Inflation (on a 12-month basis) reached 3.6% in 2001, percentage that deviates by 1.4% from the average figure of the Euro-zone. In

2001, the balance of the general government, for the first time, became a surplus, being equal to 0.1% of the GDP and it further increased to 0.4% in 2002. The ratio of public debt to GDP decreased continuously during the recent years and reached to 99.6% in 2001.

The main objective of the governmental economic policy is to maintain the conditions of macroeconomic stability and to continue the strengthening of structural changes, so that Greece achieves real convergence with the other countries of the European Union.

### 1.5.1 Development of the Gross Domestic Product

Although the annual growth of the GDP during the last decade (1991–2001) was much higher than that of the population (2.4% and 0.6%, respectively), Greece remains one of the countries with the lowest GDP per capita in the EU. The GDP per capita in Greece was 12,134 € in 2001, corresponding to 71% of the relevant figure for the EU-15.

The annual rate of increase of the GDP during the time period 1971–1980 was approximately 5.9% but dropped to 0.7% during the time period 1981–1990. During the time period 1991–2001, the annual rate of increase of the GDP was 2.4%. The last year that the GDP showed a decrease compared to the previous year was 1993 (GDP decreased by 1.6% compared to the previous year). For the time period 1994–2001, the Greek economy showed consecutive rates of growth that are higher than the average for EU-15 (3.3% for Greece, and 2.6% for EU-15).

**Table 1.1** Gross Domestic Product - percentage of change from the previous year (in constant prices)

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Greece | 0.0 | 3.1 | 0.7 | -1.6 | 2.0 | 2.1 | 2.4 | 3.5 | 3.1 | 3.4 | 4.3 | 4.6 |
| EU-15 | 2.9 | 1.7 | 1.2 | -0.4 | 2.8 | 2.4 | 1.6 | 2.5 | 2.7 | 2.5 | 3.4 | 2.8 |

The contribution of the primary, secondary and tertiary sectors to the total GDP is shown in **Figure 1.6**. In 2001, the primary sector's contribution represented 8% of the total GDP, a decrease from 9.9% in 1995. The contribution of the secondary sector for the time period 1995–2001 remained more or less stable (approximately 22% of the total GDP), while the tertiary sector's contribution increased from 67.7 % to 70% over the same time period [4]. The average annual rate of change in the primary, secondary and tertiary sectors during the time period 1995–2001 was –0.03%, 3.2% and 4.1%, respectively. These rates, as well as the structure of the GDP, have changed significantly compared to previous decades. It should be noted that the contribution of the primary sector to the total GDP in 1980 was 14.5%, a percentage that decreased to 8% in 2001 (note: the relevant share in 2001 for EU-15 was 2%).

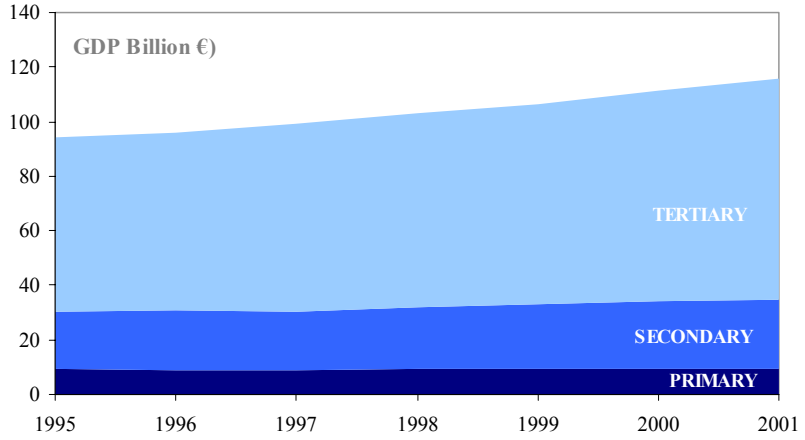


**Figure 1.6** Contribution of economic sectors to GDP (1995–2001)

The average annual rate of change in agriculture, industry and construction recorded during the time period 1995–2000 was 0.7%, 1.7% and 4.8%, respectively (**Figure 1.7**). During the same time period, transport/communications, electricity/gas/water supply, mining, commerce, tourism (hotels, restaurants) and rest services followed an annual rate of increase of 10%, 4.9%, 2.5%, 5%, 3.4% and 2.4%, respectively [5].

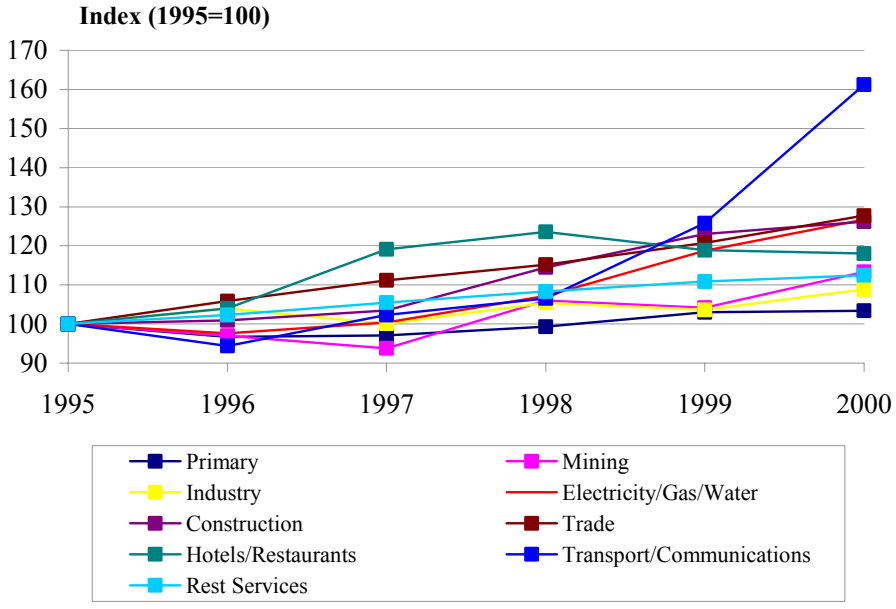


**Figure 1.7** Development of value added per economic activity

### 1.5.2 Imports-Exports

In 2000, the value of exports of goods increased by 12% (calculated at constant 1995 prices) compared to the previous year (4.2 billion GRD in 2000, expressed in current prices). On the other hand, the value of imports in 2000 showed an increase by 15.7% compared to the previous year (8.5 billion GRD in 2000, expressed in current prices) [4].

The majority of imports come from EU countries (approximately 59% of total imports' value in 2000), while this share was higher in 1999 (i.e. approximately 69%). The rest come from Asia (19% and 13% in 2000 and 1999, respectively), European countries outside EU (13% and 10% in 2000 and 1999, respectively), United States (5% and 6.5% in 2000 and 1999, respectively), Africa (3% and 2% in 2000 and 1999, respectively) and Oceania/other countries (19% and 13% in 2000 and 1999, respectively) [6].

Regarding exports, again EU countries represent the main destination (43.5% of total exports' value in 2000, compared to 54% in 1999), followed by European countries outside EU (30.5%), Oceania and Asia (13%), United States (8%) and rest of the world (5%) [6]. Following the revised Standard International Trade Classification, manufactured goods classified mainly by raw material and miscellaneous industrial goods represented the major share of total exports in 2000 (36%), followed by mineral fuels and lubricants (14.6%), machinery and transport equipment (11.5%) and chemicals (8%) [6].

Regarding imports, machinery and transport equipment represent the major share (36%), followed by chemicals (17%), food and animals (13%) and miscellaneous industrial goods (12.5%) [6].

### 1.5.3 Agriculture

The total agricultural area in Greece is approximately 3.6 million ha, more than half of which is on relatively steep slopes on which cultivation is carried out without protection against soil erosion. No significant changes took place during the time period 1990–1998 regarding fallow land (**Figure 1.8**). During the same time period, the share of irrigated land increased from 30% of the total agricultural land in 1990 to 37% in 1998)

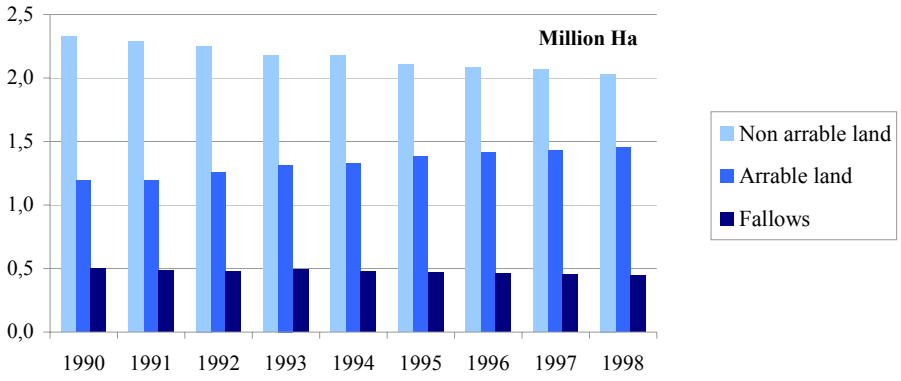


**Figure 1.8** Total agricultural and irrigated land (1990–1998)

**Figure 1.9** presents the distribution of agricultural land by basic categories of use for the year 1999. It should be noted that crops on arable land represent approximately 55% of the total agricultural land, while the share of permanent crops is approximately 28% and of grasslands and pastures 17% [8].

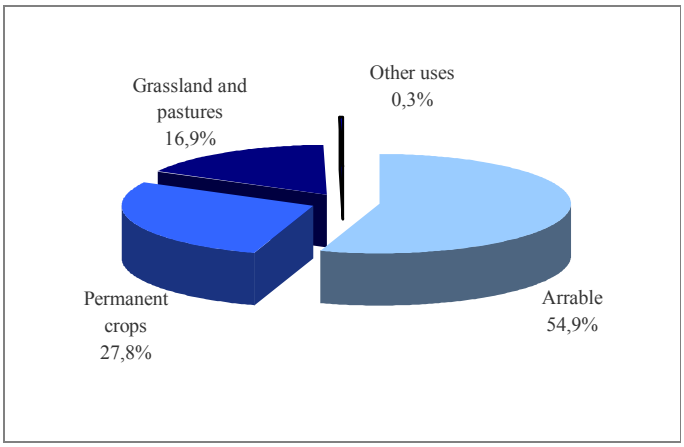


**Figure 1.9** Total agricultural land by type of use for the year 1999

The comparison between the data for 1999 and the ones of the census of 1991 [7] shows a 13.2% decrease in the number of exploitations on arable lands coinciding, while their respective total area increased by 3.3%. The number of exploitations on permanent crops increased by 2.6%, as did their total area, by 1.3%. Therefore, there is an increase by 19% of the average size of exploitations on arable lands and a decrease of the average size of exploitations on permanent crops by 1.2%. The number of exploitations on grasslands and pastures decreased significantly (by 27.2%), while their respective total area decreased to a lesser extent (by 8.1%).

In terms of acreage, the most important crops are cereals for grain (37% of the total), trees (27%) and industrial crops (15%). Modest amounts of synthetic nitrogen fertilisers are used in Greek agriculture and rates vary with the type of crop (crops on arable land: 32–250 kg N/ha, vegetables: 120–215 kg N/ha, tree crops: 23–62 kg N/ha) [9]. In 2000, the total consumption of synthetic nitrogen reduced by 24% compared to 1990, while the amount of nitrogen applied to soils was 377,000 tonnes, representing an 11.5% decrease compared to 1990 levels.

Regarding employment, in 1999 agriculture involved approximately 2.8 million employees. Of these, 1.4 million are proprietors of agricultural exploitations, 1.3 million are workers on a temporary basis and the rest are permanent workers. During the period 1991–1999, the total number of employees in agriculture remained more or less stable (increasing by merely 0.5%). However, the number of proprietors of agricultural exploitations occupied in the sector decreased significantly (by 9%), while the number of temporal and permanent workers increased (by 27% and 71%, respectively) [8].

The GDP from agriculture displays fluctuations during the period 1995–2001. During 1995–1997, there was an average annual rate of decrease by 1.4% (calculations on constant 1995 prices) [4]. During 1998–2000, however, GDP from agriculture followed an upward trend (average annual rate of increase by 2%). Then in 2001 it decreased again (by 3.5% compared to 1999, on constant 1995 prices). Among the major problems of the Greek agriculture are high

production costs and land fragmentation into small and scattered fields. In 2001, agriculture contributed 8% to the total GDP.

In 1999, livestock population comprised approximately 16 million animals (cattle: 5%, sheep: 55%, goats: 33%, horses/mules/asses: 1%, pigs: 6%) and approximately 40 million laying hens and other poultry [8]. These figures, compared to those of the 1991 census, show that the total livestock (excluding hens and poultry) remained practically unchanged during the time period 1991–1999 (decreasing by merely 0.04%). The number of cattle increased (by 8%), the number of sheep remained unchanged, and the number of the other animals decreased [7, 8]. The time period 1991–1999 saw a decrease in the number of all types of livestock exploitations except for pigs breeding (which increased by 12%). The sector with the biggest decrease was that of cattle breeding (decreasing by approximately 70%), followed by goats and sheep breeding (decreasing by 32% and 20%, respectively). Consequently, the average size of cattle exploitations doubled (from 11% in 1991 to 23% in 2000), and an increase by 51% and 32% was recorded for the size of goats and sheep exploitation, respectively. In contrast, the average size of pigs exploitations decreased by approximately 11% during the last decade [8].

### 1.5.4 Forestry

Closed forests cover less than 20% of the total country area, being a relatively small percentage considering that more than 70% of the land in Greece is mountainous and hilly. Sparsely forested steep slopes are over-grazed by goats and sheep, resulting in serious problems regarding soil erosion and landslides. Extensive forest fires and low rates of reforestation also contribute to soil erosion and desertification.

In 1999, production of round wood amounted to approximately 810,000 $m^3$ (including construction timber), presenting an increase of approximately 50% compared to 1992. In the same year, the production of resin gum, firewood and charcoal presented an increase by 180%, 15% and 10%, respectively, compared to 1992 levels. Furthermore, in 1999 the area reforested decreased by approximately 50% compared to the relevant figure of 1990 [2].

### 1.5.5 Mining

In 2000, the gross value added of the mining sector amounted to 0.7 million € (in current prices) [4]. During the period 1995–2000, the average annual rate of increase of the gross value added of the sector was approximately 2.5% (calculated with constant 1995 prices). Activities related to mining of energy materials (i.e., lignite, crude oil, natural gas) make the largest contribution to the gross value added (53%), while the rest of the activities refer to mining/quarrying of gravel and sand, chromite, nickel ores and other non-ferrous ores, marble, bauxite, clays and kaolin [5].

In 2000, the production index of the sector increased by 14.7% compared to 1993 (base year, index=100) and by 14% compared to the previous year. The production index of coal and lignite mining increased by 25.5% compared to 1993 (and by 5.2% compared to the previous year), while the index regarding mining of metal ores increased by 13.4% compared to 1993 (and by 12% compared to the previous year) [10]. It should be noted that the significant increase of the production index for extraction of crude petroleum and natural gas (index 1999: 3.1, index 2000: 49.1) is due to the fact that in 1999 the unit of Prinos did not operate.

### 1.5.6 Manufacture

According to the National Statistics, "Major Manufacturing Industry" (i.e., manufacturing establishments with more than 10 employees) in 1996 comprises approximately 5,600 manufacturing units with around 240,000 total employees (average size: 43 employees per unit) [2]. Between 1988 and 1996, the number of industries and handicrafts decreased by 36%. Compared to 1995, the number of industries and handicrafts decreased by 4% in 1996, while the number of employees decreased by 5%. The majority of industrial units are located in the prefectures of Athens and Thessalonica.

The overall industrial production index presented an increase of 15% in 2000, compared to the base year 1993. The evolution of the production index per sector for the time period 1994–2001 is shown in **Table 1.2** [4]. (It should be noted that the figures for 2001 represent the average of the first seven months, January–July, as data for the last 5 months are not yet available.) The first section of rows comprises branches that in all years show an increased production index compared to 1993. The second section of rows comprises branches showing more unstable behaviour that nonetheless presented a higher production index during the last 2–4 years than the relevant one in 1993. The last section of rows comprises branches whose production index during the time period 1994–2001 was steadily below the one in 1993. In 2001, the branch with the higher production index was "rubber and plastics," followed by "machinery" and "petroleum & coal products."

**Table 1.2** Industrial productions for the period 1994–2001 (1993=100)

| Branches | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| Rubber & plastics | 104.1 | 106.9 | 107.9 | 104.9 | 138.1 | 147.9 | 148.7 | 172.3 |
| Machinery | 106.4 | 117.6 | 124.7 | 129.5 | 137.0 | 128.6 | 152.1 | 159.8 |
| Petroleum & coal products | 118.3 | 118.2 | 139.2 | 142.2 | 161.9 | 137.2 | 162.3 | 159.6 |
| Basic metals | 100.5 | 110.3 | 107.2 | 120.7 | 113.6 | 122.4 | 137.7 | 148.3 |
| Chemicals | 102.6 | 106.9 | 110.8 | 115.8 | 122.2 | 126.8 | 129.0 | 138.3 |
| Medical instruments | 100.5 | 122.8 | 138.6 | 149.7 | 125.4 | 121.6 | 157.8 | 134.0 |
| Non-metallic minerals | 97.9 | 103.4 | 106.2 | 111.9 | 112.9 | 113.0 | 115.5 | 118.5 |
| Food & beverages | 102.3 | 104.5 | 103.6 | 111.0 | 114.4 | 115.3 | 119.4 | 114.5 |
| Tobacco | 111.9 | 132.6 | 120.9 | 117.4 | 101.5 | 109.3 | 107.7 | 104.6 |
| Radio, TV & comm. appliances | 69.1 | 57.4 | 42.6 | 44.3 | 105.9 | 93.0 | 121.3 | 155.5 |
| Electrical machines | 96.7 | 100.1 | 99.1 | 99.2 | 104.3 | 108.4 | 122.2 | 128.8 |
| Final metallic products | 99.3 | 96.1 | 100.5 | 100.2 | 100.3 | 119.8 | 121.3 | 124.1 |
| Furniture & other industries | 90.8 | 93.9 | 85.8 | 91.7 | 108.2 | 115.9 | 125.1 | 118.5 |
| Paper & paper products | 107.1 | 111.3 | 103.6 | 90.0 | 135.6 | 137.1 | 116.4 | 117.5 |
| Printing & publishing | 95.0 | 96.7 | 104.3 | 95.6 | 91.0 | 100.6 | 112.7 | 111.2 |
| Wood & cork | 89.1 | 98.1 | 96.9 | 74.8 | 61.9 | 61.5 | 100.4 | 103.0 |
| Transport equipment | 67.7 | 57.2 | 40.2 | 40.9 | 69.9 | 102.2 | 112.4 | 97.3 |
| Textiles | 96.3 | 89.4 | 89.0 | 80.4 | 78.6 | 77.6 | 84.5 | 85.8 |
| Other transport equipment | 91.3 | 96.2 | 91.3 | 81.6 | 77.5 | 73.2 | 69.2 | 71.5 |
| Leather & footwear | 101.1 | 96.4 | 92.7 | 77.5 | 63.2 | 66.6 | 67.2 | 69.5 |
| Clothing | 85.6 | 82.7 | 76.1 | 91.8 | 71.2 | 68.2 | 67.0 | 67.9 |
| Office & computing machinery | 40.6 | 22.5 | 7.4 | 60.5 | 24.0 | 18.5 | 38.4 | 20.5 |
| **TOTAL MANUFACTURING** | **99.1** | **104.2** | **101.3** | **103.3** | **107.7** | **108.4** | **115.0** | **117.5** |

The contribution of the various branches to the total gross value added of manufacturing is shown in **Figure 1.10** [5]. Food, beverages and tobacco are the sector with the highest contribution to the gross value added (23%), followed by textiles and textile products (15%) and basic metals and metal products (9%). During the time period 1995–2000, the branches of petroleum and coal products and of non-metallic minerals increased their share (1995: 4% and 5.5%, respectively; 2000: 7.9% and 7.4%, respectively), while the highest decrease of contribution was observed in the branch of textiles and textile products (1995: 20.1%; 2000: 14.6%). The contribution of the rest of the industrial branches remained practically unchanged.
During the time period 1995–2000, the contribution of industry to the total gross value added dropped from 13% to 12% (calculated on 1995 prices). During the time period 1995–1999, the gross value added from industry increased by a lower rate than that of the total GDP (average annual rate of increase: 1.7% and 3.4%, respectively).

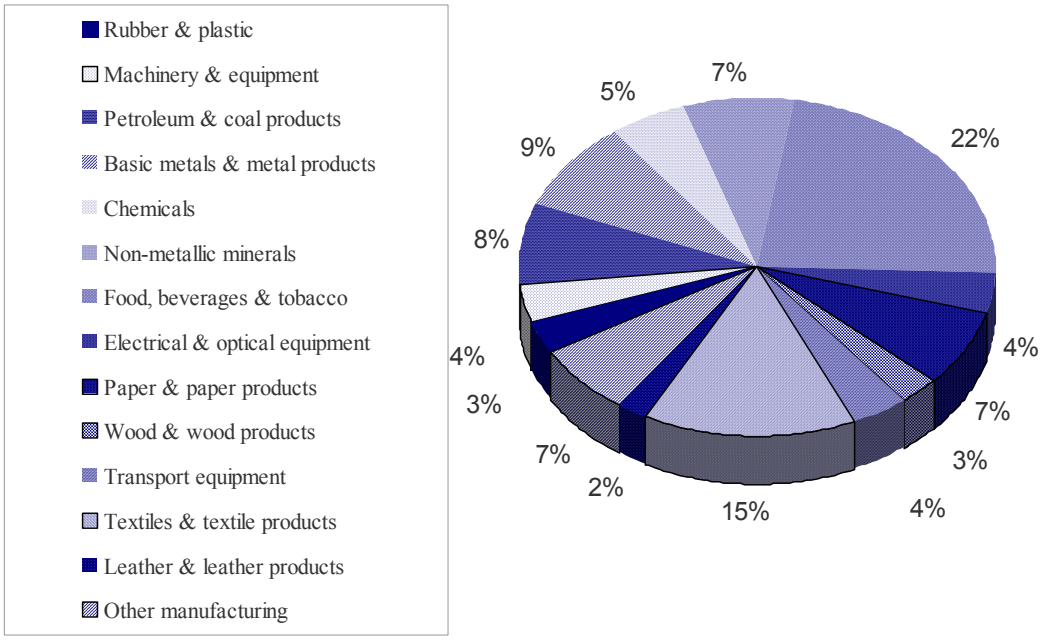


**Figure 1.10** Contribution of industrial branches to total gross production value of manufacture in 2000

### *1.5.7 Tourism*

In 1999, Greece was the 15th most popular tourist destination in the world, welcoming 12.6 million tourists [11]. The major portion (89%) came from Europe, and 70% from the EU. The majority of tourists (80%) came by plane. The total number of nights spent in hotel accommodations by foreign and domestic tourists in 2000 marked a 19.4% increase compared to 1995 [11]. In 2000, the accommodation capacity of the approximately 8,000 hotels was 592,400 beds. Furthermore, approximately 28,000 secondary accommodation establishments accounted for another 450,000 beds. There were also 330 camping sites and 950 bungalows. Compared to 1996, the number of hotel beds increased by 7.3%. About 60% of the total bed capacity is located on the islands.

In 2000, the contribution of tourism to the gross value added was 7% [4]. The receipts from tourism in 2001 were 27 million € [11]. Employment in the tourism sector is estimated to reach 10% of the economic active population (according to the figures of 1991), including both direct and indirect employment (6% and 4%, respectively).

### 1.5.8 Transportation

#### 1.5.8.1 Road transport

Greece's improving economic conditions over the last 20 years have had a significant impact on the ownership of road vehicles, as shown in **Figure 1.11**. 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. For the time period 1990–2000, the number of passenger cars, trucks and motorcycles, increased consecutively. In 1994, the number of passenger cars was 2.9 million cars (1 car for every 5 inhabitants). By 2000 this figure reached 5 million cars. Despite these drastic changes, Greece still has one of the lowest ownership rates in Europe.

In 2000, of the vehicles that were operated for the first time, 89% were new and the rest were used. For the same year, passenger cars represented 62.5% of total motor vehicles in operation, trucks 20.9%, motorcycles 15.4%, taxies 0.7% and buses 0.5%.

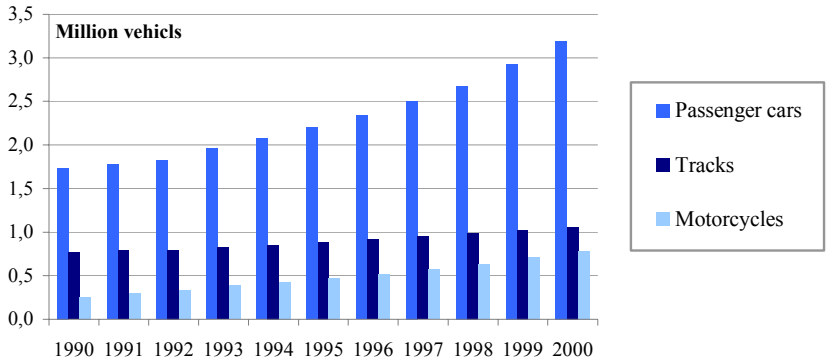


**Figure 1.11** The road vehicles market in Greece

The increase in the number of motorcycles in Greece is the result of several factors, notably the introduction of restrictive measures in Athens in the form of an inner and an outer "ring" inside which cars can only circulate on alternating days. Other factors include a lack of sufficient parking places, traffic congestion and public transportation problems. In addition to the number presented in **Figure 1.11,** it should be noted that an even larger number of mopeds are currently in operation. According to provisional data, in 2000, there were an estimated 1.5 million mopeds. 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.

Until 1992, Greece was the only country in Europe that prohibited the use of passenger cars running on diesel oil (taxis excepted). The reason for 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, trucks and taxis. In 1992, the Greek government introduced 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 Thessalonica.

#### *1.5.8.2 Shipping*

The Greek maritime fleet is one of the largest in the world, accounting for 16% of the global dead-weight tonnage in 2001. The fleet comprised 3,618 vessels, including those that do not fly the Greek flag, with a dead-weight tonnage of 100 GRT. Merchant (dry cargo) ships represent 43% of this total, 11% are passenger ships, 25% tankers and 20% other type of vessels. The merchant fleet is composed of ships of average age and specialises in "tramping," or going anywhere in the world on a single trip rather than 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 Ionian seas and to countries in the Mediterranean Sea.

#### *1.5.8.3 Air transport*

According to the data of the Civil Aviation Service, aircraft traffic in 1999 increased by 15%, growing to approximately at 396.000 (compared to 343.000 in 1998). Passengers that embark and disembark in the airports of the country in 1999, mounted approximately at 33 millions compared to 28.5 millions in 1998. Fright and mail that were loaded and unloaded in 1999 showed a slight decrease compared to 1998 (148 kt in 1999 compared to 150 kt in 1998).

Concerning international traffic at Athens airport, European airlines represent the highest share, followed by Asian, African, American and Australian airlines.

#### *1.5.8.4 Railways*

The total length of the railway network in Greece is 2,299 km. Greece was the last European country to develop a railway system, which dates only from the 1880s. Over the last 10 years, the network has undergone an extensive modernisation, the aims of which are the improvement of existing tracks, the standardisation of metric gauges, the connection to the western European network and the coordination of the development with that of roads. Both the modernisation and the extension of the system have proven costly and difficult mainly due to the complex topography of the mountainous region (Pindos mountains) that divides the western and eastern parts of Greece.

In 1999, the Railways Organisation had approximately 10,500 employees. The total has decreased annually since 1989. Also, even as the receipts total doubled during the time period 1989–1999, the total of expenditures also showed a significant annual increase.

### *1.5.9 Construction*

The number of new building licenses granted to the private sector in 1999 (including residential, industrial, commercial and buildings of miscellaneous use) totalled approximately 51,000, corresponding to a building area of 22 million m2 and a building volume of 59 million $m^3$ (**Figure 1.12**). During the time period 1990–1999, the total number of licenses issued was 565,000, the respective area was 163 million $m^2$ and the respective volume was 563 million $m^3$ [2]. In other words, approximately 18,000 thousand $m^2$/63,000 thousand $m^3$ of new buildings were added annually to the existing private building stock. Approximately 25% of the new building volume is concentrated in Attica (mainly the greater Athens area). For the year 2000,

data were only available for the first six months and show that during this time period; approximately 25,000 new licences were provided, corresponding to a volume of 30 million $m^3$ [12].

A comparison between January 2001 and January 2000 regarding the number of building licenses provided to the private sector, the relevant area and the relevant volume, shows that there was an increase by 24%, 56% and 81%, respectively. It should be noted that the largest increases of the building area took place in Sterea and Evia (by 193%), Eastern Macedonia and Thrace (by 157%), Creta (by 61%) and Athens (by 65%) [12]. It should be noted that the substantial increase in the first three regions was due to the construction of new large industrial units, while the increase in the greater Athens area was due to licences distributed for the construction of new buildings to areas that suffered damage from earthquakes.

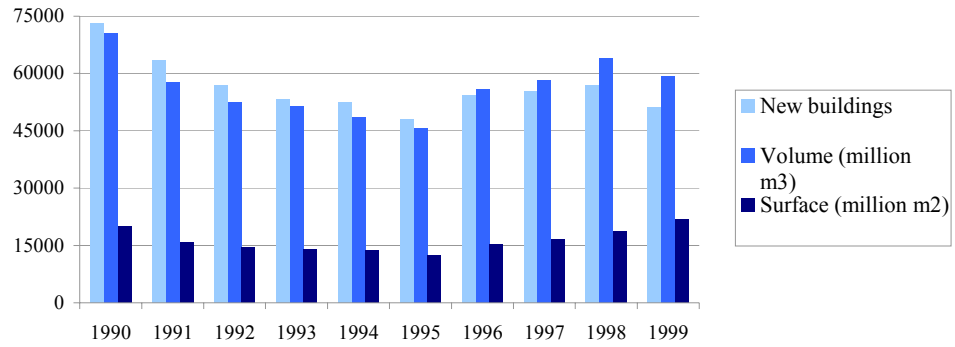


**Figure 1.12** New private buildings in Greece (1990–1999)

Regarding the evolution of the public building activity, this represents a small percentage of the total: the area of new buildings in the public sector represents approximately 2.5% of the total area of new buildings each year (on an average basis). With respect to the construction of municipal and communal works, approximately 30% of the total amounts paid in 1996 was associated to road construction, 17% to water supply, 14% to drainage, 3% to land reclamation, 15% to house building and the remaining part to miscellaneous works.

Regarding the contribution of the sector to the total GDP, in 2000 the respective share was 7%, a contribution percentage that had remained more or less stable during the period 1995–2000 [4].

## 1.6 The Greek energy system

### *1.6.1 Energy supply*

The total gross inland consumption in Greece continuously increased during the time period 1990–2000, excepting the years 1993 and 1999. In 2000, gross inland consumption reached a total of approximately 28.5 Mtoe, representing an increase of approximately 27% compared to 1990 level. Despite this increase, though, the average annual growth rate during the time period 1990–2000 decreased approximately 2.4% per year, as compared to 3.3% in the 1980s [13].

The composition of the energy carriers (**Figure 1.13**) reveals the major weakness of the Greek energy system, namely, the absence of alternative solutions for covering the country's energy demands. During the period 1990–2000, oil and coal products have provided the majority of the total energy supply. The only significant change in the Greek energy system in the last decade was the introduction of natural gas in 1997, which then represented 6% of the gross inland consumption in 2000.

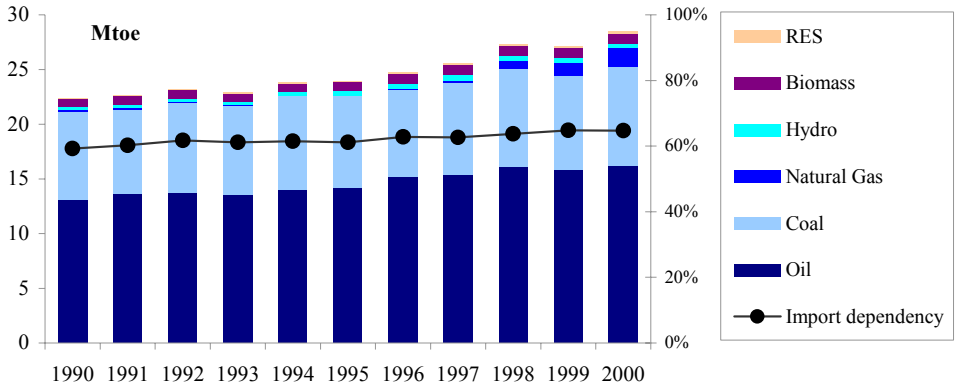


**Figure 1.13** Gross inland consumption in Greece for the period 1990–2000

The contribution of oil products decreased from 59% in 1990 to 57% in 2000 and at the same time the contribution of coal products decreased from 36% in 1990 to 32% in 2000. In absolute terms, though, consumption of oil products increased with a mean annual rate of 2.2% and consumption of coal products increased with a mean annual rate of 1.1%.

The contribution of renewable energy sources (RES), including large hydro, varies from 4.5% to 6.3% according to the fluctuations of large hydropower plants. Excluding large hydro, the share of renewable energy sources increased from 3.7% in 1990 to 4.1% in 2000. Renewable energy sources exploitation refers to biomass use for space heating in the residential sector, solar energy for water heating mainly in the residential sector and wind energy for electricity generation.
Import dependency (defined as the ratio of domestic energy supply to gross inland consumption) showed an upward trend during the last decade, from 59% in 1990 to 65% in 2000. This was a result of the increased demand for oil products and the penetration of natural gas.

The electricity-generation system in Greece consists of thermal and hydroelectric units as well as a very small percentage of other renewable energy sources. In 2000, the total installed capacity of the Public Power Corporation (PPC) generating system was 11.1 GW (**Table 1.3),** which corresponds to an increase of approximately 27% compared to 1990 levels, while the net electrical capacity of auto producers in 1999 was 282 MW [14].

Electricity generation steadily increased at an average annual rate of approximately 4.4% over the time period 1990–2000 (**Figure 1.14**). Gross electricity production in 2000 totalled 53.7

TWh, of which 64% and 17% came from the combustion of coal and petroleum products, respectively, 8% from hydropower, 11% from natural gas and 1% from other renewable energy sources (except large hydro).

**Table 1.3** Installed capacity (in MW) in 2000

| | PPC | Auto producers |
|---|---|---|
| Lignite | 4908 | - |
| Oil (fuel oil & diesel) | 2015 | 133 |
| Hydro | 3061 | 3 |
| RES | 37 | 55 |
| Natural gas-fires | 1100 | 43 |
| Other fuels | - | 48 |

***Note**: Data for auto producers refer to net capacity in 1999.*

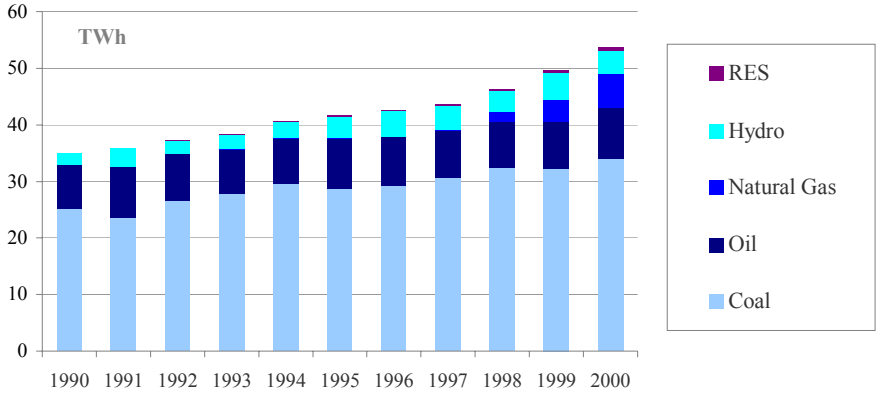


**Figure 1.14** Gross electricity generation

### *1.6.2 Final energy consumption*

Final energy demand in Greece in 2000 totalled 18.9 Mtoe, of which 24% was used in industry, 39% for transportation and 37% by the residential and tertiary sector. The mean annual increase rate for the time period 1990–2000 is estimated at 2.5%. The per capita final energy consumption increased by 20% over the time period 1990–2000 (1.45 and 1.74 toe/cap, respectively), while the respective figure at EU-level is estimated at 9% (from 2.54 toe/cap in 1990 to 2.78 toe/cap in 2000).

All three sectors increased their energy use over the time period 1990–2000, with the residential and tertiary sector showing the most significant increase (by 44%), followed by transportation (by 24%) and industry (by 16%) (**Figure 1.15**). This resulted in a total increase of 28% between 1990 and 2000.

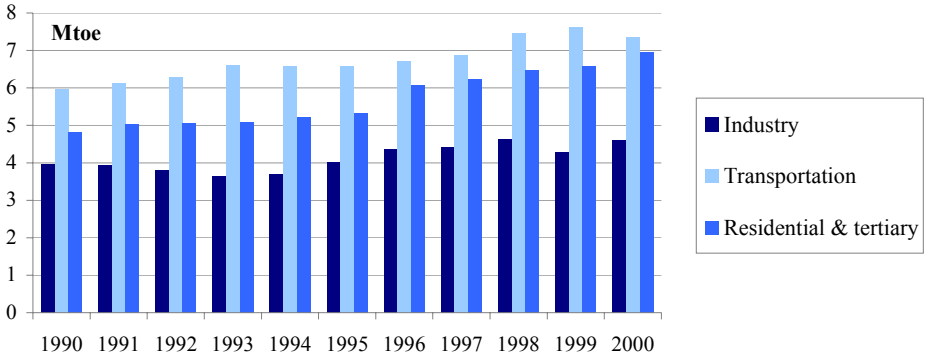


**Figure 1.15** Final energy consumption by economic sector

### *1.6.2.1 Energy consumption in industry*

In 2000, the total energy consumption of the industrial sector totalled 4.6 Mtoe (**Figure 1.16**), which equals 24% of the total energy demand in Greece. The main structural changes regarding energy consumption in industry refer to the gradual replacement of petroleum products by coal products (a trend almost solely attributed to the increased use of steam coal by the cement industry) during the time period 1980–1995 and to the penetration of natural gas for thermal uses and for use as feedstock in the chemical industry.

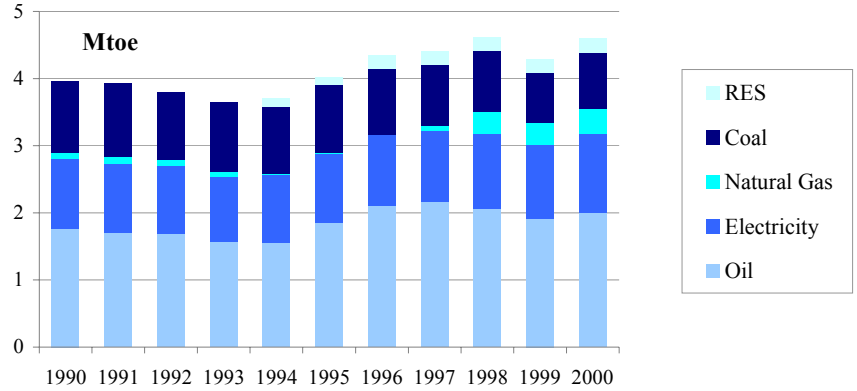


**Figure 1.16** Final energy consumption in industry by energy carrier

In 2000, oil products accounted for approximately 44% of the total energy needs of the sector, compared to 46% in 1995 and 69% in 1980. Electricity consumption has steadily increased

since 1993. In 2000, it reached a total of approximately 1.2 Mtoe or 25% of the total energy use of the sector.

### *1.6.2.2 Energy consumption in residential and tertiary sector*

In 2000, the energy use in the residential and tertiary sector totalled 7 Mtoe or 37% of the total energy demand in Greece, compared to 4.8 Mtoe in 1990 (**Figure 1.17**). This energy was primarily used for space heating and cooling, and domestic hot water production in residential, public and commercial premises. Other energy uses were in the form of electricity for appliances/equipment and for the operation of building services systems in residential, public and commercial premises. The figure also includes energy use in agriculture.

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

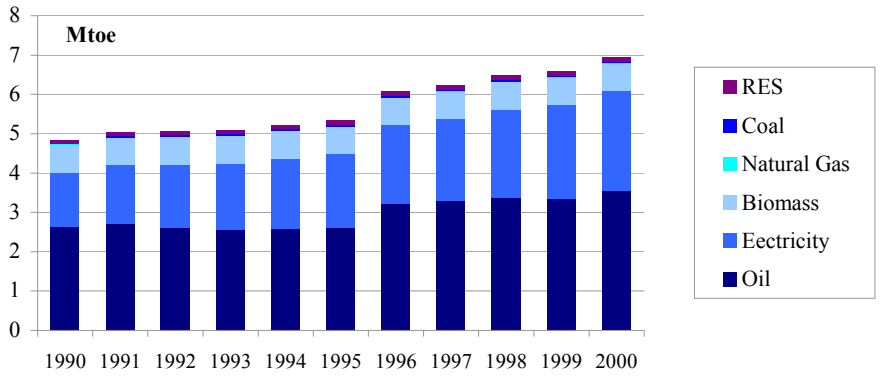


**Figure 1.17** Final energy consumption in residential and tertiary sector by energy carrier

The factors that have helped reduce the rate of increase in the energy use of the residential and tertiary 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 1.17**, is mostly the result of an increased demand for electricity and to a smaller extent of petroleum products. In 2000, the contribution of the former had increased to 36% compared to 29% in 1990, while the contribution of the latter was 51% compared to 52% in 1990. Although, in absolute figures, the use of solid fuels and biomass has remained relatively stable in recent years, their relative contribution has dropped to 10% in 1999, compared to 16% in 1990. Until 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 countryside 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 fireplaces in both private residences and apartment buildings.

### *1.6.2.3 Energy consumption in the transport sector*

The energy use of the transportation sector has almost doubled during the time period 1980–1995 period. In 2000, transportation accounted for 7.4 Mtoe (6 Mtoe in 1990) or 39% of the total final energy demand in Greece. Oil products accounted for more than 99% of the final energy use. 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. Small amounts of steam coal are used exclusively by railroads, while electricity covers the needs of the electric buses (trolleys) and of the metro (since 2000) that operate in the central Athens area. Due to the operation of the metro and the planned extensions of the network, electricity consumption is expected to increase in the future.

## 1.7 Waste

Over the time period 1990–2000, the total produced wastes show a consecutive increase. While in 1990 the total produced wastes were approximately 3.1 Mt, by 2000 this amount became 4.4 Mt. In 2000, managed waste disposal on land represented 52.4% of the total, compared to 41.7% in 1990 [15]. It should be noted, as shown in **Figure 1.18,** that this change started since 1999 when, for the first time during the time period 1990–2000, the percentage of unmanaged waste was lower than that of managed waste disposal on land.

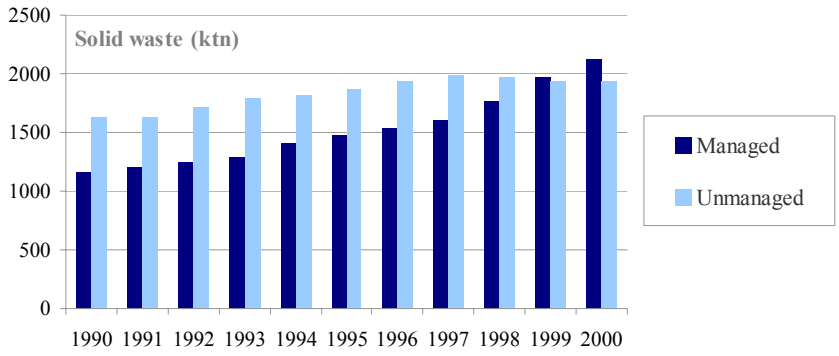


**Figure 1.18** Managed and unmanaged waste disposal on land (1990–2000)

Concerning the composition of waste (**Table 1.4)** in 2000, food wastes make up the largest share with 46.1%, followed by paper with 20.6%, plastic 9.1%, glass 4.4%, metal 4.2% and other 15.6%. Over the time period 1990–2000, slight changes were reported to the percentages

by type of waste. Food waste showed a decrease (49.1% in 1990), while plastic shows an increase (7.1% in 1990) and all other types present negligible changes [15, 16].
Also, although the total recycled wastes show an increasing trend (290,000 tonnes in 1990 to 330,000 tonnes in 2000), the recycling percentage for managed waste in 2000 was 7.6% of the total, compared to 9.4% in 1990.

**Table 1.4** Amounts of waste (tn) by type for the period 1990–2000

| | Food waste | Paper | Plastic | Metal | Glass | Other | TOTAL |
|---|---|---|---|---|---|---|---|
| **1990** | 1517153 | 574726 | 219385 | 160676 | 143373 | 474613 | **3089925** |
| **1991** | 1522745 | 586631 | 227788 | 159139 | 144162 | 479914 | **3120379** |
| **1992** | 1580778 | 619274 | 244450 | 162967 | 149929 | 501938 | **3259337** |
| **1993** | 1632481 | 650283 | 260791 | 165958 | 155120 | 522258 | **3386890** |
| **1994** | 1688301 | 683779 | 278446 | 169183 | 160723 | 544204 | **3524636** |
| **1995** | 1737083 | 715269 | 295596 | 171519 | 165680 | 564187 | **3649334** |
| **1996** | 1785261 | 747319 | 313270 | 173619 | 170600 | 584267 | **3774337** |
| **1997** | 1840845 | 783338 | 332919 | 176251 | 176251 | 607087 | **3916692** |
| **1998** | 1902478 | 822913 | 354423 | 179248 | 182507 | 632258 | **4073828** |
| **1999** | 1964901 | 863879 | 376888 | 182092 | 188868 | 658072 | **4234700** |
| **2000** | 2024969 | 904867 | 399723 | 184487 | 195030 | 683482 | **4392558** |

# 2 GREENHOUSE GAS INVENTORY INFORMATION

## 2.1 Overview

This chapter summarises greenhouse gas (GHG) emissions of Greece for the time period 1990–2000 as reported in the National Inventory Report submitted to the UNFCCC in 2002 [17]. Emissions estimates were calculated according to the CORINAIR methodology [18] and the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories [19]. The implementation of the IPCC Good Practice Guidance is in progress. Base year emissions are calculated using 1990 as the base year for carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$), and 1995 for fluorinated gases (F-gases—Hydrofluorocarbns, HFCs / Perfluorocarbns, PFCs / Sulphur hexafluoride, $SF_6$). Global warming potential (GWP) values as well as the sources of the necessary statistical data are presented in **Annex I.**

An overview of GHG emissions for the time period 1990–2000 is presented in **Table 2.1**. The detailed CRF trend tables [17] are presented in **Annex I**. Following the IPCC Guidelines, emissions from international air transport and marine bunkers have not been included in the national totals and are presented separately in **Table 2.2.** Finally, emissions of the ozone precursors gases (NOx, CO and NMVOC) along with $SO_2$ are presented in **Table 2.3.**

**Table 2.1** Greenhouse gases emissions for the period 1990–2000 (in kt CO2 eq)

| Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 85586 | 84610 | 87672 | 87268 | 88627 | 87273 | 90045 | 94380 | 101784 | 98698 | 107818 |
| $CH_4$ | 8743 | 8705 | 9007 | 9106 | 9362 | 9494 | 9811 | 9922 | 10439 | 10410 | 10562 |
| $N_2O$ | 10622 | 10520 | 10468 | 10144 | 10258 | 9899 | 10338 | 10625 | 10634 | 10418 | 10979 |
| F-gases | 1193 | 1364 | 1161 | 1791 | 2303 | 3452 | 3988 | 4360 | 4257 | 4288 | 4429 |
| **Total** | **106143** | **105199** | **108307** | **108308** | **110550** | **110119** | **114182** | **119287** | **127113** | **123814** | **133788** |
| Index (Base year = 100) | 97.9 | 97.0 | 99.9 | 99.9 | 102.0 | 101.6 | 105.3 | 110.0 | 117.3 | 114.2 | 123.4 |

**Table 2.2** Greenhouse and other gases emissions from international transport for the period 1990–2000 (in kt)

| Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 10867.7 | 9868.7 | 9923.5 | 13242.1 | 13759.5 | 14362.2 | 12823.1 | 12872.2 | 14148.3 | 12718.5 | 14497.8 |
| $CH_4$ | 0.8 | 0.7 | 0.8 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 |
| $N_2O$ | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 0.3 | 0.4 |
| NOx | 198.8 | 182.0 | 208.0 | 243.8 | 257.7 | 274.8 | 242.9 | 243.7 | 271.2 | 241.9 | 278.3 |
| CO | 21.1 | 20.2 | 23.2 | 26.9 | 28.5 | 30.3 | 26.8 | 27.2 | 30.2 | 27.5 | 31.3 |
| NMVOCs | 6.3 | 6.0 | 6.9 | 8.0 | 8.5 | 9.1 | 8.0 | 8.0 | 8.9 | 8.0 | 9.2 |
| $SO_2$ | 148.4 | 133.7 | 148.4 | 176.5 | 184.8 | 189.7 | 172.0 | 172.9 | 199.9 | 175.4 | 206.9 |

**Table 2.3** Ozone precursor gases and SO2 emissions for the period 1990–2000 (in kt)

| Αέρια | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NOx | 289.6 | 297.5 | 297.1 | 292.5 | 299.4 | 296.5 | 305.9 | 309.6 | 334.1 | 326.2 | 321.0 |
| CO | 1297.5 | 1289.7 | 1319.8 | 1284.9 | 1263.7 | 1253.9 | 1354.0 | 1356.1 | 1489.4 | 1385.7 | 1531.1 |
| NMVOCs | 255.4 | 253.2 | 260.9 | 270.3 | 274.0 | 272.7 | 284.3 | 285.2 | 289.7 | 291.1 | 305.4 |
| $SO_2$ | 493.1 | 532.0 | 545.9 | 545.4 | 516.9 | 541.4 | 525.2 | 520.7 | 527.9 | 540.0 | 482.6 |

- The total (level) uncertainty for 2000 is estimated at 30%, while the trend uncertainty is estimated at 8% [17].
- Carbon dioxide, methane and nitrous oxide emissions had increased by 23% over the time period 1990–2000, and as a result the target set in the "Hellenic Action Plan for the Abatement of CO2 and other Greenhouse Gas Emissions" was not achieved.
- The total increase of emissions regarding the 6 greenhouse gases covered by the Kyoto Protocol to the UNFCCC was 23.4% compared to base year emissions. This increase is mainly attributed to the large number of forest fires in 2000, which was three times above the average of the period 1990–1999.
- Carbon dioxide emissions accounted for 81% of total GHG emissions in Greece in 2000, while CH4 and N2O emissions accounted for 8% of total emissions each. F-gases emissions were still low (3%) but are expected to grow rapidly over the next few years.

As far as the sectoral contributions are concerned (**Figure 2.1),** energy-related activities were the largest source of GHG emissions for the year 2000 (77.9%). These include $CO_2$ emissions from the combustion of fossil fuels (95%), $CH_4$ from production, storage, distribution and combustion of fossil fuels (1.5%), and $N_2O$ (3.5%). The other sectors, namely, agriculture (7.9%), industrial processes (9.9%), waste (4.1%) and solvent use (0.1%) accounted for the remaining 22.1% of emissions.

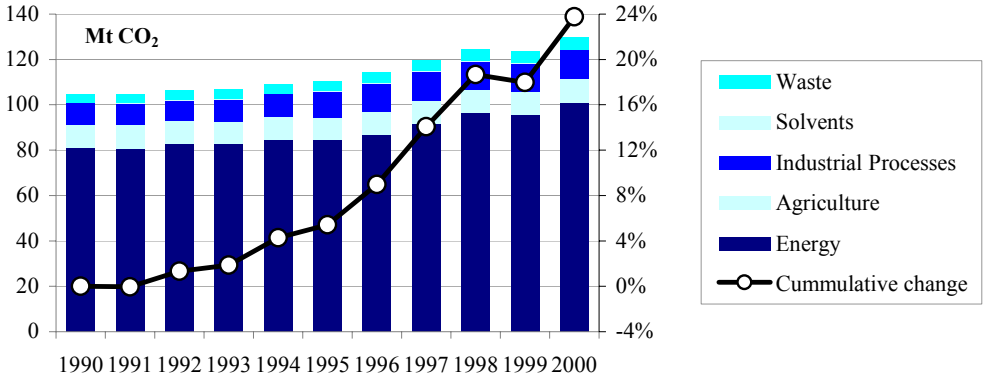


**Figure 2.1** Greenhouse gases emissions per sector for the period 1990 – 2000 (in Mt $CO_2$ eq)

## 2.2 Trend analysis per gas

### 2.2.1 Carbon dioxide emissions

As shown in **Figure 2.2**, 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, lime, aluminium and ammonia), uncontrolled burning of solid waste and solvents use.
Since 1990, the amount of carbon dioxide emitted has steadily increased (except for 1991 and 1999 when there was a reduction by 0.2% and 1%, respectively, compared to previous year emissions). In 2000, $CO_2$ emissions (emissions/removals from Land Use Change and Forestry are excluded) totalled 103.7 Mt compared to 84.3 Mt in 1990, a change of approximately 23%. The mean annual rate of increase for the time period 1990–2000 is estimated at 2.1%, while the respective rate for the period 1995–2000 is greater (3.4%) as a result of the significant increase of energy consumption since 1995. In general the increase of $CO_2$ emissions is mainly attributable to an increase in energy consumption and especially in the electricity consumption that presents a mean annual rate of 4.5% in the period 1990–2000.

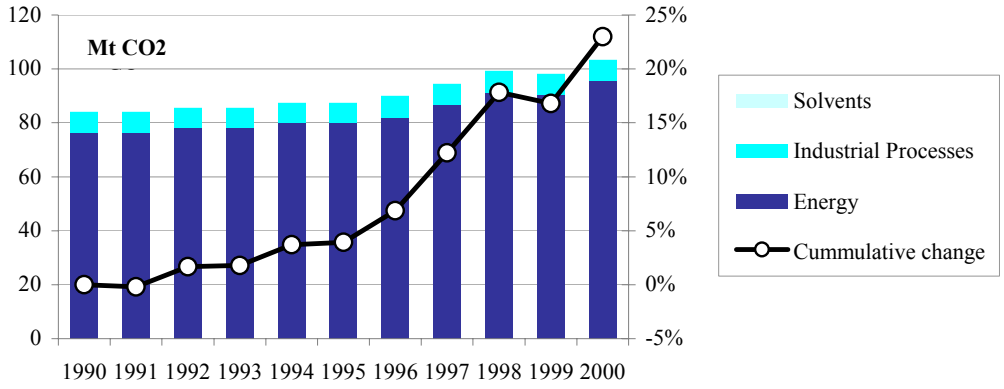


**Figure 2.2** $CO_2$ emissions per sector for the period 1990–2000 (in Mt)

### 2.2.2 Methane emissions

Methane emissions increased by 22% over the time period 1990–2000 (**Figure 2.3**) with a mean annual rate of increase of 2% approximately for the period.

Landfills and wastewater treatment are the largest anthropogenic sources of methane emissions in Greece, accounting for 51% of total methane emissions in 2000, increasing from 1990 levels by 42% approximately. The agricultural sector (enteric fermentation in domestic livestock and manure management) is the second largest anthropogenic source of methane emissions, accounting for approximately 34% of total Greek methane emissions. Fuel combustion, coal mining and the production and processing of natural gas and oil, accounted for the remaining 15% of the national total.

The increase in methane emissions is mainly attributable to the waste sector, which saw a 42% increase over the time period 1990–2000. Methane emissions from the energy sector increased by 31% over the same period, while methane emissions from agriculture decreased by 1.5%.

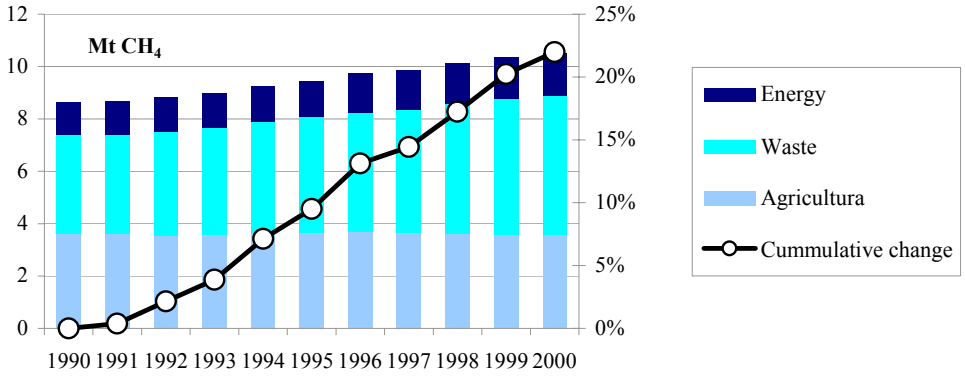


**Figure 2.3** $CH_4$ emissions per sector for the time period 1990–2000 (in Mt)

### *2.2.3 Nitrous oxide emissions*

Nitrous oxide is a chemically and radiatively active greenhouse gas that is produced naturally from biological sources in soil and water. Nitrous oxide emissions showed a 4% increase over the time period 1990–2000, with a mean annual rate of 0.3% for the period (**Figure 2.4).**

The agricultural sector is the primary anthropogenic source of nitrous oxide emissions in Greece. It accounted for approximately 61% of total nitrous oxide emissions in 2000. Nitrous oxide is also a product of the reaction that occurs between nitrogen and oxygen during fossil fuel combustion. This sector accounted for 34% of total nitrous oxide emissions in 2000. Production of nitric acid, the major industrial source of nitrous oxide emissions, accounted for approximately 6% of total nitrous oxide emissions.

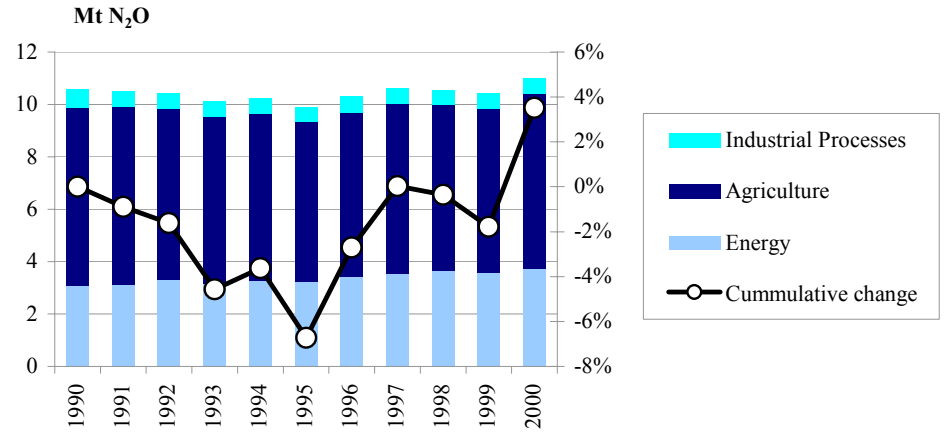


**Figure 2.4** $N_2O$ emissions per sector for the period 1990–2000 (in Mt)

The total increase of nitrous oxide emissions by 4% over the time period 1990–2000 is the result of a 22% increase in emissions from the energy sector and a 20% decrease in emissions from industrial processes due to the reduced production of nitric acid, and a 2.5% decrease in emissions from agriculture due to the reduced use of synthetic fertilizers.

### 2.2.4 Fluorinated gases emissions

Emissions of HFCs and PFCs increased from 1.2 Mt CO2 eq in 1990 to 4.4 Mt CO2 eq in 2000 (**Figure 2.5**). Emission estimates of these gases come from:

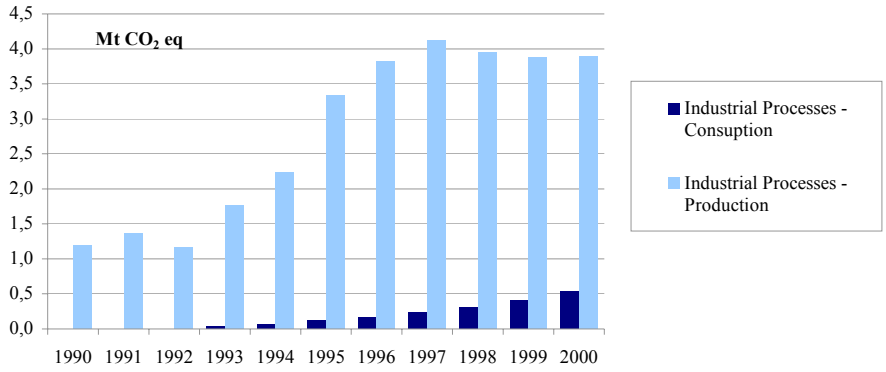


**Figure 2.5** F-gases emissions per sector for the period 1990–2000 (in Mt $CO_2$ eq)

- The production of HCFC-22 (HFC-23) and aluminium production (CF4 and C2F6). HFC-23 emissions have been increasing steadily due to an equivalent increase in the production of HCFC-22. In contrast PFCs emissions from aluminium have dropped since 1990 due to the control/reduction of the "anode effects" during the production process. These emissions account for 88% of total fluorinated gases emissions.
- Manufacturing, operation and maintenance of refrigeration (residential sector only) and air conditioning equipment. The emissions from the use of F-gases in 2000 are five times higher than they were in 1995, mainly due to an increase of air-conditioning equipment in the residential sector and new passenger cars.

$SF_6$ is used as a dielectric element in electric transmission and distribution equipment. Fugitive emissions of SF6 occur in the case of a leakage and during the maintenance of substations and circuit breakers, especially in older equipment. According to the records of PPC, the leakage of $SF_6$ in the last 20 years has not exceeded 0.1% of the total amount used. This amounts to approximately 10 Kg of $SF_6$, or 0.23 kt of carbon dioxide equivalent, over the last 20 years.

## 2.3 Factors underlying GHG emissions trends

Greenhouse gas emissions trends are mainly driven by economic development (**Figure 2.6**). Moreover, and given the fact that energy is the main source of GHG emissions, gross inland

consumption (GIC) and emissions follow the same pattern, with emissions showing a slightly lower mean annual rate of increase.

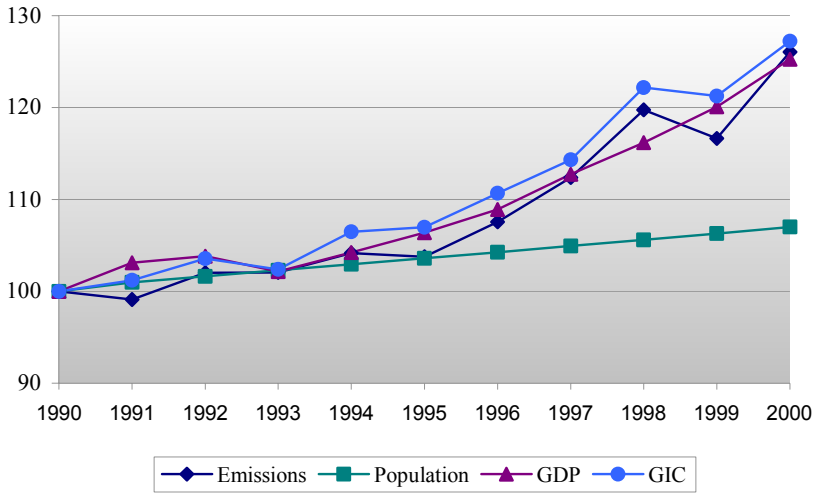


**Figure 2.6** Factors underlying GHG emissions trends

# 3 POLICIES AND MEASURES

## 3.1 Policy-making process

The Ministry for the Environment, Physical Planning and Public Works is initially responsible for environmental legislation and policy development, while other ministries are responsible for integrating environmental policy targets with the National Action Plan on Climate Change (NAPCC) within their respective fields. Final approval of policies and measures related to climate change mitigation rests with the Council of Ministers.
Policies and measures, as well as all other issues and actions regarding mitigation are discussed within the framework of an inter-ministerial committee, comprising representatives from the following ministries/organisations:

- Ministry for the Environment, Physical Planning and Public Works
- Ministry of Foreign Affairs
- Ministry of the Interior, Public Administration and Decentralization
- Ministry of Economy and Finance
- Ministry for Development
- Ministry of Mercantile Marine
- Ministry of Transport and Communications
- Ministry of Agriculture
- Public Power Corporation

Climate change mitigation is one of the main targets focussed on by the Greek policy for sustainable development. The chief environmental issues examined in this framework are:

- Climate change mitigation
- Protection of the atmosphere
- Waste management
- Water resources management
- Desertification
- Conservation of biodiversity

## 3.2 Policies and measures and their effects

In 1995 Greece developed the "Hellenic Action Plan for the Abatement of $CO_2$ and other Greenhouse Gas Emissions." The plan's objective was to restrict the increase of emissions, regarding a basket of three GHG ($CO_2$, $N_2O$ and $CH_4$) from all sources**,** of 2000 to no more than 15%±3% from 1990 level. The margin of 3% was adopted to allow for unpredictable domestic or international developments and relevant EU policy actions. Measures defined in this Plan, as well as policies introduced since 1995 and until 1997, are described in the 2nd National

Communication to the UNFCCC. A short description and a quantitative assessment of the effects of these policies and measures, together with those included in the "with measures" scenario (see chapter 5), are presented in chapter 4.2.1. The above-mentioned policies and measures are those considered as either implemented or adopted.

The second national climate change programme defines the additional policies and measures necessary for Greece to meet its Kyoto target, i.e., restricting the increase of greenhouse gases emissions to 25% over the time period 2008–2012, compared to base year emissions. These policies, considered as planned, are presented in chapter 4.2.2. Policies and measures related to Land Use change and Forestry are described in chapter 4.3. Although these measures are considered as implemented or adopted, the quantification of their effects is impossible. As a result, and in relation to the projection of GHG emissions, it is assumed that forest fires will remain at the levels observed in the 1990s.

Estimates of the expected effects of policies and measures are presented in **Annex II**. This estimation is based on:

- the expected results of policy instruments already in place (e.g., Operational Programme for Energy) according to the administrative authorities responsible for the monitoring of the progress of such instruments, and
- the definition of realistic penetration rates for the planned measures based on the characteristics of the planned policies that have already been defined,

in relation to the results of the baseline scenario. It should be mentioned that interactions between the implemented/adopted policies and measures have not been considered in the estimation of the expected effects.

### *3.2.1 Implemented – Adopted policies and measures*

#### *3.2.1.1 Energy sector – Promotion of natural gas*

The introduction of natural gas into the national energy system is one of the largest investments ever carried out in Greece. Total financing of the project is estimated at €2.5 billion (at the end of 2001). A significant part of the infrastructure—mainly related to the high-pressure transmission system and the medium-pressure network—needed to carry natural gas to the main consumption areas has been completed.
Pricing policy has been defined and the tariffs offered are related to the respective competitive fuel (e.g., fuel oil in industry, diesel in residential and tertiary sector, etc.). VAT is set at 8%, and there is no excise tax.

(A) Until now, the penetration of natural gas in electricity generation has been supported by the ***Operational Programme for Energy*** (OPE) of the Ministry for Development – Measure 1.2, which financed the fuel switching of two oil-fired power plants (360 MW) in Keratsini, and the construction of three combined cycle gas-fired power plants with a total capacity of approximately 1200 MW.
***Law 2773/99 established liberalisation of the electricity market in Greece*** in agreement with the provisions of the Directive 96/92/EC concerning "common rules for the internal market in electricity." According to this law, the electricity sector will be restructured along the following lines:

- Authorisation system for the construction of new generating capacity in the mainland and the interconnected islands, and tendering system for the non-interconnected islands.
- Regulated third-party access to the transmission and distribution system on the basis of published tariffs.
- Establishment of a new joint stock company to be appointed as the transmission-system operator. The distribution-system operator will be PPC.

It is expected that the liberalisation of the electricity market will give rise to a further penetration of natural gas for electricity generation in the near future, since up until June 2002, 98% of the approved production licences refer to natural-gas power plants.

(B) Natural-gas consumption in industry represented 8% of the total consumption in the sector in 2000 (436 million $m^3$). The OPE (Measures 2.2 and 2.3) and the Development Law (Law 2601/98, which replaced the previous development law 1892/90 and its amendments, laws 2234/94 and 2324/95) were the main policy instruments available to promote natural-gas penetration in industry. The OPE focussed on the provision of the necessary subsidies for the motivation of the investors, while with the Development Law investment subsidies, tax credits, loans at reduced interest rates and increased depreciation rates are provided. The OPE financed 84 projects of fuel switching to natural gas while the Development Law financed 8 similar projects.
Additionally, the OPE financed cogeneration projects (with natural gas) in industrial units. So far, a total installed capacity of 15.6 MW is already in operation. Investment subsidies provided by the OPE together with the favourable tariffs defined in ***Law 2244/94*** (see 2nd National Communication to the UNFCCC) constitute the framework for the promotion of cogeneration.

(C) Natural-gas consumption in the residential and tertiary sector represents only 0.2% of the total consumption in the sector in 2000 (15 million $m^3$), due to a delay in the construction of a low-pressure distribution system. ***Law 2364/95*** provides a tax exemption of 75% from the end-user purchase and installation expenses of systems using natural gas.

(D) Athens Urban Transport Association proceeded in the purchase of 295 CNG buses, which were introduced into the Athens public transport network at the end of 2000, along with the operation of a refuelling station. Furthermore, the provision of additional 120 CNG buses is anticipated for the near future.

#### *3.2.1.2 Energy sector—Improvements in the conventional power generation system*

PPC has been actively involved in the field of energy conservation (as a member of EURELECTRIC, PPC participates in the "Energy Wisdom" project, which aims to improve energy efficiency and reduce GHG emissions on a voluntary basis) in the electricity-generation system through:

(A) Efficiency improvements in the existing lignite-fired power stations. This measure is related to the enhancement of the operation of cooling towers, lignite mills, turbines, etc. The improvements introduced resulted in an energy conservation of approximately 40 ktoe.

(B) Limitation of distribution losses. This measure includes the replacement of normal loss distribution transformers. Energy conservation is estimated at 88 GWh in 2000.

(C) Promotion of combined heat and power systems. PPC has initiated the implementation of a cogeneration programme in its lignite-fired power plants by setting up a district heating network in northern Greece. Presently, two district heating plants are in operation, with an installed capacity of 50 $MW_{th}$ serving the town of Ptolemais and 70 $MW_{th}$ serving the town of Kozani. The second heating plant was financed by the OPE as part of the construction of a new lignite power plant (Agios Demetrios V). It is also expected that a new heating plant

(70 $MW_{th}$ installed capacity) will be in operation when the new lignite power plant in Florina is completed (2003). Moreover, the operation of an additional 45 $MW_{th}$ is under evaluation.

#### *3.2.1.3 Energy sector – Promotion of renewable energy sources*

The Ministry for Development considers the exploitation of renewable energy sources among its energy policy priorities. The OPE and Development Law providing investment cost subsidies in combination with Law 2244/93, which defines favourable buy-back tariffs for electricity generated from renewable energies, were the main policy instruments for the promotion of RES. The Development Law has thus far financed 20 wind-energy projects and 12 small hydro projects with installed capacities of 175 MW and 3.5 MW, respectively. On the other hand the OPE has financed:

- 18 wind-energy projects, of which 14, with a total installed capacity of 116 MW, are already operational.
- 23 small hydro projects, of which 9, with a total installed capacity of 11.5 MW, are already operational.
- 32 photovoltaic projects, of which 15, with a total installed capacity of 735 kW, are already operational.
- 13 biomass projects, with a total installed capacity of 50 MWth and 9 MWe, are already operational.
- 55 solar energy projects, of which 51, with a total installed area of 21400 m2, and 3, concerning passive solar systems, are already operational.

Additionally, PPC has continued the exploitation of the available hydro potential. Since 1997, 400 MW of large hydroelectric plants (4 units) have been introduced in the interconnected system, while another four units with a total capacity of approximately 320 MW are under construction and expected to be in operation by 2007.

#### *3.2.1.4 Energy sector – Energy conservation in industry*

Energy-efficiency improvements in various areas of the industry sector are being promoted under the provisions of the Development Law, law 2244/93 (for CHP plants) and the OPE measures 2.2 and 2.3. Measure 2.2 concerns energy-intensive units, while measure 2.3 concerns small- or medium-sized enterprises. Apart from CHP plants, projects concerning energy conservation and exhaust heat recovery have been financed in the framework of the above-mentioned laws. More specifically 161 projects financed by OPE have already been completed.

#### *3.2.1.5 Energy sector – Energy conservation in residential and tertiary sector*

Apart from the introduction of natural gas, a major intervention in the residential and tertiary sector in order to reduce greenhouse gases emissions is energy conservation. The legislative framework in force for the promotion of energy conservation in the buildings' sector includes:

(A) A joint ministerial degree (21475/4707/98) for "Reduction of $CO_2$ emissions by determining measures and conditions for improvement of the energy efficiency in buildings" was issued in 1998 in agreement with the provisions of the SAVE Directive 93/76. The provisions of this decision apply to both existing and newly constructed buildings of all types and uses. The replacement of the current thermal insulation regulation, the definition of specific design criteria, the establishment of maximum energy

consumption limits for different categories of buildings, the energy-environmental certification of buildings are some of the actions foreseen in this decision. However, the implementation of this decision requires the issuance of a Presidential Decree that is still under preparation and therefore, this policy is not a part of the "with measures" scenario.

(B) Presidential Decrees 335/1993 and 178/1998 issued in agreement with the provisions of EU Directives (92/42/EC and 96/57/EC respectively) defining minimum energy efficiency standards for non-industrial boilers and for refrigerators/freezers.

(C) Presidential Decree 180/1994 issued in agreement with the provisions of EU Directive 92/75/EC setting the general obligations for energy labelling. Particular provisions are set for refrigerators/freezers (Directive 94/2/EC – harmonisation by the Ministerial Decision 25810/1994), washing machines (Directive 95/12/EC – harmonisation by the Ministerial Decision 3972/1996), combined washer-dryers (Directive 96/60/EC – harmonisation by the Ministerial Decision 9142/1997), dishwashers (Directive 97/17/EC – harmonisation by the Ministerial Decision 10200/1998) and household lamps (Directive 98/11/EC – harmonisation by the Ministerial Decision 13897/1999).

(D) Law 2364/95 that provides a tax exemption of 75% from the end-user purchase and installation expenses of RES and energy conservation systems.

A programme for the replacement of incandescent lamps by high efficiency ones was initiated in 1996 by PPC on the island of Crete. The scope of this voluntary action was expanded to cover other Aegean islands and Thrace.

#### *3.2.1.6 Transport sector – Interventions in the transport system*

The public works regarding the enhancement of the existing infrastructure described in the 2nd National Communication (road-grid improvements in the large urban centers, reconstruction of the major highway road arteries, improvements in the traffic-light system) are in progress.

#### *3.2.1.7 Transport sector – Interventions in vehicles*

The main regulations applied to vehicles concern:

(A) The *regular technical control of vehicles,* that has been mandatory since 1983 and takes place at the Centres for Technical Control of Vehicles (currently 58 centres operate across Greece). As the frequency of inspections was not satisfactory due to problems related to infrastructure and personnel in the prefectures, a new law was introduced in 2001. This law provides for the establishment of private Centres for Technical Control, the improvement of public ones and the development of a special service to supervise the operation of the above-mentioned Centres.

(B) An *exhaust-control card* (renewed annually), which is required for all vehicles. The implementation of the measure has been expanded beyond the Attica prefecture, and in 2001 it covered 34 prefectures in total (covering 85% of vehicles). Exclusively certified auto-repair shops issue the control card. By 2001, approximately 4,000 shops had been certified. Furthermore, in order to inspect the measure's implementation, mobile inspection units have been established. By 2001, there were 10 such units in the Attica prefecture and 10 more covering the remainder of the country. During 2001, the units carried out approximately 28,000 vehicle inspections.

(C) The differentiation of the taxation applied to vehicles according to their anti-pollution technology (Law 1682/99).

(D) The differentiation of the excise-tax rates applied to the different motor fuels, with lower rates for unleaded gasoline compared to those for leaded and leaded with additives gasoline.

Additionally, the voluntary agreement between the European Commission and the European, Japanese and Korean car-manufacturers associations to improve the fuel efficiency of new cars is considered as an adopted measure.

#### *3.2.1.8 Transport sector – Interventions in public transport*

Interventions in public transportation include mainly the following measures:

(A) Construction of metro lines. Two new metro lines are in operation, and the extension of these lines is already in progress.
(B) Efficiency improvements in buses. The renewal process of the available buses is in progress. Since 1997, 750 diesel busses with EURO2 prescriptions and 216 new trolleys have been purchased.
(C) Interventions in the traffic network of buses. The establishment of priority measures for pubic transportation is a key issue in the policy for public transport. In the last few years, efforts have been focused on increasing vehicle speed, reducing waiting times and generally improving the frequency of service through the construction of bus and trolley lanes in Athens' road network. The total length of the bus lanes is 18.3 km.

#### *3.2.1.9 Waste sector*

National policies and measures for the waste sector are related to the operation of managed solid-waste disposal sites and the construction of municipal wastewater plants. In 2000, there were 2,182 unmanaged waste-disposal sites while the percentage of the population served by the wastewater plants in operation was 32%, according to the records of the Ministry of Environment. It is foreseen that:

- After 2006 there will not be any unmanaged solid-waste disposal sites.
- The percentage of the population served by wastewater plants will increase to 95% in 2006.

Additionally, the European Community's Landfill Directive imposes limits on the amount of biodegradable municipal waste that is landfilled. The targets, based on the amount of waste produced in 1995, and the timescales applied are:

- A reduction to 75% of the total amount in 2006.
- A reduction to 50% of the total amount in 2009.
- A reduction to 35% of the total amount in 2013.

### *3.2.2 Planned policies and measures*

The second national climate change programme, adopted in May 2002, defines the additional policies and measures to be undertaken in order to ensure compliance with the target set in the framework of the Kyoto Protocol. The implementation of this plan presupposes that all necessary arrangements in the legislative and administrative frameworks will be in place and the infrastructure needed will be ready.

The operational programmes formulated within the 3rd Community Support Framework (CSF) are expected to provide the basis upon which the climate change action plan will be

implemented, since sustainability and compliance with all international commitments are some of the guiding principles adopted for their formulation. Some key actions defined in the operational programmes of the 3rd CSF that will facilitate the implementation of the climate change programme include:

- Access to different supply sources for natural gas
- Definition of all necessary procedures for the electricity- and natural gas–market liberalisation
- Development of the infrastructure needed to support the penetration of renewable energy sources, especially in the islands
- Completion of the low-pressure distribution system for natural gas
- Establishment of a framework of incentives that will provide financial support to initiatives undertaken in the residential and public sector. Additionally, the promotion of voluntary agreements with the private sector is also foreseen
- Information campaigns to enhance environmental awareness not only of individuals but of public administration, too.

The key measures included in the 2nd national climate change programme are:

In the ***Energy sector – Electricity generation:***

- Further penetration of renewable energy sources. The measure involves the increase of the installed capacity of wind farms and small hydro plants by 800 MW and 250 MW, respectively, in 2010 compared to the "with measures" scenario. Other set targets refer to the installation of 10 MW of photovoltaic units, 10 MW of geothermal power plants and 200 MW of biomass power plants.
- Operation of natural-gas power plants as base load units. The average load factor of natural-gas power plants increases from 55% in the "with measures" scenario to 65%.
- Further penetration of CHP plants in the industrial and tertiary sectors.
- Emissions reductions are estimated at 4.3 Mt CO2 eq in 2010.

In the ***Energy sector – Industry*:**

- Further penetration of natural gas for thermal uses. The measure involves the increase of natural-gas penetration in industry by 15% in 2010 compared to the "with measures" scenario.
- Promotion of renewable energy sources. The measure concerns (a) the use of solar energy in industrial units for which low- and medium-enthalpy heat represents a significant share of the total thermal needs and (b) the use of biomass in wood processing units and food industries.
- Various energy conservation measures.

Emissions reductions are estimated at 0.4 Mt CO2 eq in 2010.

In the ***Energy sector – Residential and tertiary sector:***

- Improvements in the thermal behavior of existing buildings. The largest heat losses in non insulated buildings appear through the walls and windows. Therefore, the examined retrofit measures concern (a) roof insulation in residential buildings (10% of existing buildings) because it is more cost-efficient and easier than wall insulation and (b) replacement of single glazing by double-glazing in buildings of the tertiary sector. The penetration rate in the tertiary sector varies according to the use of the building.
- Promotion of renewable energy sources. The measure concerns (a) the use of solar energy for water heating and in some cases for space heating, (b) the use of roof-top photovoltaic units (5 MW), mainly in the tertiary sector and (c) the installation of 200 MW of biomass district heating plants.
- Promotion of energy efficient appliances and heating equipment. Energy-efficient appliances (including air-conditioning units) will represent up to 40% of the projected stock of appliances. Energy-efficiency improvements of heating equipment concern the systematic maintenance and the replacement of central heating boilers. The penetration rate in the tertiary sector varies according to the use of the building.
- Further penetration of natural gas for space heating and cooling (only in the tertiary sector).
- Other energy conservation measures. This measure aims at the reduction of (a) the cooling load through the external shading of buildings, night ventilation and use of roof fans and (b) electricity consumption for lighting through the use of advanced lighting-control systems.
- Emissions reductions are estimated at 4.1 Mt CO2 eq in 2010.

In the ***Transport sector:***

- Measures concerning vehicles. The measure involves energy-efficiency improvements through the maintenance of private cars and low-duty trucks. It is expected that specific consumption can be reduced by 2% per vehicle.
- Measures concerning fuels used in transport. The introduction of 550 additional CNG buses in the Athens area as well as the use of biofuels (a 2.5% blend with gasoline) is expected.
- Transport management. This measure concerns (a) the gradual increase of the transport load covered by public means of transportation, (b) the improvements in road signaling that can lead to energy conservation in the order of 0.8%–3.5% and (c) the promotion of non-technical measures (e.g. bus-lanes).

Emissions reductions are estimated at 0.5 Mt $CO_2$ eq in 2010.

In the ***Industrial processes sector:***

Significant emissions reductions are expected (4.7 Mt $CO_2$ eq in 2010) as a result of the restructuring of the operation of chemical industries (it is expected that the HCFC-22 production line will stop its operation after 2005) and the recovery of f-gases from discarded equipment.

In the ***Wastes sector***

The only measure examined is the flaring of landfill gas in all managed sites for urban centres with population more than 100,000 inhabitants. It is noted that the measure is partially

integrated (managed disposal sites covering the three largest cities of Greece) in the "with measures" scenario. Emissions reductions estimated are less that 0.1 Mt $CO_2$ eq in 2010.

In ***Agriculture:***

- Manure management systems. Further penetration of liquid management systems is examined.
- Organic farming. A target of 200,000 ha cultivated according to the practices of organic farming is set.

Emissions reductions estimated are less that 0.1 Mt $CO_2$ eq in 2010.

## 3.3 Policies and measures in Land Use Change and Forestry

The operational programme for the Greek forests (75% financed by the EU) covers all regions of Greece and includes activities such as (a) reforestation, (b) construction, maintenance and improvements in the forests' road network, (c) economic development on mountainous communities, (d) private forestry, (e) control of forest fires, (f) national forest parks, (g) inventory of forests, (h) studies, etc. The programme was successfully implemented, and in 2000 80% of the total assigned budget (for this year) has been expended.

There is another programme (in the framework of EU Directives 3529/86, 2158/92 and 2157/92), 50% financed by EU that is related to the management of public and private forests. The programme focuses on forests' protection (from fires and atmospheric pollution), improvements in degrading forests, construction of road network and information campaigns. As far as public forests are concerned, the selected areas are those that have major problems with forests' fires. Additionally, there is also a programme focusing on private forests and especially on afforestation of agricultural land.

Measures undertaken for the protection of forests are presented in **Table 3.1**, while **Figure 3.1** presents the reforested areas in the last decade.

**Table 3.1** Measures undertaken for the protection of forests (1990-2000)

| YEAR | CONSTRUCTION OF ROAD NETWORK (km) | | OBSERVATION POSTS (number) | CONSTRUCTION OF DAMS (number) | GROUND COVER CLEARING (stremmas) | TREAT OF DISEASES (in thousands €) |
|---|---|---|---|---|---|---|
| 1990 - 1996 | 5,937 | 76,835 | 155 | 587 | 142,290 | 694 |
| 1997 | 518 | 14,284 | 29 | 53 | 5,133 | 231 |
| 1998 | 275 | 14,027 | - | 150 | 5,235 | 192 |
| 1999 | 673 | 16,551 | 8 | 128 | 27,003 | 269 |
| 2000 | 2,858 | 18,742 | 6 | 131 | 16,620 | 136 |

Another field of interventions are those related to the settlement of the various streams in mountainous areas. At this point, 25% of the streams' springs (250 in total) have been settled. These interventions, for the time period 1997–2000, include (a) the construction of dams (a total volume of 170,000 $m^3$), (b) the construction of new roads (17 km) and the maintenance of existing ones, (c) various horticultural works (1,400 Ha) and (d) protections of soils from erosion through fencing.

Finally, 19 research programmes were financed during 2000, while there are other 42 programmes under evaluation.

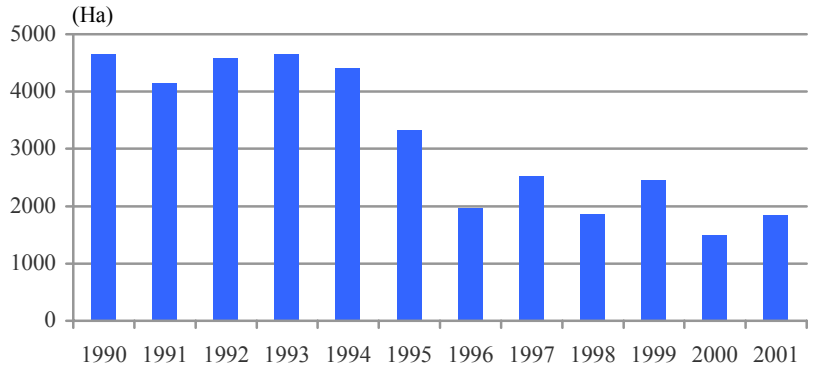


**Figure 3.1** Reforestation during the period 1990 - 2000

# 4 PROJECTIONS OF EMISSIONS

## 4.1 Overview

The "with measures" scenario indicates that emissions will be 35.8% and 56.4% above base year levels[2] (108.4 Mt $CO_2$ eq) by 2010 and 2020 respectively. Energy sector accounts for more than 75% of total greenhouse gases emissions (**Table 4.1**) while carbon dioxide emissions accounts for more than 80% of total emissions (**Table 4.2**). However, f-gases emissions are estimated to increase with a mean annual rate of more than 4 times higher compared with that of total emissions for the period 2000 – 2020 (5.1% for the f-gases compared to 1.2% for total emissions).

**Table 4.1** Projections of greenhouse gases emissions in the "with measures" scenario, disaggregated by sector, kt $CO_2$ eq

| Sources and Sink categories | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Energy | 80789 | 84386 | 101062 | 107787 | 116890 | 125205 | 133277 |
| Industrial processes | 9591 | 11725 | 12874 | 13667 | 15899 | 18467 | 20787 |
| Solvents | 177 | 156 | 169 | 173 | 177 | 179 | 181 |
| Agriculture | 10448 | 9737 | 10227 | 9736 | 9668 | 9566 | 9467 |
| Land Use Change & Forestry | 1391 | -307 | 4138 | 2030 | 2030 | 2030 | 2030 |
| Waste | 3749 | 4422 | 5319 | 4042 | 2542 | 2598 | 3793 |
| **Total** | **106145** | **110120** | **133789** | **137435** | **147206** | **158046** | **169536** |

**Table 4.2** Projections of greenhouse gases emissions in the "with measures" scenario, disaggregated by gas, kt $CO_2$ eq

| Gas | Base year | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Carbon dioxide | 85586 | 85586 | 87273 | 107818 | 111961 | 120817 | 128947 | 136834 |
| Methane | 8743 | 8743 | 9493 | 10562 | 9395 | 7936 | 8040 | 9283 |
| Nitrus oxide | 10624 | 10624 | 9900 | 10979 | 10909 | 11148 | 11285 | 11430 |
| HFCs | 3369 | 935 | 3369 | 4281 | 5022 | 7158 | 9626 | 11842 |
| PFCs | 83 | 258 | 83 | 148 | 148 | 148 | 148 | 148 |
| SF6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **108405** | **106146** | **110118** | **133788** | **137436** | **147207** | **158046** | **169537** |
| Change from base year levels | ***100*** | ***97.9*** | ***101.6*** | ***123.4*** | ***126.8*** | ***135.8*** | ***145.8*** | ***156.4*** |

As a result of additional policies and measures set out in the 2nd climate change national programme, the increase of GHG emissions in Greece could be restricted to 24.5% compared to base year levels, by 2010 (**Table 4.3** and **Figure 4.1**).

[2] 1990 has been used as the base year for $CO_2$, $CH_4$ and $N_2O$. 1995 has been used as the base year for HFCs, PFCs and $SF_6$.

**Table 4.3** Projections of greenhouse gases emissions in the "with measures" and the "with additional measures" scenario, disaggregated by sector, kt $CO_2$ eq

| Sources / Sinks | 1990 | 1995 | 2000 | 2005 | | 2010 | |
|---|---|---|---|---|---|---|---|
| | | | | With measures | With additional measures | With measures | With additional measures |
| Energy | 80789 | 84386 | 101062 | 107787 | *104441* | 116890 | *109404* |
| Industrial processes | 9591 | 11725 | 12874 | 13667 | *13667* | 15899 | *11248* |
| Solvents | 177 | 156 | 169 | 173 | *173* | 177 | *177* |
| Agriculture | 10448 | 9737 | 10227 | 9736 | *9702* | 9668 | *9604* |
| LUCF | 1391 | -307 | 4138 | 2030 | *2030* | 2030 | *2030* |
| Waste | 3749 | 4422 | 5319 | 4042 | *4016* | 2542 | *2473* |
| **Total** | **106145** | **110120** | **133789** | **137435** | ***134029*** | **147206** | ***134936*** |
| Change from base-year levels | ***97.9*** | ***101.6*** | ***123.4*** | ***126.8*** | ***123.6*** | ***135.8*** | ***124.5*** |

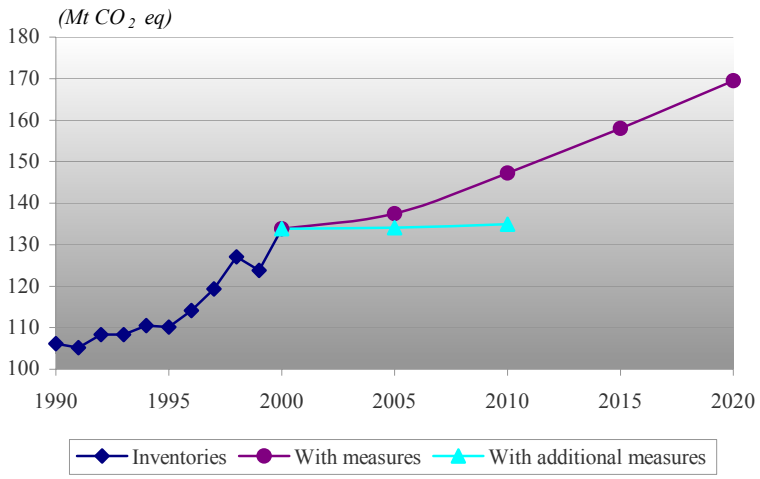


**Figure 4.1** Projections of greenhouse gases emissions in the "with measures" and the "with additional measures" scenario

## 4.2 Methodology

Two main model types / procedures have been used for scenarios development and projections.

- Economic-technical model (ENPEP) for the energy sector (energy supply and use – fugitive emissions).

- Spreadsheet models for the non-energy sectors, in which future changes in activity data are mainly derived from statistical analysis while emission factors are derived from expert assessments based on the IPCC/CORINAIR methodology.

### 4.2.1 Energy sector

In the framework of the 3rd National Communication the Energy and Power Evaluation Program (ENPEP) has been used. ENPEP was developed by Argonne National Laboratory and contains a set of analytical tools for use in integrated energy/electricity system planning and the quantification of environmental burdens. Its basic module (BALANCE) is used to trace the flow of energy throughout the entire energy system from resource extraction, through processing and conversion, to meet demands for useful energy (e.g. heating, transportation, electrical appliances) and employs a market-based simulation approach to project future energy supply/demand balances.

ENPEP model uses a non-linear, equilibrium approach to determine the energy supply demand balance. The equilibrium modelling approach used in the BALANCE Module is based on the concept that the energy sector consists of autonomous energy producers and consumers that carry out production and consumption activities, each optimising individual objectives. For its simulation, the model uses an energy network that is designed to trace the flow of energy from primary resources through to final energy. A fundamental assumption of the model is that producers and consumers both respond to changes in price. Furthermore, energy demand is sensitive to the prices of alternatives, as supply price is sensitive to the quantity demanded. ENPEP seeks to find, except the intersection of the supply and demand curves, the intersection for all energy supply forms and all energy uses that are included in the energy network. The equilibrium is reached when the model finds a set of prices and quantities that satisfy all relevant equations and restrictions. As market shares of energy are dependent on energy prices and energy prices are dependent on the quantity of fuel demands, ENPEP uses an iterative process to bring network prices and quantities into equilibrium.

The energy network used represents all energy production, conversion, transport, distribution, and utilization activities in a country or region, as well as the flows of energy and fuels among those activities. The data that are necessary to calibrate the model for a base year as well as to project the future energy needs can be divided in the following categories:

- Macro-economic data that correspond to demographic national accounts, sectoral activity and income variables.
- Structure of energy consumption in the base year and structure of activity variables (production, dwellings, passenger-kilometers, etc.).
- Technical-economic data for technologies and sub-sectors (e.g. capital cost, unit efficiency, variable costs, lifetime, etc.).

The Greek Energy system is presented in ENPEP model by sub-systems and sectors, which covers the main economic and energy activities. More specifically, the network developed, comprises the following sub-systems:

1. **Energy supply**. Energy supply is disaggregated into solid fuels (imported coal and lignite), imported liquid fuels (crude oil, diesel, gasoline, heavy fuel oil, LPG, jet fuel, naphtha and other liquid fuels), domestic liquid fuels (crude oil), natural gas, renewable energy sources (wind energy, solar energy, biomass, hydro and geothermal energy) and exports (small quantities of various oil products as well as solid fuels and electricity mainly in other Balkan countries).

2. **Energy conversion**. Energy conversion is disaggregated into the refineries (based on the total installed capacity of the four Greek refineries) and the power generation sector that is further disaggregated into the interconnected system in the mainland and the autonomous island systems. Liberalization of the electricity market is considered and it is simulated through the definition of four main categories of producers, which are differentiated regarding their economic characteristics and the needs that they cover: (a) large electric utilities, (b) industrial auto-producers, (c) independent producers in the industrial sector, covering their needs in heat and electricity through co-generation and (d) independent producers in the tertiary sector, covering their needs in heat and electricity through co-generation.
3. **Final demand**. Final demand includes six main sectors (agriculture, industry, transport, services, residential and non-energy uses), which are further decomposed into sub-sectors and then into specific energy uses (e.g. space heating, air conditioning, steam production, etc.). A technology operates at the level of an energy use and utilizes energy forms (fuels).

The strength of this approach is that it allows for a comprehensive assessment of the various interactions between the different sectors of the energy system. The market-based equilibrium together with the detailed technical description of the energy sectors and uses enables the realistic representation of the energy system as well as the modelling of different policy instruments. However, the solution obtained is closely related to the level of detail of the developed energy network. The main limitations of the model are that useful energy demand is not endogenously adjusted to changes of prices and market simulation parameters are set exogenously.

### *4.2.2 Non energy sectors*

Greenhouse gases emissions in the non-energy sectors are calculated using simplified spreadsheet models that calculate emissions based on activity data, emission factors and sector specific assumptions, according to the following general equation:

$$E_t^g = A_0 \cdot (1 + r(x_i))^t \cdot C$$

Where,

$E_t^g$ : Projection of emissions of *g*-greenhouse gas in year-*t*

$A_0$ : Activity data in base year

$r(x_i)$ : Growth rate of activity data based on the changes of a determinant parameter, if any.

C : Control factor, accounting for changes in emission factors or controls

The ***growth factor*** accounts for changes (increases or decreases) in the emission-generating activity. In estimating the growth factor, time-series analysis and/or regression analysis using an appropriate determinant parameter of the available activity data is used. Potential determinant parameters include population; value added, product output, etc.

The ***control factor*** accounts for changes in emission factors. In determining the future year emission factor, three basic parameters must be quantified: regulation control, rule effectiveness, and rule penetration. Regulation control is the level of reduction expected by assuming a fully complied measure. Rule effectiveness accounts for the level of expected compliance with the regulation. Rule penetration indicates the fraction of emissions within a source category, which are subject to the regulation, accounting for possible exemptions. These parameters are quantified by experts' assessments in close consultation with the responsible governmental departments. The main drawback of this analysis is that the models do not take

into account any overlaps or synergies between sectors or policy areas. Moreover, the extrapolation of past correlations overlooks the effects of technological advance.

## 4.3 Main assumptions in the "with measures" scenario

The level of emissions estimated in any scenario depends on assumptions regarding main parameters, such as population, economic growth, energy prices etc. It also depends on the specific reduction policies incorporated to the scenario. The main assumptions made for the projection of energy consumption and associated GHG emissions in the "with measures" scenario are presented in **Table 4.4**. Additional to the assumptions presented in table 4.4, the following were also considered:

- ***Weather conditions*:** Future weather conditions were assumed to remain the same as those in recent years. Assuming that weather conditions will be closer to the historical average would ignore the fact that the average annual temperature has already increased noticeably in the last decade, and consequently the use of the lower historical average temperature would lead to a sudden, non-justifiable increase of space heating requirements after the year 2000.
- ***Sectoral value added***: The tertiary sector excluding public services shows the highest annual rate of growth (4.04%), while its share in GDP in 2010 and in 2020 is estimated correspondingly at 57% and 61% (45% in 1990). The public sector is also projected to develop with an average annual rate of 4% during the period 2000-2010, while this rate falls to 3.5% after 2010. The annual rate of increase in industry is approximately 1.1% during the period 2000-2010 and 0.7% during the period 2010-2020, while its contribution to the total GDP decreases from 24% in 1990 to 16% in 2010 and to 13% in 2020. Finally, the annual rate of growth in the primary sector is 1% during the entire study period.
- ***Discount rates*:** The implemented discount rates for the evaluation of the various energy technologies are differentiated on the basis of the specific characteristics of the energy actors involved. More specifically, in the residential sector consumers usually prefer investments with a short payback period and so a discount rate of 14% has been adopted. On the other hand industries, utilities, refineries, etc., usually plan their investment policy on a long-term basis and therefore a 6% discount rate seems more appropriate. Finally, in the tertiary sector a discount rate of 9% has been adopted.

The "with measures" scenario defines the future development of the energy system under current policies and consumers' behaviour, as well as under the emerging future trends. Specifically, the "with measures" scenario comprises:

1. The liberalization of local electricity market.
2. The agreement between the EU and car industries (ACEA, KAMA, JAMA) regarding the decrease of fuel consumption in new cars, with the aim to achieve an average $CO_2$ emission factor of 140 gr/km by 2008 (with an intermediate target of 170 gr/km by 2003).
3. The continuation of present economic instruments for the promotion of RES, co-generation, natural gas and energy conservation.
4. The integration of the expected GHG emissions reductions from projects in the field of RES and energy conservation, which have been approved and/or already implemented within the Operational Programme for Energy (financed by 2nd Community Support Framework).
5. The Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

**Table 4.4** Main assumptions in the "with measures scenario"

| | Historic | | | Projected | | | |
|---|---|---|---|---|---|---|---|
| | 1990 | 1995 | 2000 | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2020 |
| Population (mio) | 10.16 | 10.53 | 10.87 | 0.5% | 0.4% | 0.3% | 0.2% |
| Household size (cap/hh) | 3.21 | 3.14 | 3.06 | 2.97 | 2.87 | 2.78 | 2.68 |
| GDP (bil. Euro 2000) | 96.6 | 102.8 | 121.0 | 4.4% | 3.4% | 3.0% | 2.9% |
| International fuel prices | | | | | | | |
| Coal ($90/t) | *51.3* | *40.6* | *28.5* | | *31.2* | | |
| Oil ($90/bbl) | *22.2* | *17.2* | *22.8* | *-7.7%* | *0.0%* | *0.8%* | *3.1%* |
| Natural gas ($90/toe) | *119.1* | *92.5* | *90.1* | *-7.7%* | *0.0%* | *0.8%* | *3.1%* |
| Transport activity | | | | | | | |
| Passenger transport (bil. p-km) | 96.5 | 124.3 | 151.4 | 3.3% | 2.3% | 1.7% | 1.0% |
| Goods transport (bil. t-km) | 84.8 | 94.3 | 106.0 | 2.6% | 2.3% | 2.1% | 1.9% |

## 4.4 The "with measures" scenario by sector

### *4.4.1 Energy sector*

The key developments regarding the energy sector (including transport) are summarized below, while some key figures are presented in **Table 4.5**

- **Gross inland consumption** increases continuously during the entire time period (from 23.8 Mtoe in 1995 to 34 Mtoe in 2010 and to 40 Mtoe in 2020), at an average rate of increase around 2.1%. Liquid fuels still cover the major part of gross inland consumption, but their contribution decreases from 59% in 1995 to 54% in 2010 and to 52% in 2020. The consumption of solid fuels shows an increase in the order of 15% during 1995-2020, while their share falls from 35% in 1995 (8.4 Mtoe approximately) to 24% in 2020 (9.7 Mtoe approximately). It is also projected that natural gas covers a significant part of the gross inland consumption, which is estimated at 15.1% of in 2010 and at 20.1% in 2020, thus resulting in a decrease of the relative contribution of solid and liquid fuels. The share of RES including large hydro in gross inland consumption for the entire period examined declines from 4.85% in 1995 (1.15 Mtoe) to 4% in 2010 (1.36 Mtoe) and in 2020 (1,61 Mtoe). In absolute values, their exploitation increases by 39% from 1995 to 2020.
- **The use of electricity** is expected to expand with an average annual rate of 3.1% during the period 2000 – 2010, while this rate declines to 2.5% during the next decade. As a result, total installed power generation capacity in Greece increases by some 9.8 GW in the period 1995-2020. The use of traditional lignite and oil power plants does not change significantly during the study period. The increased capacity needs are mainly covered with the installation of natural gas combined cycle power plants. Their capacity increases by almost 5 times over the period 2000 – 2020 to reach 6 GW or around 31% of the total installed capacity by 2020. At the same time, the installed capacity of large hydro units remains practically the same during the reference period, while 1.7 GW of wind farms are expected to be installed until 2020, as a result of the rich wind potential in Greece and the support policies implemented by the Greek government.

- **Final energy consumption** increases continuously during the entire time period (from 16.2 Mtoe in 1995 to 23.7 Mtoe in 2010 and to 27.6 Mtoe in 2020), with an average rate of growth in the order of 2.2%. Liquid fuels have the highest share in final energy consumption, presenting however a slight decrease of their contribution from 70% in 1995 to 64% in 2010 and to 61% in 2020. Electricity contribution to final energy consumption increases from 18.7% in 1995 (3 Mtoe) to 21.2% in 2010 (5 Mtoe) and to 23.4% in 2020 (6.5 Mtoe). Natural gas represents approximately 7.1% of final energy consumption in 2010 (1,680 ktoe), while this percentage increases to 8.5% in 2020 (2334 ktoe). The share of RES decreases from 5.1% in 1995 to 3.1% in 2010 and to 2.8% in 2020, while in absolute values their exploitation decreases by 6.8% in 1995-2020. The reduction of RES share in final energy consumption, despite the significant penetration of solar systems, is due to the reduced biomass consumption in the residential sector.

The structure of final energy consumption per sector is in line with the characteristics of the economic development. The share of industry sector in final energy consumption is reduced from 32.5% in 1995 to 27.7% in 2010 and to 25.7% in 2020. On the contrary the share of agricultural sector remains practically the same during the entire examined period. The contribution of tertiary and transport sectors increases significantly during the reference period (by more than 5% and 2% respectively). Finally, the share of residential sector in final energy consumption declines slightly during the study period.

The "with measures" scenario leads to an increase of $CO_2$ emissions from the energy sector emissions by 44.9% between 1990 and 2010 and by 65.6% between 1990 and 2020 (Table 6). $CO_2$ emissions are projected to increase annually by 2.1% in the 1990-2000 periods, while this rate declines to 1.6% in the 2000-2010 periods and to 1.3% in the following decade. The rate of increase of emissions is slowed down, mainly because of the penetration of natural gas and of various renewable energy sources especially in the power generation sector. It is not surprising that, in the period to 2020, the sectors with the fastest increase in emissions are those where energy demand is expected to grow fastest, namely the tertiary and transport sectors. However, in terms of absolute contribution to the total GHG emissions arising from the Greek energy sector, it is the electric sector, which accounts for more than 50% of the total emissions between 1990 and 2020. The transportation sector is also a major and continually increasing source of $CO_2$ emissions and its share in the total $CO_2$ emissions from the energy sector increases from 20% in 1990 to 23.5% in 2010 and to 24.1% in 2020. On the contrary, the share of $CO_2$ emissions arising from the industrial sector is continually reduced in the reference period from 15.6% in 1990 to 13.1% in 2010 and to 12% in 2020.

The evolution of non-$CO_2$ GHG emissions arising from the Greek energy sector is also presented in Table 5. Regarding $CH_4$ emissions, coal mining-oil and gas distribution constitute the most significant sources accounting for more than 75% of total $CH_4$ emissions. Total $CH_4$ emissions are expected to show a very modest decrease rate after 2000 of less than 0.4% per annum. On the other hand electric sector is the major source of $N_2O$ emissions accounting for more than 50% of the total emissions overall the study period. Total $N_2O$ emissions increase with an average annual rate of 1.2% for the next 20 years.

In terms of $CO_2$eq, GHG emissions from the Greek energy sector increase from 80.8 Mt in 1990 to 116.9 Mt in 2010 and to 133.3 Mt in 2020 with an average annual rate of 1.7% (Table 7). Tertiary and transportation sectors present the highest increase rates of GHG emissions. On the other hand it seems that GHG emissions arising from industrial and agriculture sectors increase very slightly mainly due to the modest development of these sectors. However, it should be noted that GHG emissions do not grow at the rate of economic growth because of the improvement of energy intensity.

**Table 4.5** Key figures for the "with measures" scenario in the energy sector

| | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|
| **PRIMARY PRODUCTION** | **9164** | **9355** | **9317** | **9622** | **9953** | **10317** |
| Solid fuels | 7544 | 7905 | 8008 | 8267 | 8519 | 8711 |
| Liquid fuels | 468 | 100 | 0 | 0 | 0 | 0 |
| Renewables | 1152 | 1350 | 1308 | 1355 | 1434 | 1606 |
| Natural Gas | 0 | 0 | 0 | 0 | 0 | 0 |
| **NET IMPORTS** | **14609** | **18462** | **21563** | **24426** | **27056** | **29649** |
| Solid fuels | 842 | 850 | 886 | 924 | 942 | 961 |
| Liquid fuels | 13649 | 15881 | 17023 | 18353 | 19441 | 20651 |
| Renewables | 0 | 0 | 0 | 0 | 0 | 0 |
| Natural Gas | 49 | 1732 | 3653 | 5148 | 6672 | 8036 |
| Electricity | 69 | -1 | 0 | 0 | 0 | 0 |
| **GROSS INLAND CONSUMPTION** | **23773** | **27817** | **30880** | **34048** | **37009** | **39966** |
| Solid fuels | 8386 | 8756 | 8894 | 9192 | 9462 | 9672 |
| Liquid fuels | 14117 | 15981 | 17023 | 18353 | 19441 | 20651 |
| Renewables | 1152 | 1350 | 1308 | 1355 | 1434 | 1606 |
| Natural Gas | 49 | 1732 | 3653 | 5148 | 6672 | 8036 |
| Electricity | 69 | -1 | 0 | 0 | 0 | 0 |
| **NET ELECTRICITY GENERATION** | **3236** | **4075** | **4732** | **5454** | **6199** | **7006** |
| Lignite | 2251 | 2467 | 2510 | 2590 | 2668 | 2727 |
| Oil | 652 | 609 | 591 | 711 | 783 | 874 |
| Natural Gas | 6 | 561 | 1117 | 1547 | 2059 | 2583 |
| Renewables | 327 | 438 | 515 | 606 | 689 | 821 |
| **FINAL ENERGY CONSUMPTION** | **16171** | **19417** | **21600** | **23719** | **25665** | **27588** |
| **per sector** | | | | | | |
| agriculture | 1013 | 1131 | 1218 | 1310 | 1408 | 1513 |
| industry | 5252 | 5821 | 6177 | 6564 | 6821 | 7094 |
| residential | 3324 | 4362 | 4569 | 4782 | 5040 | 5290 |
| tertiary | 869 | 1289 | 1702 | 2180 | 2684 | 3236 |
| transport | 5713 | 6816 | 7933 | 8883 | 9711 | 10455 |
| **per fuel** | | | | | | |
| Solid fuels | 1029 | 863 | 898 | 935 | 952 | 970 |
| Liquid fuels | 11246 | 13463 | 14295 | 15141 | 15919 | 16770 |
| Electricity | 3030 | 3711 | 4351 | 5023 | 5713 | 6454 |
| Thermal energy | 0 | 76 | 139 | 207 | 254 | 291 |
| Renewables | 825 | 896 | 778 | 733 | 729 | 769 |
| Natural Gas | 43 | 408 | 1138 | 1680 | 2097 | 2334 |

**Table 4.6** Evolution of GHG emissions from the Greek energy sector (kt)

| Sector | Gas | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | |
| | $CO_2$ | 76474 | 79778 | 95682 | 102083 | 110837 | 118866 | 126647 |
| | $CH_4$ | 15.1 | 16.3 | 21.8 | 19.2 | 18.8 | 18.8 | 19.2 |
| | $N_2O$ | 9.9 | 10.4 | 12.1 | 13.5 | 14.3 | 15.0 | 15.9 |
| Electricity production | | | | | | | | |
| | $CO_2$ | 41202 | 42746 | 51702 | 53199 | 58141 | 62877 | 67564 |
| | $CH_4$ | 0.3 | 0.3 | 0.4 | 0.9 | 0.9 | 0.9 | 1.0 |
| | $N_2O$ | 5.5 | 5.9 | 6.6 | 6.9 | 7.5 | 8.0 | 8.5 |
| Industry[3] | | | | | | | | |
| | $CO_2$ | 11892 | 11913 | 13771 | 14063 | 14537 | 14837 | 15189 |
| | $CH_4$ | 1.6 | 2.6 | 3.7 | 4.3 | 4.5 | 4.8 | 5.3 |
| | $N_2O$ | 1.8 | 1.8 | 2.0 | 2.4 | 2.4 | 2.4 | 2.5 |
| Transport | | | | | | | | |
| | $CO_2$ | 15358 | 16970 | 19182 | 23324 | 26070 | 28409 | 30514 |
| | $CH_4$ | 5.1 | 6.3 | 7.4 | 7.6 | 8.0 | 8.1 | 8.2 |
| | $N_2O$ | 0.6 | 0.9 | 1.2 | 2.0 | 2.3 | 2.4 | 2.6 |
| Agriculture | | | | | | | | |
| | $CO_2$ | 2815 | 2639 | 2659 | 2758 | 2871 | 3004 | 3149 |
| | $CH_4$ | 0.4 | 0.4 | 0.4 | 0.2 | 0.2 | 0.3 | 0.3 |
| | $N_2O$ | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.2 |
| Residential | | | | | | | | |
| | $CO_2$ | 4684 | 4851 | 7592 | 7840 | 8103 | 8394 | 8631 |
| | $CH_4$ | 7.0 | 6.7 | 9.8 | 6.2 | 5.1 | 4.6 | 4.3 |
| | $N_2O$ | 0.8 | 0.8 | 1.2 | 1.1 | 1.0 | 1.0 | 1.0 |
| Tertiary | | | | | | | | |
| | $CO_2$ | 523 | 659 | 776 | 899 | 1115 | 1345 | 1600 |
| | $CH_4$ | 0.7 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| | $N_2O$ | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Fugitive emissions | | | | | | | | |
| | $CO_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $CH_4$ | 44.3 | 49.1 | 55.8 | 54.8 | 57.8 | 60.7 | 63.2 |
| | $N_2O$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[3] Including energy sector

**Table 4.7** Evolution of GHG emissions from the Greek energy sector (kt)

| Sector | Gas | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | |
| | $CO_2$ | 76474 | 79778 | 95682 | 102083 | 110837 | 118866 | 126647 |
| | $CH_4$ | 1247 | 1374 | 1629 | 1554 | 1609 | 1670 | 1730 |
| | $N_2O$ | 3069 | 3236 | 3748 | 4185 | 4433 | 4650 | 4929 |
| Electricity production | | | | | | | | |
| | $CO_2$ | 41202 | 42746 | 51702 | 53199 | 58141 | 62877 | 67564 |
| | $CH_4$ | 6.3 | 6.5 | 7.5 | 18.9 | 18.9 | 18.9 | 21.0 |
| | $N_2O$ | 1705.0 | 1816.6 | 2035.2 | 2139.0 | 2325.0 | 2480.0 | 2635.0 |
| Industry [4] | | | | | | | | |
| | $CO_2$ | 11892 | 11913 | 13771 | 14063 | 14537 | 14837 | 15189 |
| | $CH_4$ | 33.6 | 53.6 | 78.0 | 90.3 | 94.5 | 100.8 | 111.3 |
| | $N_2O$ | 558.0 | 551.8 | 610.7 | 744.0 | 744.0 | 744.0 | 775.0 |
| Transport | | | | | | | | |
| | $CO_2$ | 15358 | 16970 | 19182 | 23324 | 26070 | 28409 | 30514 |
| | $CH_4$ | 107.1 | 132.5 | 155.4 | 159.6 | 168.0 | 170.1 | 172.2 |
| | $N_2O$ | 186.0 | 288.3 | 380.1 | 620.0 | 713.0 | 744.0 | 806.0 |
| Agriculture | | | | | | | | |
| | $CO_2$ | 2815 | 2639 | 2659 | 2758 | 2871 | 3004 | 3149 |
| | $CH_4$ | 8.4 | 8.4 | 9.1 | 4.2 | 4.2 | 6.3 | 6.3 |
| | $N_2O$ | 341.0 | 303.8 | 304.1 | 310.0 | 310.0 | 341.0 | 372.0 |
| Residential | | | | | | | | |
| | $CO_2$ | 4684 | 4851 | 7592 | 7840 | 8103 | 8394 | 8631 |
| | $CH_4$ | 147.0 | 141.1 | 206.4 | 130.2 | 107.1 | 96.6 | 90.3 |
| | $N_2O$ | 248.0 | 248.0 | 387.2 | 341.0 | 310.0 | 310.0 | 310.0 |
| Tertiary | | | | | | | | |
| | $CO_2$ | 523 | 659 | 776 | 899 | 1115 | 1345 | 1600 |
| | $CH_4$ | 14.7 | 0.4 | 0.5 | 0.0 | 2.1 | 2.1 | 2.1 |
| | $N_2O$ | 31.0 | 27.9 | 31.0 | 31.0 | 31.0 | 31.0 | 31.0 |
| Fugitive emissions | | | | | | | | |
| | $CO_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $CH_4$ | 930.3 | 1031.5 | 1172.4 | 1150.8 | 1213.8 | 1274.7 | 1327.2 |
| | $N_2O$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### *4.4.2 Industrial processes*

Projected emissions from industrial processes are based on the analysis (a) of the activity data of the respective industrial branches, (b) the apparent consumption of refrigeration and air-conditioning appliances. The emission factors used are those reported in the latest inventory since no technological advances of reduction policies are integrated in the scenario.

- An increase in the installed capacity of cement, chemical and aluminium production in not expected. On the contrary, an increase of 2% per annum is foreseen for lime production.

[4] Including energy sector

- The apparent consumption of air-conditioners in road vehicles and refrigerators in the residential sector increases with a mean annual rate of 2.5% for the period 2000 – 2020. The respective rate for stationery air-conditioning is estimated at 4.5%.

The "with measures" projections of greenhouse gases from industrial processes (table 8) show a total increase of 25% in 2010 and 60% in 2020 compared to 2000. Key highlights include:

1. Carbon dioxide and nitrous oxide emissions are almost constant during the period 2000 – 2020.
2. HFCs emissions as a by-product of HCFC-22 manufacture and PFCs emissions from the production of aluminium are kept at 2000 levels.
3. HFCs emissions due to the use of refrigeration and air-conditioning equipment increase with a rate of 14.5% per annum for the period 2000 – 2020. This increase is mainly attributed to the disposal of equipment with no salvage value. As a result the contribution of this sub-sector to the total emissions from industrial processes is 21% in 2010 and 40% in 2020. At the same time the share of carbon dioxide emissions is decreased from 80% in 1990 to 50% in 2010 and 40% in 2020.

**Table 4.8** Greenhouse gases emissions from industrial processes (kt $CO_2$ eq)

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 7684 | 7709 | 7877 | 7929 | 8026 | 8126 | 8230 |
| Nitrus oxide | 713 | 564 | 567 | 567 | 567 | 567 | 567 |
| F-gases | 1193 | 3452 | 4429 | 5171 | 7306 | 9774 | 11990 |
| *Production HFCs* | *935* | *3253* | *3744* | *3744* | *3744* | *3744* | *3744* |
| *Production PFCs* | *258* | *83* | *148* | *148* | *148* | *148* | *148* |
| *Consumption HFCs* | *0* | *116* | *537* | *1278* | *3414* | *5882* | *8098* |
| **Total** | **9589** | **11725** | **12874** | **13667** | **15899** | **18467** | **20787** |

### *4.4.3 Solvents and other products use*

Population is considered as the determinant parameter of carbon dioxide emissions from solvents and other products use. It is therefore estimated that emissions in 2010 will increase to 177 kt $CO_2$ eq in 2010 and 181 kt $CO_2$ eq in 2020 (**Table 4.9**).

**Table 4.9** Greenhouse gases emissions from solvents and other products use in the "with measures" scenario (kt $CO_2$ eq)

| Year | $CO_2$ Emissions |
|---|---|
| 1990 | 177 |
| 1995 | 156 |
| 2000 | 169 |
| 2005 | 173 |
| 2010 | 177 |
| 2015 | 179 |
| 2020 | 181 |

### 4.4.4 Waste

Projected emissions from wastes are based on the (a) the population trend, (b) the generation rates per region (urban, semi-urban and rural) that are assumed to follow the trends observed in the last decade, (c) the implementation of Council Directive 99/31 and (d) the establishment of managed disposal sites and municipal wastewater plants according to the strategic plan of Ministry of Environment.

The IPCC default methodology was followed for both solid waste disposal on land and wastewater handling (only domestic and commercial wastewater). Key results include (table 10):

1. Methane emissions from solid waste disposal on land show a decrease of 12% in 2010 (2.5 Mt $CO_2$ eq) compared to 1990 levels (2.8 Mt $CO_2$ eq) and an increase of 33% in 2020 compared to 1990 levels. This is due to the fact that the volume of the putrescibles recovered is kept constant at 2016 values for the rest of the period, while at the same time the total quantities of solid wastes increases.
2. Methane emissions from wastewater handling (domestic and commercial wastewater) decrease by 88% in 2005 and 94% in 2010 compared to 1990 levels as a result of the establishment of wastewater plants that serve 95% of population from 2006 and onwards.

**Table 4.10** Greenhouse gases emissions from wastes in the "with measures" scenario (kt $CO_2$ eq)

| Waste | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Solid waste disposal | 2811 | 3595 | 4767 | 3927 | 2487 | 2542 | 3737 |
| Waste water handling | 938 | 828 | 522 | 115 | 55 | 56 | 57 |
| **Total** | **3749** | **4423** | **5289** | **4042** | **2542** | **2598** | **3794** |

### 4.4.5 Agriculture

The main determinant parameters of greenhouse gases emissions from agriculture are the agricultural areas, the animal population and the quantities of synthetic nitrogen fertilizers used.

- In general agricultural areas are expected to decrease following the trends of the last decade. Thus, total agricultural areas decrease by 3.8% in 2020 compared to 1990 levels. It is only for tree cultivations and rice that an increase of 0.4% and 2%, respectively, per annum is projected. At the same time the productivity index is expected to improve during the 2000-2020 period.
- The number of sheep, goats and poultry increases with a rate of 0.3%-0.4% per annum for the period 2000-2020, while swine population is kept almost constant. The number of dairy cows and other cattle decreases with a mean annual rate of 1.8% for the period 2000-2020. The above-mentioned rates are based on the analysis of the trends observed in the last decade.
- The use of synthetic nitrogen fertilizers decreases continuously and as a result total nitrogen deposition on land decreases with a mean annual rate of 1.4% for the period 2000 – 2020 (total reduction of 36% in 2020 compared to 2000 levels).

- Other parameters like manure management systems and percentage of agricultural residues burned on site are kept constant at 2000 levels.

Total greenhouse gases emissions from agriculture decrease by 7.5% in 2010 (9.7 Mt $CO_2$ eq) and 9.4% in 2020 (9.5 Mt $CO_2$ eq) compared to 1990 levels (10.5 Mt $CO_2$ eq). This trend is observed for both methane and nitrous oxide emissions (**Table 4.11**).

**Table 4.11** Greenhouse gases emissions from agriculture in the "with measures" scenario (kt $CO_2$ eq)

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Methane | 3628 | 3646 | 3572 | 3591 | 3578 | 3566 | 3555 |
| Nitrus oxide | 6820 | 6091 | 6655 | 6145 | 6089 | 6000 | 5912 |
| **Total** | **10448** | **9737** | **10227** | **9736** | **9668** | **9566** | **9467** |

### *4.4.6 Land use change and forestry*

The estimation of emissions from land use change and forestry is quite difficult and presents a great degree of uncertainty. Especially for Greece the uncertainty increases due to the lack of relevant data. The estimation for the evaluation of emissions that is presented here (**Table 4.12**) is based on historical data along with the consideration of some pessimistic scenarios concerning forest fires in Greece. More precisely, it is assumed that forest fires for the next 20 years will destroy a number of hectares equal with the average number of hectares for the last 10 years, plus a standard deviation.

**Table 4.12** Greenhouse gases emissions from land use change and forestry in the "with measures" scenario (kt $CO_2$ eq)

| Gas | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 1441 | -366 | 3840 | 1776 | 1776 | 1776 | 1776 |
| Methane | 120 | 51 | 42 | 208 | 208 | 208 | 208 |
| Nitrus oxide | 22 | 12 | 6 | 47 | 47 | 47 | 47 |
| **Total** | **1583** | **-303** | **3888** | **2031** | **2031** | **2031** | **2031** |

## 4.5 "With additional measures" scenario

The second national climate change programme, adopted on May 2002, defines the additional policies and measures to be undertaken in order to ensure compliance with the target set in the framework of the Kyoto Protocol. The main actions (a detailed presentation of the additional measures can be found in (**Chapter 4**) foreseen in the programme include:

- Further penetration of natural gas in all final demand sectors including cogeneration.
- Promotion of renewable energy sources for electricity generation and heat production.
- Energy conservation in industrial and residential – tertiary sectors.
- Promotion of energy efficient appliances/equipment in residential – tertiary sectors.
- Structural changes in agriculture and chemical industry.
- Transport and waste management options.

Since policy projections beyond 2010 are increasingly uncertain, the total potential of the additional measures is only estimated for 2005 (3.4 Mt $CO_2$ eq) and 2010 (12.3 Mt $CO_2$ eq). As a result of the implementation of the additional policies and measures, the increase of GHG emissions in Greece could be restricted to 24.5% compared to base year levels, by 2010.

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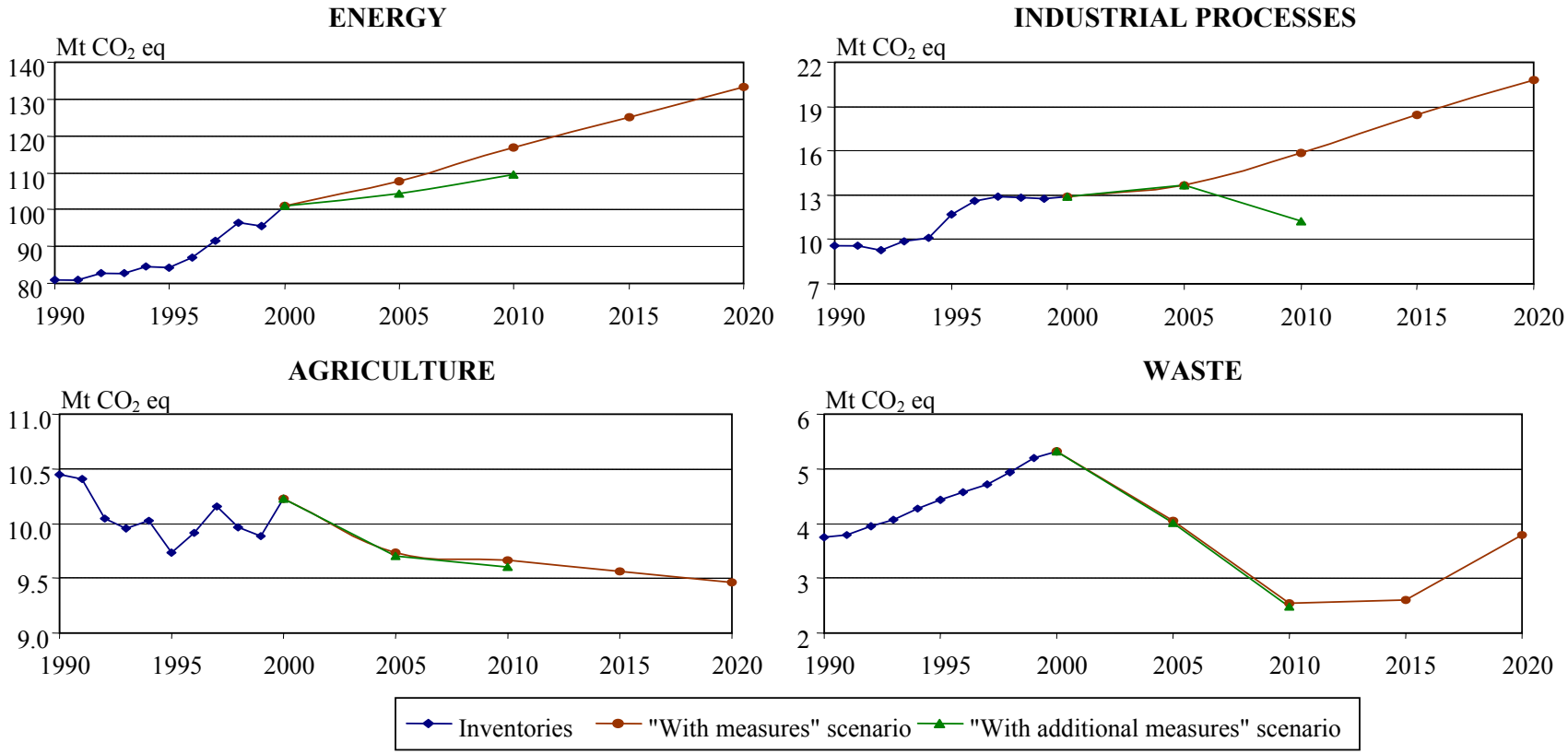


**Figure 4.2** Total effects of policies and measures by sector of implementation

# 5 VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

## 5.1 Introduction[5]

Last 420,000 years earth experienced over four climatic cycles. The latest glacial period started 120,000 years ago and ended just 16,000 years ago followed by a warm period up to the present. The strong relationship between greenhouse gases with natural origin, carbon dioxide ($CO_2$) and methane ($CH_4$), and Antarctic climate documented over the last climatic cycle has been remarkably confirmed over four climatic cycles, spanning 420.000 years. With the industrial revolution of 18$^{th}$ century, man caused a rapid increase of these two greenhouse gases to the unprecedented present-days levels. This increase was associated with a corresponding rise of global surface temperatures, lying between 0.4°C and 0.8°C since 1860.

Most of this increase has occurred in two distinct periods, 1910-45 and since 1976. The warmth of the 20th century appears to have had a naturally forced component. However, the rate of warming of the 20$^{th}$ century appears to be too large to be explained by natural influences alone. Warming since the mid-1970s has been particularly rapid with all eight of the warmest years on record occurring since 1983. The 1990s are quite likely to have been the warmest decade of the millennium in the Northern Hemisphere while 1998 is likely to have been the warmest year. In particular, summer temperatures in the Northern Hemisphere during recent decades are the warmest in at least six centuries. The average temperature near the surface of the earth in 1999 was the 5$^{th}$ highest so far recorded, an estimated 0.33°C higher than the 1961-90 average. The cooling from 1998 to 1999 was attributed to the persistence of the La Nina event, which has developed in the tropical Pacific Ocean in 1998. No year in the instrumental record with a major La Nina event was as warm globally as 1999. Concerning precipitation, it has been found that land surface precipitation is continued to increase in much the Northern Hemisphere mid and high latitudes, but over much of the tropics conditions have become drier.

## 5.2 Observed climate changes in Mediterranean

The analysis of the studies, which have dealt with the climatic changes in Mediterranean and especially in Greece, shows poor agreement even conflicts among the results. Even thought the observed trend of climatic elements could be attributed to human activities, the extent of the variations is such that probably falls in the range of the natural climatic variability.

However, specific findings are summarized below:

### *5.2.1 Temperature*

Although regional differences are relatively high, most of Europe has experienced increases in temperature of about 0.8oC in the 20th century. Over the decade 1981-1990, annual average

[5] Chapters 5.1, 5.2 and 5.3 are based on [26] and [27].

surface temperatures over much of Europe have been higher than the climatological average for the 1951-80 period with the exception of the eastern Mediterranean. Following, the 1990s has been the warmest decade of the 20th century.

The analysis of the surface air temperature averaged all over the Mediterranean basin, indicates an evolution similar to that one recorded either on the global or the hemispheric scale; namely a cooling during the period 1955-1975 and a strong warming during the 1980s and the first half of the 1990s. However, the east west Mediterranean difference in air and sea surface temperature trends is distinctive.

Sea surface temperature records for the Mediterranean region, especially the eastern Mediterranean, show a rapid cooling in 1970s while warming was resumed in the late 1970s. The cooling in the east of the region during the 1970s was much more marked than in the west.

Most of the results of the studies concerning air temperature in Mediterranean agree that there has been a positive trend in west Mediterranean and a negative trend in east Mediterranean for the periods 1950-1990 and 1975-1990. Cold period of the year appears to contribute mostly in this observed cooling of the east Mediterranean.

Air temperature in east Mediterranean presents a negative trend from the 1960s to the minimum of the 1970s, ever since the temperature is rising. The year 1999 was considerably warm for east Mediterranean with regard to the 1961-90 average, similarly to the global scale. This is due to the high summer and autumn temperatures.

The mean temperature in the central-west Mediterranean for the 20$^{th}$ century shows an increase of about 0.8$^{o}$C/100 year.

Greece is differentiated from the rest Europe since the temperature presents a slight negative trend in the 20$^{th}$ century. Most of stations in Greece have experienced a negative temperature trend from 1950 up to the early 1990s. The trend has been reversed in several areas after 1975 probably due to the simultaneous increasing trend of the summer temperatures, in spite of the significant descending trend of the winter temperatures observed after 1985.

1970s has been the coldest decade of the 20$^{th}$ century in Greece. It is worth noticing that a clear warming is discernible in Greece from the early 1990s, which is gradually strengthened. In particular, a continuous tendency for warmer summers has appeared from mid-1970s up to the present while 1999 has been the warmest year of the century for Athens. The summer of 2000 was as warm as the summer of 1998, a fact that indicates that summer temperatures during the last three years are extremely high.

There are more indications than proofs for the combined effects of urbanization on the local climate of Athens. Moreover, there are no studies proving the urbanization effect on the climate of Athens by examining the temperature differences between Athens and several areas.

In Thessalonica, no warming has been found in the 20$^{th}$ century. On the contrary a cooling has been detected in the same period, which is much more marked in summer and autumn time series.

The mean annual temperature in Athens and Thessalonica appears to gradually increase after 1980, mainly due to the occurrence of high summer temperatures. A rapid warming is present in Athens from early 1990s (**Figure 5.1**) A gradual increase has been observed since 1980 in Thessalonica while during last four years (1996-1999) a rapid warming similar to that of Athens has been detected (**Figure 5.2)** However, the size of these positive trends is smaller than the one observed in Athens.

Temperature changes in 20$^{th}$ century, as they have been spotted in several studies and reports, are summarized in **Table 5.1**.

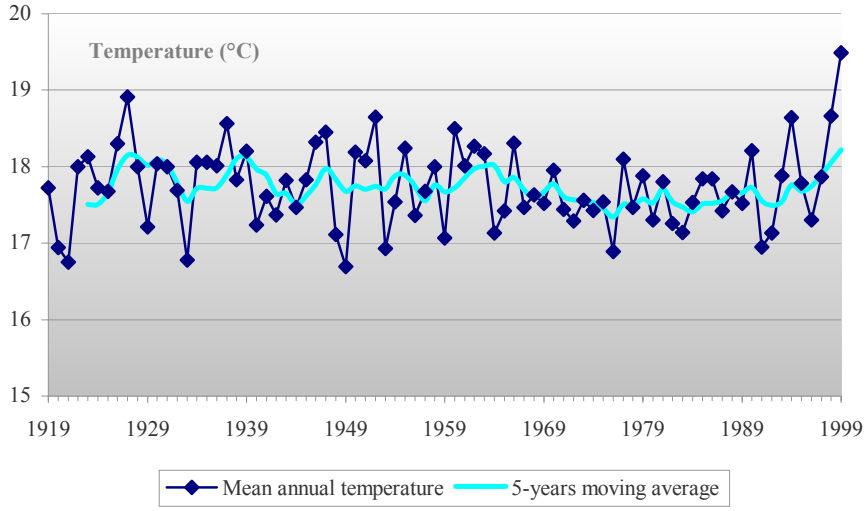


**Figure 5.1** Mean annual temperature time series in Athens for the period 1918-1999.

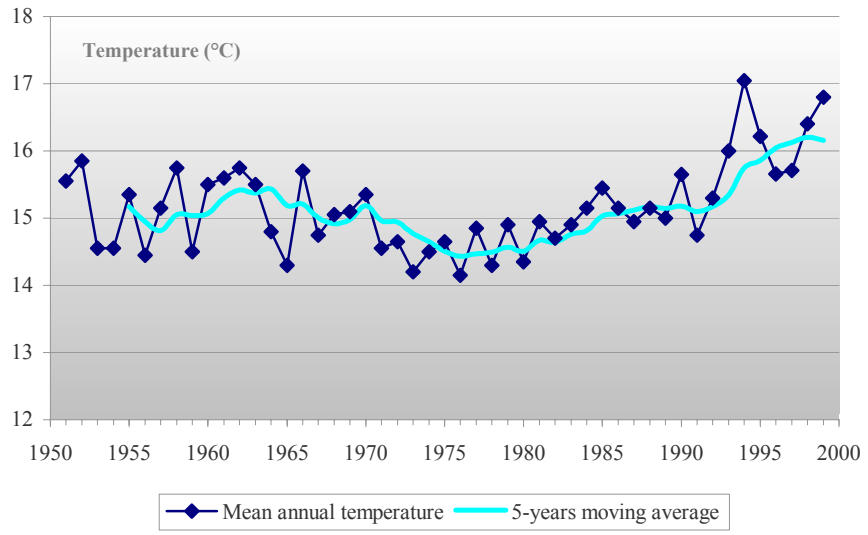


**Figure 5.2** Mean annual temperature time series in Thessalonica for the period 1951-1999

**Table 5.1** Temperature changes during the 20th century

| | 1900-2000 | 1900-10 | 1910-20 | 1920-30 | 1930-40 | 1940-50 | 1950-60 | 1960-70 | 1970-80 | 1980-90 | 1990-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **North Europe** | Most of Europe has experienced increases in temperature of about 0.8ºC | | + 0.65 ºC | | | o | o | – 0.35 | ºC | + 0.55 ºC | + (η πιο θερμή δεκαετία) |
| **South Europe** | | – – 0.40 ºC | ++ 0.70 | + ºC | o | o | o | – – 0.55 | – ºC | + | |
| **Mediterranean** | Mean temperature presents an increase in the order of 0.8ºC/100 yr | | | | | | | | + | | |
| **Greece** | Several regions experienced a slight temperature decrease | | | | | | | – | | + | + |
| **Athens** | No significant trend | – – 0.50 ºC | + 0.35 ºC | ++ 1.10 ºC | o | – 0.35 ºC | o | – 0.40 | – – ºC | + 0.25 ºC | ++ 0.70 ºC |
| **Thessalonica** | Negative trend | – – 0.85 ºC | + 0.40 ºC | – 0.55 | – ºC | ++ 0.80 ºC | – 0.60 | – ºC | – – 0.70 ºC | ++ 0.70 ºC | ++ 1.00 ºC |

| | |
|---|---|
| + | increase |
| + + | great increase |
| – | decrease |
| – – | great decrease |
| o | constant |

### 5.2.2 Precipitation

Annual precipitation trends in the 20th century, for a number of stations in Europe, shows a general increase of precipitation in northern Europe, with the exception of Finland, whereas there are indications for decrease in southern Europe and Mediterranean. In particular, a general drying has been observed over much of southern Europe in 1980's, with respect to the 1951-80 climatological average, with most of northern Europe becoming relatively wetter during the same period.

Since 1900, precipitation decreased by over 5% over much of the land bordering the Mediterranean Sea, with the exception of the stretch from Tunisia through to Libya where it increased slightly.
In particular, a negative trend is likely to be present from early 1960s to 1990, ever since this trend is turning over.

A general drying is evident over most of southeastern Mediterranean and Greece up to the early 1990s. However, it should be noticed the increased precipitation during the recent years. A precipitation decrease has been observed as well during the last 50 years in the central-west Mediterranean.

In Greece, a negative trend in precipitation is evident mainly in the last 20 years of the period 1951-1990, while ever since this trend is turning over. In particular, precipitation in northern Greece experienced a decrease after 1967, which may be attributed to the corresponding decreasing precipitation trend occurred in the coldest period of the year (October to March). This negative trend is maximum in northwest Greece and minimum in east Macedonia-Thrace.

In Athens, precipitation presented a negative trend (10%) during the period of 1925-1999, which, however, is not statistically significant (**Figure 5.3**). From 1976 to 1990 precipitation gradually decreased and culminated with the great drought of 1989-90. Ever since, a significant rise has been observed up to 1999. However, precipitation records for 2000 indicate dry conditions in Athens.

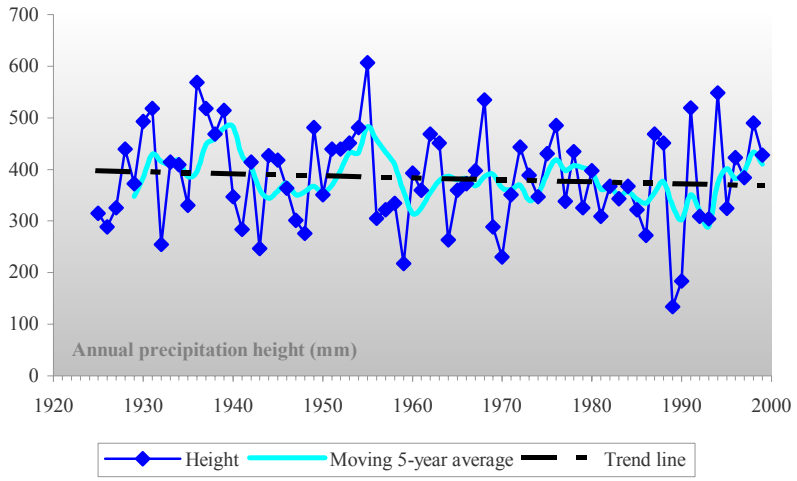


**Figure 5.3** Annual accumulated rain, trend line and five year moving averages in Athens (National Observatory of Athens) from 1924 to 1999.

In Thessalonica, precipitation presented a slightly negative trend (7%) as well during the period of 1920-1999, which, however, is not statistically significant (**Figure 5.4**). The comparison of times series for Athens and Thessalonica shows some differentiations. Thessalonica. In particular, Thessalonica, in opposition to Athens, experienced a statistically significant positive trend from 1920 to 1980. In 1980s, a significant decrease was observed. Afterwards, this decreased trend was reversed, just like in Athens.

The period 1984-1993 has been the driest one, both for Athens and Thessalonica.

Precipitation changes in 20th century, as they have been spotted in several studies and reports, are summarized in **Table 5.2**.

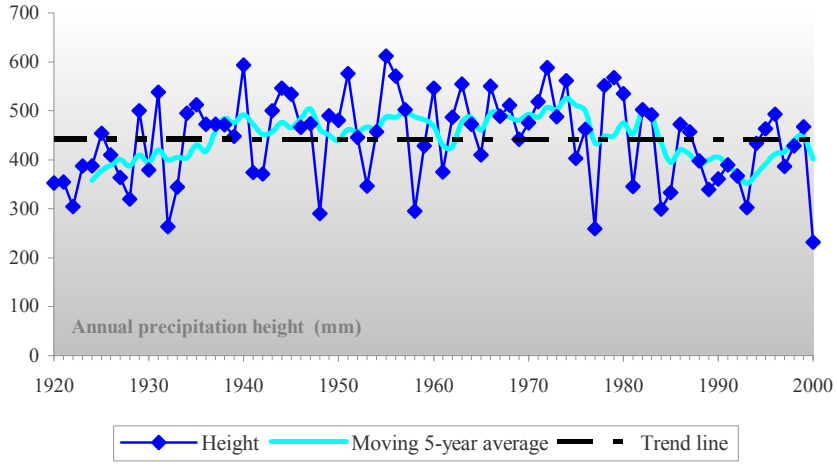


**Figure 5.4** Annual accumulated rain, trend line and five year moving averages in Thessalonica from 1920 to 1999.

**Table 5.2** Precipitation changes during the 20th century

| | 1900-2000 | 1900-10 | 1910-20 | 1920-30 | 1930-40 | 1940-50 | 1950-60 | 1960-70 | 1970-80 | 1980-90 | 1990-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **North Europe** | Increase 10% - 50% | | | | | | | | | + | |
| **South Europe** | Indications for decrease | | | | | | | | | – | |
| **Mediterranean** | Indications for decrease<br>5% – 20% | | | | | | + | – | – | – – | + ; |
| **Greece** | Decrease | | + | | | | | – | | – – | + |
| **Athens** | No significant trend | | ++ | ++ | – | – | | o | – | – – | ++ |
| **Thessaloniki** | No significant trend | | ++ | ++ | + | o | o | + | – | – – | ++ |

| | |
|---|---|
| + | increase |
| + + | great increase |
| – | decrease |
| – – | great decrease |
| o | constant |
| ; | indication |

### 5.2.3 Extreme weather effects

No trend has been found in the frequency and the intensity of severe storms in 20th century in Europe, since the number of severe storms in this century has varied randomly.

In the case of Greece, the findings are summarized as follows:

- In Greece, the frequency of heat waves in 1990s has been about three times higher than the average frequency of the three previous decades. No reverse change has been found in the frequency of occurrence of cold extremes. The period 1970-97 presents a high frequency of heavy precipitation while this frequency has further increased in 1990s.
- In Athens, the frequency of occurrence of maximum daily temperatures Tmax higher than 35o, 36o, 37o and 38oC in the last 3 years is the largest of the 20th century. A continuous positive trend in the duration of such warm events has been observed. The magnitude of the trend has significantly increased after the 2nd World War: the duration of periods with Tmax>35oC in the last few years of 1990s is double (~8) its value in 1940. In the last decade, there is evidence of an increased tendency towards longer sequences of Tmax>36oC. However, there is no evidence that the duration of events with maximum temperatures over 40oC has changed. Cold events frequency and duration has been steadily decreasing after 1950 whereas they are no longer observed after 1991, irrespective of their intensity.

### 5.2.4 Sea level rise

Much of the Mediterranean coast appears to have experienced sea-level changes within the generally accepted range of sea-level rise (1-2 mm/yr). Those areas in which the rate of the sea-level has been less than 1-2 mm/hr (e.g. the eastern Mediterranean form Ashdod, Israel to Antalya) are assumed to have undergone slight tectonic uplift, whereas several of the larger river deltas have experienced sea-level rises substantially greater than the global rise e.g. Nile (4.8 mm/yr), Thessalonica (4.0 mm/yr), Venice (7.3 mm/yr). These areas are assumed to have undergone subsidence.

No systematic research has been conducted for the study of long-lasting trends in sea-level changes in Greece. Sea-level measurements have been being recorded in Greece since 1974 whereas the most reliable time series start just in 1985.

## 5.3 Future changes of climatic parameters in Mediterranean

Confidence in local and regional climate predictions, as in the case of Mediterranean and Greece, is lower due to the weakness of models in predicting the regional and local effects of climate change. Projections vary widely depending on the model and the test area. In order to estimate climatic changes on this scale, a better knowledge of many complex processes is required.

Global temperatures are expected to increase about 0.2°C/decade and climb by between 1.7 and 4°C by the year 2100. A number of models indicate that precipitation will increase in mid and high latitudes, especially in winter, and decrease in subtropical zone.

All model simulations for Europe agree that on the average the range of temperature rise is expected to be higher in North Europe in comparison to the Mediterranean areas. Despite that the prediction of the temperature change varies widely, most of the models suggest that the winter temperature will increase more over North Europe while in summer the increase will be higher over South Europe. Moreover, the winter temperature increase over North Europe will be higher than the increase in summer whereas the summer temperature increase over South Europe will be slightly higher than the increase in winter.

Concerning precipitation, most of the models agree in winter increase over North Europe and give some indications for increase in summer precipitation. These results could be positively correlated with the observed general increase over North Europe in 20th century. On the contrary, all models suggest that the summer temperature over South Europe will be declined whereas there are only some indications for an increase in the summer precipitation.

Models offer conflicting evidence over how climate may change on average over the Mediterranean region and particularly over Greece; thus it is very difficult to distinguish possible future climatic changes on this scale. All model simulations, however, have one common feature: temperature will increase considerably during the next decades.

### *5.3.1 Temperature*

Temperatures over Mediterranean may increase to as high as 3.5°C by the year 2050 assuming a doubling of the $CO_2$ concentration. The estimation of warming range over Mediterranean presents a considerably high variation (2.0 to 6.0oC by the year 2100). A lower temperature increase is expected over the sea and the coastal regions compared to the inland Mediterranean areas. The regions presenting the maximum temperature increase and sensibility are over the southern part of the Mediterranean.

Summer temperature increase over Mediterranean is substantially higher than the one over North Europe. Concerning the seasonal differences, warming over Mediterranean in winter is of the same order (or it is slightly lower) with the corresponding warming in summer.

The average temperature increase over Greece, estimated by drawing on the results of recent studies and reports, lies between 0.9°C and 2°C depended on the scenario of greenhouse gases reduction and it is expected to be slightly higher in summer than in winter (as far as 0.5 oC). However, it should be mentioned that detection of climate change on this scale is extremely difficult due to the uncertainties induced by the downscaling methods used for the increase of the coarse resolution of the regional models.

Temperature increases in 20th century, as they have been spotted in several studies and reports, are summarized in **Table 5.3**

### *5.3.2 Precipitation*

Most projections point to significantly less precipitation in summer over the region as a whole. On the contrary, several models suggest an overall increase in winter precipitation mainly over the north part of the Mediterranean region; this increase however is quite less than the one in North Europe.

In general, the prospects for precipitation over the Mediterranean region in a warmer world are still highly uncertain due to the general weakness of general circulation models (GCMs) in predicting regional precipitation. Most models offer conflicting evidence over how precipitation

may change on average over the Mediterranean region. A common feature, however, of many projections is that the increase of annual precipitation over much of the Mediterranean region north of 40 or 45° N is more likely, whereas to the south of this projections point to less precipitation.

Only few studies concerning the future precipitation regime in Greece have been found and most of them offer conflicting evidence over how precipitation may change over the area. There are serious indications, however, for a remarkably decline in summer precipitation, which is consistent with the projections over the Mediterranean region as a whole.

It should be mentioned that, according to the simulation results of one study, east and south Greece and especially Attica, Thessalia, Thessalonica and eastern Peloponese are likely to experience the larger decrease in mean annual precipitation in the northern part of Mediterranean region. However, the Greenpeace technical report for the climatic change in Crete suggests that the mean annual precipitation will rise from 14.3 to 23.8 mm by the year 2030.

Estimated precipitation changes during the 21th century, as they have been spotted in several studies and reports, are summarized in **Table 5.4**

### *5.3.3 Extreme weather effects*

Despite the uncertainties over exactly how climate variability and extremes will change in the Mediterranean region, the overall picture does suggest an increase in the frequency of extreme events and, in particular, of droughts in the western Mediterranean. In general, warmer conditions over the Mediterranean region should lead to an increase in the occurrence of extremely high temperatures and a decrease in extremely low temperature events. In areas experiencing a general decrease in precipitation, droughts are likely to become more frequent as the probability of dry days and the length of dry spells increases.

### *5.3.4 Sea level rise*

Mean sea level in Mediterranean is expected to rise at the rate of 5 cm/decade. In particular sea level will rise about 50 cm by the year 2100 (with an uncertainty range of 20-86 cm). Delta Nile, Venice and Thessalonica appear to be the more sensitive areas in Mediterranean.

**Table 5.3** Estimated temperature changes during the 21st century.

| | In general | 2030 | | | 2050 | | | 2100 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Winter | Summer | Annually | Winter | Summer | Annually | Winter | Summer | Annually |
| **North Europe** | Winter temperature increase is greater than the respective increase in summer | increase 2.5 to 4°C | increase 1 to 3°C | | | | | increase 4 to 7°C | increase 2 to 5°C | |
| **South Europe** | Summer temperature increase is slightly greater than the respective increase in winter | increase 1.5 to 3.5°C | increase 2 to 4.5°C | | | | | | | |
| **Mediterranean** | Summer temperature increase is slightly greater than the respective increase in winter | | | | | | increase 3.5 °C | increase 4 to 5°C | increase 4 to 7 °C | increase 4 to 6 °C or 2.5 to 5 °C |
| **Greece** | Summer temperature increase is slightly greater than the respective increase in winter | | | increase 0.9 to 2°C | | | | | | increase 2 to 2.5 °C |

**Table 5.4** Estimated precipitation changes during the 21st century.

| | In general | 2030 | | | 2050 | | | 2100 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Winter | Summer | Annually | Winter | Summer | Annually | Winter | Summer | Annually |
| **North Europe** | Increase in winter and some indications for increase in summer | increase 0 to +20% | increase | increase | increase 0 to +20% | Increase 0 to +20% | increase | increase 0 to +30% | change -20% to +10% | increase |
| **South Europe** | Decrease in summer and indications for a slightly increase in winter | | decrease | | increase 0 to +10% | decrease -5% to -15% | | increase | decrease | |
| **Mediterranean** | Great decrease in summer and increase in winter to the north | decrease | | decrease -10% | | | | increase 0 to +20% in particular to the north | decrease 0 to -40% | increase to the north, decrease -10 to -40% to the south |
| **Greece** | Decrease of the summer precipitation. Indications for increase in northern Greece only. | Only few studies concerning the future precipitation regime in Greece have been found and most of them offer conflicting evidence over how precipitation may change | | | | | | | | |

## 5.4 Adaptation measures

### 5.4.1 Desertification

Lately, an ever increasing area worldwide is being threatened by desertification, and an even wider one by soil degradation, resulting in the inability of the earth to provide plants and animals with water and nutritive components for them to grow and survive. The international concern has led to the ratification and entry into force of the Framework Convention of the United Nations for Combating Desertification (CCD).

Greece has ratified CCD (Law 2468 of 1997), has established National Committee has been established and has prepared a National Action Plan that was approved by a Decision of the Greek Ministerial Council. The National Action Plan addresses the urgent need to combat a discernable desertification trend in 35% of the land as well as to prevent on the onset of desertification in an additional 60% of the country's area.

The National Action Plan includes a critical analysis and assessment of the factors and processes that control desertification pressures in Greece as well as general and sector-specific measures (agriculture, forests, livestock, wild fauna and water resources) to mitigate them.

The main issues in relation to **agriculture** are erosion of soils and drought problems. Means of addressing them include:

- Land Use Planning under sustainability criteria to protect soils from erosion by establishing clear criteria for inclusion of agricultural land, in planning scheme, by appropriate selection of anti-erosion measures and by improving cultivating techniques.
- Covering of land with crop residues, rocks and chemical amendments, (thus reducing the danger of erosion and simultaneously conserving the moisture of the soil) to combat drought and improve ground water conservation.

In **Forestry**, measures to reduce the frequency and decrease the spread of forest fires are under consideration. These measures include:

- Introduction of less flammable plants.
- Thinning, clearing and maintenance of forest structure.
- Ground cover clearing, thinning, disbudding, appropriate settlement or removal of residues and possibly, implementation of controlled grazing.
- Forest fire detection systems to facilitate quick response.

In addition, measures to counter after-fire impacts and avoid soil erosion have been adopted which include prohibition of grazing in burned lands and soil support to allow for natural regeneration by not clearing burned trees and bushes or by planting appropriate trees, bushes and plants where rapid natural coverage of the ground is not ensured.

Measures against forests desertification will be supported with relevant research. Among the issues to be investigated are:

- Definition of sensitivity factors and extent of forests desertification
- Restoration methods for natural vegetation in degrading areas
- Processes and control of soil erosion
- Management of protective forests
- Hydrology of forests areas
- Prevention of fires
- Conditions of controlled grazing.

The increased soil erosion and the reduction of natural vegetation result in the degradation of ground fertility and respectively of **fauna**, which is a determinant of the soil productivity. Measures proposed in the National Action Plan are:

- Systematic and consecutive collection of data concerning population of the species
- Selection and protection of appropriate sites with enhanced ecological interest to ensure the preservation of species population and diversity
- Control of over-grazing in pastures
- Set of incentives for creation of vegetable fences from the farmers, perimetric to agricultural cultivation areas
- Introduction of controlled hunting in specific areas.

In the **water resources** sector, the suggested measures for water conservation are of particular interest as water shortage in a number of areas in now endemic. The rational management of water resources is important to provide security of supply to address a variety of needs, but also to protect the quality of aquifers and other groundwater reserves. The measures concern:

- Reduction of water loss through the improvement of irrigation efficiency. For this purpose, restoration of the networks structure, implementation of integrated management systems of irrigation water, recycling and reuse of water, are proposed. It is expected that with the implementation of these measures the conservation achieved will vary from 10% to 50% of current use.
- Reduction of water losses and demand in urban and industrial use. The suggested measures are the upgrading of piping networks for the reduction of leaks and rapid leak tracing and restoration of the network damages, as well as the introduction of incentives for the construction of private tanks and collection of rain water.
- Increase of water supply through (1) funding of programs for water recycling and reuse, (2) studies for the risks associated with water shortage in threatening areas, (3) restraint and storage of surface runoff water, (4) transfer of surface water to areas threatened by desertification, (5) management of forests ecosystems so as to limit rainwater losses through surface flow and (6) implementation of systems for artificial concentration of ground water, re-injection of water surplus and replenishment of its reserves.

The Ministry of Agriculture has initiated the construction of small rain water catchment works (dams, reservoirs) in threatened areas and put into effect procedures to impose rational use of water for irrigation. The Ministry for the Environment, Physical Planning and Public Works and the Ministry of Development have contributed in the configuration of the appropriate framework with series of legislative and institutional measures. The total budget for combating

desertification in the fields of water management and forest protection, amounts to 450 million €.

### 5.4.2 Protection of biodiversity and natural ecosystems

Greece has an exceptionally rich biological diversity in species and ecosystems, a large part of which are endemic to these regions. At present, 4% of the flora species and 22% of the fauna species are considered to be under threat.

Greece has ratified the Framework Convention of the United Nations for Biodiversity and has formulated the relevant national strategy aiming to reverse the current trends of biodiversity loss and to restore biotopes.

The National Strategic Plan for biodiversity includes the following major areas for actions:

- Conservation and restoration of wild flora and fauna species to acceptable levels of the more significant ecological sites
- Management of water and terrestrial resources to reverse the current trends of biodiversity loss
- Promotion of horizontal environmental policies, with the most important being the assessment of environmental impacts and the evaluation of environmental impact statements, as provided in the new Directive for the Strategic Evaluation of Impacts.
- Incorporation of the biodiversity component to the action plans of other ministries.

The above priority actions also concern the areas adjacent and in-between protected areas in an effort to remove or at least reduce separation. In areas where activities of the primary sector have developed, the role of agriculture, livestock and forestry in maintaining ecosystems and conserving biological diversity should be acknowledged and assisted.

A basic tool for the conservation of biodiversity is the demarcation of areas to be protected and the subsequent protection by statute. Under current legislation, 2,5% of the Greek territory has already been given "protected" status and 231 sites representing 20% of the terrestrial area of the country have been declared under incorporation to the European network of protected areas NATURA 2000 (Directive 92/43/EU). Additionally, during 2001, Greece submitted a list of 60 new Zones of Special Protection.

As a first step in implementing the NATURA 2000 (92/43/EU) Directive in Greece, a project for the "Registration, Identification, Estimation, Mapping of the habitat types and of the species of Flora and Fauna in Greece" has been initiated, funded by Community Support Fund for Greece and administered by the Ministry for the Environment, Physical Planning and Public Works and the Ministry of Agriculture (General Secretariat of Forests and Natural Environment). During the 1st phase of the project, which was completed in 1996, 231 areas covering approximately 2.600.000 Ha (26.000 km2) were identified as eligible for coming under the provisions of the Directive 92/43.

It should be noted that Annex I of the Directive 92/43 lists 255 natural habitat types. Of those, 110 habitat types i.e. 43% of the habitat types of the Annex I of the Directive are present in the NATURA 2000 areas in Greece. Additionally, 76 species of animals (38.2%) and 39 species of plants (9%) that are noted in the Directive (Annex II) have been identified in these areas of

Greece. Twenty six out of 110 habitat types are classified as priority habitat types (**Table 5.5**), while 10 out of a total of 76 species of animals and 26 out of 39 species of plants in Greece are considered as priority species.

Of the 231 NATURA 200 areas, 18 (approximately 8% of the total area) come also under the provisions of Directive 79/409/EU for the protection of wild birds which covers 34 additional areas (approximately 355.000Ha). As a result, the total number of protected areas (Directive 93/43 and Directive 79/409) amounts to 265 covering a total area of approximately 3.000.000 Ha. Ten out of 265 protected areas (about 158.000 Ha or 5% of the total) are also under the Ramsar Convention.

The implementation of the above-mentioned Directives is today in its 2nd phase of the formulation of detailed Action Plans for each site. Special Environmental Studies have been completed for 119 out of the 265 areas (which correspond to 45% of the total number and to 57% of the total area). Also, in 15 additional areas, a Special Environmental Study has been elaborated for specific species or a part of the region. Additionally, management entities have been established in 26 out of 265 areas, but at present only one of them is fully operational.

**Table 5.5** Natural habitats types - Animal and plant species in Greece compared to those included in Annexes I and II of the Directive *92/43*

| | Directive 92 / 43 / EC | | GREECE | | | |
|---|---|---|---|---|---|---|
| | Total | Priority | Total | Priority | % Total | % Priority |
| **NATURAL HABITAT TYPES** | 255 | 91 | 110 | 26 | 43 | 28,6 |
| *Coastal and halophytic habitats* | 22 | 5 | 14 | 5 | 63,6 | 100 |
| Coastal sand dunes and inland dunes | 30 | 12 | 10 | 2 | 33 | 17 |
| Freshwater habitats | 19 | 2 | 11 | 1 | 58 | 50 |
| Temperate heath and scrub | 9 | 5 | 1 | - | 11 | - |
| Sclerophyllous scrub (matorrals) | 21 | 3 | 13 | 1 | 62 | 33 |
| Natural and semi-natural grassland formations | 26 | 8 | 17 | 8 | 65 | 100 |
| Raised bogs and mires and fens | 10 | 6 | 4 | 4 | 40 | 67 |
| Rocky habitats and caves | 23 | 2 | 12 | 1 | 52 | 50 |
| Forests | 66 | 30 | 31 | 9 | 47 | 30 |
| ANIMALS | 199 | 27 | 76 | 10 | 38,2 | 37 |
| Mammals | 38 | 11 | 22 | 2 | 58 | 18,2 |
| Reptiles | 19 | 3 | 10 | 2 | 53 | 67 |
| Amphibians | 19 | 3 | 4 | - | 21 | - |
| Fishes | 62 | 5 | 28 | 3 | 45,2 | 60 |
| Invertebrates | 61 | 5 | 12 | 3 | 19,7 | 60 |
| PLANTS | 433 | 164 | 39 | 26 | 9 | 16 |

### *5.4.3 Management of water resources*

The management of water resources is at present considered to be adequate. A number of problems that have arisen lately, including increased use of water, irrational use of irrigation

and cultivating practices and the high percentage of losses in combination with the increase in the magnitude of annual fluctuations of precipitation and the uneven geographical distribution of reserves have made improvements in water management practice imperative.

This will be achieved mainly through the implementation of an integrated management plan (in accordance with the provisions of the framework Directive 2000/60/EC), which will ensure, in a long-term basis, the sustainable use of water. The preparation for the full implementation of this Directive has already started. The Ministry for the Environment, Physical Planning and Public Works in cooperation with all other Ministries involved has already drafted an appropriate legislative framework and is in the process of submitting it to Parliament for approval.

# 6 FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

## 6.1 Contributions to the Global Environmental Facility

The Global Environment Facility (GEF) was established to forge international cooperation and finance actions in the hopes of addressing four critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, and ozone depletion. GEF is the international entity entrusted with the operation of the financial mechanism of the UNFCCC. GEF climate change projects fall under four areas: (a) removing barriers to energy efficiency and energy conservation, (b) promoting the adoption of renewable energy by removing barriers and reducing implementation costs, (c) reducing the long-term costs of low greenhouse gas emitting energy technologies, and (d) supporting the development of sustainable transport.

Greece contributed US$5.5 million to the 2nd replenishment of the GEF covering the time period 1998–2001, while the contribution of Greece to the 3rd replenishment, covering the period 2003–2006, will be US$4.50 million (5.73 million €).

**Table 6.1** Financial contributions to Global Environmental Facility

| | Contributions (millions US dollars) | | | |
|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 |
| Global Environmental Facility | 1.28 | 1.30 | 1.25 | 1.05 |

## 6.2 Financial support

### *6.2.1 Financial contributions to multilateral institutions and programmes*

Multilateral financial institutions of which Greece is a member play an important role in the creation of various systems and methods for achieving sustainable development. Greek contributions to multilateral financial institutions are given as regular payments and as support for specific projects or programmes. Funding supplied to these institutions totalled US$27.65 million over the time period 1997–2000 (**Table 6.2**). Funding on an annual basis is more or less consistent but one has to bear in mind that the time period coincided with a period in which Greece was pursuing tight macro-economic policies in order to meet the conditions for joining the Euro-zone. More than 70% of this funding is directed to the World Bank and the European Bank for Reconstruction and Development.

**Table 6.2** Financial contributions to multilateral institutions and programmes

| Institution or Programme | Contributions (millions US dollars) | | | |
|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 |
| World Bank | 4.23 | 3.00 | 3.36 | 3.20 |
| International Finance Corporation | 0.00 | 0.00 | 1.00 | 0.00 |
| European Bank for Reconstruction and Development | 1.20 | 2.05 | 2.40 | 2.06 |
| United Nations Development Programme | 0.26 | 0.47 | 0.23 | 0.19 |
| United Nations Environment Programme | 0.05 | 0.03 | 0.21 | 0.49 |
| UNFCCC | 0.06 | 0.03 | 0.08 | 0.08 |
| Other | 0.56 | 1.30 | 0.59 | 0.52 |

### *6.2.2 Bilateral development assistance*

As a result of its geographic location, Greece's own security and welfare is closely linked to stability and economic prosperity in developing and transition countries in the Balkans, the Black Sea area and the eastern Mediterranean. As one of the most developed and stable countries in these complicated multicultural regions, Greece responds to development challenges in its neighbourhood. Consequently, encouraging democratic practices and sustainable economic development in surrounding regions in Greece's national interest and the main strategic orientation of the official Greek aid programme. More than four-fifths of Greece's bilateral official development assistance (ODA) is provided to developing countries in south Eastern Europe.

In August 1996, with Membership of the OECD's Development Assistance Committee (DAC) in view, the Greek government launched a five-year programme to develop a substantive bilateral aid programme, committing US$400 million for this purpose over the time period 1997–2001. Since 1996, Greece's net bilateral ODA disbursements have quadrupled, from US$27 million to US$99 million. In 2000, Greece's total net ODA disbursements were US$226 million, or 0.20% of its gross national income (GNI), almost reaching the DAC average of 0.22%.
Achievements of the medium term five-year programme include:

- Passing Law 2731 of 5 July 1999, which provided the necessary legal basis and expanded to 13 the number of ministries/agencies able to implement development cooperation activities.
- Mobilising several committees to manage specific aspects of the bilateral aid programme:
  i. Assigning responsibility for planning and overall strategy to the Interministerial Committee for the Coordination of International Economic Relations, an existing cabinet-level committee responsible for Greece's external economic and trade relations.
  ii. Creating the Monitoring and Administrative Committee of the Development Co-operation Programme of Greece, with representatives at official level from each implementing ministry/agency and responsibilities mainly related to managing disbursement of the bilateral aid budget.

iii. Establishing the National Advisory Committee on Non-Governmental Organisations (NGOs) to formulate and recommend policies related to development NGOs and address implementation issues of a systemic nature.

- Setting up a directorate within the Ministry of National Economy to coordinate the Greek bilateral aid programme and provide the secretariat for the Interministerial Committee and the Monitoring and Administrative Committee.
- Establishing a general directorate within the Ministry of Foreign Affairs (known as "Hellenic Aid") responsible for coordinating, supervising and promoting development projects, humanitarian assistance and development-education activities implemented by Greek NGOs.
- Publishing annual reports to Parliament on Greece's development cooperation, a guide to the Greek aid programme for the general public and a handbook for Greek NGOs and other civil society institutions seeking official co-financing for development activities.
- Bringing into the aid programme an impressive number of Greek ministries, universities, consultants, businesses and NGOs with substantial interest and experience in working in the Balkans, the Black Sea area and the eastern Mediterranean.
- Putting in place an NGO co-financing scheme consistent with international good practices and registering more than 150 Greek NGOs that then become eligible for receiving co-financing from Hellenic Aid.
- Developing the Hellenic Plan for the Economic Reconstruction of the Balkans and a Strategic Plan for Hellenic Aid, both of which are intended to be integral parts of the new five-year programme.

The Greek government's objective during the second five-year programme, which is under preparation, is to maintain a total aid/GNI ratio of 0.2%, a percentage that implies a steady increase of the Greek development assistance.

The Ministry for Environment, Physical Planning and Public Works is responsible for bilateral assistance in environmental issues. Since 1999 (starting date of the bilateral development programme of the ministry), 7 projects in the field of climate change have been funded. Six of them are related to capacity building for climate change mitigation in Balkan counties (see Chapter 7.3), while the 7th one is related to the development of technological infrastructure for the protection of water resources due to climate change oriented pressures in Cyprus. The total budget of these projects is €1.2 million.

## 6.3 Assistance in preparing National Communications

National Communications are essential for the coordination of international climate policy. The Greek Ministry for Environment, Physical Planning and Public Works has financed a capacity-building project within the framework of DAC. The purpose of this project is to enable Balkan countries to set up policies for limiting their GHG emissions, to effectively implement the objective of the Convention and to prepare for their participation in the Kyoto Protocol when it comes into effect. Seven different Balkan countries will participate in this framework: Greece, Albania, FYROM, Bosnia and Herzegovina, Yugoslavia, Bulgaria and Romania.

Bulgaria and Romania are Countries with Economies in Transition included in Annex I of the Convention, and therefore must adopt national policies and take corresponding measures to

limit the emissions of GHG. As countries undergoing the process of transition to a market economy, they need to enhance their ability to address climate change issues. The establishment of an effective monitoring system for their GHG emissions, the improvement of energy efficiency in various sectors, and the development of a framework in order to effectively host Joint Implementation projects are identified as the major priorities for these countries.

Albania, Bosnia and Herzegovina, FYROM and Yugoslavia are not included in Annex I of the Convention, however the UNFCC creates a variety on obligations on these countries. The priority areas for action in the context of this capacity-building framework for these countries will be: (i) establishment of an effective monitoring system for their GHG emissions, (ii) elaboration of national action plans for limiting GHG emissions, (iii) improvement of energy efficiency in industrial, transportation and residential/commercial sectors, and (iv) exploitation of Kyoto mechanisms.

# 7 RESEARCH AND SYSTEMATIC OBSERVATIONS

## 7.1 Research

Research in Greece is carried out at research centres and universities, and in industry. Its monies come from public funds provided by the Greek government and the European Commission and from private funds in industry, foundations and other business enterprises. In 1999 (the last official data available), the overall amount spent for research was 0.68% of GDP (0.52% Greek state funds, 0.16% private funds).

The majority of the national research centres active in the physical and social sciences are funded and supervised by the General Secretariat for Research and Technology (GSRT) of the Ministry for Development. Various other ministries, such as the Ministry of Health, the Ministry of Agriculture and the Ministry of National Defence also fund and supervise their own research centres. The GSRT budget for Fiscal 2002 is 56 million EURO of which 82% went toward the support of the 9 national research centres and 5 specialized institutes under its supervision
The research priorities of Greece cover the following sectors (not ranked):

- renewable energy sources
- food and hydro culture
- knowledge-intensive culture and tourism
- sports
- sea transport
- health and biomedical, diagnostic and therapeutic methods
- natural environment (atmosphere, sea, water dynamic, forest fires, recycling, etc.)
- structured environment and earthquake protection
- new forms of organization for businesses
- labour and training
- e-learning and e-business
- organizational structures for technological forecast research activities
- selection of priorities through social consent

Climate-related research is carried out in two of the national research centres, the National Observatory of Athens (NOA) and the National Centre for Marine Research. (NCMR). In addition, the majority of Greek universities conduct meteorological and climatological research covering a wide range of subjects, as does a small group in the Academy of Athens. Finally, the National Agricultural Research Foundation of the Ministry of Agriculture carries out research on the impact of climate change to agricultural activity.
The National Observatory of Athens is also the focal point for IPCC.
There is no coordinated national climatic research program. In the past 4 years, GSRT and other ministries that are directly or indirectly related to the environment have funded a number of individual research projects. Most of these projects address problems of forecasting

meteorological parameters, such as rainfall and wind. These parameters may create adverse conditions with the potential for severe impacts on daily activity, including forest fires and floods.

In the Operational Program of the Ministry of Development in the scope of the 3rd Community Support Framework Program of the European Union for the time period 2000–2006, funds totalling 32.657 million EURO, of which 69% are to be public funds, have been allocated for support of research projects addressing "Natural Environment and Sustainable Development." This includes initiatives to advance technology related to monitoring the marine environment, managing coastal ecosystems and water resources in a rational manner and reducing air pollution and forest fires.

Recently, in 2001, the GSRT provided funds to the National Observatory of Athens for improving its modelling capability for both short-term prediction capability (3–5 days) and longer-term climatic forecasts (3–6 months). NOA is currently running, in an operational mode, 2 mesoscale models for weather forecasting, which are being altered for medium-length climatic forecasts (6 month). NOA has also implemented and is currently evaluating 2 additional regional climate models.

It is the policy of GSRT to provide supplemental support to research groups involved in projects co-funded by the European Commission through its research Framework Programs. In this respect, Greek research teams are involved in a number of projects funded or co-funded mainly by the Directorate-General for Research of the European Commission in the scope of the Environment and Climate area of the 5th Framework Programme. Examples of such projects are MEDALUS (Mediterranean land use and desertification) and MEDFLUX (Measuring fluxes of greenhouse and other gases in the Mediterranean).
The GSRT has also provided funds for some collaborative projects in meteorology and atmospheric physics to groups in Eastern European and other Mediterranean countries through its international bilateral agreements program. These are small grants for travel and miscellaneous expenses to assist the establishment of scientific dialogue and advance joint efforts.

The Ministry for Development has been supporting research for the promotion of renewable energy sources, rational use of energy and urban environment protection on a priority basis. In the scope of the 3rd Community Support Framework Program for the time period 2000–2006, funds totaling €26.66 million, of which 75% are to be public funds, have been allocated for support of collaborative research projects. This includes projects to advance technology related to earthquake monitoring and management and risk reduction, and projects to reduce cost and improve performance for RES equipment.

## 7.2 Systematic observation

Systematic observations of parameters that register or affect climate and its change are carried out by a number of ministries and agencies, research centers, academic institutions and private enterprises. Chief amongst them are the Hellenic National Meteorological Service (HNMS), services of the Greek Armed Forces, the Ministry of Environment, Physical Planning and Public Works and the Ministry of Agriculture. The networks cover all areas of Greece, including a number of islands in the Aegean, Ionian and eastern Mediterranean seas.

### 7.2.1 Atmospheric climate observing systems

#### 7.2.1.1 Climatological stations

The Hellenic National Meteorological Service (HNMS) operates a network of 26 stations that provide meteorological data on a continuous basis to the international networks. It also operates 3 upper air measurement stations that release rawinsondes every 6 hours. In addition, it collects data from an even larger number of stations, 28 of which are registered with WMO as 1st Class stations.

The Ministry of Agriculture has been operating a large network of agrometeorological stations, some of which have been operating for more than 50 years. In the last 5 years, it has refurbished 40 stations so that they can provide a full and continuous set of data to be collected automatically and centrally stored.

The National Observatory of Athens (NOA) also operates a 1st class meteorological station in Athens. This station, established in 1842, has the longest uninterrupted time series of meteorological observations in Greece. Among other things, this station measures, on a continuous basis, a full set of solar radiation parameters with time series that reach back at least 10 years for the full set, and 50 years for global measurements of total, direct and diffuse insolation.

A number of national research centers and universities also operate meteorological stations. The time series of these stations vary in length from a few years to a few decades, and their data are widely available.

The Ministry of Agriculture, HMNS and the Ministry for the Environment, Physical Planning and Public Works operate a large network of rain gages and snow gages. The network comprises more than 238 rain gages and over 1000 snow tables.

An effort is underway, with financing from the Ministry for the Environment, Physical Planning and Public Works to gather all available meteorological and hydrological data in one database. The project has already been launched, and the infrastructure is now capable of receiving data. The policy on availability and access to this database is now under examination.

#### 7.2.1.2 Carbon dioxide monitoring program

The National Observatory of Athens has recently installed a station in a remote location on top of Mount Helmos (2,350m above MSL), which has no local sources nearby, to initiate measurements of $CO_2$ and other greenhouse gases as well as climatological parameters.

#### 7.2.1.3 International Programs

Greece is a member EUMETSAT, the consortium that operates the meteorological monitoring satellite METEOSAT. It is also a member of and an active personnel supplier to the ECMWF effort. In both these international efforts, Greece is represented by the HNMS.

For the past two years, the National Observatory of Athens has been operating a network of stations aimed at detecting lightning strikes. The network consists of 6 recording stations positioned between Denmark and Romania in the north and Cyprus and Portugal in the south.

The lightning-strike data provide real-time information regarding the location of thunder cells and severe rainstorm activity from the coast of Florida to the Persian Gulf. This is crucial information for predicting floods and providing more accurate local forecasts. This information is provided to the meteorological community via the Internet. There are plans, in collaboration with the US National Oceanic and Atmospheric Agency, to extend this network further south and east to cover North Africa and India.

The University of Thessaloniki–Laboratory of Applied Physics operates the World Ozone Mapping Center, which utilizes measurements from the 90 stations of WMO Global Ozone System (part of GAW) and of TOMS to generate and archive global maps of total ozone density.

#### *7.2.1.4 Ozone and UV-radiation measurements*

The universities of Thessalonica and Athens have been monitoring the total (column) ozone amount at two locations on a continuous basis for more than 30 years. The University of Thessalonica has also maintained a background ozone measuring station at Livadi (1,000m above MSL), in northern Greece.

The University of Thessalonica, the University of Athens, the Academy of Athens and the National Observatory of Athens measure UV (UV total, UV-B and total solar radiation components) and other relevant meteorological parameters at over 7 stations. Some of these stations have been included in the GAW network.

#### *7.2.1.5 Ground level air pollutants*

The Ministry for the Environment operates local networks for monitoring air pollution in Greece's major urban areas. In greater Athens, the network consists of 19 stations that measure air pollutants; 16-measure ground level ozone and 12 also measure standard meteorological parameters. The greater Thessalonica network consists of 8 stations, 7 of which measure ozone. Eight additional stations, all of which measure ozone, are located in other cities. The data are available to the public through the National Environmental Data Center of the Ministry of the Environment and through the European Environmental Agency.

In addition, the Public Power Corporation of Greece operates 8 air quality stations near its power plants that monitor all standard air pollutants ($SO_2$, NOx, $O_3$, TSP) but also $CO_2$ and meteorological parameters.

### *7.2.2 Marine climate observing systems*

The National Center for Marine Research (NCMR) is the chief organization charged with the collection of marine data from the seas surrounding Greece. NCMR operates a fleet of marine research vessels, including a bathyscaph capable of reaching 610m below sea level. It also operates 9 buoys with both meteorological and oceanographic instrumentation.

The Hellenic Navy Hydrographic Service maintains and operates an extended network of 21 tidal (sea level) gages.

### 7.2.3 Terrestrial climate observing systems

In conjunction with the rain-gage networks operated by various agencies, the Institute of Geology and Mineral Exploration of the Ministry of Development monitors groundwater supply and quality at about 450 sites nationwide. By the end of 2002, the number of monitoring sites should reach 500.

The Greek Public Power Corporation operates a network of 45 river-level and water-flow measurement stations. For the majority of these sites, data are available going back more than 30 years.

### 7.2.4 Support supplied to other countries to establish and maintain observing stations

For the past 10 years, within the framework of bilateral agreements, Greece has provided funds and technical assistance to neigh boring Balkan countries (Albania, Former Yugoslav Republic of Macedonia, Bulgaria) for the establishment and operation of a network of stations to monitor the amount and quality of water in the rivers that, in their course to the sea, cross the international boundaries shared with these countries.

# 8 EDUCATION AND PUBLIC AWARENESS

It is irrefutable that action on climate change will have a favorable outcome only when it becomes known and understood by the public. This can be accomplished with intensive programmes of education, awareness and training at all levels. Greece has proceeded in a series of actions concerning education and information.

## 8.1 Education

### *8.1.1 Student education*

The Ministry of Education and Religious Affairs is responsible for the introduction of Environmental Education (EE) in the typical educational system.

Greece participates in several international programmes concerning environmental education for students. Various thematic networks of environmental education (both national and international) operate within these programmes. Participation of schools is on a voluntary basis after an invitation. Such networks are: SEMEP, GLOBE-Alexandros, «Ecologic schools», «Young journalists» «The river», «The sea», «The forest », «Lakes», «The sustainable city».

The implementation of GLOBE (Global Learning and Observations to Benefit the Environment) is coordinated by the Ministry of Environment, Physical Planning and Public Works and the Ministry of Education and Religious Affairs, while the University of Athens is responsible for the provision of scientific and technical support. During implementation of the program, designated as ALEXANDROS, 29 schools of different educational levels and from different geographic regions of Greece were included. The aim of the programme is to increase students' awareness regarding environmental problems at the local, regional and global level, as well as to develop an open, international environmental cooperation network, bringing together students from countries all over the world. The programme makes use of educational material (printed, electronic, etc) for the comprehension of environmental issues in combination with the continuous monitoring of environmental parameters by students.

The scope of the «Ecologic schools» programme**,** which mainly concerns students of elementary education, is to underline environmental merits and to identify environmental problems of a certain region in order to activate students in the direction of environmental protection. The main issues of the programme are energy, water and waste.

The «Solar Schools» network has been developed in Greece with the cooperation of the Ministry of Environment, Physical Planning and Public Works, the Ministry of Education and Religious Affairs, and Greenpeace. It is foreseen that Solar Schools will be connected through the Internet and will be part of a developing international network of Solar Schools. Apart form the economic benefit for schools, the hope of this programme is to inform students on new, clean-energy technologies, to allow for the exchange of experiences on environmental issues, to increase environmental awareness, etc.

Moreover, other pilot programmes are implemented, and supportive material is distributed at schools with the cooperation of governmental and non-governmental, organisations. Such programmes include cooperation with:

- The Ministry of Environment, Physical Planning and Public Works for (a) schools' participation in the «Day without car» initiative, (b) Solar schools network, (c) student visits to the waste-processing plant of Psyttalia, (d) co-organization (with the Greek Corporation for the Protection of Environment and Cultural Heritage) of the International Conference of UNESCO «ENVIRONMENT & SOCIETY: education and sensitization of the public on sustainability» in the town of Thessalonica.
- The Center for Renewable Energy Sources (CRES) concerning, in particular, seminars for the responsible for Environmental Education and, in general, for educational staff regarding the use of RES (2000–2001)
- The Center for Environmental Education «GAIA» of Goulandris Museum regarding production of educational material for students and educators.
- WWF for implementation of pilot educational programs such as «The Mediterranean Forest» and with the Greek Corporation for Nature's Protection for the schools networks «Ecology schools» and «Young journalists».

### *8.1.2 University education*

Environmental education has been introduced as a specific course mainly to the Educational Faculties of universities. Teacher training on Environmental Education is provided by services (such as the Regional Training Centres, the Centres of Environmental Education, Prefectural Educational Management), supervised by the Ministry of Education and Religious Affairs and coordinated by the responsible of Environmental Education.

### *8.1.3 Public education*

The Ministry of Education and Religious Affairs has incorporated into its planning the establishment of 20 Centres of Environmental Education situated all over the country. To date, 17 Centres of Environmental Education are in operations. Services at these centres include: (a) offering special programmes of environmental education to groups of students, (b) organizing training seminars to teachers and other interested population groups,(c) publishing tutorial material, (d) coordinating networks of Environmental Education and (e) cooperating with the regional administration, universities and environmental organisations at the national and international level. They also support programmes of Environmental Education in schools within their jurisdiction.

## 8.2 Supporting projects to environmental education in the framework of OPEPPT 1994-2000

The Operational Program of Education and Prime Professional Training (OPEPPT), includes the following supportive projects concerning environmental education:

- **Establishment and operation of Environmental Education Centers**. Activities funded include improvements in infrastructure (special formation of classrooms and laboratories) and the provision of all necessary equipment (PC, microscopes, projectors,

measurement instruments etc.). Also funded are specific programmes of Environmental Education for students, training programmes for teachers, international cooperation with other Centres of Environmental Education, and the publication of informational and tutorial material.

- **Teachers' training on Environmental Education**. University departments in cooperation with the Ministry of Education and Religious Affairs and other entities have undertaken this training. Approximately 3,500 teachers in all regions of the country participated in 78 different training seminars that covered issues not included in the basic training of teachers. A sub-programme of this project was the establishment of the 10 "thematic councils" that are responsible for the elaboration of points of view on issues related to the integration of Environmental Education into the Greek educational system.
- **Development of educational material on Environmental Education**. This project concerns the purchase of educational material (CD-ROMs and educational packages on various issues) and the development of 12 thematic educational packages for Environmental Education under the supervision of universities.
- **Integration of Environmental Education into the curriculum of schools**. This project concerns the lessons of Natural Sciences in high schools. It is pressing for the adoption of a multi-scientific approach to the incorporation of Environmental Education into analytical programs. The pilot application of the educational material was implemented in 14 high schools in the country. The relevant conclusions are included in nine volumes, which are at the disposal of the teachers in the offices of the responsibles for Environmental Education.

## 8.3 Environmental awareness and the role of NGOs

Although climate change issues have been a concern to non-governmental organisations (NGOs) since the 1980s, it is only in the mid-1990s, when the Greek government ratified the UNFCCC and began enforcing laws for the promotion of RES, that NGOs became more actively involved.

However, in most cases the involvement of NGOs on climate change issues and especially those issues related to energy policy is not of a systematic nature (long term involvement, the undertaking of campaigns, submissions of proposals, etc.), and it is restricted to the provision of basic information to a small audience.

There is one NGO (Greenpeace) that has been actively involved in Greece in the area of energy and climate change since the beginning of the 1990s. Initiatives undertaken by Greenpeace cover a variety of issues that include:

- Information campaigns regarding the causes and the impacts of climate change
- Actions that urge administrative authorities to implement all issues foreseen in the Kyoto Protocol and for the development of an environmental-friendly energy policies
- Actions that urge industrial associations to implement measures to reduce GHG emissions (e.g., abatement of F-gases)

- Promotion of renewable energy sources (especially wind and solar energy) and energy conservation through information campaigns, compilation of informative leaflets, TV spots, demonstration of the operation of clean technologies (e.g., photovoltaic), etc.
- Information campaigns promoting public transportation, efficient vehicles and the substitution of F-gases (affecting both producers and consumers).

It should be mentioned that initiatives undertaken by other NGOs are also related to climate change mitigation. Such initiatives include campaigns for the protection of forests, the promotion of waste recycling and ecological agriculture.

The National Center for Environment and Sustainable Development (NCESD) was established in 2000, under the supervision of the Ministry of Environment, Physical Planning and Public Works, with the intended purpose of assisting the processing of environmental policies. The role of NCESD on issues concerning environmental awareness and education focuses on cooperation with all relevant entities (Ministry of Education and Religious Affairs, Pedagogic Institute, Ministry of Environment, Physical Planning and Public Works, Non-Governmental Environmental Organizations (NGOs), Local Administration, Research Institutes, Educational Institutions, etc.) for:

- The development of a consistent policy for Environmental Education
- The production and evaluation of the educational material
- The training of teachers
- The environmental education of the general public
- The appraisal of environmental friendly actions (e.g., awarding)
- The promotion of actions for environmental awareness and activation of the public (e.g., campaigns, seminars, conferences, exhibitions, etc.)
- The environmental training of members of the media
- The environmental awareness and education of the local societies, with priority to dependant areas (e.g., NATURA net)
- The training of special target groups, with priority to public administration staff

In general the involvement of NCESD in environmental-policy issues is related to (a) the collection, evaluation, diffusion and updating of environmental information, (b) the development of a network of all entities involved in environmental awareness (c) the fulfillment of Greece's international commitments concerning issues of environmental awareness and education (RIO+10, Olympic games, etc.) and (d) the submission of specific proposals to decisions centers, aiming to the promotion of environmental awareness and education and consolidation of their positive results.

The National Network of Environmental Information (NNEI), the objective of which is to facilitate the access to information concerning environmental quality, was completed. This project, funded by the 2nd CSF for the environment, aims at:

- The networking, by means of information exchange, of the main environmental entities of the country
- The activation of regional authorities and other local administrators about environmental issues, through information exchange

- Being a focal point of environmental information, for the public and all interested entities
- The provision of necessary data for (a) estimation of environmental impacts of sectoral policies, (b) compilations of environmental reports and (c) the processing of environmental pressure indices

A number of environmental information centers (regarding sites under the RAMSAR treaty and NATURA 2000, as well as general public) were established and operate under supervision of the Ministry of Environment, Physical Planning and Public Works, the Ministry of Agriculture and the local authorities.

Finally, the realisation of an awareness campaign for climate change is also foreseen. This campaign, associated with the 2nd National Action Plan for climate change mitigation, will be incorporated in the framework of the commemoration of the Global day for the Environment in 2003. The campaign will include the production of TV spots, the organization of debates through television at national and regional levels, the release of informative material and the organisation of various activities for the 5th of June (Global day for the Environment) 2003.

## ABREVIATIONS

| | |
|---|---|
| **$CH_4$** | Methane |
| **CNG** | Compressed Natural Gas |
| **$CO_2$** | Carbon dioxide |
| **CORINAIR** | Co-ordination of Information on Air Pollution |
| **CRES** | Center for Renewable Energy Sources |
| **CSFP** | Community Support Framework Program |
| **DAC** | Development Assistance Committee |
| **ECMWF** | European Center for Medium-range Weather Forecast |
| **EE** | Environmental education |
| **EIC** | Environmental Information Center |
| **ENPEP** | ENergy and Power Evaluation Program |
| **EU** | European Union |
| **EUMETSAT** | EUropean organization for the exploitation of METeorological SATellites |
| **GDP** | Gross Domestic Product |
| **GEF** | Global Environmental Facility |
| **GIC** | Gross Inland Consumption |
| **GLOBE** | Global Learning and Observations to Benefit the Environment |
| **GNI** | Gross National Income |
| **GSRT** | General Secretariat for Research and Technology |
| **HFCs** | Hydrofluorocarbons |
| **HNMS** | Hellenic National Meteorological Service |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **LPG** | Liquified Petroleum Gas |
| **MEPPPW** | Ministry for the Environment, Physical Planning and Public Works |
| **MERA** | Ministry of Education and Religious Affairs |
| **Mtoe** | Million tones oil equivalent |
| **$N_2O$** | Nitrous oxide |
| **NCESD** | National Center for Environment and Sustainable Development |
| **NCMR** | National Center for Marine Research |
| **NGOs** | Non-Governmental Environmental Organizations |
| **NNEI** | National Network of Environmental Information |
| **NOA** | National Observatory of Athens |
| **OASA** | Athens Urban Transport Organization |
| **ODA** | Official Development Assistance |
| **OECD** | Organization for Economic Co-operation and Development |
| **OPE** | Operational Programme for Energy |
| **OPEPPT** | Operational Program of Education and Prime Professional Training |
| **PFCs** | Perfuorocarbons |
| **PPC** | Public Power Corporation |
| **RES** | Renewable Energy Sources |
| **$SF_6$** | Sulphur hexafluoride |

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# ANNEXES

# ANNEX I

## EMISSIONS INVENTORY 1990 – 2000

### Global Warming Potential for the primary greenhouse gases (in kg of CO2 equiv) for the 100-year horizon.

| AEPIO | GWP |
|---|---|
| Carbon dioxide | 1 |
| Methane | 21 |
| Nitrous oxide | 310 |
| ***Hydrofluorocarbons (HFCs)*** | |
| HFC-23 | 11700 |
| HFC-125 | 2800 |
| HFC-134a | 1300 |
| HFC-143a | 3800 |
| HFC-152a | 140 |
| HFC-227ea | 2900 |
| HFC-236fa | 6300 |
| HFC-4310mee | 1300 |
| ***Perfluorocarbons (PFCs)*** | |
| $CF_4$ | 6500 |
| $C_2F_6$ | 9200 |
| $C_4F_{10}$ | 7000 |
| $C_6F_{14}$ | 7400 |
| **Sulphur hexafluoride** ($SF_6$) | 23900 |

### Sources of statistical data by activity sector.

| SECTOR | STATISTICAL DATA | SOURCES |
|---|---|---|
| Electricity production | Fuel use | ❖ Greek Public Power Corporation<br>❖ Energy balance (Ministry of Development - IEA/OECD) |
| Industry | Fuel use | ❖ Energy balance (Ministry of Development - IEA/OECD) |
| Transport | Number of vehicles<br>Aircraft landing and take off cycles | ❖ Association of Greek Auto Importers<br>❖ Greek Civil Aviation Authority |
| Residential, tertiary and agricultural sector | Fuel use | ❖ Energy balance (Ministry of Development - IEA/OECD) |
| Mining / Distribution of fuels | Amount of Fuels | ❖ Energy balance (Ministry of Development - IEA/OECD) |
| Industrial Processes | Annual production data | ❖ National Statistical Service of Greece<br>❖ Information from Industy |
| Solvent and other products use | Amount of solvent use | ❖ Ministry for the Environment, Physical Planning and Public Works |
| Agriculture | Agricultural area<br>Number of animals | ❖ National Statistical Service of Greece<br>❖ Ministry of Agriculture |
| Land Use Change and Forestry | Forest areas<br>Δασικές Πυρκαγιές | ❖ Ministry of Agriculture<br>❖ Directorate General for the Forests and the Natural Environment |
| Waste | Ποσότητες και σύνθεση απορριμμάτων | ❖ Ministry for the Environment, Physical Planning and Public Works |

## Greenhouse and other gases emissions for the year 2000

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ emissions (kt) | $CO_2$ removals (kt) | $CH_4$ (kt) | $N_2O$ (kt) | HFCs (kt $CO_2$ eq) | PFCs (kt $CO_2$ eq) | $SF_6$ (kt) | $NO_x$ (kt) | CO (kt) | NMVOC (kt) | $SO_2$ (kt) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total National Emissions and Removals** | **107,567.17** | **0.00** | **518.44** | **35.51** | **4,281.02** | **148.38** | **0.00** | **321.05** | **1,531.13** | **305.41** | **482.62** |
| **1. Energy** | **95,681.67** | | **77.58** | **12.09** | | | | **312.91** | **1,297.42** | **246.19** | **472.04** |
| A. Fuel Combustion — Reference Approach | 94,696.46 | | | | | | | | | | |
| Sectoral Approach | 95,681.67 | | 21.76 | 12.09 | | | | 312.91 | 1,297.32 | 225.72 | 463.27 |
| 1. Energy Industries | 55,058.21 | | 0.46 | 6.96 | | | | 77.25 | 46.08 | 15.97 | 354.04 |
| 2. Manufacturing Industries and Construction | 10,414.71 | | 3.62 | 1.58 | | | | 37.79 | 26.35 | 8.87 | 66.42 |
| 3. Transport | 21,678.35 | | 7.71 | 2.18 | | | | 188.47 | 1,044.91 | 186.12 | 25.47 |
| 4. Other Sectors | 8,530.40 | | 9.98 | 1.38 | | | | 9.40 | 179.99 | 14.77 | 17.34 |
| 5. Other | 0.00 | | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Fugitive Emissions from Fuels | 0.00 | | 55.83 | 0.00 | | | | 0.00 | 0.10 | 20.47 | 8.77 |
| 1. Solid Fuels | 0.00 | | 54.30 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2. Oil and Natural Gas | 0.00 | | 1.52 | 0.00 | | | | 0.00 | 0.10 | 20.47 | 8.77 |
| **2. Industrial Processes** | **7,876.98** | | **0.00** | **1.83** | **4,281.02** | **148.38** | **0.00** | **1.43** | **22.11** | **4.66** | **10.59** |
| A. Mineral Products | 7,624.99 | | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 4.41 |
| B. Chemical Industry | 0.00 | | 0.00 | 1.83 | 0.00 | 0.00 | 0.00 | 1.03 | 0.00 | 0.23 | 3.67 |
| C. Metal Production | 251.99 | | 0.00 | 0.00 | | 148.38 | 0.00 | 0.35 | 21.95 | 0.00 | 2.31 |
| D. Other Production (3) | no | | | | | | | 0.04 | 0.16 | 4.43 | 0.20 |
| E. Production of Halocarbons and $SF_6$ | | | | | 3,744.00 | 0.00 | 0.00 | | | | |
| F. Consumption of Halocarbons and $SF_6$ | | | | | 537.02 | 0.00 | 0.00 | | | | |
| G. Other | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **3. Solvent and Other Product Use** | **168.61** | | | **0.00** | | | | | | **54.56** | |
| **4. Agriculture** | **0.00** | **0.00** | **170.11** | **21.47** | | | | 2.37 | 58.92 | 0.00 | 0.00 |
| A. Enteric Fermentation | | | 139.03 | | | | | | | | |
| B. Manure Management | | | 22.49 | 0.86 | | | | | | 0.00 | |
| C. Rice Cultivation | | | 5.79 | | | | | | | 0.00 | |
| D. Agricultural Soils | | | 0.00 | 20.55 | | | | | | 0.00 | |
| E. Prescribed Burning of Savannas | | | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | |
| F. Field Burning of Agricultural Residues | | | 2.81 | 0.07 | | | | 2.37 | 58.92 | 0.00 | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ emissions (kt) | $CO_2$ removals (kt) | $CH_4$ (kt) | $N_2O$ (kt) | HFCs (kt $CO_2$ eq) | PFCs (kt $CO_2$ eq) | $SF_6$ (kt) | $NO_x$ (kt) | CO (kt) | NMVOC (kt) | $SO_2$ (kt) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| G. Other | | | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | |
| **5. Land-Use Change and Forestry** | **3,839.91** | **0.00** | **17.45** | **0.12** | | | | **4.34** | **152.68** | **0.00** | **0.00** |
| A. Changes in Forest and Other Woody Biomass Stocks | 0.00 | -185.41 | | | | | | | | | |
| B. Forest and Grassland Conversion | 4,226.98 | | 17.45 | 0.12 | | | | 4.34 | 152.68 | | |
| C. Abandonment of Managed Lands | 0.00 | 0.00 | | | | | | | | | |
| D. CO2 Emissions and Removals from Soil | 0.00 | -201.67 | | | | | | | | | |
| E. Other | 0.00 | 0.00 | 0.00 | 0.00 | | | | 0.00 | 0.00 | | |
| **6. Waste** | **0.00** | | **253.30** | **0.00** | | | | **0.00** | **0.00** | **0.00** | **0.00** |
| A. Solid Waste Disposal on Land | 0.00 | | 227.02 | | | | | | 0.00 | 0.00 | |
| B. Wastewater Handling | | | 26.28 | 0.00 | | | | 0.00 | 0.00 | 0.00 | |
| C. Waste Incineration | 0.00 | | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| D. Other | 0.00 | | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| **7. Other (please specify)** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | | | | | | | | | | | |
| **Memo Items:** | | | | | | | | | | | |
| **International Bunkers** | **14,497.80** | | **1.14** | **0.38** | | | | **278.33** | **31.29** | **9.19** | **206.86** |
| Aviation | 3,138.62 | | 0.04 | 0.09 | | | | 15.68 | 4.29 | 0.44 | 1.00 |
| Marine | 11,359.18 | | 1.09 | 0.29 | | | | 262.66 | 27.00 | 8.76 | 205.86 |
| **Multilateral Operations** | **0.00** | | **0.00** | **0.00** | | | | **ne** | **ne** | **ne** | **ne** |
| **CO2 Emissions from Biomass** | **4,089.08** | | | | | | | | | | |

## Greenhouse and other gases emissions for the year 2000 in kt of CO2 eq

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Total |
|---|---|---|---|---|---|---|---|
| **Total (Net Emissions)** | **107,567.17** | **10,887.27** | **11,008.93** | **4,281.02** | **148.38** | **0.00** | **133,892.77** |
| **1. Energy** | **95,681.67** | **1,629.28** | **3,748.21** | | | | **101,059.17** |
| A. Fuel Combustion (Sectoral Approach) | 95,681.67 | 456.94 | 3,748.21 | | | | 99,886.82 |
| 1. Energy Industries | 55,058.21 | 9.56 | 2,157.60 | | | | 57,225.37 |
| 2. Manufacturing Industries and Construction | 10,414.71 | 75.98 | 488.25 | | | | 10,978.94 |
| 3. Transport | 21,678.35 | 161.93 | 675.80 | | | | 22,516.08 |
| 4. Other Sectors | 8,530.40 | 209.48 | 426.56 | | | | 9,166.44 |
| 5. Other | 0.00 | 0.00 | 0.00 | | | | 0.00 |
| B. Fugitive Emissions from Fuels | 0.00 | 1,172.34 | 0.00 | | | | 1,172.34 |
| 1. Solid Fuels | 0.00 | 1,140.38 | 0.00 | | | | 1,140.38 |
| 2. Oil and Natural Gas | 0.00 | 31.96 | 0.00 | | | | 31.96 |
| **2. Industrial Processes** | **7,876.98** | **0.00** | **567.30** | **4,281.02** | **148.38** | **0.00** | **12,873.68** |
| A. Mineral Products | 7,624.99 | 0.00 | 0.00 | | | | 7,624.99 |
| B. Chemical Industry | 0.00 | 0.00 | 567.30 | 0.00 | 0.00 | 0.00 | 567.30 |
| C. Metal Production | 251.99 | 0.00 | 0.00 | | 148.38 | 0.00 | 400.37 |
| D. Other Production | no | | | | | | 0.00 |
| E. Production of Halocarbons and $SF_6$ | | | | 3,744.00 | 0.00 | 0.00 | 3,744.00 |
| F. Consumption of Halocarbons and $SF_6$ | | | | 537.02 | 0.00 | 0.00 | 537.02 |
| G. Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **3. Solvent and Other Product Use** | **168.61** | | **0.00** | | | | **168.61** |
| **4. Agriculture** | **0.00** | **3,572.32** | **6,656.23** | | | | **10,228.56** |
| A. Enteric Fermentation | | 2,919.57 | | | | | 2,919.57 |
| B. Manure Management | | 472.23 | 265.98 | | | | 738.21 |
| C. Rice Cultivation | | 121.61 | | | | | 121.61 |
| D. Agricultural Soils(2) | | 0.00 | 6,369.88 | | | | 6,369.88 |
| E. Prescribed Burning of Savannas | | 0.00 | 0.00 | | | | 0.00 |
| F. Field Burning of Agricultural Residues | | 58.92 | 20.37 | | | | 79.29 |
| G. Other | | 0.00 | 0.00 | | | | 0.00 |
| **5. Land-Use Change and Forestry(1)** | **3,839.91** | **366.37** | **37.18** | | | | **4,243.46** |
| **6. Waste** | **0.00** | **5,319.30** | **0.00** | | | | 5,319.30 |
| A. Solid Waste Disposal on Land | 0.00 | 4,767.40 | | | | | 4,767.40 |
| B. Wastewater Handling | | 551.90 | 0.00 | | | | 551.90 |
| C. Waste Incineration | 0.00 | 0.00 | 0.00 | | | | 0.00 |
| D. Other | 0.00 | 0.00 | 0.00 | | | | 0.00 |
| **7. Other *(please specify)*** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | | | | | | | 0.00 |
| **Memo Items:** | | | | | | | |
| **International Bunkers** | **14,497.80** | **23.84** | **118.73** | | | | **14,640.37** |
| Aviation | 3,138.62 | 0.86 | 28.21 | | | | 3,167.69 |
| Marine | 11,359.18 | 22.97 | 90.52 | | | | 11,472.67 |
| **Multilateral Operations** | **0.00** | **0.00** | **0.00** | | | | **0.00** |
| **$CO_2$ Emissions from Biomass** | **4,089.08** | | | | | | **4,089.08** |

## Evaluation of $CO_2$ emissions for the period 1990 – 2000 (kt)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Energy** | **76,473.99** | **76,450.23** | **78,085.28** | **78,191.49** | **80,051.87** | **79,778.45** | **82,058.86** | **86,518.25** | **91,287.69** | **90,593.46** | **95,681.67** |
| A. Fuel Combustion (Sectoral Approach) | 76,473.99 | 76,450.23 | 78,085.28 | 78,191.49 | 80,051.87 | 79,778.45 | 82,058.86 | 86,518.25 | 91,287.69 | 90,593.46 | 95,681.67 |
| 1. Energy Industries | 43,302.00 | 42,148.56 | 44,091.10 | 44,366.35 | 46,323.37 | 45,056.01 | 44,204.59 | 47,668.22 | 50,254.46 | 50,219.64 | 55,058.21 |
| 2. Manufacturing Industries and Construction | 9,792.29 | 9,695.21 | 9,327.02 | 9,070.09 | 8,897.45 | 9,602.69 | 10,412.09 | 10,570.22 | 10,771.98 | 9,552.32 | 10,414.71 |
| 3. Transport | 18,039.11 | 19,050.76 | 19,250.58 | 19,402.60 | 19,446.03 | 19,435.01 | 19,925.30 | 20,523.31 | 22,148.94 | 22,907.74 | 21,678.35 |
| 4. Other Sectors | 5,340.59 | 5,555.70 | 5,416.58 | 5,352.45 | 5,385.02 | 5,684.74 | 7,516.88 | 7,756.50 | 8,112.31 | 7,913.76 | 8,530.40 |
| 5. Other | no | no | no | no | no | no | no | no | no | no | no |
| B. Fugitive Emissions from Fuels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1. Solid Fuels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2. Oil and Natural Gas | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2. Industrial Processes** | **7,685.71** | **7,598.87** | **7,510.96** | **7,481.60** | **7,259.73** | **7,709.06** | **7,946.97** | **7,991.29** | **7,973.33** | **7,866.56** | **7,876.98** |
| A. Mineral Products | 6,984.21 | 6,979.27 | 7,021.69 | 7,252.68 | 7,045.80 | 7,386.39 | 7,578.70 | 7,634.83 | 7,565.46 | 7,618.67 | 7,624.99 |
| B. Chemical Industry | 469.54 | 383.42 | 251.91 | 0.00 | 0.00 | 119.80 | 165.41 | 150.86 | 181.47 | 0.00 | 0.00 |
| C. Metal Production | 231.96 | 236.17 | 237.37 | 228.92 | 213.93 | 202.87 | 202.86 | 205.60 | 226.40 | 247.89 | 251.99 |
| D. Other Production | no | no | no | no | no | no | no | no | no | no | no |
| E. Production of Halocarbons and $SF_6$ | | | | | | | | | | | |
| F. Consumption of Halocarbons and $SF_6$ | | | | | | | | | | | |
| G. Other | no | no | no | no | no | no | no | no | no | no | no |
| **3. Solvent and Other Product Use** | **176.51** | **181.31** | **177.86** | **173.49** | **167.50** | **156.15** | **157.19** | **158.35** | **158.29** | **165.96** | **168.61** |
| **4. Agriculture** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| A. Enteric Fermentation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Manure Management | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C. Rice Cultivation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| D. Agricultural Soils (2) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| E. Prescribed Burning of Savannas | no | no | no | no | no | no | no | no | no | no | no |
| F. Field Burning of Agricultural Residues | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| G. Other | no | no | no | no | no | no | no | no | no | no | no |
| **5. Land-Use Change and Forestry** | **1,441.05** | **609.60** | **2,177.39** | **1,601.52** | **1,405.89** | **-365.67** | **-75.17** | **-399.62** | **2,538.18** | **66.17** | **3,839.90** |
| A. Changes in Forest and Other Woody Biomass | 18.35 | 0.98 | -100.04 | -119.20 | 171.62 | -772.37 | -505.87 | -547.67 | -1,059.69 | -147.09 | -185.41 |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stocks | | | | | | | | | | | |
| B. Forest and Grassland Conversion | 1,422.70 | 608.62 | 2,277.43 | 1,720.72 | 1,402.94 | 659.70 | 683.70 | 655.88 | 3,682.20 | 552.42 | 4,226.98 |
| C. Abandonment of Managed Lands | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne |
| D. $CO_2$ Emissions and Removals from Soil | 0.00 | 0.00 | 0.00 | 0.00 | -168.67 | -253.00 | -253.00 | -507.83 | -84.33 | -339.17 | -201.67 |
| E. Other | no | no | no | no | no | no | no | no | no | no | no |
| **6. Waste** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| A. Solid Waste Disposal on Land | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Waste-water Handling | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C. Waste Incineration | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne |
| D. Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **7. Other *(please specify)*** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | | | | | | | | | | | |
| **Total Emissions/Removals with LUCF** | **85,777.26** | **84,840.01** | **87,951.49** | **87,448.10** | **88,884.98** | **87,277.99** | **90,087.85** | **94,268.26** | **101,957.49** | **98,692.14** | **107,567.17** |
| **Total Emissions without LUCF** | **84,336.21** | **84,230.41** | **85,774.10** | **85,846.58** | **87,479.09** | **87,643.66** | **90,163.02** | **94,667.89** | **99,419.31** | **98,625.98** | **103,727.26** |

| Memo Items: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **International Bunkers** | **10,867.67** | **9,868.67** | **9,923.50** | **13,242.06** | **13,759.50** | **14,362.20** | **12,823.10** | **12,872.21** | **14,148.29** | **12,718.49** | **14,497.80** |
| Aviation | 2,839.91 | 2,500.63 | 1,459.64 | 3,373.42 | 3,289.53 | 3,107.78 | 2,958.84 | 2,945.20 | 3,090.48 | 2,880.78 | 3,138.62 |
| Marine | 8,027.76 | 7,368.04 | 8,463.86 | 9,868.64 | 10,469.97 | 11,254.42 | 9,864.26 | 9,927.01 | 11,057.81 | 9,837.71 | 11,359.18 |
| **Multilateral Operations** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** |
| **$CO_2$ Emissions from Biomass** | **2,473.61** | **2,473.61** | **2,473.61** | **2,473.61** | **2,611.56** | **2,611.56** | **4,083.82** | **4,092.84** | **4,079.20** | **4,089.08** | **4,089.08** |

## Evaluation of $CH_4$ emissions for the period 1990 – 2000 (kt)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Energy** | **59.35** | **60.20** | **62.11** | **62.32** | **64.30** | **65.42** | **71.95** | **71.42** | **73.56** | **74.94** | **77.58** |
| A. Fuel Combustion (Sectoral Approach) | 15.03 | 15.20 | 15.13 | 15.59 | 16.03 | 16.30 | 21.04 | 21.20 | 21.14 | 21.13 | 21.76 |
| 1. Energy Industries | 0.35 | 0.34 | 0.36 | 0.36 | 0.37 | 0.37 | 0.39 | 0.39 | 0.40 | 0.40 | 0.46 |
| 2. Manufacturing Industries and Construction | 1.49 | 1.26 | 0.87 | 1.02 | 2.47 | 2.48 | 3.63 | 3.66 | 3.45 | 3.35 | 3.62 |
| 3. Transport | 5.41 | 5.67 | 5.97 | 6.24 | 6.34 | 6.61 | 6.86 | 7.01 | 7.20 | 7.47 | 7.71 |
| 4. Other Sectors | 7.78 | 7.92 | 7.94 | 7.98 | 6.85 | 6.83 | 10.16 | 10.14 | 10.09 | 9.91 | 9.98 |
| 5. Other | no | no | no | no | no | no | no | no | no | no | no |
| B. Fugitive Emissions from Fuels | 44.33 | 45.01 | 46.98 | 46.73 | 48.27 | 49.12 | 50.92 | 50.22 | 52.42 | 53.81 | 55.83 |
| 1. Solid Fuels | 44.11 | 44.79 | 46.79 | 46.58 | 48.17 | 49.03 | 50.81 | 50.02 | 51.75 | 52.74 | 54.30 |
| 2. Oil and Natural Gas | 0.22 | 0.22 | 0.19 | 0.15 | 0.10 | 0.09 | 0.10 | 0.20 | 0.67 | 1.07 | 1.52 |
| **2. Industrial Processes** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| A. Mineral Products | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Chemical Industry | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C. Metal Production | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| D. Other Production | no | no | no | no | no | no | no | no | no | no | no |
| E. Production of Halocarbons and $SF_6$ | | | | | | | | | | | |
| F. Consumption of Halocarbons and $SF_6$ | | | | | | | | | | | |
| G. Other | no | no | no | no | no | no | no | no | no | no | no |
| **3. Solvent and Other Product Use** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| **4. Agriculture** | **172.75** | **171.41** | **169.61** | **170.78** | **172.52** | **173.62** | **174.56** | **174.27** | **172.65** | **170.97** | **170.11** |
| A. Enteric Fermentation | 141.70 | 140.02 | 139.15 | 138.96 | 139.44 | 140.07 | 140.45 | 140.11 | 139.65 | 139.18 | 139.03 |
| B. Manure Management | 23.66 | 23.30 | 23.17 | 23.11 | 23.07 | 23.01 | 23.00 | 22.90 | 22.78 | 22.59 | 22.49 |
| C. Rice Cultivation | 4.79 | 4.30 | 4.28 | 5.89 | 6.89 | 7.60 | 8.33 | 8.46 | 7.55 | 6.51 | 5.79 |
| D. Agricultural Soils | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| E. Prescribed Burning of Savannas | no | 0.00 | no | 0.00 | no | no | 0.00 | 0.00 | no | no | no |
| F. Field Burning of Agricultural Residues | 2.60 | 3.80 | 3.02 | 2.83 | 3.12 | 2.94 | 2.79 | 2.80 | 2.67 | 2.69 | 2.81 |
| G. Other | no | 0.00 | no | 0.00 | no | no | 0.00 | 0.00 | no | no | 0.00 |
| **5. Land-Use Change and Forestry** | **5.71** | **2.29** | **9.44** | **7.00** | **5.89** | **2.44** | **2.70** | **2.56** | **15.62** | **1.98** | **17.45** |
| A. Changes in Forest and Other Woody Biomass Stocks | | | | | | | | | | | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B. Forest and Grassland Conversion | 5.71 | 2.29 | 9.44 | 7.00 | 5.89 | 2.44 | 2.70 | 2.56 | 15.62 | 1.98 | 17.45 |
| C. Abandonment of Managed Lands | | | | | | | | | | | |
| D. $CO_2$ Emissions and Removals from Soil | | | | | | | | | | | |
| E. Other | no | no | no | no | no | no | no | no | no | no | no |
| **6. Waste** | **178.51** | **180.60** | **187.69** | **193.52** | **203.09** | **210.59** | **217.96** | **224.16** | **235.24** | **247.86** | **253.30** |
| A. Solid Waste Disposal on Land | 133.84 | 136.80 | 145.03 | 152.73 | 162.90 | 171.18 | 179.48 | 186.99 | 199.65 | 214.16 | 227.02 |
| B. Waste-water Handling | 44.68 | 43.80 | 42.67 | 40.79 | 40.20 | 39.41 | 38.48 | 37.18 | 35.59 | 33.70 | 26.28 |
| C. Waste Incineration | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne |
| D. Other | no | no | no | no | no | no | no | no | no | no | no |
| **7. Other *(please specify)*** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |

| Memo Items: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **International Bunkers** | **0.80** | **0.73** | **0.84** | **0.98** | **1.04** | **1.11** | **0.98** | **0.99** | **1.10** | **0.99** | **1.14** |
| Aviation | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 |
| Marine | 0.77 | 0.71 | 0.81 | 0.95 | 1.01 | 1.08 | 0.95 | 0.96 | 1.07 | 0.95 | 1.09 |
| **Multilateral Operations** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** |
| **$CO_2$ Emissions from Biomass** | | | | | | | | | | | |

## Evaluation of $N_2O$ emissions for the period 1990 – 2000 (kt)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Energy** | **9.90** | **10.03** | **10.73** | **10.21** | **10.46** | **10.43** | **11.01** | **11.43** | **11.80** | **11.45** | **12.09** |
| A. Fuel Combustion (Sectoral Approach) | 9.90 | 10.03 | 10.73 | 10.21 | 10.46 | 10.43 | 11.01 | 11.43 | 11.80 | 11.45 | 12.09 |
| 1. Energy Industries | 5.74 | 5.67 | 6.46 | 6.04 | 6.27 | 6.13 | 6.12 | 6.45 | 6.65 | 6.56 | 6.96 |
| 2. Manufacturing Industries and Construction | 1.56 | 1.57 | 1.49 | 1.37 | 1.40 | 1.50 | 1.69 | 1.67 | 1.71 | 1.43 | 1.58 |
| 3. Transport | 1.66 | 1.83 | 1.83 | 1.87 | 1.91 | 1.88 | 1.95 | 2.04 | 2.12 | 2.16 | 2.18 |
| 4. Other Sectors | 0.94 | 0.97 | 0.95 | 0.93 | 0.89 | 0.92 | 1.25 | 1.28 | 1.33 | 1.30 | 1.38 |
| 5. Other | no | no | no | no | no | no | no | no | no | no | no |
| B. Fugitive Emissions from Fuels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1. Solid Fuels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2. Oil and Natural Gas | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2. Industrial Processes** | **2.30** | **1.90** | **1.98** | **1.88** | **1.83** | **1.82** | **2.08** | **1.83** | **1.83** | **1.83** | **1.83** |
| A. Mineral Products | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Chemical Industry | 2.30 | 1.90 | 1.98 | 1.88 | 1.83 | 1.82 | 2.08 | 1.83 | 1.83 | 1.83 | 1.83 |
| C. Metal Production | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| D. Other Production | no | no | no | no | no | no | no | no | no | no | no |
| E. Production of Halocarbons and $SF_6$ | | | | | | | | | | | |
| F. Consumption of Halocarbons and $SF_6$ | | | | | | | | | | | |
| G. Other | no | no | no | no | no | no | no | no | no | no | no |
| **3. Solvent and Other Product Use** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| **4. Agriculture** | **22.01** | **21.96** | **20.93** | **20.54** | **20.66** | **19.65** | **20.17** | **20.95** | **20.41** | **20.29** | **21.47** |
| A. Enteric Fermentation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Manure Management | 0.97 | 0.95 | 0.93 | 0.92 | 0.91 | 0.91 | 0.91 | 0.90 | 0.89 | 0.86 | 0.86 |
| C. Rice Cultivation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| D. Agricultural Soils | 20.97 | 20.93 | 19.93 | 19.55 | 19.67 | 18.67 | 19.19 | 19.98 | 19.49 | 19.37 | 20.55 |
| E. Prescribed Burning of Savannas | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F. Field Burning of Agricultural Residues | 0.06 | 0.09 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.04 | 0.06 | 0.07 |
| G. Other | no | no | no | no | no | no | no | no | no | 0.00 | 0.00 |
| **5. Land-Use Change and Forestry** | **0.07** | **0.04** | **0.12** | **0.09** | **0.14** | **0.04** | **0.08** | **0.07** | **0.23** | **0.02** | **0.12** |
| A. Changes in Forest and Other Woody Biomass Stocks | | | | | | | | | | | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B. Forest and Grassland Conversion | 0.07 | 0.04 | 0.12 | 0.09 | 0.14 | 0.04 | 0.08 | 0.07 | 0.23 | 0.02 | 0.12 |
| C. Abandonment of Managed Lands | | | | | | | | | | | |
| D. $CO_2$ Emissions and Removals from Soil | | | | | | | | | | | |
| E. Other | no | no | no | no | no | no | no | no | no | no | no |
| **6. Waste** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| A. Solid Waste Disposal on Land | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Waste-water Handling | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne |
| C. Waste Incineration | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne | ne |
| D. Other | no | no | no | no | no | no | no | no | no | no | no |
| **7. Other *(please specify)*** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |

| Memo Items: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **International Bunkers** | **0.28** | **0.26** | **0.30** | **0.35** | **0.37** | **0.45** | **0.34** | **0.34** | **0.38** | **0.34** | **0.38** |
| Aviation | 0.08 | 0.08 | 0.08 | 0.10 | 0.10 | 0.16 | 0.09 | 0.09 | 0.09 | 0.08 | 0.09 |
| Marine | 0.21 | 0.19 | 0.22 | 0.25 | 0.27 | 0.29 | 0.25 | 0.26 | 0.29 | 0.25 | 0.29 |
| **Multilateral Operations** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** | **no** |
| **$CO_2$ Emissions from Biomass** | | | | | | | | | | | |

## Evaluation of F-gases for the period 1990 – 2000 (kt)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Emissions of HFCs(5) - $CO_2$ equivalent (Gg)** | **935.06** | **1,106.82** | **908.39** | **1,637.92** | **2,209.01** | **3,369.00** | **3,916.16** | **4,194.38** | **4,052.99** | **4,156.43** | **4,281.02** |
| HFC-23 | 0.08 | 0.09 | 0.08 | 0.14 | 0.18 | 0.28 | 0.32 | 0.34 | 0.32 | 0.32 | 0.32 |
| HFC-32 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.09 |
| HFC-41 | | | | | | | | | | | |
| HFC-43-10mee | | | | | | | | | | | |
| HFC-125 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.09 |
| HFC-134 | | | | | | | | | | | |
| HFC-134a | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.03 | 0.05 | 0.07 | 0.10 | 0.13 | 0.17 |
| HFC-152a | | | | | | | | | | | |
| HFC-143 | | | | | | | | | | | |
| HFC-143a | | | | | | | | | | | |
| HFC-227ea | | | | | | | | | | | |
| HFC-236fa | | | | | | | | | | | |
| HFC-245ca | | | | | | | | | | | |
| **Emissions of PFCs(5) -$CO_2$ equivalent (Gg)** | **257.62** | **257.55** | **252.30** | **152.59** | **93.62** | **82.97** | **71.74** | **165.11** | **203.75** | **131.72** | **148.38** |
| $CF_4$ | 0.03 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 |
| $C_2F_6$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $C_3F_8$ | | | | | | | | | | | |
| $C_4F_{10}$ | | | | | | | | | | | |
| c-$C_4F_8$ | | | | | | | | | | | |
| $C_5F_{12}$ | | | | | | | | | | | |
| $C_6F_{14}$ | | | | | | | | | | | |
| **Emissions of $SF_6$(5) - $CO_2$ equivalent (Gg)** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| $SF_6$ | | | | | | | | | | | |

## Evaluation of Greenhouse Gases for the period 1990 – 2000 (kt CO2 eq)

| GREENHOUSE GAS EMISSIONS | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Net $CO_2$ emissions/removals | 85,777.26 | 84,840.01 | 87,951.49 | 87,448.10 | 88,884.98 | 87,277.99 | 90,087.85 | 94,268.26 | 101,957.49 | 98,692.14 | 107,567.17 |
| $CO_2$ emissions (without LUCF) | 84,336.21 | 84,230.41 | 85,774.10 | 85,846.58 | 87,479.09 | 87,643.66 | 90,163.02 | 94,667.89 | 99,419.31 | 98,625.98 | 103,727.26 |
| $CH_4$ | 8,742.91 | 8,704.56 | 9,006.02 | 9,106.13 | 9,361.91 | 9,493.46 | 9,810.71 | 9,920.72 | 10,438.53 | 10,410.65 | 10,887.27 |
| $N_2O$ | 10,623.29 | 10,521.25 | 10,466.59 | 10,142.94 | 10,258.02 | 9,899.25 | 10,336.83 | 10,627.89 | 10,625.10 | 10,414.18 | 11,008.93 |
| HFCs | 935.06 | 1,106.82 | 908.39 | 1,637.92 | 2,209.01 | 3,369.00 | 3,916.16 | 4,194.38 | 4,052.99 | 4,156.43 | 4,281.02 |
| PFCs | 257.62 | 257.55 | 252.30 | 152.59 | 93.62 | 82.97 | 71.74 | 165.11 | 203.75 | 131.72 | 148.38 |
| $SF_6$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total (with net $CO_2$ emissions/removals)** | **106,336.13** | **105,430.19** | **108,584.79** | **108,487.67** | **110,807.55** | **110,122.66** | **114,223.29** | **119,176.36** | **127,277.87** | **123,805.12** | **133,892.77** |
| **Total (without $CO_2$ from LUCF)** | **104,895.08** | **104,820.59** | **106,407.40** | **106,886.15** | **109,401.66** | **110,488.33** | **114,298.46** | **119,575.98** | **124,739.68** | **123,738.95** | **130,052.86** |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Energy | 80,787.86 | 80,824.97 | 82,714.65 | 82,664.96 | 84,645.76 | 84,384.28 | 86,983.59 | 91,562.67 | 96,491.44 | 95,717.00 | 101,059.17 |
| 2. Industrial Processes | 9,591.39 | 9,551.00 | 9,286.38 | 9,855.83 | 10,129.97 | 11,725.85 | 12,579.68 | 12,918.08 | 12,796.44 | 12,722.01 | 12,873.68 |
| 3. Solvent and Other Product Use | 176.51 | 181.31 | 177.86 | 173.49 | 167.50 | 156.15 | 157.19 | 158.35 | 158.29 | 165.96 | 168.61 |
| 4. Agriculture | 10,449.30 | 10,408.72 | 10,050.42 | 9,952.98 | 10,027.02 | 9,737.13 | 9,919.35 | 10,154.00 | 9,954.15 | 9,881.20 | 10,228.56 |
| 5. Land-Use Change and Forestry | 1,582.28 | 671.52 | 2,413.94 | 1,776.42 | 1,572.35 | -303.11 | 6.33 | -324.16 | 2,937.50 | 113.95 | 4,243.45 |
| 6. Waste | 3,748.79 | 3,792.66 | 3,941.55 | 4,063.98 | 4,264.95 | 4,422.36 | 4,577.16 | 4,707.42 | 4,940.04 | 5,205.02 | 5,319.30 |
| 7. Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

# ANNEX II

## EFFECTS OF IMPLEMENTED / ADOPTED POLICIES AND MEASURES

| Policies and Measures | Objective / Activity affected | GHG affected | Type of instrument | Status | Implementing entity/entities | Effects of policies and measures (kt $CO_2$ eq) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995 | 2000 | 2005 | 2010 |
| **PROMOTION OF NATURAL GAS** | | | | | | **0** | **2,995** | **10,227** | **15,231** |
| Natural gas in electricity generation | | | | | | 0 | 2,669 | 7,543 | 9,635 |
| | Elec. generation | $CO_2$ | Economic | I | PPC | 0 | 2,669 | 5,139 | 5,303 |
| | Elec. generation | $CO_2$ | Economic | A | PPC | 0 | 0 | 2,404 | 4,331 |
| Natural gas in industry | Thermal uses | $CO_2$ | Economic | I | MD | 0 | 307 | 1,983 | 4,371 |
| Natural gas in residential / tertiary sector | Thermal uses | $CO_2$ | Economic | I | MEPPPW | 0 | 19 | 697 | 1,220 |
| CNG busses | Road transport | $CO_2$ | Economic (public investments) | I | MTT | 0 | 0 | 4 | 6 |
| **IMPROVEMENTS IN THE CONVENTIONAL POWER GENERATION SYSTEM** | | | | | | **0** | **436** | **543** | **552** |
| District heating | Elec. generation | $CO_2$ | Economic | I | PPC | 0 | 25 | 25 | 25 |
| Limitation of distribution losses | Elec. generation | $CO_2$ | Economic (PPC investments) | I | PPC | 0 | 92 | 99 | 108 |
| Efficiency improvements in existing lignite fired power plants | Elec. generation | $CO_2$ | Economic (PPC investments) | I | PPC | 0 | 318 | 419 | 419 |
| **PROMOTION OF RENEWABLE ENERGY SOURCES** | | | | | | **1,116** | **1,856** | **3,223** | **3,125** |
| Wind energy | Elec. generation | $CO_2$ | Economic Regulatory | I | RAE / MD / Private | 0 | 476 | 948 | 900 |
| Small hydroelectric units | Elec. generation | $CO_2$ | Economic | I | RAE / MD / Private | 0 | 53 | 213 | 203 |

| Policies and Measures | Objective / Activity affected | GHG affected | Type of instrument | Status | Implementing entity/entities | Effects of policies and measures (kt $CO_2$ eq) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995 | 2000 | 2005 | 2010 |
| Large hydroelectric units | Elec. generation | $CO_2$ | Regulatory Economic (PPC investments) | I | RAE / MD / Private | 0 | 0 | 770 | 731 |
| Photovoltaic units | Elec. generation | $CO_2$ | Economic | I | RAE / MD / Private | 0 | 1 | 1 | 1 |
| Biomass | Elec. generation | $CO_2$ | Economic Regulatory | I | RAE / MD / Private | 0 | 295 | 284 | 276 |
| Solar energy in the residential sector | Electricity substitution | $CO_2$ | Economic | I | MEPPPW | 1,116 | 1,028 | 1,002 | 1,011 |
| Solar energy in the tertiary sector and in energy | Electricity / Oil products substitution | $CO_2$ | Economic | I | MEPPPW | 0 | 4 | 4 | 4 |
| **TRANSPORT** | | | | | | **0** | **0** | **0** | **365** |
| ACEA agreement | Road transport | $CO_2$ | Regulatory | I | MTT | 0 | 0 | 0 | 365 |
| **RESIDENTIAL – TERTIARY SECTOR** | | | | | | **0** | **13** | **12** | **12** |
| Replacement of incandescent bulbs by high efficient ones | Electricity conservation | $CO_2$ | Economic | I | MD | 0 | 13 | 12 | 12 |
| **WASTE** | | | | | | **0** | **0** | **2,429** | **5,876** |
| Landfill Directive | Waste management | $CH_4$ | Regulatory | A | MEPPPW | 0 | 0 | 2,429 | 5,876 |

*I : Implemented*
*A : Adopted*

## EFFECTS OF PLANNED POLICIES AND MEASURES

| Policies and Measures | Objective / Activity affected | GHG affected | Type of instrument | Status | Implementing entity/entities | Effects of policies and measures (kt $CO_2$ eq) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995 | 2000 | 2005 | 2010 |
| **PROMOTION OF NATURAL GAS** | | | | | | **0** | **0** | **3,191** | **3,925** |
| Operation of natural gas power plants as base load units | Elec. generation | $CO_2$ | Regulatory | P | MD / RAE / PPC | 0 | 0 | 3,065 | 3,350 |
| Natural gas in industry | Elec. generation | $CO_2$ | Economic | P | MD | 0 | 0 | 126 | 336 |
| Natural gas in residential/tertiary sector (space heating and cooling) | Thermal uses | $CO_2$ | Economic | P | MEPWPP | 0 | 0 | 0 | 237 |
| CNG busses | Road transport | $CO_2$ | Economic (pub. investments) | P | MTT | 0 | 0 | 0 | 2 |
| **PROMOTION OF RENEWABLE ENERGY SOURCES** | | | | | | **0** | **0** | **1,489** | **6,361** |
| Wind energy | Elec. generation | $CO_2$ | Economic | P | MD / RAE / Private | 0 | 0 | 487 | 1,850 |
| Small hydroelectric units | Elec. generation | $CO_2$ | Economic | P | MD / RAE / Private | 0 | 0 | 0 | 1,033 |
| Photovoltaic units | Elec. generation | $CO_2$ | Economic | P | MD / RAE / Private | 0 | 0 | 0 | 29 |
| Geothermal energy units | Elec. generation | $CO_2$ | Economic | P | MD / RAE / Private | 0 | 0 | 0 | 50 |
| Biomass | Elec. generation | $CO_2$ | Economic | P | MD / RAE / Private | 0 | 0 | 306 | 1,438 |
| Biofuels | Road transport | $CO_2$ | Economic Regulatory | P | MTT | 0 | 0 | 0 | 319 |
| Solar energy in the residential sector | Electricity substitution | $CO_2$ | Economic | P | MEPWPP | 0 | 0 | 376 | 1,302 |
| Solar energy in the tertiary sector and in energy | Electricity / Oil products substitution | $CO_2$ | Economic | P | MEPWPP | 0 | 0 | 320 | 340 |
| **INDUSTRY** | | | | | | **0** | **0** | **234** | **238** |
| Energy conservation interventions | Thermal / Electric uses | $CO_2$ | Economic | P | MD | 0 | 0 | 234 | 238 |

| Policies and Measures | Objective / Activity affected | GHG affected | Type of instrument | Status | Implementing entity/entities | Effects of policies and measures (kt $CO_2$ eq) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995 | 2000 | 2005 | 2010 |
| **TRANSPORT** | | | | | | **0** | **0** | **188** | **595** |
| Maintenance of private cars and low-duty trucks | Road transport | $CO_2$ | Regulatory | P | MTT | 0 | 0 | 69 | 76 |
| Improvements in road signalling | Road transport | $CO_2$ | Economic (pub. investments) | P | MTT | 0 | 0 | 0 | 58 |
| Promotion of public means of transport | Road transport | $CO_2$ | Economic (pub. investments) | P | MTT | 0 | 0 | 119 | 461 |
| **RESIDENTIAL AND TERTIARY SECTOR** | | | | | | **0** | **0** | **874** | **2,251** |
| Improvement of the thermal behaviour of existing buildings | Energy conservation | $CO_2$ | Economic Regulatory | P | MEPWPP | 0 | 0 | 35 | 106 |
| Systematic maintenance of central heating boilers | Energy conservation | $CO_2$ | Economic Regulatory | P | MEPWPP | 0 | 0 | 59 | 130 |
| Replacement of central heating boilers | Energy conservation | $CO_2$ | Economic Regulatory | P | MEPWPP | 0 | 0 | 2 | 61 |
| External shading of buildings, night ventilation and use of roof fans | Energy conservation | $CO_2$ | Economic Regulatory | P | MEPWPP | 0 | 0 | 20 | 57 |
| Energy efficient air conditioning units | Energy conservation | $CO_2$ | Regulatory | P | MD | 0 | 0 | 43 | 116 |
| Energy efficient electric appliances | Energy conservation | $CO_2$ | Regulatory | P | MD | 0 | 0 | 113 | 291 |
| Replacement of incandescent bulbs by high efficient ones | Energy conservation | $CO_2$ | Information | P | MD | 0 | 0 | 602 | 1,467 |
| Advanced lighting control systems | Energy conservation | $CO_2$ | Economic Regulatory | P | MEPWPP | 0 | 0 | 0 | 23 |
| **WASTE** | | | | | | **0** | **0** | **37** | **98** |
| Flaring of landfill gas | Waste management | $CH_4$ | Regulatory | P | MEPWPP | 0 | 0 | 37 | 98 |

| Policies and Measures | Objective / Activity affected | GHG affected | Type of instrument | Status | Implementing entity/entities | Effects of policies and measures (kt $CO_2$ eq) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995 | 2000 | 2005 | 2010 |
| **INDUSTRIAL PROCESSES** | | | | | | **0** | **0** | **0** | **4,651** |
| Restructuring of chemical industries | Chemical industry | HFCs | Voluntary agreement | P | MD | 0 | 0 | 0 | 3,744 |
| Recovery of F-gases from discarded equipment | F-gases consumption | HFCs | Regulatory | P | MD | 0 | 0 | 0 | 907 |
| **AGRICULTURE** | | | | | | **0** | **0** | **49** | **92** |
| Manure management systems | Agriculture | $CH_4$ | Economic | P | MA | 0 | 0 | 33 | 62 |
| Organic farming | Agriculture | $N_2O$ | Economic | P | MA | 0 | 0 | 16 | 30 |