PREFACE

At the Earth Summit, held in Rio in June 1992, the international community recognised the urgent need for a worldwide approach to the imminent danger of climatic change posed by the alarming increase in CO_2 and other greenhouse gas emissions.

The Convention on Climate Change, signed in Rio by 154 countries and by the European Community, set up a first Action Framework for the effective approach - at a worldwide level - to the greenhouse effect, while also establishing the targets of the international community and the commitments of the signatory States.

Faithful to these commitments, the Greek government has elaborated a National Action Programme for Climate Change, in its desire to contribute to the world's effort to protect the natural environment. This Action Programme is to ensure the achievement of drastic reductions in the emissions of CO_2 and of the other greenhouse gases.

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SUMMARY

Introduction

1. The Greek Programme for the reduction of CO_2 and other greenhouse gases was elaborated under the responsibility and supervision of the Ministry for the Environment, Physical Planning and Public Works, in collaboration with the Ministry of Industry, Energy and Technology. The preparation of the programme was however completed with the participation and contribution of other competent Ministries, bodies of the wider public sector and experts from the private sector. Responsibility for the scientific support was assigned to a research team of the National Technical University of Athens.

2. Far from being dealt with in a disjointed manner, the programme for the reduction of CO_2 and other greenhouse gas emissions is perceived as a necessary element of any modern and global approach to the nation's development policy.

Greece's Contractual Obligations

3. At the Earth Summit held in Rio (June 1992), 154 countries, along with the European Union, signed the ***Convention on Climate Change,*** in a joint effort to tackle the imminent threat posed by the greenhouse effect which is attributed to the alarming increase in CO_2 and other greenhouse gas emissions.

4. Following the ratification of the Summit's resolutions in April 1994 by the national Parliament, Greece is henceforth committed to the realisation of the objectives set out in the United Nations' Framework-Convention. These obligations essentially consist in the ***stabilisation of crucial gas emissions by the year 2000*** at 1990 levels.

5. Although the European Union has globally adopted the stabilisation objective, it nevertheless acknowledges the different levels of development attained by each of the Member States. The Council of Ministers has thus initially accepted that the Community's effort to reduce all greenhouse gas emissions should be based on a ***fair distribution of responsibilities and burdens***.

The data

6. The trend in Greece's CO_2 emissions from 1970 to 1990 was marked by a drastic increase from 22 to 82 million tonnes, and was, thus, ***the worst*** noted in the entire European Community. This trend is linked to the developments in the field of power generation, as well as in final use sectors (domestic-commercial-services sector, industrial sector and transports).

7. The ***sharp increase in the energy demand*** recorded throughout the 1970's and 1980's triggered an increase in the supply of electricity and an increased recourse to lignite, i.e. an energetically poor and, at the same time, highly polluting fossil fuel.

8. Although this specific policy helped to meet the needs of the times by restricting energy costs and reducing Greece's energy dependence, the environmental impact was nonetheless severe.

9. Greece's per capita energy consumption still remains comparatively low. However, the ***required energy per unit product*** (primary demand or final consumption / GDP) is not only high, but has furthermore steadily increased throughout the 1970's and 1980's, contrary to the

improvement noted in almost all of the countries of the Community and the OECD.

10. Although the ***electricity generation sector*** accounts for the greatest direct participation in the emissions of CO_2, what is even more striking is the impressive increase actually registered by this contribution (rising to 50% in 1990 from 32% in 1970).

11. In terms of final energy users: the ***domestic - commercial - services sector*** registered the sharpest increase in CO_2 emissions and the highest global (direct and indirect) participation in 1990 (rising from roughly 32% in 1970 to 39% in 1990). Although the emissions of the ***industrial sector*** increased in absolute numbers, their proportional contribution to the global emissions of CO_2 actually decreased (from approx. 46% in 1970 to 41% in 1990). The relative contribution of ***transports*** to the emissions of CO_2 remained stable (at around 20%).

The Programme

12. In a "spontaneous" course of events (in the absence, in other words, of abatement measures), it is estimated that CO_2 emissions would increase by roughly 27% or 22 Mt CO_2 between 1990 and 2000 (increasing from 82 to 104 million tonnes). This "spontaneous" trend has obviously been established with consideration to such factors as the magnitudes forecasted in the European Convergence Programme for the Greek economy, the restoration and maintenance of a reasonable ratio between the final prices of competitive fuels, the international estimates of future energy prices, the impact of technologies which have already penetrated the market and of policies that were first implemented prior to 1990.

13. It is necessary to point out that the projected estimates for the year 2000 would have been lower, had there not been such a distortion, in recent years, in the final energy price ratio and, more specifically, if the relative price of electricity had not decreased in relation to the respective prices of liquid fuels. The maintenance of this distortion obviously leads to even higher estimates of emission levels for the year 2000.

14. It should, furthermore, be underlined that the currently projected estimates are noticeably different from those initially presented in the Interim Report (the emission increase had then been estimated at approx. 50%). This difference is attributed to the changes which have come about, in the meantime, in a number of technical and non-technical parameters.

15. On the basis of exclusively technological criteria, it would ***theoretically*** be possible to achieve a much greater abatement of CO_2 and other gas emissions, and even to approach the stabilisation target by the year 2000. In practical terms, however, this objective is dismissed as utterly unfeasible, due to the pressing time factor and other serious restrictions such as: the limited availability of financial resources, the weaknesses of the Greek Administration, the inflexibility of the production system and the inertia displayed by consumers.

16. The programme presented for the abatement of CO_2 and other greenhouse gas emissions is based on the ***specific development programmes*** that have been elaborated for the energy sectors (Public Power Corporation, Public Gas Corporation, etc.), transports, residences, etc. The complementary measures, which are proposed, are aimed at achieving ***reasonable improvements*** in the means by which energy is either produced or used.

17. Satisfactory ***safety margins*** - of 25% to 33% - have been estimated and adopted, as far as the realisation of each isolated target is concerned, whenever the proposed measures involve a new type of intervention or are related to the behaviour of numerous economic categories.

18. The ***availability of financial resources*** (from national and community funds) has also been taken into consideration in the estimation of the necessary public expenditures. The financial feasibility of the programme will be largely ensured by the Operational Programmes of the 2nd Community Support Framework (CSF).

19. Having co-assessed all of the existing data, the Greek government considers that a realistic objective for its national programme would consist in ***restricting the total increase in CO_2 emissions - during the 1990-2000 period - to 15% (or 12.4 Mt)***. Discrepancies of +/- 3% have been allowed for, due to unpredictable internal and international developments and to possible revisions of the European Union's relevant policy.

20. The abatement of CO_2 and other greenhouse gas emissions is to be achieved with the implementation of: (a) a drastic ***energy conservation policy*** in all sectors of final consumption (domestic-commercial-services, industries, transports) aimed at ***rationalising energy consumptions*** without affecting the population's standard of living and (b) a bold investment policy in order to ***promote new energy generation means*** (involving Natural Gas at an initial stage and Renewable Energy Sources in the longer term) in an aim to ***substitute for conventional fuels*** without altering the basic characteristics of the energy system (safety, stability and reasonable operating costs).

21. The effective management of biological resources and systems can make a very decisive contribution to the abatement of anthropogenic CO_2 emissions. The proposed measures achieve reduced emissions by substituting for conventional fuels (with the up-grading of traditional uses and the advancement of new uses for bioenergy) and by increasing the terrestrial ecosystems' annual CO_2 fixation capacity (by either increasing the resource reserve in existence, or by reducing its rate of depletion).

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

23. All the requirements for reduced greenhouse gas emissions (and, generally speaking, for the rational use and conservation of natural resources) should not be perceived as a constraint. The abatement objective should, on the contrary, become a matter of voluntary and persistent pursuit for all those who wish to help overcome the well-known impasses, so that growth, in the future, may continue in a more friendly manner towards mankind and nature (sustainable development). The urgency of the matter becomes all the more apparent when - in addition to economic costs - one also considers the "external cost" factor (i.e. the social and environmental impact) which is induced by

energy generation and use, especially in the case of electricity.

The programme's implementation

24. The possibility of a ***worse result occurrence*** cannot be excluded, although such an outcome would imply a major failure in the programmes both of the Public Power Corporation (PPC) and Public Gas Corporation (PGC), and a serious incapacity of the Administration to allocate the necessary funds or to ensure their effective absorption.

25. A worse result could also ensue if the energy demand were to increase at rates higher than the ones officially forecasted, for example, (a) if the importance of the shadow economy and invisible resources failed to be curtailed and/or (b) if the policy of low electricity pricing (both in relative and absolute terms) were to be continued.

26. The achievement of ***better results*** is, however, feasible, even in the context of the proposed programme. Such an outcome would - in addition to the restoration of a rational pricing policy - require the realisation of other conditions, such as, for example, the maximum possible use of the new gas-fired power generation plants (in order to meet base loads). Such a decision would, of course, inevitably entail a small increase in the average production costs per Kwh.

27. Better abatement results could also be achieved if additional capital were to be secured for the financing of necessary interventions (leading to an acceleration in the development of Renewable Energy Source exploitation and of co-generation, and the promotion of new energy conservation technologies).

28. An increase in the ***available financial resources*** could be achieved through the undertaking of new community initiatives or from increased taxation on energy uses. Should the CO_2 tax however be implemented, steps would then have to be taken to ensure that the ensuing revenues are used - in part, if not in whole - to finance emission abatement and environmental protection measures.

29. The ***legal framework*** which is essential to the programme's realisation has already been largely elaborated. Newly passed Law 2244/94 is, in this respect, expected to play a particularly decisive role in the promotion of Renewable Energy Sources and co-generation.

30. Significant measures and actions have already been planned for execution in the very near future. These measures primarily involve: the establishment of maximum emission limits, the organisation of intermediate consultancy service markets specialised in energy matters, and the elaboration of mechanisms for the standardisation, labelling, certification and quality guarantee of energy consuming appliances and equipment, etc.

31. The systematic monitoring and continuous control of the programme's implementation will require the appointment of an **Expert Action Team,** that will be invested with the necessary authority in order to assume the above-mentioned tasks. The actual composition of the team will have to meet two essential requirements: the participation / representation of the main bodies / organisations concerned, and the ensured provision of continuous scientific support to the team itself.

CLIMATE CHANGE
THE GREEK ACTION PROGRAMME

1. INTRODUCTION

1.1 This report sets out the Greek programme for reducing the emissions of CO_2 and other greenhouse gases, an obligation which arises from the United Nations' Framework Convention on Climate Change, signed in June 1992 and ratified by the Greek parliament in April 1994.[1]

1.2 The Greek programme was elaborated with consideration to: (a) the general commitments set out by the Convention[2], for the control and abatement of the greenhouse gas emissions not covered by the Montreal Protocol, (b) the more specific commitments[3] according to which the developed countries - with respect to their obvious differences in "starting points and approaches, economic structures and resource bases"- are to set an example by promptly returning anthropogenic emissions of CO_2 and other greenhouse gases to previous levels, and (c) the Community policy and the obligation assumed by the Community (as of 1990)[4] to stabilise CO_2 emissions at 1990 levels by the year 2000, as well as the Member-States' agreement to a fair distribution of responsibilities and burdens.

1.3 Greece has carefully examined[5] the package of measures that it is in a position to adopt, in the context of its contribution to the international community's effort to mitigate and tackle the impact of climate change. The elaboration of the programme, which came under the responsibility and supervision of the Ministry for the Environment, Physical Planning and Public Works, was carried out with the participation of all the competent bodies from the wider public sector, and of experts from the private sector as well. The scientific support was provided by a research team at the National Technical University of Athens[6].

1.4 The Greek Programme focuses particularly on the control and abatement of the emissions of CO_2, -the most important greenhouse gas- but also assesses the possible interventions for the other greenhouse gases. The extensive chapter on CO_2 emissions with great accuracy (a) appraises the current situation and growth trends, (b) sets out the goals, as well as the measures and policies necessary for goal achievement, and (c) estimates the cost-effectiveness of the necessary actions.

1.5 There are no simple solutions at hand. The targeted reduction in greenhouse gas emissions will not be achieved by dramatic interventions in any one given sector of activity or geographical area. What is necessary is a general mobilisation of Greece's entire economy and society. The fair distribution of the measures' costs will not only enable the immediate implementation of the programme, but will, in addition, serve to reinforce growth with respect to both man and the environment.

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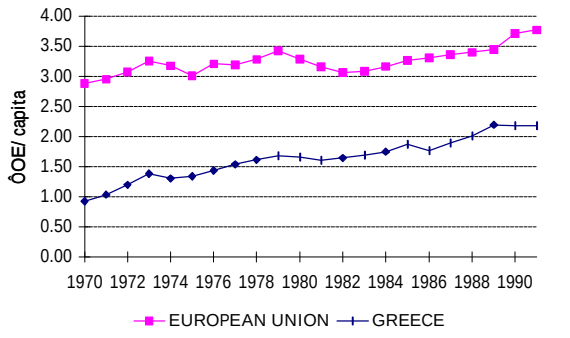
1 Law 2205 on the "Ratification of the United Nations' Framework-Convention on Climate Change", Gazette Á'/60/15.4.94.
2 As stipulated in Article 4 thereof.
3 As specified in Article 4.2a of the same Convention.
4 Council of Energy and Environment Ministers, 29 October 1990.
5 See the Technical Report which accompanies the Main Report.
6 The names of all the Working Team members are listed in the Preface to the Technical Report.

2. THE GREEK PROGRAMME IN CONTEXT

2.1 Energy generation and consumption are responsible for 88% of all greenhouse gas emissions and, in particular, for 98% of the CO_2 emissions. Any effort to tackle the greenhouse gas problem (present situation, projected trends, possible reductions, etc.) must therefore obviously be based on our knowledge of the national **energy system**, i.e. of how energy is generated and consumed in Greece. Before the Greek programme for reducing greenhouse gas emissions was actually elaborated, the **domestic energy demand** (level, structure, growth) and **domestic energy production** (i.e. the manner in which this demand is satisfied)[1] were both carefully analysed.

Figure 2.1
Primary energy demand per capita



Source: Elaboration of OECD data

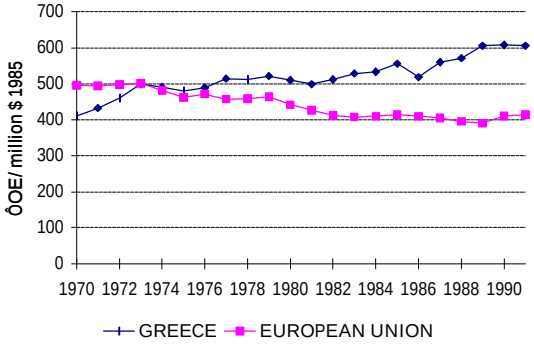
2.2 The paradox of the situation is that: ***in comparison with other EC countries, the primary energy demand in Greece is very small on a per capita basis but very important per unit of Gross Domestic Product*** (Figures 2.1 and 2.2). This basic finding gives us a first insight into the "pressures" likely to be exerted by consumers, but also points to the structural interventions which can and must be carried out on supply and demand sides.

THE NATIONAL ENERGY SYSTEM

2.3 The level, structure and evolution of the domestic energy demand depend on the corresponding domestic economic activity, and the economy/energy ratio. Although the average per capita income remains comparatively low, the Greek economy nevertheless underwent a period of intense development in the recent past, especially during the 1960s. Economic growth slackened in the 1970s, and was plunged into crisis during the 1980s, following the second energy crisis of 1979. Signs of a temporary recovery were observed during the 1986-89 period, while a more stable and long-term phase of growth is anticipated for the second half of the 1990s, with the implementation of the European Convergence Programme[2].

2.4 In the present context however, the economic crisis continues to take its toll on the nation's public finances and productive base, while consumer activity levels have, on average, remained rather high (shadow economy, invisible resources, etc.). Therefore, despite the stagnation of production, ***the energy demand continued to rise sharply throughout the***

Figure 2.2
Final energy consumption per unit of GDP



Source: Elaboration of OECD data

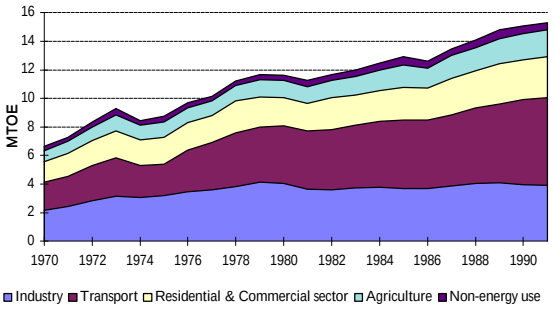
[1] See Technical Report, Vol. 2, for a detailed presentation of recent national trends in comparison with the other EU countries.

[2] A programme dictated by the Maastricht Treaty and incorporated in the Community Support Framework.

1980s (Figures 2.3 and 2.4). Furthermore, while the industrial sector's contribution to the final energy consumption has remained stable, the contribution of other sectors has increased (domestic sector, transports, services, etc.).

2.5 Turning to the manner in which the energy demand is actually met, it is worth noting: (a) the substantial increase (in both absolute and comparative terms) in the contribution of electricity[3], in all final consumption sectors (except transports where there is an obvious predominance in liquid fuel consumption), (b) the fact that the rapidly increasing electricity demand is met through domestic power generation, which from the 1970s onwards made an impressive switch over to nationally extracted lignite, to the point where it now relies almost 75% on the combustion of this solid fuel (Figure 2.5), (c) the similarly important increase in solid fuel consumption by the industrial sector (primarily of coal by the cement industry) and (d) the absence of other energy forms (gas fuels, nuclear energy, renewable sources), the sole exception being the limited contribution of hydroelectric energy to power generation.

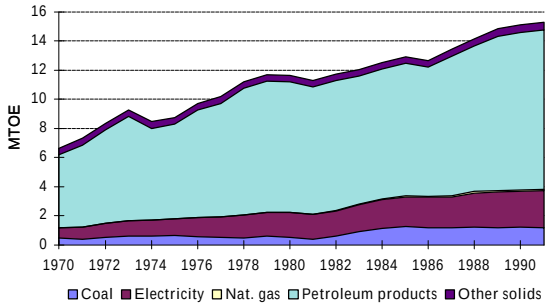
Figure 2.3
Final energy consumption: evolution and structure



Source: Elaboration of OECD data

2.6 The extensive substitution of electricity for liquid fuels at final consumption levels and the massive use of such a poor fuel as domestic lignite for electricity production initially served the purpose of the basic energy policy (at national and community levels), by reducing ***dependence upon liquid fuel imports*** (Figure 2.6) while, at the same time, ***restricting energy costs***. As a result, however, Greece presents almost the ***highest electricity intensity*** per unit GDP and the ***highest degree of energy losses*** due to conversions, in comparison with its EU counterparts.

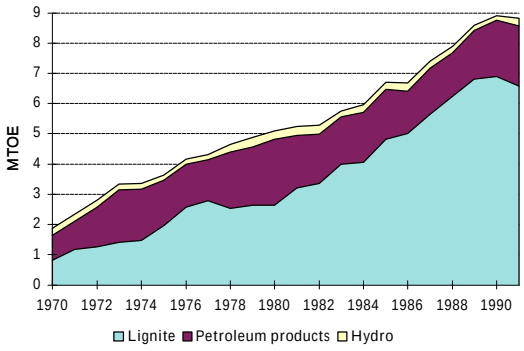
Figure 2.4
Evolution of the final energy consumption, per type of fuel



Source: Elaboration of OECD data

2.7 All of the facts mentioned above explain why - although the per capita energy consumption remained comparatively low - ***the energy required per unit product (primary demand or final consumption / GDP) steadily increased during the 20-year 1970-90 period (Figure 2.7), in contrast with the improvement achieved in almost all other Community and OECD countries***. This phenomenon - which,

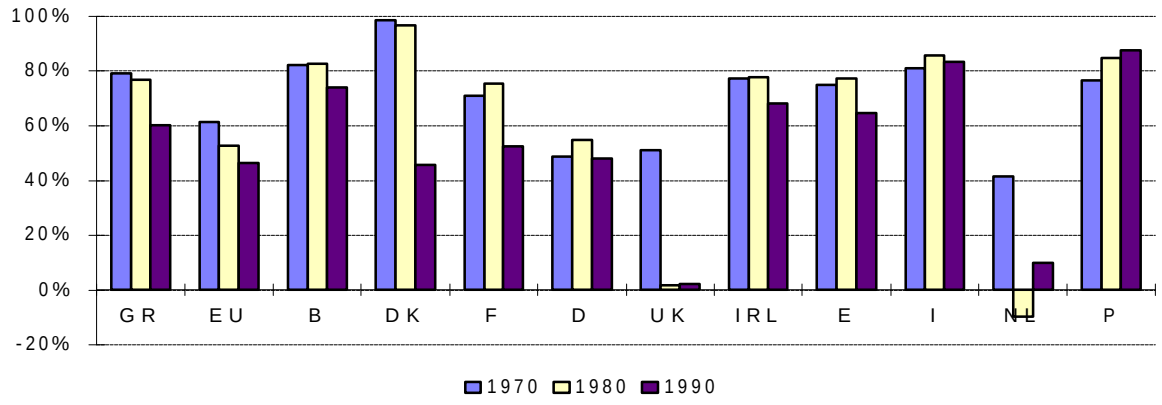
Figure 2.5
Power generation input per type of fuel



Source: Elaboration of OECD data

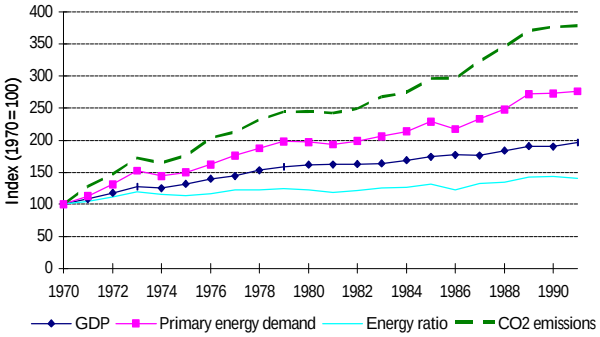
[3] The use of electrical energy per unit GDP is much higher in Greece than in the other EU countries.

Figure 2.6
Energy dependency on imports



Source: Elaboration of OECD data

Figure 2.7
Trend in Energy Demand, Energy Ratio, GDP and CO_2 emissions

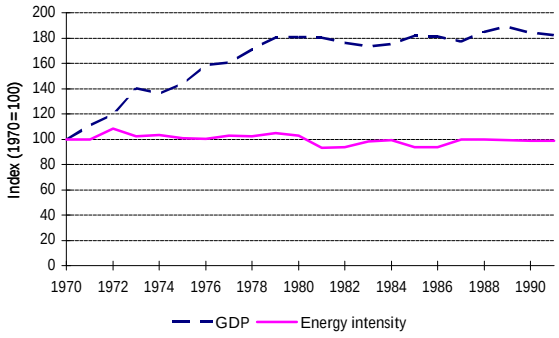


Source: Elaboration of OECD data

asides for Greece, has been noted only in Portugal and, until recently, in Spain - is mainly attributed to: (a) the lower national standards of living which are still far from saturation point in these three countries, as shown by the growth of the residence and transport sectors, and (b) the noted inflexibility of the local energy systems and, consequently, their difficulty in adapting to the new energy policies established at an international level for the advancement of rational energy use.

2.8 In the **industrial sector** in particular, the energy intensity[4], although apparently stable, remains comparatively high (Figure 2.8). This high level of energy intensity is attributed to the disproportionately high and, until recently, increasing participation of heavy energy consuming sectors in the "make-up" of the domestic industrial product (basic metallurgy, cement, fertilisers, etc.). The stabilising of energy intensity is attributed to the gradual proportional increase of less energy consuming sectors, a structural change which is expected to continue and perhaps even to increase in the near future. Furthermore, the few companies that dominate the energy-consuming sectors have either completed their necessary modernisation (in response to the pressures of previously high energy prices and to increased competition), or have gradually been eliminated from the market.

Figure 2.8
Evolution of the GDP and energy intensity in the industrial sector



Source: Elaboration of OECD data

2.9 The drop in energy prices initially led to a

[4] Defined as the ratio of final energy consumption (in Tones of Oil Equivalent, TOE) per unit of Gross Domestic Product (GDP)

slackening of efforts towards more efficient energy uses. However, after a relatively long period of adaptation to the Community environment and following the recently completed unification process, the domestic industrial sector has finally begun to respond to market deregulation and increased competition. Though relatively few in number due to general stagnation, recent industrial investments principally involve the improvement of product quality or the production of new goods, while production modernisation is achieved through the use of imported and usually more energy efficient equipment. It should, of course, be pointed out that it is particularly difficult for the numerous small industrial units to follow suit. The substantial delays, that have been noted in this respect, are attributed to the decision-makers' lack of awareness and/or to the lack of adaptation in the necessary information and financing mechanisms.

2.10 The adverse evolution in energy intensity is primarily attributed to the **domestic, commercial and -both private and public- service sectors.** The ***building reserve has, in the long term, sharply increased.*** This tendency was and/or still is attributed to multiple factors, such as: (a) intense internal migration and the expansion of urban centres, (b) the ambition of the average Greek family to acquire a first home and to eventually purchase a country-house, (c) the sharp development of tourism, and (d) the equally sharp growth of commerce and services, due to the pressures mentioned beforehand or as a result of technological developments.

2.11 As far as ***space heating*** is concerned, the energy requirements would naturally have been much greater, had the new General Construction Regulation (GCR) not been applied to all new constructions since the 1970s. The fact that the GCR can still be substantially improved is not considered an issue of major importance however, as the ***rapid growth of electrical energy consumption*** has been at the base of the problem for the past 20 years. This last fact is attributed to multiple factors and, most importantly, to:

- The unavailability of more suitable alternatives (such as natural gas for cooking, etc.), and the use of electrical energy for heating, in very old buildings and sometimes even in very new constructions due to the lack or non-application of regulations and standards.
- The natural and foreseeable desire for better quality services in the home, at the office, etc., which of course led to the widespread use of equipment and appliances, and to the rapid penetration of new products.
- The new demand for air-conditioning (mainly for cooling in the summer), a tendency which is rapidly expanding, mainly in the commercial and service sectors.

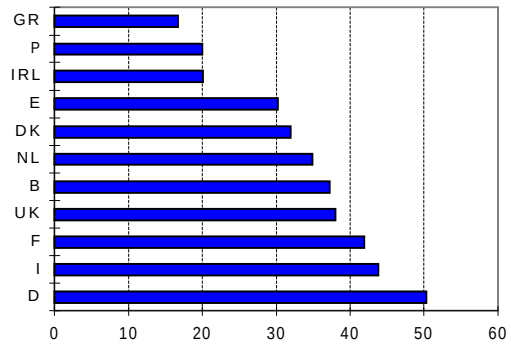
2.12 **The transport sector** is, of course, also largely accountable for the Greek economy's high and increasing energy intensity. The main factors responsible for this serious contribution are listed immediately below:

- Due to the poor conditions of public transports in general and of the railroad network in particular, an overwhelmingly high proportion of the passenger and freight transport is carried out by private road transport means.
- The energy efficiency of public transports is particularly low, due to the lack of adequate itinerary scheduling, of optimal routing and of other simple interventions, which in addition to improving the quality of the services provided, could lead to a substantial decrease in CO_2 emissions.
- The number of passenger cars has noticeably increased, after having started at a very low

level in comparison with other EU countries (Figures 2.9 and 2.10).

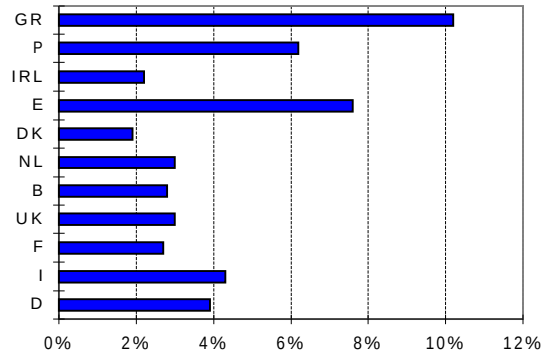
- The fiscal policy, until recently in effect, which, by imposing high taxes on the actual purchase rate of a vehicle and only small duties on fuels, in fact favoured the ownership of old and high-consuming vehicles.

Figure 2.9
Number of passenger vehicles per 100 inhabitants in 1990



Source: Elaboration of OECD data

Figure 2.10
Passenger vehicles: Mean annual rate of increase (1970-1990)



Source: Elaboration of OECD data

CO_2 EMISSIONS

2.13 The unsatisfactory evolution of the Greek economy's energy intensity over the 1970-90 period brought about similar evolutions in the emissions of CO_2 (and other greenhouse gases). Thus, the quantities of CO_2 emitted[5] increased from 22 Mt in 1970 to respectively 54 Mt in 1980 and approx. 82 Mt in 1990. The mean annual increase rate, which was particularly high in the 1970s (approaching the 10% level), decreased considerably during the 1980s, though still remaining at very high levels (4.5%).

2.14 This restriction of the increasing trend in CO_2 emissions is directly linked to the stagnation of economic activity (as the mean annual increase in GDP fell from approx. 4.5% in the 1970s to 1.5% in the 1980s). The drastic increases in energy losses, energy intensity and CO_2 emissions induced by the switch to lignite-fired power generation ("or lignite electricity") are nevertheless most evident.

2.15 During the same period (1975-85), the rapid development of the domestic cement industry led to a doubling of production levels, and consequently to the release of additional quantities of CO_2 resulting not only from combustion, but also from the production process.

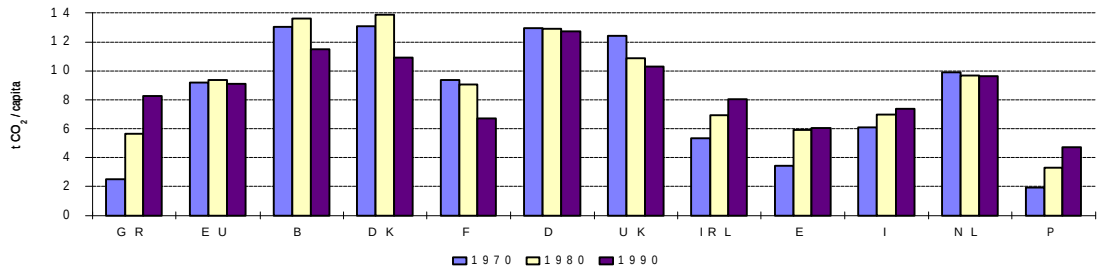
2.16 The evolution of CO_2 emissions in Greece, over the 1970-90 period, is the worst of those noted within the entire European Community. Thus, while the emissions per inhabitant (Figure 2.11) remained low due to discrepancies in the level of economic activity, the emissions of CO_2 per unit GDP (Figure 2.12) actually surpassed the respective levels of all the other Community members[6].

2.17 Although the electricity generation sector has the highest level of direct contribution to CO_2 emissions, a major reason for concern lies in the fact that this contribution has drastically increased from 32% in 1970 to 50% in 1990 (Figure 2.13). As far as the other sectors are concerned, their direct proportional contribution appears either to have remained stable (transports) or to have even decreased

[5] Expressed in million tones (Mt) CO_2.

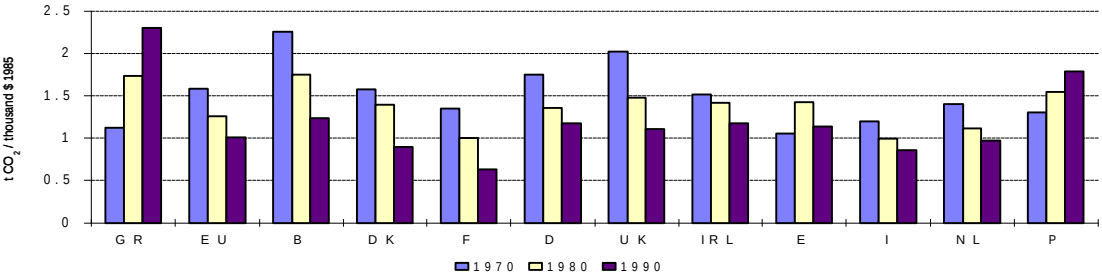
[6] The CO_2 emission levels for the other EU countries are approximations, as the only analytical energy balances available were global ones for the OECD.

Figure 2.11
CO_2 emissions per capita



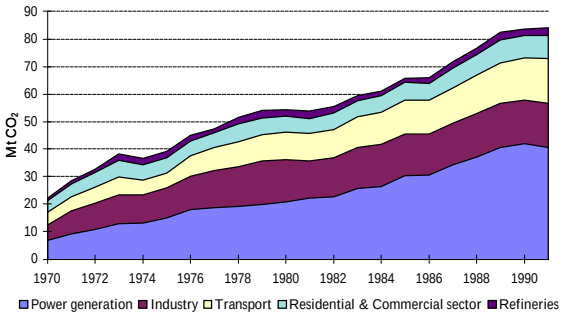
Source: Elaboration of OECD data

Figure 2.12
CO_2 emissions per unit of GDP



Source: Elaboration of OECD data

Figure 2.13
Evolution of CO_2 emissions per sector of activity



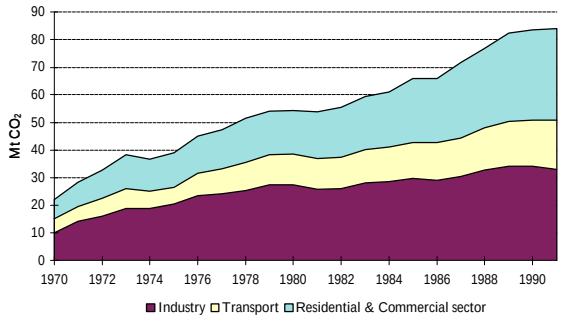
Source: Elaboration of OECD data

(domestic-commercial-public sector, industrial sector). However, if the emissions arising from electricity generation and oil product productions are redistributed to their final users, we see that the domestic-commercial-services sector, in fact, presents the highest increase and the highest total (direct and indirect) contribution to CO_2 emissions in 1990 (rising from roughly 32% in 1970 to 39% in 1990, as shown in Figure 2.14). This same "redistribution" procedure reveals that, while the CO_2 emissions from the industrial sector increased in absolute numbers, their proportional contribution to total CO_2 emissions actually decreased (from approx. 46% in 1970 to 41% in 1990). As for the transport sector, its relative contribution to total CO_2 emissions has remained stable (in the order of 20%).

CURRENT TRENDS

2.18 In the absence of any essential interventions from 1990 onwards, the ***"spontaneous"*** evolution of CO_2 emissions (based on the present structure and operation of the Greek energy system) would normally be characterised by a ***further and considerable increase***. These calculations are of course based on: projected magnitudes for the Greek economy in view of the European Convergence Programme's application, international forecasts concerning energy prices, the impact of recent technologies and of policies which were initially implemented prior to 1990. In the absence of additional post-1990 measures, it is therefore

Figure 2.14
Evolution of CO2 emissions per category of final user



Source: Elaboration of OECD data

estimated that CO_2 emissions would increase from 82 Ì t in 1990 to some 104 Ì t by the year 2000.

2.19 Although resulting from what were at the time entirely justified decisions, this trend towards an increase in CO_2 emissions by 22 Ì t in the 1990s - i.e. of 27% over the decade or 2.4%, on average, per year - is in total contradiction with the European Union's stabilisation objective.

2.20 In reality however, Greece has, since 1990, adopted measures which directly or indirectly affect C Ï $_2$ emissions, and has thereby aligned its efforts with those of the EU and the international community in their precautionary approach to the threats induced by the greenhouse effect. The ***Greek action plan*** therefore assesses the impact of the measures already adopted, and proposes complementary measures so as to ensure the best ultimate result.

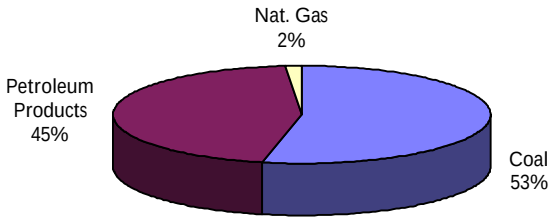
3. THE CO_2 PROGRAMME

3.1 The Greek programme for the abatement of CO_2 emissions is made up of the following units:

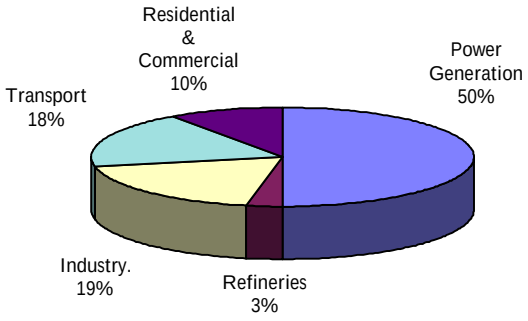
- **Data**. Once the CO_2 emission levels have been estimated for base year 1990 - with reference to the energy balance and current emission factors-, projected levels are then calculated for the year 2000. Currently available data are also compared with those of the 1992 Interim Report.
- **The setting of objectives.** The objectives set by the Greek government in its CO_2 abatement programme are outlined following a previous evaluation of the proposals put forward in the Technical Reports.
- **Measures and policies.** All of the adopted or pending abatement measures are classified according to category and sector of activity. A description is also given of the support policies - either actually in effect or at a final stage of elaboration - which appear capable of ensuring the programme's greatest ultimate effectiveness.
- **Necessary conditions and procedures**. The factors capable of accelerating or hindering the effectiveness of the measures and policies are evaluated. Effective procedures for monitoring and controlling the programme's implementation are furthermore proposed.

Figure 3.1
CO_2 emissions in 1990

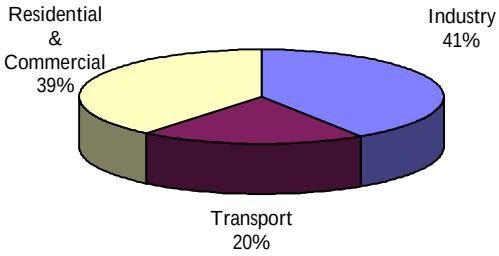
a. per type of fuel



b. per source of emission



c. per end user category



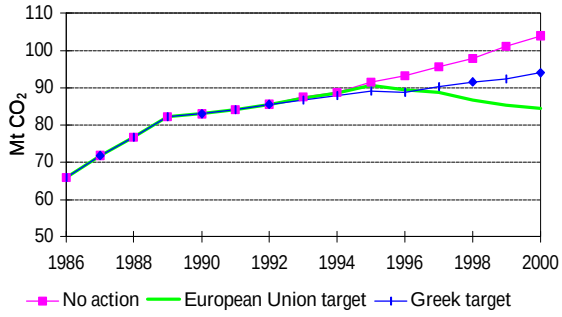
Source: Elaboration of OECD and EUROSTAT data

DATA

3.2 ***CO_2 emissions are estimated to have amounted to a total 82 Ì t in 1990***. A thorough analysis of these 1990 emissions is provided in the Technical Report (Vol. 1), while Fig. 3.1

breaks down the emission structure per type of fuel, activity and end user.

Figure 3.2
CO_2 emission scenarios until the year 2000



3.3 Although the overall C Ï $_2$ emission estimates for 1990 are roughly the same as those presented in the Interim Report (1992), noticeable differences can nevertheless be spotted for individual sectors. More specifically, according to the 1992 estimates:

- The CO_2 emissions arising from the Public Power Corporation's (PPC) lignite-fired power generation plants are approx. 1.1 Ì t CO_2 lower than in 1990[14].
- CO_2 emission levels from the transport sector were also found to be approx. 2.5 Ì t CO_2 lower, due to a change in the recording procedure which now acknowledges that the emissions from international air transport are not to be imputed to solely one country[15] (as was already the case for sea transports).
- CO_2 emissions from the domestic-commercial sector were also some 2.1 Ì t CO_2 lower, as the use of wood (biomass) for heating purposes was redefined as largely carbon-neutral.
- CO_2 emissions from the industrial sector were, on the contrary, increased by approx. 5.9 Ì t CO_2, due to the inclusion of emissions from non energy-related uses (for ex., the emissions of the domestic cement industry caused not by combustion, but by the actual production process).

3.4 ***In the event that no additional abatement measures were to be adopted, it is estimated that the CO_2 emissions would reach 104 Ì t CO_2 in the year 2000.*** This estimate, which was obtained with the use of the Midas econometric model[16], was made on the basis of the following working hypotheses:

- A basic hypothesis, according to which it was assumed that no new abatement measure, apart from the conventional ones, will have been adopted after 1990[17].
- A macroeconomic environment (extending until the year 2000) in concordance with the objectives set out for the Greek economy in the European Convergence Programme.
- A restitution and maintenance of a logical ratio between the final prices of competitive fuels.

The projected estimates for the year 2000 would normally have been lower by approx. 2 Mt CO_2. However, the distortion in relative fuel prices, during recent years, and, more specifically, the comparatively very low increase of electricity in relation to liquid fuels, has had a particularly adverse impact on the CO_2 balance. The maintenance of this distortion - as a hypothesis - furthermore leads to even higher emission projections for the year 2000[18].

[14] See Technical Report (Vol. 1) regarding the emission factors quoted by the PPC in recent studies.

[15] According to UN guidelines, see. "Guidelines for the preparation of first communications", decision 9/2, Framework Convention on Climate Change, Internal Working Paper, U.N., 28.3.1994.

[16] The Midas model and its results are presented, in brief, in sections 3.98-3.100 and, more extensively, in the Technical Report (Vol. 3).

[17] The favourable impact of the measures adopted prior to 1990 and the minimum interventions in the system already in existence in 1990 have, however, been taken into account.

[18] While the consumer prices for diesel in the domestic-commercial-services sector, during the 1990-1994 period, increased by an average annual rate of 21.6%, the respective increase for electricity amounted to only 8.7%. The increase in the energy demand, forecasted by services of the Public Power Corporation (PPC) on the basis of recent and current developments, would normally imply an additional increase in CO_2 emission

3.5 The CO_2 emission levels obtained for the year 2000 with the Midas Model are approx. 1 Ì t higher than the levels quoted in the 1992 Interim Report. All of the recording procedure modifications - mentioned in paragraph 3.3 - regarding lignite, international air-transports, biomass and the cement industry of course still apply. Furthermore, if -for reasons of comparability- abstraction had been made of the beneficial impact to ensue from the introduction of Natural Gas in the national energy system, then the Interim Report's estimate of CO_2 emissions for the year 2000 would, in fact, have been considerably higher, due to divergences in the respective estimates of macroeconomic magnitude evolution.

THE SETTING OF OBJECTIVES

3.6 The objective of the European Union is to achieve a stabilisation of CO_2 emissions - i.e. to return them to 1990 levels by the year 2000. In the absence of additional abatement measures, C Ï $_2$ emissions in Greece would, by the year 2000, increase by roughly 27% in comparison with 1990 levels (Fig. 3.2: *Spontaneous Trend*).

3.7 The target of the Greek abatement programme has therefore been set within these two extremes (0%-27%). Aside from the measures and policies already in application, complementary measures have also been provided for, so as to increase the feasibility of this objective. Consideration has, of course, also been given to: (a) past commitments (for ex. involving the use of lignite), (b) basic political decisions (such as Greece's negative position on the issue of nuclear energy), (c) the availability of funds for the programme's financing, (d) current technical infrastructure levels, (e) the Greek Administration's previous experience with programmes of such importance and, what is more, with such strict time restrictions and (f) the ability of the Greek economy and society to adapt to the implications of the proposed changes.

3.8 The realistic measures - from a technological viewpoint - which have been tested world-wide and are particularly advisable in the case of Greece are presented in the Technical Report[19]. It has been estimated that the concerted implementation of all these measures could eventually even lead to a stabilisation of CO_2 emissions in the year 2000 at 1990 levels. This ambitious target must, of course, be rejected as totally unfeasible, due to budgetary and time restrictions, and to major organisational insufficiencies.

3.9 Available funds are limited, as public expenditure allocations until 1999 have been specifically prescribed by the 2nd Community Support Framework (CSF)[20]. The total absorption of these funds, with the help of appropriate policies, could of course encourage private investments with direct or indirect effects on the abatement of CO_2 emissions[21].

3.10 The serious time restrictions are an additional deterring factor, as it would be inconceivable to reverse such a long-term trend in the 6 years remaining until the year 2000. This does not mean that important decisions have not been adopted since 1990, nor that measures have not been implemented or sufficiently elaborated. What is certain, however, is that measures of crucial importance to the abatement of CO_2 emissions are objectively difficult to implement and/or cannot yield results

levels by 3 Mt CO_2 in the year 2000. The significance of these estimates is discussed in sections 3.85-3.87.

19 The official report on the Greek programme for the abatement of CO_2 and other greenhouse gas emissions is accompanied by a Technical Report (Vol.1-10), which contains all the processed data and proposed measures, listed per category.

20 Greece's entire public expenditure programme has been committed, as national participation in the works and actions which, for the most part, will be financed by Community funds.

21 The general recession, low energy prices and the normally low contribution of energy to overall production costs do not favour these investments.

by the year 2000. Furthermore, it remains to be seen just how effective the promotion of new technologies or products will be, since their effectiveness could, depending on general circumstances, prove to be smaller or greater than initially anticipated.

3.11 The Greek Administration is still characterised by organisational weaknesses which, as a rule, tend to cause delays either in the execution of the works undertaken by the public sector or in the implementation of legal reforms and economic policies.

3.12 In the light of the restrictions mentioned above, the abatement measures were evaluated and ranked according to priority on the basis of: (a) their cost-effectiveness and (b) their feasibility. This led to the formulation of a basic reference scenario which will constitute the Greek programme's focus-point in its CO_2 abatement objectives.

3.13 Having jointly assessed all of the previous data, the Greek government has decided that **a realistic objective, for the year 2000, would consist in restricting the overall increase in CO_2 emissions to "only 15%" (or 12.4 Ìt CO_2) as against 1990 levels**. Discrepancy margins of +/-3% have been allowed for, in view of unpredictable domestic or international developments and of the EU's policy on the matter.

MEASURES AND POLICIES

3.14 The realisation of the programme's objectives calls for: (a) the rationalisation of energy consumptions, i.e. the achievement of ***energy conservation*** without any reduction in the population's standards of living and (b) a diversification in the means used for satisfying the energy demand, i.e. the ***substitution of conventional fuels***, without causing any major disruption to the energy system's basic features (safety, stability and reasonable operating costs).

3.15 At a primary level, the proposed measures thus aim at bringing about small or large-scale improvements in the manner in which energy is either produced or used. At a secondary level, they also aim at inducing changes either in user mentality and behaviour, or in the operating conditions of the entire or parts of the energy system. In all instances however, the implementation of the measures is supported: either by ***administrative policies*** which focus on the necessary regulations, or by ***economic policies*** which strive to modify the behaviour of the "players" involved, and the criteria according to which their energy-related decisions are adopted.

3.16 The group of measures, which enhances the feasibility and best serves the previously mentioned objective, is presented in Table 3.1.

THE RESTRUCTURING OF THE ENERGY SUPPLY

3.17 The manner in which national energy needs are presently met is far from satisfactory, at least in terms of energy efficiency and $CÏ_2$ emissions - not to mention those of other greenhouse gases. The structural inflexibility of Greece's energy system is a major problem capable of "defeating" any serious attempt to promote energy conservation and $CÏ_2$ emission abatement.

3.18 In the present context, the most important interventions which can feasibly be attained at an energy supply level are:(a) the introduction of Natural Gas (NG) which, in comparison with other conventional fuels, emits less $CÏ_2$, and (b) the maximum possible advancement of renewable energy sources (RES) and of co-generation systems. These essential improvements are of the utmost urgency, due to the exorbitantly high $CÏ_2$ emission levels recorded in the existing conventional system. These excessive emissions

are attributed primarily to the extensive use of lignite for domestic power generation and to losses in the electricity transmission and distribution system.

The conventional power generation system: a need for increased efficiency

3.19 ***50% of all CO_2 emissions*** in Greece are induced by electricity generation. This particularly alarming contribution is attributed to the fact that Greece's power generation system is based on the combustion of lignite, poor in calorific value. The success of any CO_2 emission abatement policy therefore depends on the effectiveness of decisions affecting the power generation sector. The basic principle underlying the policy pursued in this field consists in attaining a proportional decrease in emissions per unit of production increase. According to the Public Power Corporation's Development Programme, power generation will increase by 42% over the 1994-2003 period, while the corresponding CO_2 emissions will increase by less than 25%.

3.20 The abatement of CO_2 emissions will basically be attained with the introduction of Natural Gas (NG) and the intensified use of Renewable Energy Sources (RES), as analysed below.

3.21 A substantial improvement is, however, also to be expected from the incorporation in the Public Power Corporation's Programme of ***large hydroelectric works of a 600 MW capacity***. Financing for these units has already been secured, and their construction is most likely to be completed on time. It is estimated that the 950 GWh generated by these plants in the year 2000 will bring about CO_2 savings of 1.1 Ì t CO_2.

3.22 The plans of the Public Power Corporation (PPC) also include:

- a variety of measures for ***improving the existing power stations' efficiency***.
- the gradual replacement of "normal loss" distribution transformers by "limited loss" transformers[22].
- the incorporation of a third transmission line (400 KV) between the northern and southern systems.

The implementation of these measures is expected to improve the plants' efficiency by at least 1% and to reduce energy losses within the system, thus leading to CO_2 savings of 0.3 Ì t.

3.23 A further reduction - beyond the year 2000 - in the quantities of CO_2 emitted by the existing power generation system seems feasible. The measures, however, capable of inducing a substantially positive effect on the CO_2 emission levels have to be carefully examined, so as to determine when and to what extent they can be implemented. It is in this objective that the Ministry of Industry, Research and Technology has decided to appoint a committee, which will consist of Public Power Corporation (PPC) officials and experts from Greece and the Community. This committee is to submit its conclusions within 6 months of its formation and no later than June 1995.

3.24 The Greek government attaches considerable importance to the ***use of "cleaner" technologies for future lignite combustion.*** The task of the committee will be to decide when and which of the available technologies can be implemented in the Greek case. Due to the power generation system's specific structure, particular attention will have to be given to the evaluation of technologies involving: (a) the pressurised combustion of lignite in liquefied bed units[23] and (b) the more promising

[22] Approx. 46% of the "normal loss" transformers have been replaced since 1984.

[23] This technology is now available on the market. If applied to a 300 MW lignite-fuelled unit for example, this technology is capable of achieving an annual reduction in CO_2 emissions of 0.3 MtC Ï 2 in

Integrated Gasification Combined Cycle (IGCC)[24].

3.25 There are other measures which may prove very valuable in the future, but which need to be previously and seriously examined before any decision concerning their adoption is taken. A modification in the "charging sequence" of the power stations, so as to increase generation in the less-polluting but more costly plants, is just one example of a pricing policy-related measure applicable in already existing or scheduled facilities. Measures of a technological nature could encompass the introduction and use of bio-oil/methanol in diesel-fuelled plants and gas-turbines.

Natural Gas: maximum penetration and optimal distribution

3.26 The introduction of Natural Gas (NG) in the national energy system is one of the largest investments to have ever been carried out in Greece. After having been held up by considerable delays since the signing of the basic contracts in 1987, the construction of the central pipeline is now back on schedule and ***the supply of Natural Gas is expected to begin within 1996*** (0.9 billion m^3). According to the programme of the Public Gas Corporation (PGC)[25], the secondary pipelines and city networks are to be completed by 2005, at which time the total absorption of NG will reach an estimated 3.5 billion Ím^3 per year[26].

3.27 With the completion of the project in 2005, a great part of the available Natural Gas (1.5 billion Ím^3 per year) will be absorbed for power generation. Additional annual consumptions are expected to reach 1.0 billion Ím^3 in the industrial sector and 1.0 billion Ím^3 in the remaining domestic-commercial-public sectors. During the first years of operation, the Public Gas Corporation (PGC) will be largely dependent on the Public Power Corporation (PPC) for the absorption of the greatest share of imported gas. The construction of network ramifications so as to ensure the connection of other user categories is expected to begin with the few large industrial units, and to be gradually extended, at a second stage, to the numerous small users of the domestic sector.

REDUCTION OF CO_2 EMISSIONS AS A RESULT OF NATURAL GAS INTRODUCTION (in million tonnes)

• Electricity generation	4.2
• Industry	0.7
• Residences-Commerce-Services	1.1
Total	**6.0**

3.28 Plans to use Natural Gas (NG) for ***electricity generation*** have been finalised and incorporated in the Public Power Corporation's programme[27], as decisions have been made to switch some of the existing plants over to NG and to construct new gas-fired power stations (amounting to a total capacity of some 1100 ÌW by the year 2000[28]). Once in operation, these power plants alone are expected to enable the

comparison with conventional technologies (emissions reduced from 2.27 MtC Ï$_2$ to 1.9 MtC Ï$_2$).

24 A technology which will not reach maturity until the beginning of the next century.. If applied to a 300 MW lignite-fuelled unit for example, this technology is capable of achieving an annual reduction in CO_2 emissions of 0.94 MtC Ï$_2$ in comparison with conventional technologies (emissions reduced from 2.27 MtC Ï$_2$ to 1.33 MtC Ï$_2$).

25 The Public Gas Corporation (PGC) has assumed responsibility for the project.

26 Approx. 85% of the NG will be imported from Russia, via Bulgaria, by pipeline. The remaining 15% will be imported from Algeria in liquefied form and stored in special tanks close to Athens.

27 Provided of course that the State's taxation policy does not eliminate the economic advantage arising from the use of Natural Gas, as against fuel-oil.

28 These projects include the construction of the "large Lavrion" plant and the "switching over" of the "small Lavrion" and Aghios Georgios plants.

PPC to meet its NG absorption commitments, while yielding an annual production of approx. 5300 Gwh. The C Ï 2 savings, ensuing from the substitution of more polluting fuels and primarily of lignite, are expected to reach 4.2 Ì t[29].

3.29 The completion of the central pipeline ramifications will lead to the rapid penetration of Natural Gas (NG) ***in the industrial sector***. Of the total industrial NG consumption of 1.0 billion Nm^3 anticipated for the year 2000, approx. 80% will be absorbed by a limited number of large industrial units, to judge from the negotiations currently in progress with potential clients[30]. The smaller manufacturing units, however, will also draw multiple economic benefits from the use of NG and it is certain that their connection to the network will be carried out as soon as possible. Total savings of C Ï 2 emissions from the industrial sector are expected to reach approx. 0.7 Ì t CO_2 in 2000.

3.30 Natural Gas (NG) penetration will be slower ***in the other sectors*** and is not expected to exceed the 0.5 billion m^3 level in the year 2000. This is basically attributed to the long time periods necessary for the construction of the distribution networks in residential areas and the inertia characteristic of current consumer behaviour. Because of the significant expenses needed to switch cooking and water-heating installations over to NG, it is furthermore estimated that a small proportion of electricity substitution will only be achieved in cases where the use of NG is substantially more energy efficient. The larger part of the NG will be used for heating purposes, as a substitute for diesel. However, the substitution of NG for electricity has also been envisaged in air-conditioning applications with the use of new types of equipment, mainly in the commercial and services sector. C Ï 2 savings, based of these data, are expected to reach approx. 1.1 Ì t CO_2 in the year 2000.

3.31 As the introduction of Natural Gas (NG) in the national energy system is a major infrastructure project, the ***economic benefits*** will only be felt in the long-term and, to a large extent, indirectly[31]. The ***energy benefits*** will, on the other hand, be immediate and proportional in importance to the achieved degree of substitution for electricity (in its final uses) and lignite (in power generation). The ***environmental benefits*** will also be considerable. Based on the current programmes of the Public Power and Public Gas Corporations (PPC and PGC), it is estimated that CO_2 savings of ***a total of 6.0 Ì t CO_2*** will be achieved in the year 2000.

3.32 The total cost of the NG project is expected to reach approx. ***2 billion ECU***, of which 1.5 billion ECU will be disbursed by the year 2000. Only a small participation of the private sector is anticipated, while the global public expenditure will be largely financed by the European Union and the European Investment Bank[32].

[29] This is the C Ï 2 savings level obtained on the assumption that the gas-fired stations will be used to meet intermediate loads. Should they be used to meet base loads however, thereby substituting for additional lignite-fired plants, then: (a) greater quantities of NG will be absorbed, (b) power generation could reach 7000 GWh per year and (c) C Ï 2 savings would reach 5.8 Mt. In this case, the average cost per kwh would of course be increased. These deterring cost differences could however be limited by increases in the respective prices of lignite, for ex., with the possible imposition of a coal tax.

[30] The NG will be basically used as a substitute for fuels, such as: oil, fuel oil, coal, etc. Co-generation is not expected to be substantially used by the large industrial units before 2000.

[31] Asides from the actual construction works, considerable investments will also be necessary to adapt or convert existing equipment and appliances. The demand for these services will therefore boost production, while also increasing revenues and employment.

[32] Regarding private sector participation, 30% of the shares of the NG management companies will be made available to consumers in the urban centres. An amendment in the relevant legislation is expected to increase this participation to 40-45%. The cost of the

3.33 The use of Natural Gas (NG) will require that considerable expenses be made by consumers[33], although the investments of the Public Power Corporation (PPC) and other large consumers will be adequately funded by the 2nd Community Support Framework (CSF)[34]. The Ministry for Industry, Research and Technology is, in addition, elaborating an appropriate ***incentive policy*** designed to encourage smaller consumers to use NG instead of fuels and electricity. The necessary public expenditure is also funded through the 2nd CSF[35].

3.34 By the end of 1994, the Ministry for Industry, Research and Technology will also establish an elaborate ***Natural Gas (NG) pricing policy***. Guided by international practice, the prices of competitive fuels and the taxation policy applied by the European Union in the energy sector, this policy will focus on two main objectives: (a) the quickest possible and maximum absorption of NG on the national market and (b) the optimal distribution of available NG to end users, by encouraging its direct use and the substitution for electricity.

3.35 Finally, in order to ensure the success of the Natural Gas (NG) venture, an extensive ***information campaign*** - to be launched at the beginning of 1995 - is presently being elaborated by the Ministry for Industry, Research and Technology, in collaboration with the Public Gas Corporation (PGC) and the Hellenic Standardisation Organisation. This campaign will be directed at ***consumers*** so as to inform them of the usage modes and the specific/general benefits arising from the use of NG. The ***Business sectors*** (manufacturers and tradesmen) will also be briefed on the standards of equipment and appliances, and on the other regulations applicable to this emerging market which is expected to expand very rapidly.

low pressure networks has been estimated at 600 million ECU.

33 Connection with the network, purchase or conversion of equipment and appliances.

34 The Operational Energy Programme (measure 1.2) provides for the financing of the PPC's gas-fired power station construction. The Industrial Energy Programme (measure 2.2.3), in addition, provides for the financing of the 450 MW capacity gas-fired power station, in order to meet LARCO's energy needs (ferro-nickel metallurgy).

35 Operational Energy Programme (measure 2.2).

Combined Heat and Power (CHP) generation: a substantial potential.

3.36 The ***co-generation*** of heat and electricity achieves optimal fuel efficiency[36], while producing notable economic and environmental benefits. As far as the ***large systems*** are concerned, the Public Power Corporation (PPC) has initiated the implementation of a co-generation programme in its lignite-fired power plants by setting-up a tele-heating network in Ptolemaida. In another lignite-fired power station, presently under construction, plans have been made to use the discarded steam for tele-heating in the town of Kozani. The planned switch from fuel-oil to Natural Gas (NG) in the Agios Giorgios unit is, in addition to other benefits, expected to enable the tele-heating of Keratsini. Financing for these projects has been secured from the PPC's 10-year programme and from the 2nd Community Support Framework (CSF)[37].

3.37 Aside from the Public Power Corporation (PPC), a co-generation system may also be installed by the LARCO company. Financing for this project has been provided for in the 2nd Community Support Framework (CSF)[38].

3.38 Combined Heat and Power (CHP) generation will be promoted in ***other cases*** as well, due to encouraging prospects for application in several energy-consuming units of

36 Conversion efficiency of 80-85% compared with 30-35% from conventional plants.

37 The Keratsini project has been included in the Operational Energy Programme (measure 1.2).

38 Concerning the LARCO company, see footnote 26.

the cement and metallurgy industries, not to mention public buildings and other sectors, such as the ceramics, food and textile industries. Despite the legal difficulties[39], 18 co-generation systems had already been installed in 1990[40], while the new legal framework[41] creates more favourable conditions for the development of co-generation technologies[42]. The new Law and the introduction of natural gas are expected to boost interest in co-generation investments in industrial zones, in smaller-scale systems and even on non-industrial premises. The necessary expenditure, which is not expected to exceed the 12 billion Drs. level by the year 2000, could be covered in part by the Ministry for Industry, Research and Technology in the form of energy-conservation grants[43].

3.39 Despite the fact that the legal framework has been markedly improved by the law 2244/94 and that the financing of co-generation systems has been largely secured, spectacular results are not immediately expected. The corresponding reduction in CO_2 emissions is therefore not expected to exceed the *0.2 Ì t CO_2* level by the year 2000.

The drastic promotion of Renewable Energy Sources (RES)

3.40 Renewables are ***the only energy sources that do not increase the CO_2 burden to the atmosphere.*** But aside from this fundamental environmental advantage, renewable energy sources (RES) also present a series of other advantages: they are inexhaustible, they favour regional development and they contribute indirectly to the generation of employment. The development and promotion of the RES is an alternative with a considerable energy market penetration potential in the medium and long term. During the last decade, impressive progress was noted in the RES sector, despite the limited funds invested and the generally unfavourable conditions due to low oil prices. Overall RES costs dropped considerably and will continue to decrease provided that appropriate strategies are implemented for the technological development and the introduction of RES on the market. The variety of technologies and systems presently available are capable, under favourable conditions, of increasing the competitiveness of RES against conventional energy sources.

3.41 As Greece is particularly endowed with Renewable Energy Sources (RES), the Greek government, from the early 1980s onwards, decided to promote their development. Decisions to exploit wind energy thus led to the first important wind farm installations, recently completed by the Public Power Corporation (PPC). The ***Law 1559/85*** set up a legal framework which provided for the conditional generation of electricity from RES by producers other than the PPC. According to this law, "self-sufficient producers" were allowed to produce energy for their own consumption and sell surpluses to the PPC, while particularly favourable conditions were elaborated for the Local Government Organisations. Unfortunately though, this law had serious short-comings and did not yield the anticipated results[44]. On

[39] In accordance with Law 1559/85, only industrial units could obtain the right to co-generate heat and power, while the kwh buying/selling rates were fixed in special agreements between the PPC and each individual producer.

[40] With a total installed generating capacity of 309 Mw and a production of 755 Gwh in 1990.

[41] See Technical Report (Vol. 9).

[42] Extension of the right to co-generate to a wider range of producers, possibility of distribution to third parties, better kwh rates and long-term agreements with the PPC.

[43] Operational Energy Programme (measure 2.2).

[44] Law 1559/85 authorised the generation of electricity from RES in cases where the "self-sufficient producers" did not have the means to transfer all of their production to the area where the energy was to be consumed. This surplus electricity was sold per kwh at rates equal to 1/3 of the rate at which the "self-sufficient producers" purchased extra electricity when their production was deficient.

the other hand, the national production and installation of solar collectors for water-heating purposes rapidly increased. Curiously enough, one relatively small financial incentive was sufficient enough to trigger widespread interest in this application[45].

3.42 The Ministry for Industry, Research and Technology (MIRT) has placed the development of renewables amongst its energy policy priorities. Having appraised the global situation, the MIRT concluded that a revision of the legal framework for the RES was absolutely necessary. ***The Bill of Law 2244/94 recently passed by the Greek parliament was thus conceived as a means of correcting the short-comings of Law 1559/85***. More specifically, (a) this B/L promotes relatively large investments and enables "independent" producers - aside from the "self-sufficient producers"- to use RES for the generation of electricity, although this electricity can still only be sold to the Public Power Corporation (PPC), (b) it substantially improves the rate at which the kWh is purchased by the PPC, and (c) it ensures long-term contracts (ten-year contracts with the possibility of extensions) for the "self-sufficient" and independent producers. All of these elements, together with the reinforcement of RES-related investments promoted by the Energy Programme of the Community Support Framework (CSF) and by development Law 1892/90, are expected to substantially increase RES development in Greece during the next five years. At the same time, the necessary infrastructure will be set up in order to support more intense RES utilisation after the year 2000.

3.43 ***Wind energy*** presents the most favourable prospects for immediate and intensified development in Greece. On one hand, technology has been perfected and wind-generators of a global capacity of approx. 1500 MW have been installed throughout the European Union (EU). At the same time, Greece has a substantial wind potential, which is mainly concentrated in the insular regions where power generation costs are particularly high. The Public Power Corporation (PPC) has already installed a capacity of 23 MW, while other agencies have installed an additional limited capacity. According to the PPC's 10-year development programme, the installation of an additional 72 MW has been planned for 1998. The new legislative framework, the CSF and the development law combined should normally succeed in prompting private sector involvement, as private investors have already shown considerable interest in the installation of wind farms and the manufacturing of wind-generators. The total installed generating capacity is expected to reach 300 MW by the year 2000, thus leading to CO_2 savings in the order of 1.0 Mt CO_2. The total cost of the measure, which is expected to reach 85 billion Drs., will be covered in part (15 billion Drs.) from public funds, in the form of incentives.

REDUCTION OF CO_2 EMISSIONS WITH THE ADVANCEMENT OF RENEWABLE ENERGY SOURCE EXPLOITATION (in million tonnes)

• Wind farms	1.0
• Solar energy applications	1.0
• Biomass utilisation	0.9
• Small hydroelectric works	0.2
• Geothermal energy utilisation	0.06
• Pillot projects	0.1
Total	**3.3**

3.44 ***Solar energy*** applications can be divided into 3 categories: active, photovoltaic and passive solar systems. During the past 15 years, water-heating solar systems have become widespread in Greece and now amount to 1.8 million m^2 , i.e. more than half of the global

[45] Purchasers of a solar geyser were allowed to deduct part of its value, up to a maximum of 100,000 Drs., from their taxable income.

European Union total (3.5 million m^2). At the same time, the domestic solar collector manufacturing industry has grown and now covers approx. 50% of the EU market. Estimates indicate that the Greek market is capable of absorbing an additional 2.8 million m^2 in solar collectors and that the installation of approx. half of these (1.3 million m^2) is feasible within the 1990s. An incentive policy will thus be implemented, which will allow part of the expenditure for installing a solar collector in an existing building to be deducted from the beneficiary's taxable income. At the same time though, an effort will be made to promote large active solar systems, as well as new technology solar systems and new solar energy uses (for ex., for space-heating) on the market. Estimates indicate that the gradual installation of 0.2 million m^2 of such systems, entailing a total cost of approx. 50 billion Drs., is feasible by the year 2000. The incentive policy conceived for the promotion of such applications will provide for grants from public funds in the total amount of 10 billion Drs. The total CO_2 savings from the use of solar energy are expected to reach ***1.0 Mt CO_2*** . Applications of photovoltaic and thermal systems for power generation with the use of solar energy are not expected to reach extensive levels before 2000. Their reinforcement either at a pilot project level or for the development of industrial activity is however of the utmost future importance. As far as the passive solar collectors are concerned, it is estimated that the few years remaining until 2000 will prepare the ground for the introduction of bioclimatic architecture in Greece. The Ministry for the Environment, Physical Planning and Public Works has already appointed a committee for the elaboration of the relevant standards. It is also working on a programme for the dissemination of information to the public and for the supply of technical assistance to architects and designers.

3.45 Another sector involving renewable energy sources (RES) with a particularly interesting potential is the exploitation of ***biomass*** energy. In view of the major changes anticipated in the agricultural sector - due both to restructuring and to the revised Common Agricultural Policy (the "setting aside" of agricultural land) -, the usage of biomass towards non-food products (energy and other raw materials) can play an important socio-economic role, particularly at local and regional levels (generation of employment, the maintaining of population levels, stabilisation of agricultural incomes, etc.). This usage has the additional advantage of being simultaneously beneficial to the environment, since it substitutes for conventional fuels and does not contribute to CO_2 emissions. It should nevertheless be stressed that the usage of bioenergy in ***traditional*** applications already makes a substantial contribution to the energy economy in rural regions (space heating with fuel-wood, in particular, accounts for approx. 300-400 kTOE). The noted trend towards a contraction

BASIC CONTRIBUTION OF LAW 2244/94 TO THE ADVANCEMENT OF RENEWABLES AND CO-GENERATION

- *The favourable conditions provided for by the previous legislation now also apply to private independent producers.*
- *Favourable pricing and long-term contracts with the PPC are now ensured.*
- *The use of conventional fuels in co-generation systems is encouraged.*

of these applications could be compensated by the installation of new biomass-using heating systems (for ex., distinct heating systems), capable of producing CO_2 savings of 60 ktCO_2 in the year 2000. The greatest interest, however, lies in the application of ***new technologies*** for the exploitation of two main types of biomass: agricultural by-products and energy crops in areas that will be withdrawn from the CAP system. The most promising of these new technologies involve: (a) the production of industrial heat and/or ***bioelectricity***, with the possibility of installing up to 80 Ì W_e by the year 2000 and (b) the production of liquid transport ***biofuels***, in a first stage 50,000 tonnes of bioethanol after a testing period at demonstration level. These biomass exploitation applications are expected to lead to C Ï $_2$ savings of 0.9 MtCO_2 in the year 2000. The total cost of the interventions for the promotion of biomass, which amounts to roughly 70 billion Drs., will be subsidised in the amount of 18 billion Drs. from public funds.

3.46 The ***construction of small hydroelectric works*** is an old and technologically satisfactory application. Experience in this area goes back to before 1950, although the development of such projects was discontinued. According to its ten-year programme, the Public Power Corporation (PPC) has planned the installation of 24 MW of small hydroelectric works. It is thus estimated that total installations will have reached 34 MW in the year 2000, with an expected annual electricity generation of 178 GWh and CO_2 savings of 0.2 Mt CO_2[46]. The total cost of this measure, rising to 18 billion Drs., will be subsidised in the amount of 1 billion Drs. from public funds.

3.47 The necessary technology for the ***utilisation of the geothermal energy*** contained in underground fluids has now been tested world-wide in large-scale projects and can actually prove quite competitive. Even though the confirmed medium and high enthalpy potential in Greece is considerable, no installations have been envisaged in the immediate future. Errors which had been committed in an experimental unit in the past have caused a general feeling of apprehension. Applications for the exploitation of geothermal fluids of low and medium enthalpy are, on the other hand, most likely to be promoted, primarily in agricultural uses (greenhouse heating, use in fishfarming, etc.). The substitution for conventional fuels is expected to reach an annual 20 kTOE in 2000, resulting in CO_2 savings of 60 kt CO_2. The total cost of the measure, rising to 4 billion Drs., will be subsidised in the amount of 1 billion Drs. from public funds.

3.48 From all of the above, it ensues that a systematic policy for the development of renewable energy sources (RES) can yield substantial benefits as quickly as by the year 2000. By aggregating the respective contributions estimated for each RES, we obtain total ***CO_2 savings of some 3.3 Mt CO_2*** in the year 2000. This total would furthermore be expected to increase substantially in the years following 2000, as new and competitive RES technologies would gradually penetrate the market. However, as the penetration of new energy technologies is characterised by high levels of uncertainty, due to the Greek administration's inefficiency and to basic consumer inertia, it is estimated that the RES programme objective will be only achieved in a proportion of approx. 70%, thereby yielding CO_2 savings of ***2.2 Mt CO_2*** in the year 2000.

3.49 ***The Greek government believes that investments in renewable energy sources (RES) are, at this point, essential to any a national energy policy and to any serious***

[46] Through the development of initiatives on behalf of the Local Government Organisations with the possible participation of private investors.

attempt to forward CO_2 emission abatement. The implementation of the measures mentioned above, which will entail total expenditures of 240 billion Drs., will be covered in the amount of 50 billion Drs. from public funds. After promoting the legislative reform which was indubitably a first priority, the Ministry for Industry, Energy and Technology has set aside an amount of 30 billion Drs. for the granting of incentives in the context of the Community Support Framework's ***operational energy programme*** (sub-programme 3). Certain isolated projects which incorporate the rationale of the above measures have been included in the CSF programme of two other Ministries (Agriculture and Environment). The possible incorporation of important RES-related projects in other Community Initiatives (Interreg II, Leader II) is also being considered. It should, in addition, be stressed that support will be provided for exploration, development and pilot projects with funds of approx. 15 billion Drs. to be drawn from the CSF for Energy and Research-Technology, as well as from the EU's 4th Framework Programme for Research and Technological Development.

OPTIMAL DEMAND SIDE MANAGEMENT

3.50 All efforts to improve the system's energy and economic efficiency, and to achieve an abatement in the emissions of CO_2 (and other greenhouse gases) require that energy conservation be given immediate priority.

3.51 In all sectors of activity, there are still numerous possibilities for profitable investments in technologies and/or products which contribute decisively to energy conservation. Experience acquired in the past will serve as an additional asset and ensure the greater effectiveness of the adopted measures and elaborated policies.

Domestic - Commercial - Public Sector

3.52 The domestic - commercial - public sector absorbed 57% of all electricity in 1990, while accounting for 30% of the global final energy consumption. It is therefore, both directly and indirectly, responsible for 39% of the total CO_2 emissions (once the consequences of power generation have been allocated to final users). Furthermore, because of the rate of electrification, the emissions caused both indirectly and directly by the Domestic-Commercial and Public Sector increase at a faster rate than those of other sectors. It is thus estimated that, in the absence of additional abatement measures, CO_2 emissions from this sector will, in the year 2000, be 8.2 Ì t CO_2 (or 34.3%) higher than in 1990.

3.53 The major energy conservation interventions consist in: (a) ***reducing energy requirements***, either by ensuring that all new constructions have enhanced insulation[47], or by improving the situation in the existing building reserve[48], (b) ensuring the ***rational use*** of all available energy sources, including new fuels, and (c) promoting ***energy conservation*** with the introduction of new technologies (equipment and appliances of increased efficiency) and with the proper maintenance of existing equipment and appliances.

[47] The Ministry for the Environment, Physical Planning and Public Works is working on a new heat insulation regulation.

[48] See Technical Report (Vol. 6).

3.54 The ***designing of new buildings and equipment*** in accordance with energy efficiency criteria can, in the long term, reduce the sector's energy requirements by 50%. The Ministry for the Environment, Physical Planning and Public Works, together with other competent bodies, is currently evaluating: (a) new technological developments and the possible need to review the standards in force[49], and (b) the practical means that will ensure the effectiveness of controls on the application of standards[50]. This initiative is in line with the Community's general policy (as far as equipment is concerned), and more specifically with its CO_2 policy [51], and is expected to yield at least partially perceptible results by the year 2000. The Greek State, by means of the Ministry for the Environment, Physical Planning and Public Works and other competent bodies, will assume responsibility for all major pilot programmes capable of setting an example for more widespread subsequent application (public buildings, schools, hospitals and public housing with model energy efficiency).

REDUCTION OF CO_2 EMISSIONS IN THE DOMESTIC-COMMERCIAL-PUBLIC SECTOR
(in million tonnes)

Previously mentioned measures	
• Natural Gas penetration	1.1
• Co-generation	0.05
• Solar energy applications	1.0
Additional measures	
1.1	
• Building/ Equipment Design	0.0
• New Lighting technologies	0.7
• Boiler Maintenance	0.4
Total	**3.25**

3.55 Substantial energy conservation can also be achieved in existing buildings with interventions described, for the most part, above: (a) the ***introduction of Natural Gas*** (see paragraph 3.30) for space and water heating as well as for air-conditioning purposes, which could reduce CO_2 emissions in the year 2000 by approx. 1.1 Ìt CO_2, (b) the ***extensive use of solar collectors/geysers*** for water heating purposes (see paragraph 3.44) capable of reducing CO_2 emissions by approx. 1.0 Ìt CO_2, and finally (c) the ***promotion of co-generation systems*** (see paragraphs 3.38 and 3.39), although this measure will only yield limited results by the year 2000.

3.56 An equally drastic intervention can also be achieved in the ***lighting sector.*** As far as the public lighting of roads and squares is concerned, the conversion of existing installations and the use of sodium lamps will be rapidly advanced, at an estimated cost of 10 billion Drs.[52]. The exclusive use of sodium lamps in new installations will be made compulsory by law, even though these lamps are not considerably more expensive than fluorescent ones. Considerable energy conservation can also

[49] Special consideration is given to the legal provisions (regulations, standards, etc.) that encourage or impose: heat insulation, sound-proofing, the installation of internal natural gas networks, the use of new construction materials, the incorporation of active or passive solar systems and, more generally, the adoption of new technologies. Standards are also being elaborated for the bioclimatic design of buildings and the allocation of relevant subsidies, while consideration is also being given to measures for the generation of microclimates, through tree-planting and other means, that contribute to the passive cooling of buildings. The compulsory application of all the above measures by the wider public sector is also being examined.

[50] Evaluations of consumer-briefing mechanisms are being conducted in order to determine which would be the most appropriate for the promotion of energy-efficient technologies. The necessary schemes are also being elaborated for the technical training of engineers (energy engineers) and technicians involved in the use of new materials or in the installation and maintenance of thermal systems.

[51] Allusion is more specifically made here to the Directive 93/76/EEC on the "Stabilisation and Reduction of CO_2 Emissions and the Energy Certification of Buildings".

[52] The cost of all of the sodium lamps to be installed.

be achieved with the gradual switch from incandescent to fluorescent lamps[53] in the home as well as in other buildings of the private and public sectors, at a cost of approx. 15 billion Drs. by the year 2000[54]. It is estimated that the above interventions will globally reduce CO_2 emissions by approx. 0.7 Mt CO_2 in the year 2000. In order to ensure the measure's immediate advancement, the Ministry for Industry, Research and Technology and the Public Power Corporation (PPC) are considering the possibility of financing the entire venture directly and gradually recouping the expenditure (25 billion Drs.) from duties to be imposed on benefiting consumers[55].

3.57 The proper ***maintenance of central heating boilers***[56] is also important. While the direct cost of this measure is negligible, its potential contribution to the abatement of CO_2 emissions in the year 2000 is estimated at 0.4 Mt CO_2. Being of an administrative nature though, this measure could very well be undermined by the Administration's all too frequent inefficiency in matters of control, and by general user indifference. The proper implementation of this measure furthermore calls for the setting-up and proper operation of the necessary service market[57]. The timely development of this market will however prove costly, as funds will have to be allocated for the training, equipment and organisation of boiler maintenance-men (operating as natural persons or preferably as corporate bodies). These costs could be covered from various sources, for ex. through the Save Programme and from other funds allocated to the Ministry for the Environment, Physical Planning and Public Works and to the Ministry of Labour[58].

3.58 The Industry Ministry's ability to control this market will inevitably lead to a gradual substitution of old boiler systems, thereby ensuring even better abatement results. The replacement of these old boilers, however, cannot be promoted in the context of this programme, as the incentives necessary for the achievement of such an objective would place too much of a burden on public expenditures. The development of specialised companies that would assume the financing and execution of this and other energy conservation measures is an interesting possibility, which deserves serious consideration. These companies' earnings could be drawn from consumer savings (third party financing).

3.59 It is estimated that the implementation of all of the above-mentioned complementary energy conservation measures will restrict CO_2 emissions by ***1.1 Mt*** in the year 2000[59]. Due to the complexity of the policies that need to be implemented and to the large numbers of consumers directly concerned, an achievement of this goal in excess of 2/3 is not considered feasible. In this context, the abatement of CO_2 emissions in the year 2000 is not expected to exceed the ***0.7 Mt*** level.

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53 The introduction of automatic regulation systems, suggested in the relevant technical report, would entail an excessively high expenditure both in absolute terms and in relation to the yielded benefits and was therefore judged inadvisable, at least for the time being. The same remark applies for the other measures suggested in technical report that are not adopted either in part or in full.

54 Various degrees of measure implementation, for different cases, have of course been provided for.

55 A procedure followed by EDF and previously by Detroit Edison.

56 The relatively limited requirements of the industrial sector have also been taken into consideration.

57 The setting-up of a register of maintenance-men with adequate and certified training, the institution of a compulsory "emissions control card", record keeping, etc.

58 This, more particularly, concerns the necessary technical training in the context of the Programme for the Promotion of Human Resources.

59 If these measures were to be applied in conjunction with ones previously mentioned (involving Natural Gas, Renewables and Co-Generation), then the restriction of emissions would be expected to reach 3.2 Mt CO_2 by the year 2000. This means that the increase in emissions, in comparison with 1990 levels, would fall from 8.2 to 4.8 Mt CO_2 or, percentage-wise, from 34% to 20%.

The Industrial Sector

3.60 As the industrial sector absorbed 42% of all electricity in 1990 and accounted for 26% of the final energy consumption, it is therefore, directly or indirectly, responsible for 40% of all CO_2 emissions. It is furthermore estimated that - in the "natural" course of events, i.e. in the absence of additional abatement measures - CO_2 emissions would only increase by 0.7 Mt CO_2 or a mere 2% over the 1990-2000 period, due to the recession and to a diversification in the "make-up" of the domestic industrial product.

3.61 As has been shown to be the case in other sectors as well, the most effective measure for reducing CO_2 emission levels is the introduction of Natural Gas (see paragraph 3.29), as estimates point to an abatement of approx. 0.7 Mt CO_2. The other measures mentioned above, such as the promotion of new technology solar systems (see paragraph 3.44) and co-generation (see paragraphs 3.38 and 3.39) will have a smaller impact.

3.62 A wide range of what are usually considered "minor improvements" can be made in the auxiliary operations of industrial units. The most important of these interventions involve the ***supply of steam*** and ***compressed air*** or even the ***lighting*** of the industrial premises. Other measures, such as the improvement of ***space/water heating***, are expected to have a smaller impact, at least until 2000. The measures listed above are expected to lead to global CO_2 savings of some 0.5 Mt CO_2 in the year 2000.

3.63 There are also numerous ***technological interventions*** which can be carried out in the production procedure of all of the industrial sectors. The industries which present the greatest abatement potential are of course the more energy-consuming ones, such as: the cement industry, metallurgy (steel and non-ferrous metals), fertilisers and the sugar industry. These measures are expected to lead to global CO_2 savings of approx. 0.8 Mt CO_2 in the year 2000.

REDUCTION OF CO_2 EMISSIONS IN THE INDUSTRIAL SECTOR
(in million tonnes)

Previously mentioned measures	
• Natural Gas Penetration	0.7
• Co-generation Systems	0.1
Additional measures	
1.3	
• Improvement in auxiliary operations	0.5
• Production modernisation	0.8
Total	**2.1**

3.64 All of the interventions in the industrial sector combined are expected to lead to global CO_2 savings of approx. 2.1 Mt CO_2. Their concerted implementation would make the industrial sector the only sector capable of registering an actual reduction in CO_2 emissions, by as much as ***4.5%*** or ***approx. 1.4 Mt CO_2*** in the year 2000 as against 1990 levels.

3.65 The additional energy conservation measures will contribute to the abatement of CO_2 emissions by approx. ***1.3 Mt CO_2*** in the year 2000, at a cost that is not expected to exceed the 40 billion Drs. level. In order to ensure the measures' accelerated implementation, part of these costs may be financed, in the form of incentives, from the energy conservation funds of the Ministry for Industry, Research and Technology[60].

3.66 It is doubtful, however, if incentives alone - as a means of generating motivation - can be sufficiently effective. In addition to the financial question, it seems that another major obstacle, as far as the SMEs are concerned, is the lack of actual awareness of the situation and of the possibilities for profitable interventions. In the

[60] Operational Energy Programme (Sub-programme 2).

context of the Operational Energy Programme, the Ministry for Industry, Research and Technology has therefore provided for necessary expenditures in order to support and/or develop energy engineering firms (these firms are to elaborate energy balances, certify that the manufacturing units are operating correctly from an energy viewpoint, etc.).

3.67 The financing of all possible interventions poses just as serious a problem. The pressures caused by competition, the normally small participation of energy in production costs, and the relative slackening of international prices are only some of the deterring factors in the area of energy conservation investments. The Ministry for Industry, Research and Technology is currently examining ways to support and/or develop specialised firms capable of assuming the indirect financing of necessary interventions (see also paragraph 3.58). The necessary expenditures will be covered, in part, in the form of incentives, through the Operational Energy Programme.

3.68 In any event, support will be granted to R&D and to the pilot applications of new technologies. Priority will be given to the solar systems for space and water heating processes.

3.69 The Ministry for Industry, Research and Technology, finally, is examining whether the Centre for Renewable Energy Sources (CRES) will assume a coordinating role in the promotion of new services and technologies. In the present state of affairs (see also paragraph 3.59), a success rate of 2/3 by the year 2000 in the achievement of the energy conservation programme's objectives would be judged satisfactory. In such an event, the abatement of C Ï $_2$ emissions would then reach approx. *0.9 Ì t CO_2*..

Transport

3.70 The needs of the transport sector account for approx. 40% of the final energy consumption and are met almost exclusively by liquid fuels (55% of the total final consumption of liquid fuels). This sector is thus directly responsible for 20% of the global CO_2 emissions. The domestic transports[61] which are targeted by the proposed CO_2 emission abatement measures absorbed 4.9 MTOE in 1990, an amount corresponding to 82% of the energy consumption of the entire transport sector.

3.71 The energy demand in the domestic transport sector continues to increase at higher rates than in other sectors of the economy (mean annual increase of 5.3% in decade of 1980). In the absence, therefore, of additional abatement measures, CO_2 emissions would increase by 4.5 Ì t CO_2 by the year 2000, meaning an increase of 30% compared to 1990.

3.72 The road transports make up the core of the domestic transport system, as they absorb approx. 87% of the sector's total consumption. Any CO_2 emission abatement policy will therefore have to focus in priority on the road transports sector.

3.73 The possible interventions for reducing the CO_2 emissions from the transport sector can be either direct or indirect in nature. The first category includes measures targeted in priority at restricting CO_2 emissions. In the indirect measure group, the reduction in emissions, on the contrary, results from the pursuit of other objectives, mainly related to the improvement of transport services. Whatever the case, the CO_2 abatement measures must, by no means, lead to a deterioration in the already poor quality of transport services.

3.74 The category of direct measures is primarily made up of interventions in the types

[61] International sea and air transports are excluded.

of engine fuel used, and which, in the long term, prove to be the most efficient. Such promotion measures involve the use of diesel, liquefied petroleum gas and biofuels, which do not release CO_2 into the atmosphere[62]. On the contrary, it is considered that the overall CO_2 budget would not benefit from the promotion of electric driven vehicles, since the use of electricity in Greece's transport systems increases the atmospheric CO_2 burden much more than the use of liquid fuels does. It is estimated that, by the year 2000, CO_2 emissions can be restricted by approx. 0.1 Ìt with the use of biofuels (see paragraph 3.45) and by an additional 0.05 Ìt as a result of the remaining interventions. More substantial benefits are expected to be recorded after the year 2000, particularly due to the expansion anticipated in the use of biofuels.

3.75 Significant benefits can also be obtained from interventions on the actual vehicles, as CO_2 abatement can be achieved through the systematic maintenance of the vehicles, as well as from the use of more economical automobiles[63]. The implementation of such measures is capable of inducing an abatement of 0.3 Mt in CO_2 emissions by the year 2000.

3.76 The most effective category of measures is the one which involves the rational management of the entire transport system. These measures are, in majority, aimed at improving the standards of the transport services, by ensuring the faster, more economical and safer transportation of passengers and freight. They range from simple interventions in the existing transport system (improvements in signalling, in the road network, etc.), to interventions for the restructuring or the combined use of transport modes, and even measures that require an overall change in driver attitude and mentality. The ensuing reduction in CO_2 emissions is expected to reach 0.45 Mt by the year 2000[64].

3.77 Finally, a noteworthy contribution can also be achieved with measures primarily aimed at up-grading and modernising public transports, which continue to provide particularly poor quality services (metro, tram, improvements in urban bus routes, etc.). Indirect interventions of this nature are capable of inducing an additional abatement in CO_2 emissions of approx. 0.4 Mt.

3.78 It is estimated that the entire package of interventions for the transport sector is capable of restricting emissions by as much as *1.2 Mt CO_2* by the year 2000. For reasons mentioned above (paragraphs 3.59 and 3.69), a success rate of 2/3 in the achievement of the programme's objectives - resulting in an abatement of emissions by 0.8 Mt CO_2 - is judged satisfactory. The abatement possibilities in the transport sector will increase substantially after the year 2000, provided, of course, that the appropriate policies are implemented and that the necessary actions are financed[65].

3.79 The particularly high costs of the remaining measures are however expected to be covered through the 2nd Community Support Framework by funds that will be allocated to the Ministry for the Environment, Physical Planning and Public Works, on one hand, and to the Ministry of Transports. As far as biofuels, in particular, are concerned (see paragraph 3.45), the necessary expenditures have been incorporated in the Operational

[62] Due to the "closed carbon circuit".

[63] When speaking of more economical models, we mean the promotion of more economical automobiles within each HP category. It is not feasible, at least by the year 2000, to reverse present consumer trends and to encourage the purchase of smaller HP vehicles.

[64] The results of these measures could actually be increased three-fold (1.4 $MtCO_2$), as estimated in the Technical Report. However, the Administration's inefficiency in implementation and control matters, and consumer resistance (indifference) do not leave much room for optimism.

[65] Even by the year 2000 however, CO_2 savings of 2.8 Mt could theoretically be attained provided that the measures are fully implemented and yield maximum results.

Energy Programme (sub-programme 3) of the Ministry for Industry, Research and Technology. The maintenance of boilers will require the support and/or development of reliable services, to be provided in the domestic sector by boiler maintenance-men (see paragraph 3.57) and in the industrial sector by energy engineers (see paragraph 3.66). The implementation of this measure has already begun, but its completion will require concerted efforts and financing from multiple sources (Ministry of Transports, Min. for Industry, Research and Technology, Min. for the Environment, etc.).

REDUCTION OF CO_2 EMISSIONS IN THE TRANSPORT SECTOR (in million tonnes)

Previously mentioned measures	
0.1	
Additional measures	
1.2	
Involving	
• fuels	0.05
• vehicles	0.3
• system management	0.45
• public transports	0.4
Total	**1.3**

GLOBAL ABATEMENT OF CO_2 EMISSIONS IN ALL SECTORS BY THE YEAR 2000 (in million tonnes)

Supply-side measures	
7.2	
• Improvements in Lignite-Fired Stations	0.3
• Natural Gas Penetration	4.5
• Renewable Energy Sources	2.2
• Co-Generation Systems	0.2
Additional Demand-Side measures	*2.4*
• Residences-Commerce-Services	0.7
• Industry	0.9
• Transports	0.8
Total	**9.6**

NECESSARY CONDITIONS AND PROCEDURES

3.80 The Greek programme for the abatement of CO_2 emissions is expected to result in global savings of ***9.6 Ì t CO_2***, which correspond to 44% of the increase in emissions normally to be anticipated if no abatement measure were to be adopted from 1990 onwards.

3.81 This achievement presupposes that all of the separate measures will, in fact, attain a ***70% success rate***, since the aggregation of the quantified objectives of all the above-mentioned interventions amounts to a total 13.4 Mt CO_2. This success rate was not arbitrarily set, but results from detailed estimates as to the feasibility of the presently applied or proposed plans. More specifically, the following execution rates were considered satisfactory by the year 2000: 100% for the Public Power Corporation (PPC) programme, 75% for the Public Gas Corporation (PGC) programme and 67% for all the others (renewables and additional energy conservation measures at final consumption levels).

3.82 Consequently, ***the increase in CO_2 emissions, in the year 2000 as against 1990 levels, is expected to be restricted to 12.4 Ì t CO_2 or 15%***. Under the present circumstances, this objective seems quite feasible. It should furthermore be stressed that similar conclusions have been drawn by community experts in their evaluation of the interim reports[66]. Of course, there is always the possibility that the situation may, in fact, evolve more[67] or less favourably than initially anticipated in the basic programme.

[66] Assessment of the expected CO_2 emissions from the Community in the year 2000. Provisional text.

[67] The scenarios are characterised as "better" or "worse" exclusively on the basis of the CO_2 emission criterion.

ANTICIPATED GLOBAL INCREASE IN CO_2 EMISSIONS

[in the year 2000, as against 1990]

In million tonnes: 12.4 Ìt

In percentage: 15%

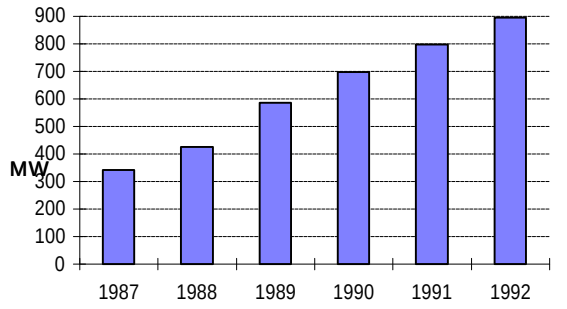
Least favourable scenarios

3.83 In the light of our past experience, it is difficult to be optimistic. It should, however, be stressed that for the critical sectors (energy conservation measures, renewables and co-generation), satisfactory safety margins have been adopted, even in the more conservative calculations. Nevertheless, the possibility of a worse result occurrence cannot be excluded. Such a result would, of course, imply ***a major failure on behalf of the Administration***: (a) either in its implementation of the measures, meaning that the available funds will not have been distributed, (b) or in its control of implementation, meaning, in this case, that the available funds will have been misused. A failure of this nature would of course also point to a ***serious inability of the Greek society and economy to adapt*** to modern requirements.

3.84 Considering the Administration's operating conditions and the present consumer behaviour patterns, a worse scenario could potentially materialise only ***if the programmes of Public Power and Public Gas Corporations*** - i.e. the most "certain" and effective CO_2 abatement interventions - ***were to be called into question***. Such a development is obviously out of the question, due to the contractual obligations, i.e. to all of the legal, economic and other commitments that these public corporations have given to the suppliers and financiers of the projects already scheduled from now until the year 2000. Delays in the completion of such large and complex works cannot, of course, be excluded[68]. The fact remains though that these works will definitely be completed.

3.85 A drastic change on the demand side is, at least officially, not considered likely, as the possibility of a more rapid growth of the national economy has been dismissed by Greek and foreign experts alike. At the same time, the Greek economy's energy intensity is not expected to deteriorate any further[69]. The importance of the shadow economy and of invisible resources could, nevertheless, cause the energy demand to increase at a rate faster than officially forecasted. In the light of recent and current trends, the Public Power Corporation (PPC) has, for ex., estimated that the energy demand will, in fact, exceed the level forecasted in view of the European Convergence Programme's implementation. The possibility of similar pressures being exerted on the other sectors of demand can obviously not be disregarded.

Figure 3.3
Installed air contidioning systems

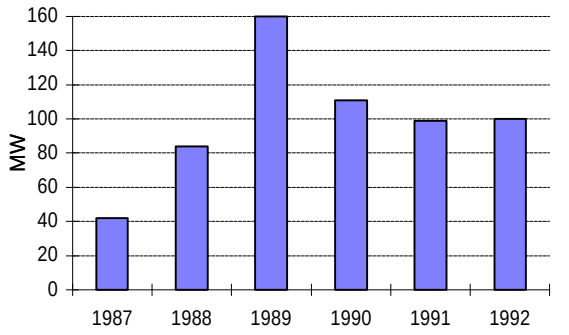


Source: Elaboration of CRES data

[68] Small delays are likely to occur with the Natural Gas project, due to the lack of any previous experience on Greek territory. A success rate of 80% in the realisation of the Public Gas Corporation's objectives by the year 2000 would therefore be more than satisfactory.

[69] On the contrary, the energy intensity of the Greek economy is expected to improve, as the gradual recovery will go hand in hand with the introduction of more efficient production and consumer equipment.

Figure 3.4
Annual sales of air-conditioning systems



Source: Elaboration of CRES data

3.86 ***Air-conditioning*** constitutes a new and rather unpredictable factor, as there has been a sharp increase (see Fig. 3.3) in recent years in the number of installed air-conditioning systems (mean annual increase of 21%!). For the time being, this phenomenon- which causes a definite "peak" problem in the electricity system[70]- has remained concentrated in the commercial and services sector. The expansion of air-conditioner use to the entire domestic sector - which cannot be excluded after the panic reactions to the climatic and atmospheric conditions recorded in 1988-89 (Fig. 3.4) - would obviously have very adverse consequences on CO_2 emissions[71].

3.87 In the unfortunate case where all of the adverse conditions mentioned above were to arise, then the emissions of CO_2 in the year 2000 could very well exceed the levels anticipated in the abatement programme by some 2-3 Mt. In such an event, global CO_2 emissions would be 14.8 Mt or 18% higher than in 1990.

Most favourable scenarios

3.88 More ***optimistic scenarios*** could very well arise from more drastic State intervention ***on the supply side***, since the size of the energy corporations and their relationships with the State create favourable conditions for almost immediate and highly effective interventions (modernisation of the PPC's lignite-fired power stations, the full and optimal utilisation of Natural Gas, maximum possible assistance for the development of renewables and co-generation).

3.89 Time restrictions do indeed pose a problem to the modernisation of the lignite-fired power stations. If the Public Power Corporation, however, were to succeed in accelerating the introduction of new technologies in its lignite-fuelled stations, then CO_2 savings could be increased by 1.0 Ì t[72].

3.90 The same, however, does not apply to Natural Gas. In terms of CO_2 abatement criteria, the efficiency of this large enterprise could be much greater:

[70] Especially in the tourist zones which are not linked up to the interconnected system, such as Crete, Rhodes and the other Aegean Islands.

[71] The adverse impact of this phenomenon could be substantially moderated if gas-fired air-conditioning technologies were to be used. In the long term, of course, the objective will be to reduce the need for artificial cooling, by improving the environmental conditions in the urban centres and through the advancement of bioclimatic architecture.

[72] See Technical Report, Vol. 4.

- if the Public Gas Corporation programme were to be 100% successful in the objectives set for the year 2000, implying that optimal organisation and management would have to be attained,
- if the gas-fired power stations were used to meet base loads, meaning of course that at least the visible average production cost / Kwh would slightly increase,
- if a target were to be set to achieve the maximum possible substitution of natural gas for electricity in kitchen uses, a policy which calls for strong incentives (for the replacement of the existing cooking equipment) and thus entails a considerable public expenditure.

If these conditions were to be met, the CO_2 abatement would be 2.5-3 Ì t greater than the level foreseen in the context of the programme.

3.91 In the case of renewable energy sources (***RES)***, the problem lies in the securing of new funds, asides from those to be allocated from the Operational Energy Programme (sub-programme 3), so as to enable the implementation of a wide-scale incentive policy. The possibility of resorting to tax-exemptions seems rather remote, due to the public finance crisis that the nation has been facing. However, private investor interest could reach higher than anticipated levels, considering that important legal reforms have recently been completed and provided, of course, that new obstacles do not arise. These interesting prospects could be reinforced: (a) through information and advertisement campaigns on the new possibilities and the multiple benefits of these uses, (b) with new forms of financing (such as third party financing). In this case, the abatement of CO_2 from the use of RES could exceed the anticipated programme levels by 1.5-2.0 Ì t. The same remarks also apply to the advancement of ***co-generation***, either for meeting the heating needs of industrial zones, or in combination with the tele-heating of urban districts.

3.92 Equally drastic interventions can be carried out ***on the demand side.*** The use of all technologically feasible possibilities could engender a further abatement of 2.5-3.0 Ì t CO_2. In this case as well, however, the problem lies in the mobilisation of funds (asides from the public funds that have been ear-marked in the 2nd Community Support Framework). The State, in other words, must examine how it can trigger private investor interest and must, more specifically, provide for: substantial legal reforms, the systematic dissemination of information to users and the encouragement of new forms of financing.

TECHNOLOGICALLY FEASIBLE POSSIBILITIES FOR REDUCING CO_2 EMISSIONS IN ALL SECTORS BY THE YEAR 2000

(in million tonnes)

Supply-side measures	*14.3*
• Conventional Power Generation	2.3
• Natural Gas Penetration	7.6
• Renewable Energy Sources	4.2
• Co-generation Systems	0.2
Additional demand-size measures	*5.5*
• Residences-Commerce-Services	1.6
• Industry	1.4
• Transports	2.5
Total	19.8

Source: Technical Report (Vol. 4-8)

3.93 An essential element in any effective energy conservation and CO_2 abatement policy is the ***creation of a market of services and intermediaries*** between the controlling authorities and the vast number of decision-makers. (a) The elaboration and monitoring of energy balances in the SMEs and large

buildings, (b) the certification of proper operation and the detection of necessary adjustments or corrections, and (c) the regular maintenance of boilers, engines and other equipment all require services from numerous fields of specialisation, from energy engineers to specialised technicians. A recently appointed committee has been given one year to thoroughly examine the questions related to the organisation of these markets, i.e. the general and technical training qualifications that will be required from the providers of the services, their obligation to be listed in a register of professionals or firms, whether and how client and certification files will be kept, etc. The funds necessary to promote this endeavour will be secured from the Operational Industrial Programme (Measures 3.2 and 4.2).

3.94 Necessary initiatives will also be undertaken towards the substantial advancement of legal matters, such as, for ex., the specification of limits and standards, the ***standardisation*** and ***labelling*** of energy-consuming appliances and equipment. As far as electric appliances are concerned, a Presidential Decree has already been issued following the ratification of the relevant Community directive (1994). The Ministry of Industry, Research and Technology is participating in the Community's effort to prepare implementation directives and has provided for the relevant expenditures in the Operational Industrial Programme (Measure 1.1)[73].

[73] The entire effort is also financed by the Save Programme.

COMMUNITY SUPPORT FRAMEWORK
FINANCIAL RESOURCES FOR PUBLIC EXPENDITURES
(In million ÅCU)

Relevant Operational Programme	Sub-programme[1]	Amount[2]
Energy		
• Gas-fired Electricity Generation	1.2	184.4
• Energy Conservation	2	152.5
• Renewable Energy Sources	3	100.4
• Raw Energy Materials	4.1	[6.4]
Industry		
• Infrastructure	1.1,1.2	[220.0]
• Private Investment Advancement	2.2.3	[220.0]
• Enterprise Modernisation	3.2	[100.0]
• Small-Medium Enterprises (SMEs)	4.2	[42.3]
Research and Technology (Programme II)		
• Environment and living conditions	1.1	8.2
• Technology transfers	2.3	[77.4]
Environmental Protection		
• National level	3.5, 3.9	3.5
	5.1, 5.2, 5.4	1.1
	6.2	7.0
• Regional level		[338]

1. The first number denotes the specific sub-programme, while the second one refers to the measure.
2. The amounts quoted in brackets cover a wider group of interventions. The exact amount that could serve to finance the programme's CO_2 related actions is therefore not known. The entire programme is also indirectly financed through funds from the Operational Programmes for Agriculture and Transports, which are not explicitly aimed at reducing the emissions of CO_2.

Source: Community Support Framework - Operational Programmes

3.95 The success of the programme will also depend on the timely establishment of new institutions and procedures (limits, standards, service markets, new forms of financing, etc.). These improvements become all the more necessary if an aggressive policy with much more ambitious objectives is to be envisaged. As already pointed out, even a much greater abatement of CO_2 and other greenhouse gas emissions would be theoretically possible, at least from a technological viewpoint; this abatement could, furthermore, approach the stabilisation objective by the year 2000. Realistically speaking though, the likeliness of this achievement has to be dismissed due to numerous and serious limitations, such as: the Administration's inability to meet the requirements of such important programmes,

the consumers' resistance to the abrupt changes necessary for the rational management and conservation of energy, the limited time period left from now until the year 2000.

3.96 In addition to other difficulties, there is also the cost restriction factor to be dealt with. Even if private investment initiatives are attracted, the financing of the "stabilisation objective" cannot possibly be achieved with the mobilisation of private capital alone. The availability of extensive public funds is imperative, at least for the financing of core infrastructures (Natural Gas, industrial zones, transport networks, etc.), not to mention the policies (incentives, etc.) necessary to motivate private initiatives.

3.97 In the light of the present conditions and requirements, it is considered that the CO_2 emissions could, in the most favourable of cases, be restricted by an additional 2-3 Mt by the year 2000. This means that the increase in emissions, in comparison with 1990 levels, could be reduced to ***9.8 Mt CO_2 or 12%***.

SCENARIO EVALUATION WITH THE MIDAS ENERGY MODEL

3.98 An increase in financial resource availability could be achieved with the undertaking of new Community initiatives or from the imposition of a CO_2 tax. ***The repercussions of this tax*** were studied and evaluated with the help of the Midas model. This model was basically used to evaluate the intervention scenarios that have so far been considered, on the demand as well as on the supply-side. More specifically, the examined scenarios included:

(a) a ***"no action" scenario***, which assumed that no measures have been adopted after 1990 (see paragraph 3.4).

(b) a ***reference scenario,*** which evaluates the impact caused by the introduction of Natural Gas in the national energy system and of other measures that have already been adopted.

(c) a ***3$/bbl and non-shifting CO_2 tax scenario***, which evaluates the impact of a stable and non-shifting CO_2 tax of 3$/barrel.

(d) a ***10$/bbl and non-shifting CO_2 tax scenario***, which evaluates the impact of a stable and non-shifting CO_2 tax of 10$/barrel, as has been proposed by the European Union.

(e) various ***technological scenarios*** and more analytically:

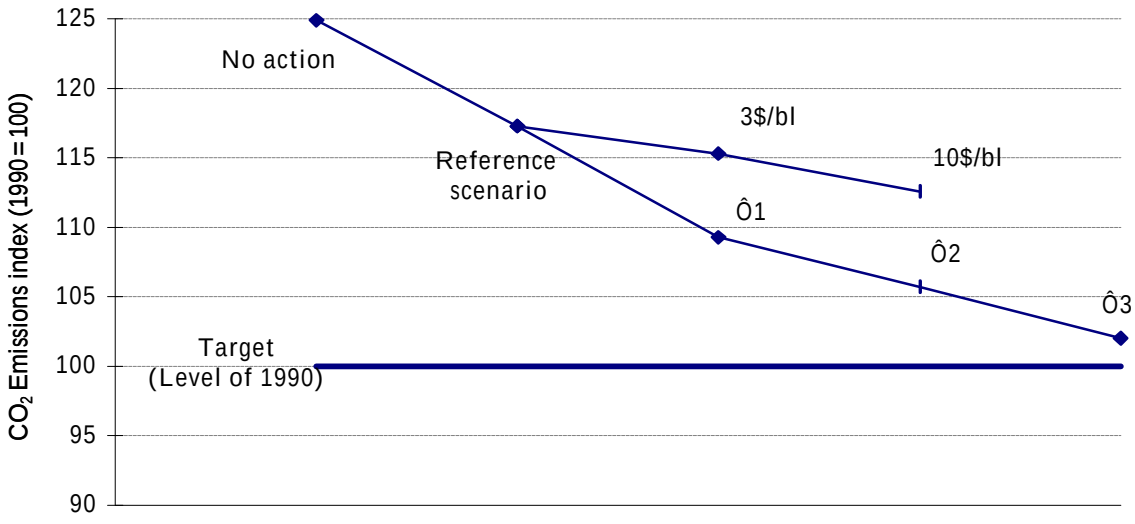
- the ***"T1-demand actions" scenario***, where emphasis is placed on feasible demand-side management interventions in individual sectors (residential - commercial - services, industries, transports).
- the ***"T2-demand and supply actions" scenario***, where the emphasis is concurrently placed on supply-side interventions, in addition to those previously mentioned in the T1 scenario.
- the ***"T3- maximum demand and supply actions" scenario***, where the emphasis, in addition to the above, is concurrently placed on interventions for the modernisation of power generation, and, more specifically, on the topping of the lignite-fired stations with gas turbine units, so as to reduce lignite-fired generation and consequently restrict the ensuing emissions of CO_2.

3.99 Although the scenarios that have been inserted into the model do not fully correspond to the programme's final options, the conclusions drawn from the evaluation are nonetheless very significant. Fig. 3.5.[74] graphically represents the efficiency of the various scenarios in terms of CO_2 emissions and, more specifically, in relation to the general target of stabilisation. The imposition of the CO_2 tax thus appears to have a rather small impact

[74] For more analytical data, see Technical Report, Vol. 3.

Figure 3.5

Scenario efficiency



on CO_2 emission abatement, while much higher scores are, on the contrary, recorded by the technological measures both on the demand and supply sides, even when the financing of the necessary interventions is to be assumed by the State.

3.100 The imposition of the CO_2 tax can, however, prove decisive for the financing of technological interventions. If this tax were to be imposed and if the collected revenues were to be allocated, either in total or in part, to programmes for the abatement of CO_2 and other greenhouse gas emissions[75], then the abatement results would not only be consistent with the objectives set in the present programme, but would actually approach those set in the most optimistic scenarios.

MONITORING THE PROGRAMME'S IMPLEMENTATION

3.101 In any event, the success of the programme - and even more so, the realisation of the more ambitious scenario objectives - call for a vast range of multi-level actions and measures (technological feasibility, cost-effectiveness, legal revisions and/or support, etc.[76]). The Greek government will appoint and devolve the necessary authority to an **Expert Action Team** that will assume the systematic monitoring and the continuous control of measure/action implementation. As for the actual composition of the team, two essential criteria will be met: the necessary participation/representation of the main bodies/organisations concerned, and the need to ensure continuous scientific support within the actual team.

3.102 The programme for the abatement of CO_2 and other greenhouse gas emissions is not dealt with disjointedly as an isolated issue but, on the contrary, is regarded as a fundamental element of a modern development policy. The reduction of CO_2 emissions calls for energy conservation and the restructuring of required energy

[75] Other policies, such as the establishment of global emission levels and the creation of a "market" for emission licenses are not favourably viewed at a European level and cannot be applied to transboundary phenomena such as CO_2.

[76] Emission limits, process standards, intermediate consultancy services on energy matters, as well the standardisation, labelling, certification, and quality guarantee of appliances.

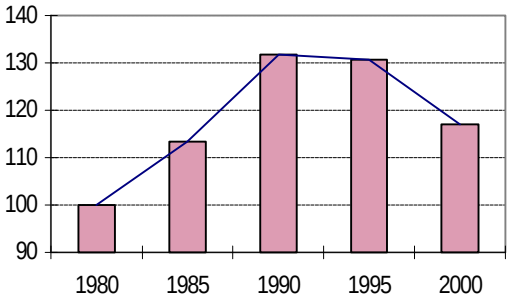
production means. These requirements (and, more generally, the rational use and conservation of natural resources) are not, however, perceived as a constraint, but as a consistently pursued objective in the context of a policy which strives to overcome well-known impasses. The ultimate goal is, of course, to ensure that the growth process in the future will be more friendly both to man and his physical environment (sustainable development).

3.103 As shown in Fig. 3.6, the Greek programme, by the year 2000, should normally succeed in reversing the alarming trend of development not only of CO_2 emissions, but also of the primary demand and final energy consumption per unit GDP. It goes without saying that the achievement of even better results, as far as CO_2 emissions are concerned, will further improve the Greek economy's energy intensity. These objectives are not only dictated by Greece's international obligations and commitments, they are also directly linked to the general quality of life in Greece and to the competitiveness of the Greek economy.

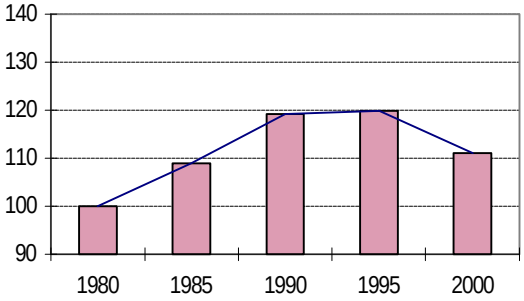
Figure 3.6

Forecasted evolution of basic magnitudes (Index 1980 = 100)

1. CO_2 emissions per unit of GDP



2. Primary energy demand per unit of GDP



3. Final energy consumption per unit of GDP

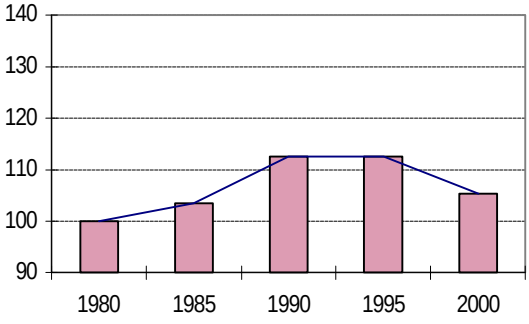


TABLE 3.1: SUMMARY LISTING AND TYPOLOGY OF THE CO_2 ABATEMENT MEASURES

A: In progress, **Â**: Starting, **C**: In the process of being elaborated

MEASURES	Measure Typology	Emission Abatement (kt CO_2)	Public Expenditure (MECU)	Degree of Implementation
ELECTRICITY GENERATION				
Natural Gas Penetration	PPC Investment	4200	184 (1)	Â
Co-generation/ Tele-heating	PPC Investment	70	-(1)	A
Improved efficiency of Lignite-fired Stations	PPC Investment	300	-(1)	A
TOTAL		*4570*		
RENEWABLE ENERGY SOURCES				
Wind Energy 300 MW	PPC Investment, Incentives granted to private investors	1000	52 (1)	A
Small Hydroelectric Works 34 MW	Subsidies granted	221	3.5 (1)	A
Solar Systems				
- conventional systems 1.300.000 m^2	Tax exemption	939	(2)	A
- new technology systems 200.000 m^2	Subsidies	37	34.5	C
Geothermal Energy	Subsidies	60	3.5	A
Biomass				
- tele-heating 50 MWth	Subsidies	60	10	B
- electricity eneration 80 Mwe	Subsidies	750	40	C
- biofuels 50 kt/year	Incentives	100	10	C
Research & Development	Project Grants allocated	100	50	C
TOTAL		*3267*	*204 (3)*	
INDUSTRY				
Natural Gas Penetration	Incentives	720	(4)	B
Co-generation 37.5 MWel	Incentives	80	(4)	A
Improvements in auxiliary operations *(industrial premises, steam production, compressed air)*	Regulating Interventions, Information, Training	430	(4)	A
Interventions in energy intensive sectors	Regulating Interventions, Incentives	808	(4)	A
Environmental Energy Listings	Legislative regulation	50	(4)	C
TOTAL		*2088*	*>153*	

MEASURES	Measure Typology	Emission Abatement (kt CO_2)	Public Expenditure (MECU)	Degree of Implementation
RESIDENCES-COMMERCE-SERVICES				
Natural Gas Penetration	Incentives	1092		B
Co-generation	Incentives	51		C
Lighting	Subsidies	470		C
Street lighting	Investment	239	13	A
Central Boiler Maintenance	Regulating interventions, Training	343		A
TOTAL		*2195*		
TRANSPORTS				
Fuel-related interventions (Technical Report 8, Table 13)	Regulating Interventions, Incentives	56	(5)	A
Vehicle-related interventions (Technical Report 8, Tables 18,21)	Regulating Interventions, Incentives	300	(5)	A
Interventions in the transport system(Technical Report 8, Tables 23,28,30)	Investment, Information	470	(5)	A
Interventions in Public Transports (Techn. Rep. 8, Tables 31,32,33)	Investment	437	(5)	A
TOTAL		*1263*	(5)	
GENERAL TOTAL		13457		
Anticipated result		9500		

(1) The required expenditure is actually greater: the extra financing is ensured from the PPC's ten-year development programme.

(2) The indirect cost of tax exemption has not been taken into account in the context of the abatement programme. The measure is also promoted by means of an information and publicity campaign.

(3) Part of the expenditure amounting to 100 MECU is covered by the Operational Energy Programme (Sub-programme 3, Measure 4.1). The remaining amounts will be drawn from the Operational Programme for Research and Technology, from the respective budgets of the Environment and Agriculture Ministries, and from Community initiatives (Interreg II, etc.).

(4) An amount of 153 MECU will be covered by the Operational Energy Programme (Sub-programme 2). Additional funds will be drawn from relevant Community initiatives.

(5) The cost of these measures does not directly concern the CO_2 abatement programme.

4. THE RATIONAL MANAGEMENT OF BIOLOGICAL RESOURCES AND SYSTEMS

4.1 Biological systems affect the CO_2 balance in three different ways, as they simultaneously constitute: (a) an important natural ***reservoir of organic carbon*** (in soils, vegetation and other organisms), (b) the most important natural mechanism for the ***fixation of CO_2*** through photosynthesis, and (c) a substantial source of ***bioenergy and biofuels***, capable of substituting for conventional energy sources and therefore of leading to corresponding savings of CO_2, since the carbon contained in bioenergy and biofuels comes from renewable, photosynthetic CO_2 fixation.

4.2 This chapter deals with the present (1990) and projected (2000-2010) contribution of the Greek ***terrestrial ecosystems*** to CO_2 savings, and outlines the necessary rational management measures which, amongst other beneficial impacts, could enhance this contribution. It should be noted that the values of the various physical parameters used here, correspond to ***estimates*** of the national average; they must therefore be taken as ***approximations*** of the respective magnitudes and not as actually measured values[77].

4.3 The total carbon ***reserve*** contained in the Greek terrestrial systems is estimated to have been approx. 2300 Mt of CO_2 equivalent for base year 1990. A relatively small portion of this carbon (almost 11-12%) is encountered in ***plant material***, while a quantity seven times greater is stored in the ***soils***. In terms of biological systems, about 70% of the stored carbon is concentrated in ***forest ecosystems,*** specifically in productive forests (more than 50% of the total). The rest 30% is concentrated in ***agriculture ecosystems*** (crops and pastures).

4.4 The total ***annual fixation*** of CO_2 for base year 1990 is estimated to have been approx. 10 $MtCO_2$, with ***forest*** and ***agricultural*** systems accounting respectively for 2/3 and 1/3 of this total quantity. This CO_2 fixation is linked exclusively to **vegetation** growth - i.e. plant biomass located 60% above ground and 40% underground. From this quantity, one of course has to deduct the CO_2 emissions and other organic carbon losses, caused by external factors such as: forest fires, soil erosion and various changes in land use, examined below.

4.5 ***Forest fires*** have multiple adverse effects on the national CO_2 balance. First of all, they reduce the annual "net" carbon fixation level, due to the CO_2 released from the burning of plant material. Secondly, they pose a serious threat to the national carbon reserve and, thirdly, they reduce the CO_2 fixation rates of the burnt areas during the years following the fire occurrence. According to official sources[78], the recent trend in forest fire occurrence is characterised by: (a) several years during which forest fires extended to an average total of 30,000 ha/year, entailing a release of 0.4 Mt CO_2/year, and (b) certain years (roughly one out of every 3-4 years) during which forest fires were more than triple the national average. This last factor - which is apparently attributable to a combination of particularly "favourable" natural conditions and to limited fire-prevention/ fire-fighting capacities - has, at a national level, almost doubled the mean annual rate of fire-induced organic carbon loss. The ***increasingly more effective control*** of forest-fires should therefore constitute the prime target of relevant measures.

[77] Analytical information on these estimates is given in the Technical Report, Vol. 9.

[78] See technical Report, Vol. 9.

4.6 ***Soil erosion*** not only poses an additional serious threat to the systems' organic carbon reserve, but also affects annual CO_2 fixation rates, as it reduces soil fertility. More specifically, important organic carbon losses due to erosion have been recorded in most types of terrestrial systems - with the noteworthy exception of productive forests - and are estimated at a total of approx. 1.7 Ì t CO_2 equivalent per year. More than 40% of this irreversible loss involves partly forested areas and pastures, while an additional 30% involves crop cultivation areas. The ***gradual reduction*** of these soil erosion rates to their lower historical levels should therefore constitute an additional long-term target of special policy measures.

4.7 Of all the various forms of intervention in land use, ***reafforestation*** obviously occupies a position of key strategic importance. Unfortunately however - and regardless of the criteria used for calculating our estimates - current reafforestation rates remain extremely ***low***: only 4000-5000 ha are reafforested each year, while the areas destroyed by forest fires on an annual basis are approx. 10 times greater. Reafforestation rates will therefore have to be intensified as quickly as possible, while an appropriate first objective would be to ***double*** the current rate by the year 2000.

4.8 ***Fallowing***, i.e. the setting-aside of arable land for non-agricultural use, is another change in land use which is expected to have a major impact on biological resources and systems of Greece in years to come. More specifically, while the total arable land area which was set aside as fallow land remained fairly stable throughout the 1975-1993 period (at a level of roughly 0.5 Mha), the Common Agricultural Policy (CAP) revisions will lead to an increase - and possibly even a doubling - of uncultivated land area within the next decade. This new factor is expected to have a small beneficial impact on the national CO_2 balance, as annual carbon fixation rates will improve. The most important impact, however, both overall and in terms of the CO_2 balance, is most likely to be generated by the gradual "liberation" of extensive land areas from the CAP protection system, thus favouring their eventual use for ***energy*** purposes. Let us therefore examine the question of bioenergy.

4.9 ***Bioenergy*** already makes a notable contribution to the energy economy in rural areas, with ***traditional*** applications involving primarily the use of ***fuel-wood for heating purposes***. In terms of carbon, the use of solid biofuels in 1990 is estimated to have led to CO_2 savings of 2.9 $MtCO_2$. As the examination of historical data, however, reveals, this traditional usage normally undergoes a gradual downward trend which, in the long term, inevitably leads to the substitution of (traditional) bioenergy by conventional sources, with all the underlying implications for the CO_2 balance. This trend will therefore have to be palliated by an increase - with the adoption of appropriate measures[79] - in the ***penetration of modern heat generation systems*** using biomass (i.e. biological resources of forest or crop origin) in applications such as district heating. Policy measures should strive to increase present biomass use levels by at least 10-20% by the year 2000.

4.10 The recent development of ***new technologies*** for the utilisation of energy from biological resources has made the use of biomass more feasible. Consisting primarily of ***agricultural by-products*** - which are available in massive quantities from national agricultural practices -, this biomass can contribute to the generation of ***industrial heat and electricity (bioelectricity)***, possibly in combined form with the use of co-generation systems. In the long term, these new applications could feasibly ***double*** the biological systems' current contribution to the CO_2 and national energy

[79] See Technical Report, Vol. 9

balance; 50% of this objective could be attained by the year 2000 with the adoption of appropriate measures[80].

4.11 The production of **liquid transport fuels** from biomass - and more specifically of ***bioethanol*** for use in mixtures with gasoline - is another possible biological resource application, which presents interesting prospects in Greece and is capable of contributing to the energy and CO_2, balances. The cultivation of ***energy crops*** in agricultural areas that will be set aside from the CAP system is indicated as the best possible means of attaining such an objective. In the long term, these applications -when added to those of paragraph 4.10 - could ***more than triple*** the present contribution of bioenergy. In the few years remaining until 2000, necessary measures should be taken to ensure the practicable large-scale ***demonstration*** of relevant technologies and to construct a ***first industrial plant*** with an annual bioethanol production capacity of 50 kt[81].

4.12 If the exploitation of energy from biological resources is to make a notable contribution to the CO_2 balance by substituting renewable for fossil carbon, then other forms of non-food uses should also be developed. The production of ***chemical products*** or other ***materials*** from renewable raw materials would lead to the saving of non-renewable sources and, more specifically, of hydrocarbons (for ex., with the substitution for petrochemical products and plastics). The production of ***industrial timber*** is, at present, the only noteworthy application of this type to use organic carbon, without producing CO_2. The gradual ***tripling*** of the Greek forests' current productivity in industrial timber by the year 2010 is proposed, with the adoption of appropriate measures for the more rational management of these forests and the amelioration of relevant infrastructure by the year 2000.

4.13 In addition to the measures necessary for achieving the objectives set out in the previous paragraphs per sector[82], adequate support will also have to be provided to ***research, demonstration, training, continuing and general education projects***. It should, however, be stressed that the achievement of all established long-term objectives will be largely determined by socio-political factors and, more specifically, by the extent of ***active participation and response*** of the concerned social groups to the proposed procedures.

4.14 The proposed measures are expected to lead to a substantial reduction in anthropogenic CO_2 emissions by the ***year 2000:***

- due to the substitution for conventional fuels, either up-grading the old uses or by advancing new uses for bioenergy. The achievable abatement has been estimated at 0.9 Mt CO_2 (see section 3.45).
- due to the increase in the terrestrial ecosystems' annual CO_2 fixation capacity (either by increasing the resource reserve in existence or by reducing its rate of depletion).

4.15 The policy for the management of biological resources and systems presents encouraging prospects in the long term. It is estimated that, by the year 2010, the proposed measures - but more particularly the development of energy crops and the utilisation of biomass (efficient combustion, bioelectricity, biofuels for transports) - will enable a substitution for conventional fuels, thus reducing anthropogenic CO_2 emissions by approx. 8 Mt CO_2. This could furthermore be accomplished, without inducing any change in the terrestrial ecosystems' present CO_2 reserve or their annual CO_2 fixation capacity.

[80] See Technical Report, Vol. 4-8.
[81] See Technical Report, Vol. 5.
[82] The measures for bioenergy are presented in Vol. 5 of the Technical Report, while those concerning the management of biological resources and systems are presented in Vol. 9.

TABLE 4.1: " SUMMARY LISTING AND TYPOLOGY OF THE MEASURES FOR THE MANAGEMENT OF BIOLOGICAL RESOURCES AND SYSTEMS"
(Estimates for the year 2000)

A: In progress, **B**: Starting, **C**: In the process of being elaborated

MEASURES	Measure Typology	Additional CO_2 Fixation (kt/year)	Public Expenditure (MECU)	Degree of implementation
Acceleration of Reafforestation Programmes	Investment	20	36	A
Reinforcement of the Forest Resource Control Programme	Investment	100	104	A
Protection of soils from erosion	Investment	200	130	A
Study for the rational use of forest resources	Research	10*	150	B
"The role of forests in the CO_2 balance"	Research	---	10	C
Rational use of farmland	Information-Training	100	80	B
Support for the utilisation of agricultural by-products	Investment	1470	75	A
Support for the promotion of energy crop cultivations	Investment	---	25	C
"The role of agriculture in the CO_2 balance"	Research	---	5	C
TOTAL		*1900*	*615*	

5. OTHER GREENHOUSE GASES

METHANE

Introduction

5.1 Methane (CH_4) is one of the primary greenhouse gases, since it contributes substantially to the absorption of the Earth's infra-red radiation and its proportional contribution to the global warming is ever increasing.

Inventory of emission sources-trends

5.2 The main anthropogenic sources of methane emissions in Greece are: landfills, agriculture, lignite mining, and natural gas systems. More specifically, the annual methane emissions in 1990 are estimated to have been 342.8 Êt, of which: 30.3% were caused by waste disposal sites, 50.9% by agriculture, 11.4% from lignite mining and 5.6% from the combustion of fuels for energy production. There are uncertainties in the estimation of methane emissions, for while the emissions largely depend on the specific local conditions, emission factors have not yet been established from experimental measurements in Greece[83].

5.3 Projected estimates for the year 2000 point to a reduction in methane emissions from waste disposal sites, an increase in emissions from the Natural Gas (NG) networks, a slight increase from lignite mining activities, while no substantial change is expected in the emissions from agriculture. The overall methane emission level in 2000 is thus expected to fall below 1990 levels.

Waste disposal sites

5.4 The anaerobic decomposition of organic waste in landfills produces biogas, which consists mainly of methane (in volume ranging from 50-70%) and carbon dioxide. The actual quantity of methane produced depends on the composition of the waste -and, more specifically, on its content in organic material-, the manner in which the layers of waste have been covered, the temperature, the humidity and other parameters. Depending on the conditions and the composition of the waste, the anaerobic digestion process - which lasts more than 10 years - produces a quantity of biogas varying from 60 m^3 to 290 m^3 per tone of waste. The annual emissions for base year 1990 from this source are estimated to have been: 100.4 kt from the landfills of the large urban centers and 3.5 kt from open dumbing and burning practices[84].

5.5 Although Greece did not have any major waste disposal problem a few decades ago, this situation began to change with the gradual development of large urban centres, the progressive modification in consumer behaviour patterns and the growth of tourism. In 1990, the situation was as follows: around 50% of all waste was disposed in landfills, 35% was discarded in open dumbs, while approx. 15% was subject to uncontrolled burning. After 1990, the proportion of uncontrolled waste disposal and burning drastically decreased due to the intensification of controls, the pressures of tourism and the public outcry following certain devastating forest fires which were shown to have been caused by the spontaneous combustion of waste.

5.6 The management of municipal waste materials in Greece is assumed by the Local

[83] See Appendix.

[84] Ibid.

Government Organizations (LGOs), while the relevant policy is elaborated by the Ministry for the Environment, Physical Planning and Public Works. The Ministry of the Interior - which ensures the general supervision of the LGOs - collects and processes annual statistical data from all LGOs with a population of more than 2,000 inhabitants. Until now, some 5,000 disposal sites have been recorded, of which only 2,000 are licensed in accordance with the legislation presently in force, while the operation of the remaining 3,000 sites is still uncontrolled.

5.7 The basic aims of the policy for reducing methane emissions from landfills and waste tips are:

- To promote the utilization of biogas in the controlled waste disposal sites.
- To reduce the volume of solid waste with the implementation of recycling programmes.

5.8 The utilization of biogas for the purpose of meeting energy needs promotes energy conservation, while minimizing methane emissions. It should be pointed out that the carbon dioxide obtained from the flaring of methane absorbs much less infra-red radiation than methane does. Therefore, even if biogas flaring were the only measure to be implemented in order to neutralise the toxic gases contained within it, an environmental benefit would still ensue, since certain quantities of methane would be replaced by the less drastic carbon dioxide.

5.9 The policy for reducing waste volume achieves a reduction in the biodegradable materials which are responsible for methane emissions. The recycling policy, in turn, achieves considerable energy conservation and consequently reduces the emissions of greenhouse gases produced by combustion for energy production.

5.10 According to the legislation in force[85], the new landfills must, at least in the large cities, be equipped with a pipe-system permitting biogas recovery and utilization. It is estimated that the creation of new controlled tipping sites will absorb around 30 billion Drs in the next decade and, in fact, essentially by 1999. Necessary infrastructure plans for the collection of biogas are being made for all of the new landfills. It is thus estimated that, by 2000, the necessary methane collection infrastructure will have been set up for 65% of all discarded waste.

5.11 The Ministry of the Interior and the Ministry for the Environment, Physical Planning and Public Works, with co-financing from the European Union, are presently elaborating waste management studies, in an aim to eliminate uncontrolled disposal, to rehabilitate and restore disposal grounds and to set up new waste disposal facilities. The Ministry of the Interior has also promoted a special development programme nationwide for the rational management of household refuse by the Local Government Organization (LGOs) which encompassed a total of 80 projects (1991). Furthermore, in the context of the Regional Development Plans (RDPs), recycling programmes are being promoted nationwide by Associations, Municipalities and Communities[86].

5.12 The Joint Association of Municipalities and Communities of the Attica Prefecture first initiated a programme for the collection of recyclable material “at the source” in 1985 and, in 1994, a large-scale programme was launched for the recovery of paper from household refuse. Similar paper recycling programmes have been carried out in the Municipalities of Thessaloniki, while plans for their extension to glass and aluminium recovery have already been revised[87].

[85] Joint Ministerial Decision 49541/1424/86 and the legislative act incorporating Directive 151/91/EEC
[86] See Technical Report, Vol. 10.
[87] Ibid.

5.13 In the context of the restoration works on the landfill sites of Schistos and Ano Liossia (Attica), installations[88] will be set up for the utilization of biogas, in an estimated capacity of 14 million m^3 (the relevant calls-for-tender have already been issued). The Association of Local Government Organization (LGOs) of the Wider Thessaloniki Area has already begun the construction of an experimental biogas management network, with a 600 m^3/hour capacity.

5.14 The Municipality of Kalamata is currently building a compost production unit, designed to utilize the household refuse and sludge from the town's biological sewage treatment plant[89].

Sewage

5.15 The production of methane from urban sewage occurs during their transport and disposal in the tanks. During the actual waste water treatment process, methane is only produced by the anaerobic digestion of the sewage sludge[90]. A common practice, which minimizes methane emissions, consists in using the biogas produced from the urban waste water to meet the treatment plants' own operating needs.

Agriculture

5.16 Methane emissions arise from the cultivation of rice and from the decomposition of organic matter and their actual production rates depend on various factors, such as ground temperature. Rice is cultivated in Greece on a total area of 15,000-17,000 ha and the related methane emissions are estimated to have reached around 5 kt in 1990[91]. Although the national rice production increased slightly during the last two years, the ensuing additional burden is negligible in comparison with emissions from other sources. The open burning of agricultural residues emits an additional 4.9 kt of methane per year.

Stock-breeding

5.17 Methane emissions arise from the enteric fermentation in ruminant livestock and from the anaerobic digestion of livestock wastes. At a national level in 1990, methane emissions are estimated to have been 141.3 kt from enteric fermentation in livestock and 23.4 kt from manure management. There are considerable uncertainties in the calculation of the manure-related methane emissions, since emission factors have yet to be established for Greece's specific climatic conditions and agricultural practices[92].

5.18 According to the Ministry of Agriculture, no increase in livestock numbers is expected until 2000. Methane emissions from stock-breeding sources will, therefore, remain stable at 1990 levels.

5.19 Of all the stock-breeding units, only in pigsties manure is managed as a liquid which, according to the legislation in force, must be treated in specially built tanks. These liquid wastes have a high organic content and, in compliance with relevant provisions, cannot be disposed of in the field without previous treatment[93]. Also a substantial proportion of the wastes from poultry farms undergo special treatment for the production of composts, which serve as fertilizes. Therefore the conditions which give rise to methane emissions are, in this instance, basically avoided.

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88 The "Calls-for-Tenders" for the specific works have already been completed, and the bids submitted are currently being evaluated.

89 See Technical Report, Vol.10.

90 The framework for the treatment of urban waste water has been defined by Joint Ministerial Decision 69269/90 and by the legislative act incorporating Directive 91/271/ÅU.

91 See Appendix.

92 Ibid.

93 See Technical Report, Vol. 10.

5.20 According to the Ministry of Agriculture, the manure from stock-breeding activities is essentially used as a fertilizers. Consequently, do not exist the anaerobic conditions responsible for methane emissions. However, as this practice has led to a deterioration in the quality of underground water, a Code of Good Agricultural Practices[94] for the Protection of Water has been issued. In line with Directive 91/676/EU, this code also covers the question of manure disposal[95].

Lignite / oil extraction and gaseous fuel distribution networks

5.21 While methane is a by-product yielded by the physico-chemical processes leading to the formation of coal, the quantities of methane actually produced depend on the location, pressure and temperature of the coal deposit. In general, the deeper the location of the coal beds, the greater the methane content. This explains why lignite extraction in Greece, which is carried out close to the surface (opencast mining), does not release large quantities of methane. The overall methane emissions from this source in 1990 are estimated to have been approx.: 36 kt from lignite extraction, 2.7 kt from hydrocarbon transportation, storage and distribution, and 0.37 kt from municipal gas network leakage in the Athens area[96].

5.22 The natural gas, which is extracted from the Prinos oil field in Northern Greece, is either used to fuel the pumping installations or is reinjected into the deposit to increase oil pressure.

5.23 The leakage of methane from the low pressure system of the Athens' municipal gas distribution network is estimated to have been of 370 t in 1990. This leakage has been steadily reduced in recent years and should be minimized by the year 2000, as new polyethylene mains are gradually installed in place of the old metal ones. As for the natural gas distribution network which is currently under construction and will be incorporated in the national energy system, all the necessary measures are being taken to ensure methane leakage prevention.

NITROUS OXIDE

Introduction

5.24 Over a one-hundred year time horizon, nitrous oxide (N_2O) absorbs some 270 times more infra-red radiation than does carbon dioxide. However, as N_2O is released in much smaller quantities, its contribution to the greenhouse effect is much smaller.

Inventory of emission sources - trends

5.25 The annual emissions of nitrous oxide in Greece are estimated to have been 13.67 kt in 1990, of which 55% are attributed to agricultural practices, 27.3% to fuel combustion in the wider energy sector and 17.5% to other industrial processes.

5.26 The quantities globally emitted on an annual basis are relatively low and they point to an icrease for the year 2000. The increase in emissions due to the use of catalysts in motor-vehicles will be partially palliated by the anticipated reduction in emissions from agricultural practices.

Fuel combustion

5.27 Nitrous oxide emissions arise during the combustion procedure, from the oxidation of the nitrogen contained in the combustion air and fuels. The actual emission rates depend on the technology in use and combustion conditions. The emissions from fuel combustion in 1990 are

94 In accordance with Directive 91/676/EU
95 Ibid..
96 See Appendix.

attributed mainly to the transport and commercial/residential sectors[97].

5.28 Considering that the use of 3-way catalysts in motor-vehicles increases nitrous oxide emissions, the continued substitution of all old-technology vehicles is expected to lead to a further increase in emissions. This adverse impact will, however, be largely compensated by the simultaneous reduction in emissions of nitrogen oxides, volatile organic compounds (VOCs) and carbon monoxide, i.e. of pollutants which cause the onset of photochemical smog in urban centres and count as secondary greenhouse gases.

Other industrial activities

5.29 Nitrous oxide emissions arise from the production of inorganic chemicals. However, as Greece has no industry for the production of adipic acid, global Í2Ï emission levels from the entire industrial sector remain low.

Agriculture

5.30 Nitrous oxide is emitted from cultivated soil as part of the natural process of nitrogen circulating within the environment. Various agricultural practices, and primarily the use of fertilizers, are capable of inducing an increase in the quantities emitted. Estimates for 1990 show that crop cultivations with the use of fertilizers accounted for 6.42 kt of Í2Ï emissions, while the remaining cultivations accounted for 1 kt[98].

5.31 The deregulation of the fertilizer market in 1992 has triggered an increase in prices and a simultaneous decrease in consumption levels, a trend which is expected to intensify in the future. As a result, nitrous oxide emissions from agricultural practices have decreased.

5.32 The Code of Good Agricultural Practice for the Protection of Water published by the Ministry of Agriculture in 1994[99], sets out a series of rules which, amongst other matters, also cover the rational use of fertilizers. The subsidizing of "ecological" cultivations - i.e. of cultivations without the use of fertilizers - in the context of European Union policies is expected to cause a further considerable drop in the use of fertilizers.

NITROGEN OXIDES

Introduction

5.33 Nitrogen oxides (NOx) are classified as greenhouse gases, due to their contribution to photochemical reactions leading to the formation of ozone, a primary greenhouse gas. On the other hand though, nitrogen oxides increase the oxidizing capacity of the atmosphere, thereby leading to a decrease in methane concentrations. The correlation between these two opposing effects, however, has yet to be accurately established.

Inventory of emission sources - trends

5.34 The main sources of nitrogen oxide emissions in Greece for 1990 were found to be the combustion of fossil fuels for energy production (97.5%)[100]. Despite the anticipated implementation of abatement measures, a 10% increase in emission levels is expected by the year 2000, since motor-traffic induced emissions are expected to increase with the rise in car numbers.

Fuel combustion

5.35 Nitrogen oxide emissions arise during the combustion procedure, from the oxidation of

97 1.23kt and 1.22 kt respectively
98 See Appendix.
99 Technical Report No. 10
100 See Appendix.

nitrogen contained in the combustion air and fuels. Actual emission levels of course depend on the technology in use and on combustion conditions. The combustion of fossil fuels for the production of energy in 1990 is estimated to have led to nitrogen oxide emissions in the amounts of: 60.2 kt from thermal power plants, 4.2 kt from the energy sector (refineries), 49.7 kt from the industrial sector, 44 kt from the residential and commercial sector and, finally, 2.5 kt from the combustion of biomass for the heating of households[101].

5.36 Greece has signed the Convention on Long-Range Transboundary Air Pollution (Geneva, 1979) and the Protocol to the above convention for the Control of Emissions of Nitrogen Oxides (1988). Also Greece has enacted the control of nitrogen oxide emissions from large combustion plants[102], i.e. from plants with a nominal thermal capacity superior to 50 MW. The limits specified in the legislation apply to large plants constructed after 1.7.1987, while a maximum total emission level of 70 kt was set for those in operation prior to that date[103].

5.37 The newly instituted "Environmental Impacts Assessment" which must be obtained prior to the foundation, modernization or license renewal of all industrial plants, has set the basis for the control of nitrogen oxides, amongst other pollutants[104]. Furthermore, following a series of legislative regulations, the control of energy producing plants now extends to all combustion parameters[105].

5.38 The penetration of natural gas in the national energy system by 2000 is expected to bring about a certain reduction in nitrogen oxide emissions, since other higher emitting fuels will be partly substituted for. Moreover, in the context of urban programmes for the reduction of photochemical smog, steps will be taken to encourage the use of technologies emitting reduced quantities of nitrogen oxide[106].

Transport

5.39 Transport, in base year 1990, was responsible for the release of 169.2 kt or 51.2% of the total nitrogen oxides emitted by the entire energy sector. The higher emission levels recorded for motor vehicles, in comparison with other sectors, are due to the high temperatures that develop inside the engines. An increase 10-15% in the nitrogen oxide emissions is expected by the year 2000, despite the implementation of major abatement programmes, as considerable increases are anticipated both in the number of passenger cars and in total vehicle kilometers.

5.40 In 1989, the Ministry for the Environment, Physical Planning and Public Works initiated a programme for the promotion of new technologies and the withdrawal of old technology cars.[107] Law 1858/89 reduced the Special Consumption Tax (SCT) rates by 20% on the purchase of a new vehicle, while other provisions granted as much as 40% reductions in SCT rates in cases where the purchase of the new car was accompanied by the withdrawal and destruction of an old-technology car. The same regulations also exempted beneficiaries from the payment of the additional specific tax and of circulation dues for a period of 5 years. An incentive programme was also set up to encourage owners to have their conventional cars fitted with catalytic converters[108].

[101] Ibid.
[102] Joint Ministerial Decision 58751/2370/93, incorporating Directive 88/609/ÅÅC ("Determination of Measures and Conditions for Limiting Air Pollution from Large Combustion Plants")
[103] See Technical Report, Vol.10.
[104] Joint Ministerial Decision 69269/90
[105] See Technical Report, Vol.10.
[106] Ibid.
[107] 368.000 old-technology cars were withdrawn and 384.000 cars, equipped with new catalytic converters, have been introduced.
[108] Technical Report No. 10

5.41 Law 2052/92 established the compulsory control of exhaust emissions for all categories of motor vehicles, a measure expected to lead to a notable decrease in fuel consumption levels and pollutant emissions. For the implementation of this new regulation, the Exhaust Control Card system was set up. This certification card is issued to vehicle owners by authorised private repair shops operating under State control. These compulsory exhaust emission controls are annual for all private passenger cars, and biannual for taxis and lorries.

5.42 In the context of the 2nd Community Support Framework (CSF), major infrastructure works are being carried out to update and expand the national railroad network. It should be stressed that there is still considerable scope for increasing railroad passenger numbers and freight loads. Success in this endeavour would contribute to a substantial reduction in pollutant emissions, due to the reduced fuel consumption levels in comparison with private road transport means.

5.43 The basic aims of the transport policy in the large urban centres are: to develop public transportation means (while also discouraging the use of private passenger cars), to promote correct traffic management and to regulate city activities. This policy will also have particularly favourable repercussions on the greenhouse gas control programme, due to the ensuing and substantial decrease in fuel consumption levels. The joint transportation body, which was recently founded (Law 2078/93), now encompasses all of the public transport systems operating in Attica. The overall objective is to achieve optimal public transport effectiveness, through the development of a joint policy and planning[109].

5.44 The modernization of the public transportation systems will also have a beneficial impact on pollutant emission levels. The programme for the total renewal of the Athens bus fleet provides for the allocation of 32 billion Drs. for the procurement of 615 new buses by the end of 1995. In addition, Law 882/90 sets out the specific incentives to be granted for the substitution of old taxis that run on oil with new technology vehicles[110].

5.45 The construction of the new Athens Metro, financed by the 2nd Community Support Framework (CSF), with a total route length of 59 Kms, is expected to bring about a reduction in motorized traffic by 250,000 cars per day and, consequently, a reduction in the corresponding Í Ox emission levels.

VOLATILE ORGANIC COMPOUNDS

Introduction

5.46 Are considered non-methane volatile organic compounds (Í Ì VOCs) all the organic compounds - other than methane - which, due to their contribution to photochemical reactions, cause an increase in tropospheric ozone levels. Increased NMVOC concentrations in the atmosphere also cause an increase in the levels of various greenhouse gases, such as methane and hydrofluorocarbons (HFCs). NMVOCs do not count as primary greenhouse gases, as they do not absorb infra-red radiation. They nevertheless contribute indirectly to the greenhouse effect, due to their participation in the chemical reactions responsible for the formation of primary greenhouse gases.

Inventory of emission sources - trends

5.47 NMVOC emissions in Greece were attributed to the following major sources for base year 1990: fuel combustion for energy

[109] Ibid.

[110] Ibid.

production (224.7 kt), leakage from hydrocarbon systems (30.4 kt) and the use of solvents, where there were no available data to develop a credible estimation.

5.48 Projected emissions for the year 2000 point to a decrease in NMVOC emissions, due to the measures currently implemented in all sectors, and mainly in the transport sector.

Fuel combustion

5.49 Non-methane volatile organic compound (NMVOC) emissions arise from the combustion of fossil fuels and are the product of incomplete combustion. The actual quantities which are emitted essentially depend on combustion means and conditions. It is worth underlining that the transport sector accounts for more than 80% of the NMVOC emissions from the entire energy production sector (162.2 kt out of a total 194.3 kt).The implementation of a series of measures in the transport sector and the use, in particular, of new anti-pollution technologies in vehicles are expected to produce a reduction in emissions by the year 2000.

5.50 All of the measures for the transport sector, mentioned in previous sections and which focus on the reduction of NOx emissions, also have a beneficial impact on the emissions of volatile hydrocarbons. The widespread introduction of 3-way converters in cars, in particular, is expected to bring about a considerable reduction in the emissions arising from motorized traffic. Furthermore, the control of car exhausts and the regular tuning of engines will lead to reductions in the emissions from all types of cars, regardless of their respective technology.

5.51 Ministerial Decision 41385/85 sets out the operating conditions and the allowable pollutant emission levels which apply to industrial boilers. It also details the relevant monitoring equipment that the industrial units will have to install. Controls are carried out systematically by specialized Control Corps groups from the Ministry for the Environment, Physical Planning and Public Works and the Prefectures, especially in units with important fuel consumption levels. This Control Corps also checks boiler operation in public organizations, hospitals and homes, so as to ensure proper adjustment, fuel savings and reduced pollutant emissions.

Gas leakage

5.52 As a signatory to the Protocol Concerning the Control of Emissions of NMVOCs (Geneva, 1991) - which embodies the conclusions of the Geneva Convention on Long-Range Transboundary Air Pollution (1979) - Greece has committed itself to returning its 1999 NMVOC emissions to below 1988 levels. In accordance with the same Protocol, Greece has also committed itself to: the implementation of measures for the withdrawal of old-technology cars, the promotion of renewable energy sources, the gradual restructuring of its transport system and the adoption of economic incentives.

5.53 In the context of the "Environmental Impacts Assessment" applicable to all polluting units [111], the regulations in force aim at reducing hydrocarbon gas leakage from refineries and oil product storage and distribution facilities. Various solutions have been provided for, such as the placing of floating ceilings in the petrol tanks, the proper paint-coating of the tanks' surfaces and valve fitting. The programme of the Ministry for the Environment, Physical Planning and Public Works to combat the Athens Smog problem (June 1994) contains measures for limiting the levels of volatile organic compounds emitted from the storage and distribution of oil products.

[111] Joint Ministerial Decision 69269/90

5.54 In the context of the European Union's policy, stringent measures will soon be implemented for the reduction of NMVOC emissions from the storage of petrol and its subsequent distribution to the service stations. More specifically, the relevant Community Directive, which will soon be issued, sets out the requirements concerning: the design and operation of petrol storage facilities, loading and unloading equipment, mobile tanks, and the loading/storage facilities in service stations.

Solvents

5.55 NMVOC emissions also arise from the evaporation of solvents used in various industrial and other processes, such as the use of special glue substances, the domestic use of various paints, and the production and processing of chemical products. The implemented measures are expected to bring about a considerable reduction in emissions by the year 2000.

5.56 In 1988 the types of solvents to be used by the industrial metal-plating units were specified[112], in an aim to reduce the use of toxic solvents.

5.57 A Directive proposal is currently being discussed in the European Union for limiting the emissions of volatile organic compounds arising from the use of organic solvents, in various processes and industrial facilities. Once this Directive has been approved and incorporated in the national legislation, Greece will be able to enforce specific emission levels and implement procedures and specific technological measures for controlling NMVOC emissions from the use of solvents.

CARBON MONOXIDE

Introduction

5.58 Carbon monoxide (CO) indirectly affects the radiation budget of the atmosphere, due to its contribution to the photochemical processes which lead to increased concentrations of ozone and methane, in the lower levels of the atmosphere.

Inventory of emission sources - trends

5.59 CO emissions in Greece are estimated to have reached a total of 1480 kt in 1990 and can be broken down as follows: 65.7% from transport, 17.2% from the burning of biomass for domestic heating purposes, and 7% from the open burning of agricultural residues[113].

5.60 Projected estimates for year 2000 point to a decrease in CO emissions, due to the generalised implementation of measures in all combustion-related sectors and, chiefly, in the transport sector.

Fuel Combustion

5.61 The measures mentioned in previous sections, regarding the abatement of NMVOC and NÏx emissions arising from fuel combustion, have an equally positive impact on CO emissions. The controls carried out during the last 8 years by special Control Corps squads, both in the industrial and residential/ commercial sectors, have proved quite effective in reducing CO emissions.

Transport

5.62 As described above (see the NMVOC and NÏx emission abatement measures), the policy administered in the transport sector consists of: the introduction of anti-polluting technology in

[112] Joint Ministerial Decision 47943/88

[113] See Appendix.

motor vehicles, intensified exhaust controls (with the establishment of the Exhaust Control Card system) and the expansion/modernisation of public transport means. This policy is also expected to bring about a considerable reduction in CO emissions by the year 2000.