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General Information on the Greek Electricity Sector for the period 2000-2003 : Installed capacity, production & consumption levels, Renewable Energy Sources and Long Term Energy Planning.

Introduction

This report has been prepared by the Greek Regulatory Authority of Energy (RAE) at the request of the Ministry for the Environment, Physical Planning and Public Works and aims to provide a brief overview on issues related to power generation in Greece over the period from 2000 to 2003 and to highlight anticipated energy and emission trends until 2010.

Section 1 reviews the installed capacity for power generation on and provides information on electricity production per energy source (thermal, hydro, renewable), net imports and consumption levels.

Section 2 focuses on the electricity production from renewable energy sources (RES), includes a brief outline of the most recent legislative framework and the financial incentives for the promotion of RES and provides information in terms of installed capacity per RES technology type.

Section 3 presents a short overview of the draft Long Term Energy Planning until 2010 with quantitative projections on the energy production and demand, the anticipated contribution of renewable sources in the power sector and the estimated emission levels of major combustion produced pollutants such as carbon dioxide (CO_2) and nitrogen and sulphur oxides (NO_x and SO_2). The analysis was based on the mathematical model PRIMES for the energy system and on statistical data published by EUROSTAT.

Apart from the EUROSTAT data, the report utilises material provided by a number of other organisations including European Commission DG for Energy and Transport, the International Energy Agency (IEA), the Union for the Co-ordination of Transmission of Electricity (UCTE), the Hellenic Transmission System Operator (HTSO – ΔΕΣΜΗΕ), the Public Power Corporation (PPC), the Centre for Renewable Energy Sources (CRES) as well as RAE's own records. Additional information on the Long Energy Planning may be obtained from RAE or from the "European Energy and Transport-Trend –Trends to 2030" report of the EU DG Energy and Transport.

1. Electric Energy Production & Consumption

In 2002, the installed electric power generation capacity in Greece amounted to 12236 MW, up by about 6.8 % from 2001. In 2003, a further increase in the installed capacity of 3.6% resulted in a total of 12679 MW as shown in Table 1. Out of the total installed capacity, 88% is on the mainland whereas 12 % is distributed on the so called "Non Interconnected Islands", that is on islands with autonomous systems not connected to the mainland grid. Additional generation capacity of the order of 50 MW was temporarily installed on the non-interconnected islands to provide further electric power during the summer period of 2003 (1.6.2003 to 31.9.2003).

TABLE 1 INSTALLED ELECTRIC POWER GENERATION CAPACITY (MW)

	2000	2001	2002	2003	annual change (%)		
					01/00	02/01	03/02
MAINLAND AND INTERCONNECTED ISLANDS							
Thermal Power Plants							
Coal	4908	4933	4958	5288	0,51	0,51	6,66
HFO	777	771	858	858	-0,72	11,20	0,00
Natural Gas	1100	1103	1693	1693	0,25	53,54	0,00
Total Thermal	**6785**	**6807**	**7509**	**7839**	**0,33**	**10,31**	**4,39**
Hydroelectric Plants							
small (1-10 MW)	24	31	35	38	**29,17**	**12,90**	**8,57**
large (>10 MW)	3039	3039	3039	3039	**0,00**	**0,00**	**0,00**
Total Hydroelectric	**3063**	**3070**	**3074**	**3077**	**0,23**	**0,13**	**0,10**
Other RES	**137**	**199**	**217**	**308**	**45,65**	**8,58**	**42,40**
TOTAL	**9985**	**10077**	**10799**	**11224**	**0,92**	**7,17**	**3,93**
NON-INTERCONNECTED ISLANDS							
Thermal Power Plants							
Coal							
HFO & LFO	1290,0	1315,0	1365,0	1365,0	1,94	3,80	
Natural Gas							
Total Thermal	**1290,0**	**1315,0**	**1365,0**	**1365,0**	**1,94**	**3,80**	**0,00**
Hydroelectric Plants							
small (1-10 MW)	0,3	0,3	0,3	0,3	0,00	0,00	0,00
large (>10 MW)							
Total Hydroelectric	**0,3**	**0,3**	**0,3**	**0,3**	**0,00**	**0,00**	**0,00**
Other RES	**76,3**	**78,8**	**83,0**	**107,1**	**3,28**	**5,33**	**29,04**
TOTAL	**1366,6**	**1394,1**	**1448,3**	**1472,4**	**2,01**	**3,89**	**1,66**
TOTAL	**11351,5**	**11470,6**	**12247,7**	**12696,6**	**1,05**	**6,77**	**3,67**

source : PPC Generation Licence (Official Journal of the Greek Government 92/Jan. 2002), PPC annual report 2002, proposed modification of PPC license (RAE ref doc O-4242/16.9.2003).

On mainland Greece, thermal power plants using domestic coal, heavy fuel oil (HFO) and natural gas constitute a total of 70 % of the installed electric power generation capacity, 27% is large hydroelectric and about 3% is based on renewable energy sources (RES) such as wind, small hydro and biomass. On the Non-Interconnected islands, 93% of the installed capacity is thermal (heavy and light fuel oil) and about 7% is based on renewable energy sources. It should be noted that over the last two years, the installed capacity of power plants burning natural gas as a main fuel has increased by a factor of 53%.

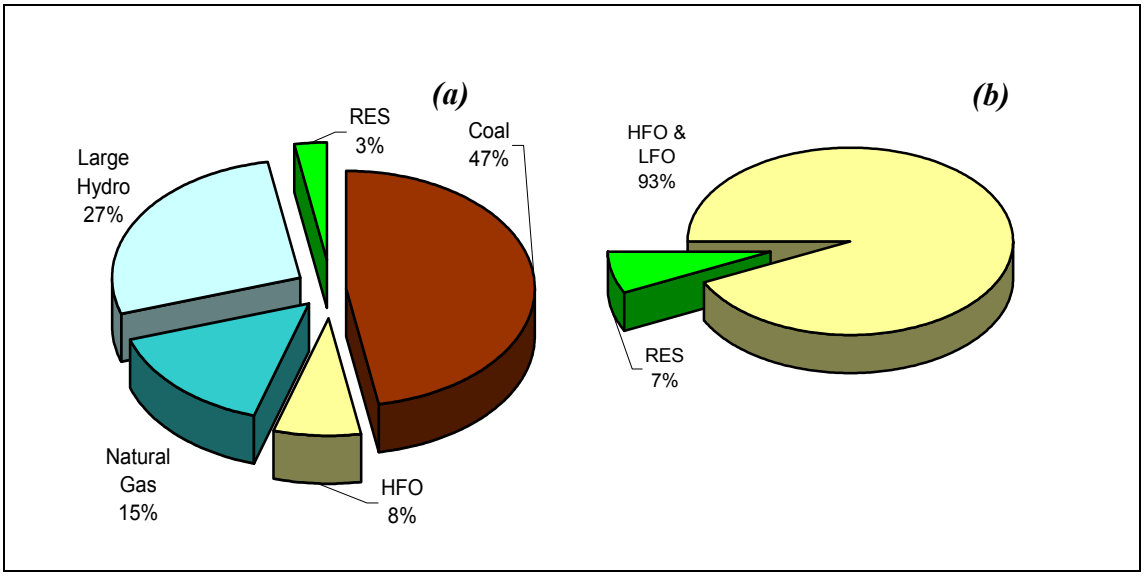


FIGURE 1 Installed electric power generation capacity on as a function of energy source (*a*) Mainland Greece (*b*) Non-interconnected Islands.

TABLE 2 GROSS ELECTRICITY PRODUCTION (GWh)

	2001	2002	annual change (%)
Thermal Power Plants	**50223**	**50404**	**0,36**
incl. CHP	2386	2213	-7,25
incl. CHP autoproducers	906	907	0,11
Hydroelectric Plants	**2725**	**3463**	**27,08**
incl. pumped storage	628	663	5,57
RES (wind only)	**756**	**651**	**-13,89**
TOTAL	**53704**	**54518**	**1,52**

souce : CRES, information reported to IEA

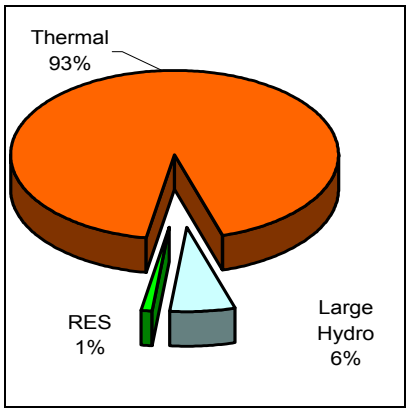


FIGURE 2 Electricity production from thermal, hyrdo and RES sources as a proportion of the gross electricity production for 2002

Gross electricity production in 2002 totalled 54.5 TWh, up by about 1.5% from the 2001 values. Electricity produced from thermal power plants accounts for 93%, exploitation of

hydroelectric power for 6% and energy from renewable energy sources for 1% of the total electricity produced, as shown in Table 2 and Figure 2.

Electricity consumption[1] in Greece in 2002 totalled 53.5 TWh, up by about 2.8% from 2001. Although consumption levels for 2003 are not yet available, preliminary data for the first three quarters of 2003 shown in Table 3 indicate that the increase in electricity consumption in 2003 could exceed 5% from the 2002 levels. Detailed information on electric energy production from thermal power plants and consumption levels for the period from 2001 to 2003 for mainland Greece and the interconnected islands, is reported in Tables 4 and 5. Electricity consumption in mainland Greece has increased from 45.9 TWh in 2001 to 49.83 TWh in 2003, up by 8.5%. Accordingly, electricity production from thermal power plants has increased by about 6.5% during the last two years while the average rate of increase in the use of natural gas as a fuel for power production in the period 2000-2003 exceeds 10%, Table 6. Figure 4 shows that the electricity sector contributes by almost 75% to the overall natural gas consumption.

Energy indicators for the last two years (2002-2003) are not yet available neither from EUROSTAT nor from IEA. According to the IEA Key Energy Statistics 2003, the electricity consumption per capita in 2001 was 4679 kWh/capita.

TABLE 3 ELECTRICITY CONSUMPTION LEVELS

2001	2002	1Q2002	2Q2002	3Q2002	1Q2003	2Q2003	3Q2003
Consumption (TWh)							
52	53,5	12,9	12,9	14,5	13,7	13,5	15,5
Percent Change from the same period of the previous year							
0,8	2,8	5,5	6,2	0,2	6,2	5,0	6,7

source : IEA Monthly Electricity Survey – October 2003

TABLE 4 NET THERMAL ENERGY PRODUCTION (GWh)

	2000	2001	2002	2003	annual change (%)		
					01/00	02/01	03/02
MAINLAND AND INTERCONNECTED ISLANDS							
Coal	30943	32042	31197	32133	3,55	-2,64	3,00
HFO	4143	3543	3394	3316	-14,48	-4,21	-2,30
Natural Gas	5572	5814	6725	7705	4,34	15,67	14,57
TOTAL THERMAL	**40658**	**41399**	**41316**	**43154**	**1,82**	**-0,20**	**4,45**
NON-INTERCONNECTED ISLANDS							
Coal	—	—	—	—	—	—	—
HFO & LFO	3678	3886	4122	N/A	5,66	6,07	N/A
Natural Gas	—	—	—	—	—	—	—
TOTAL THERMAL	**3678**	**3886**	**4122**	**0**	**5,66**	**6,07**	**N/A**
TOTAL	**44336**	**45285**	**45438**	**N/A**	**2,14**	**0,34**	**N/A**

source :PPC annual report 2000-2002, HTSO, data reported to RAE for 1.1.2003-31.12.2003.

[1] *IEA Monthly Electricity Survey – October 2003*

TABLE 5 MAINLAND ENERGY CONSUMPTION, DEMAND AND IMPORTS

	2001	2002	2003	annual change (%) 02/01	03/02
Electricity Consumption (GWh)	45914	47300	49830	3,0	5,4
Peak Demand (MW)	8598	8924	8897	3,8	-0,3
Net Imports (GWh)	2500	2914	2500	16,6	-14,2

souce : PPC, HTSO, UCTEE

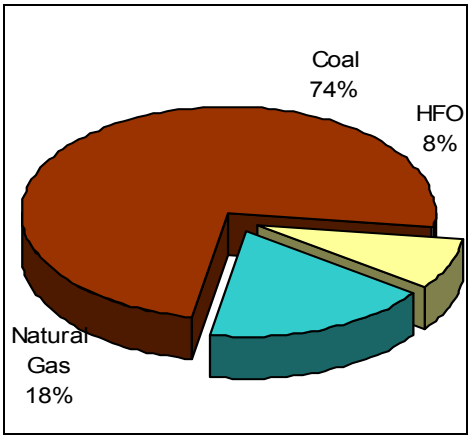


FIGURE 3 Electricity production from coal, fuel oil and natural gas as a proportion of the net thermal electricity production on mainland Greece for 2003.

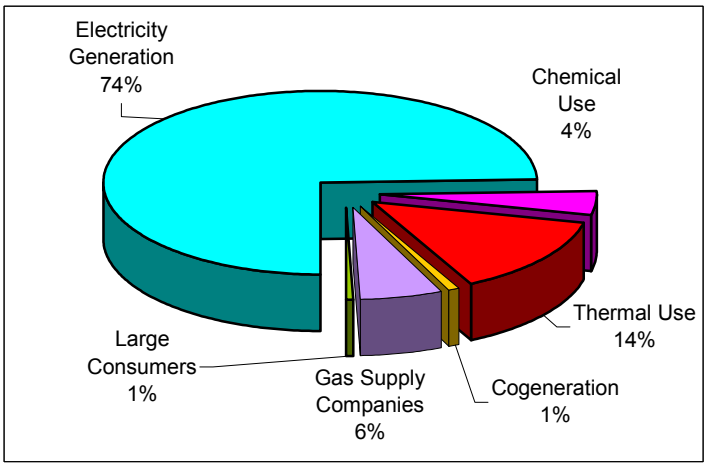


FIGURE 4 Natural gas consumption per sector in 2002 (source DEPA).

TABLE 6 NATURAL GAS CONSUMPTION (million cubic metres)

2001	2021
2002	2171
1Q2003	448
2Q2003	655
3Q2003	558
Oct 2003	172
% Change Year to Date[(1)]	8

[(1)] Percentage change over corresponding period (beginning of year to current month of previous year), source IEA.

2. Renewable Energy Sources For Electricity Production

Promotion of electricity produced from renewable energy technologies is of high priority within the European Community for reasons related to security and diversification of energy supply, environmental protection and social and economic cohesion[2.] In this context and within a period extending over the last ten to fifteen years, Greece has taken steps to promote the installation of power plants using renewable energy sources (RES). Although current market trends are encouraging, the predictions, based on analysis, presented in Section 3

[2] White Paper on Renewable Energy Sources

show, that the ambitious indicative target of Directive 2001/77/EC, for a 20.1% RES electricity contribution (including the large hydro power plants) to the gross electrical consumption by 2010, is unlikely to be achieved, unless strong financial incentives continue to be provided, bureaucratic barriers are overcome and the public acceptance is increased.

In terms of production, the RES electricity production (including large hydro plants) increased from 1.77 TWh in 1990[3] (5.1% of total electricity generation) to 4.15 TWh (7.8%) in 2000[4] and to 6.39 TWh in 2003 (11.85% of total electricity generation).

In terms of installed capacity, the wind energy sector has made an outstanding progress during the last five years and the wind turbine installed capacity is expected to be close to 550 MW by the end of 2004.

Figure 5 shows the increase in the installed wind power plant capacity for a 14 years period in a cumulative way. Up to 2003 the installed capacity is presented and for the year 2004 the predicted total installed capacity is shown, including the capacity currently under construction.

On February 1999 the Law 2773/99 has come to force, which is the first law for the liberalisation of the Greek electricity market. This law includes some provisions regarding the energy produced from RES, such as:

- Priority of access to the electricity grid for RES power plants of capacity up to 50 MWe (in the case of hydroelectric plants up to 10 MWe).
- Ten-year renewable contracts between independent producers and the System Operator.
- Redefinition of the basic components of a feed-in tariff system for RES electricity pricing.

According to the Law 2273/99, a production license is necessary for all the electricity producers, except for those with small power plants of capacity up to 20 kWe. Over the last four years, investor interest for RES installations has grown significantly and the Greek Regulatory Authority for Energy (RAE), also established by Law 2773/99, has issued till the end of 2003 a considerable number of production licences as shown in Figure 6, which presents also the installed capacity of RES power plants till the end of 2003.

[3] IEA Renewables Information 2003 (data of up to year 2001)
[4] IEA Renewables Information 2003 (data of up to year 2001)

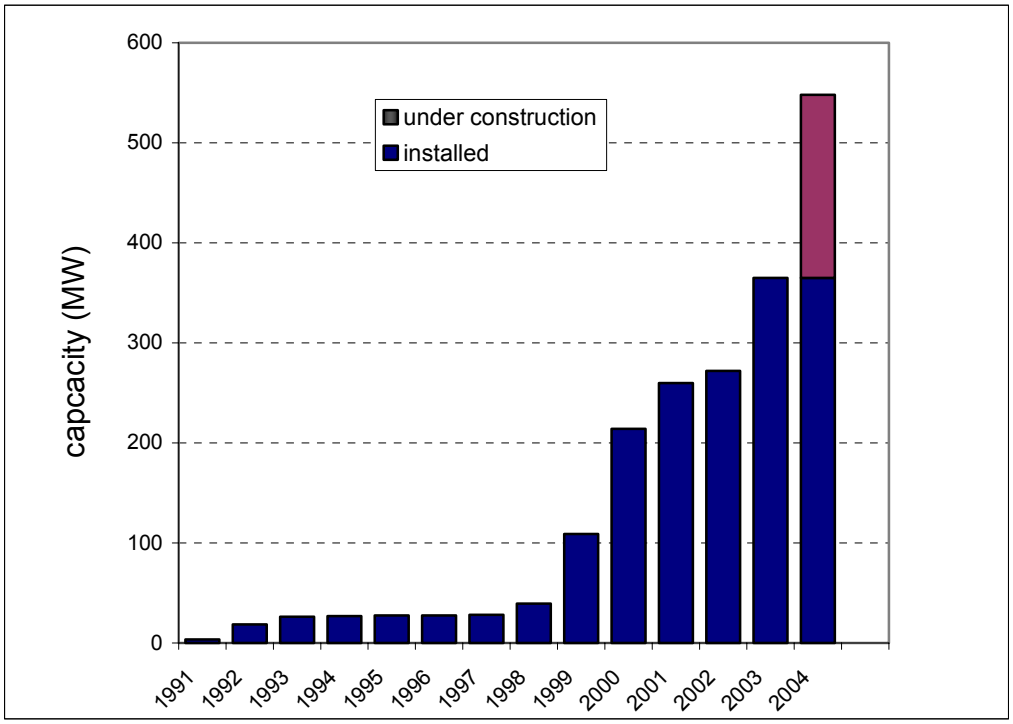


FIGURE 5 The development of wind power plants

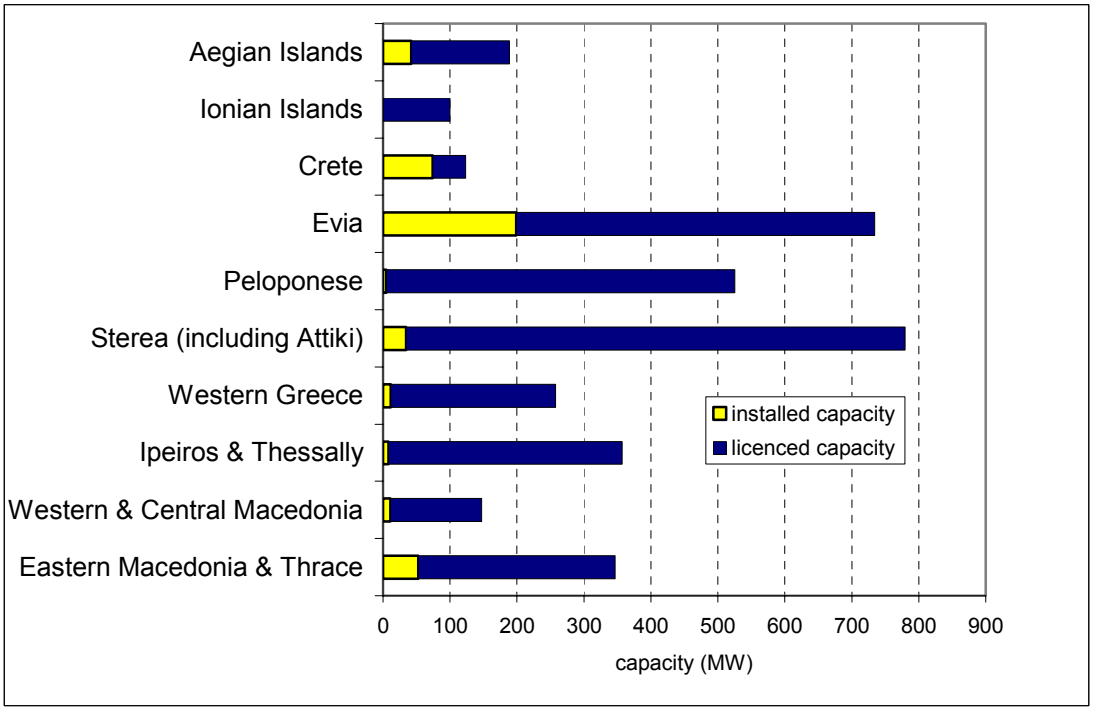


FIGURE 6 Regional licensed and installed capacity of RES power plants by the end of 2003.

Figures 6 and 7 show the licensed and installed capacity of RES power plants as it is distributed in 10 geographical regions of Greece and per type of RES technology (small

hydro, biomass/geothermal/Photovoltaic, Wind). As shown in Figure 8, by the end of 2003, wind turbines represented 84% of RES installed capacity, 10% was due to small hydro plants while the remaining 6% was small biomass plants and grid connected photovoltaic systems.

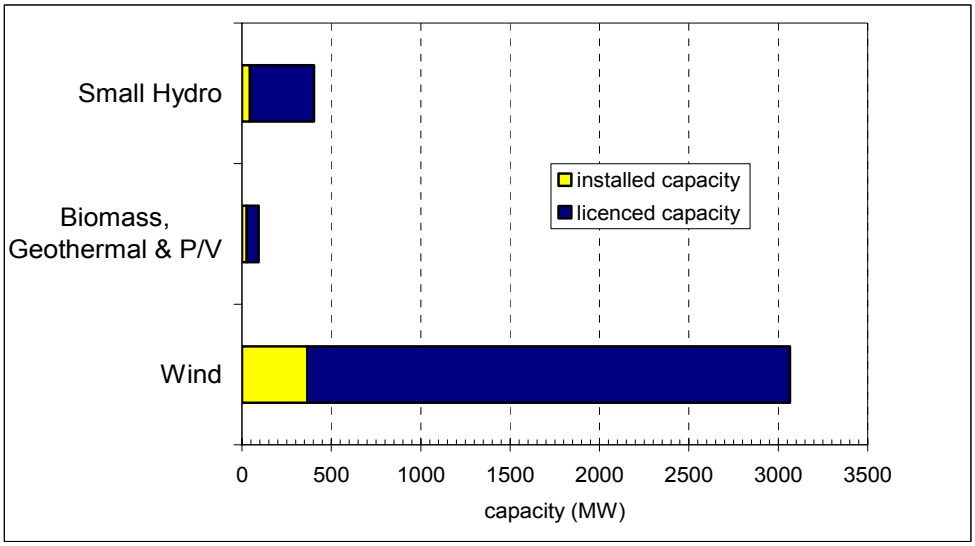


FIGURE 7 Licensed and installed capacity of RES power plants by the end of 2003 per type of RES.

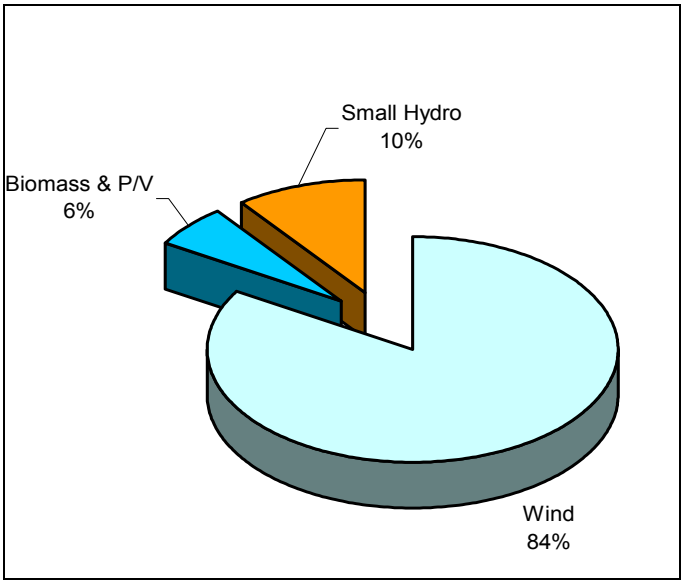


FIGURE 8 RES Installed capacity by the end of 2003

Increased investor interest in hydro and wind energy generation is due to the sufficient availability of these renewable energy sources in selected regions of the Greek territory, to the fact that hydro and wind energy generation technology is moderately mature and also due to a relevantly high subsidy (40% and 30% of their installation cost respectively plus additional subsidies for connection costs). However, in Non Interconnected Islands, that is in islands

with autonomous systems not connected to the mainland grid, wind energy penetration cannot exceed a limit of about 15% of the local energy consumption due to restrictions related to the impact of wind produced energy to the island grid.

The development of the rest of RES is slower, as it can be concluded from the above diagrams. The installation of a new 8 MW power plant in the island of Lesvos exploiting geothermal power has been approved and additional proposals for the use geothermal power for electricity generation of up to 120 MW in the Milos-Kimolos-Polyaigos island complex and up to 50 MW in Nisiros are currently reviewed by RAE. However, the geothermal energy development is expected to be promoted by the enforcement of the recent Law 3175/2003, which encourages the exploitation of geothermal sources providing the legal framework.

The first power stations in Greece producing electrical energy from biomass have been already constructed with a capacity of 24 MW. A further capacity of about 100 MW may be in operation up to 2006 with most plants allocated in the vicinity of towns for exploitation of the municipal waste.

Despite of the excellent solar potential of Greece, development of PV systems for electricity generation has been hindered due to their high installation cost. In contrast, solar energy for thermal applications has been exploited extensively over the last 25 years with more than 3.000.000 m^2 of solar water-heater panels. Regarding PV systems, the new PV systems licensed within the period 2001-2003 for supply to the grid amount to a total capacity of 1.65 MW as summarised in Table 1.

TABLE 7 Licensed P/V Systems

Area	**Number of Projects**	**Power (MW)**
Crete	8	0.89
Central Macedonia (Kilkis)	2	0.6
Attiki	1	0.16
TOTAL	**11**	**1.65**

Since the 1990's, the progress in the penetration of RES in the Greek electricity market has been financially supported by the Renewable Energies Sub-Programme of the Operational Programme for Energy (OPE). The first part of the programme, from 1994 to 1999, initially involved two calls for proposals and funded 82 Projects of 241 MW_e and 91 MW_{th} total capacity from a budget of 340 M€.

The second part of the OPE, started in 2000 and ending in 2006, has an allocated budget of 505 M€. As in the previous programme, the maximum subsidised rates vary as a function of the type of RES plant with values of up to 50% for PV systems, 30% for wind power plants and 40% for hydro-plants.

3. Long Term Energy Planning of Greece for the period 2001-2010

3.1 Introduction

In accordance with article 3 of law 2773/1999 re "Liberalization of the electricity market, regulation of energy policy matters and other articles", the Regulatory Authority for Energy in order to form an opinion and propose to the Minister of Development the Long Term Energy Plan of Greece, has prepared the 'Draft for the Long Term Energy Planning of Greece for the period 2001-2010' which has been put to public debate.

The analytical part of the Long Term Energy Planning includes quantitative scenarios of the development of the energy system of Greece, in which all sectors of consumption, production and supply of energy are included together with all forms of energy. Each scenario contains a future projection on the energy balance of Greece for a five-year period until 2030, as well as an evaluation of the cost and prices of energy products and evaluations for the type and size of the investments within energy structures. The quantitative analysis was based on the mathematical model PRIMES for the energy system and on the statistical data as published by EUROSTAT of the European Commission.

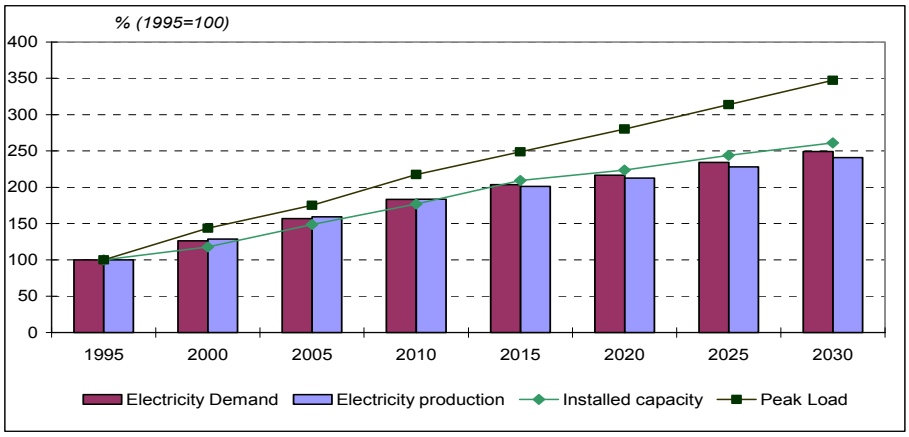
The Baseline Scenario is based on the hypothesis that the existing energy policy will continue without significant turnabouts and deviations. Included in this policy are the full liberalization of electricity and gas markets, the further improvement of technological energy, but without significant accomplishments that would be able to change the structure of the energy balance (as for example, nuclear fusion or fuel cells) the continuation of enhancement of the Renewable Energy Sources (RES) and cogeneration, the expansion of the network of natural gas, the implementation of agreements between the European Union and car industries for the vehicle emissions and the implementation of existing European Directives for the large combustion installations and quality of fuels. Also, it is assumed that there will not be a change in the existing regime of fuel taxation.

The Baseline Scenario anticipates also that there will be a sufficient fuel supply for the Greek energy market for the total duration of the period. The assumptions for the future developments of the international energy prices are based on the corresponding acknowledgements of the General Energy and Transportation Directorate of the European Commission. Specifically, the price of oil is expected to be between 18 and 28 dollars a barrel (prices of 2000), whereas the disengagement of natural gas from that of oil is not anticipated, and as a result the average natural gas import price is expected to be in the region of 80% of the respective import price of oil. Finally, the import prices of coal are expected to remain stable.

The evolution of the power generation sector and the environmental consequences according to the baseline scenario are presented in the following chapters.

3.2 The Power Generation Sector – Baseline Scenario

The demand for electricity will increase at a greater rate than the increase rate of the GDP. This phenomenon, which has been observed in Greece for many years, as a developing country, will continue, with a lesser intensity, leading to an average rate of increase for electricity demand of 4% for the current decade, rather than 4.8% in the previous decade. In the long-term, this increase will modulate at 1.4%, maintaining stable rates slightly a little higher than the average European ones. As the expected increase will come, mainly, from the tertiary and domestic sector and to a lesser extent from industry, the average coefficient load of the total electricity demand will decrease and the maximum peak of the load will be transferred to the summer months. The evolution of electricity production and demand is shown in Figure 9.



in GWh	1995	2000	2005	2010	2015	2020	2025	2030
Electricity Demand	35637	44974	55900	65299	72537	77197	83464	88791
Electricity Generation	41291	53139	65696	75717	83058	87724	94167	99464

FIGURE 9 Evolution of electricity production and demand

The increased demand for electricity requires significant investments in new power units. In 2010 the installed capacity must be 50% greater than that of 2000, which is about equal to 11000 MW, and by 2020 it must increase by a further 26%. This means that new units have to be added to the system by 2010 and amount to 5500 MW- about 550 MW per year-including the power stations of PPC SA currently under construction and for the next decade another 4360 MW or 440 MW per year. As a minimum cost solution for the expansion of the potential power generation in the medium term perspective, emerges the combined cycle gas turbines technology with natural gas. Essential prerequisite for this is the competitive price of

natural gas, in conjunction with the competitive operation of the market. The development of installed capacity of power generation plants is presented in Table 8.

TABLE 8 Development of installed capacity of power generation units in the Baseline Scenario

Installed Capacity of Power Plants (MW)						
Plant Type	**1995**	**2000**	**2005**	**2010**	**2020**	**2030**
Lignite	4533	4900	5250	5110	4577	3164
Other conventional thermal plants	2009	2269	2349	2349	1950	979
NG combined cycle plants	275	845	2022	4166	6482	6972
Gas Turbines (diesel/NG)	221	361	857	1054	1255	1726
Coal	0	0	0	22	1408	4940
Large Hydro Plants (without pumping)	2244	2397	2482	2658	2658	3040
Sum of Plants of controlled production	9282	10771	12959	15358	18330	20821
Small Hydro plants	0	10	150	150	216	225
Wind Turbines	30	189	741	958	2280	3126
Other RES	2	3	4	5	7	160
TOTAL	**9314**	**10974**	**13855**	**16472**	**20833**	**24332**

The combined cycle gas turbines units will comprise about 70% of the new power for the current decade, whereas their share in the total installed capacity is expected to reach 25% in 2010 and increase to 29% in 2020. Also significant will be the open cycle gas turbine units capacity, for the peaks, which in the long-term, is expected to reach the level of 7% of the installed capacity. In the long-term, the tendency of hydrocarbon price increases, in conjunction with the improvement of clean coal combustion technologies and the price stability of coal, makes these technologies competitive for base load units. Investments in oil units are not generally anticipated, with the exception of non-interconnected islands (Figure 10).

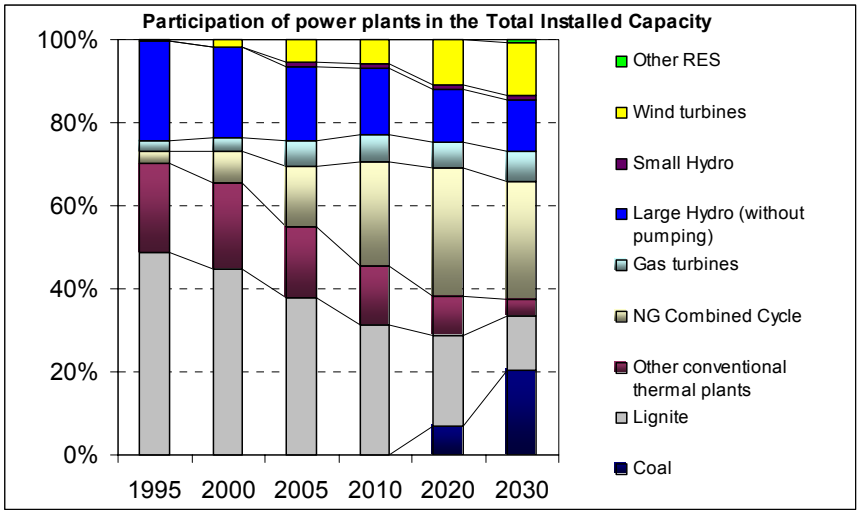


FIGURE 10 Participation of power plants in the Total Installed Capacity

The share of RES in the total power generation of the country will amount to 25% for the whole period under review. But their share in covering the demand in 2010 will be about

10%, significantly below the national target in the framework of the European policy for the development of the RES which is 20.1% for that year (Figure 11). For the decrease of the balance there must be extra effort, with additional support measures of the RES. There will also be a turnabout of the installed capacity R.E.S. from the large hydro-electrical to the smaller and scattered units. Thus, only the installation of about 640 MW of new hydro-electric units is expected over the next thirty years, whereas the capacity from smaller units will exceed 3800 MW, of which more than half will be installed in the current decade and consist mainly of wind-power generators.

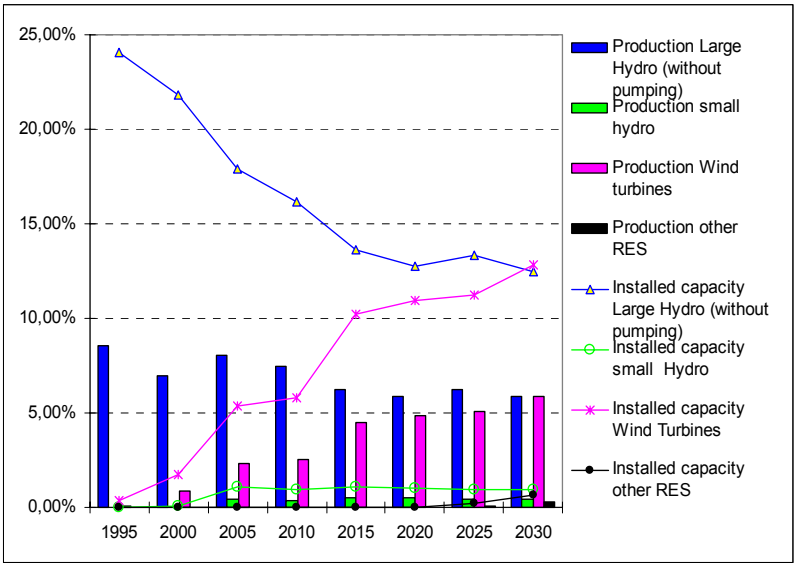


FIGURE 11 Participation of RES in total installed capacity and electricity production

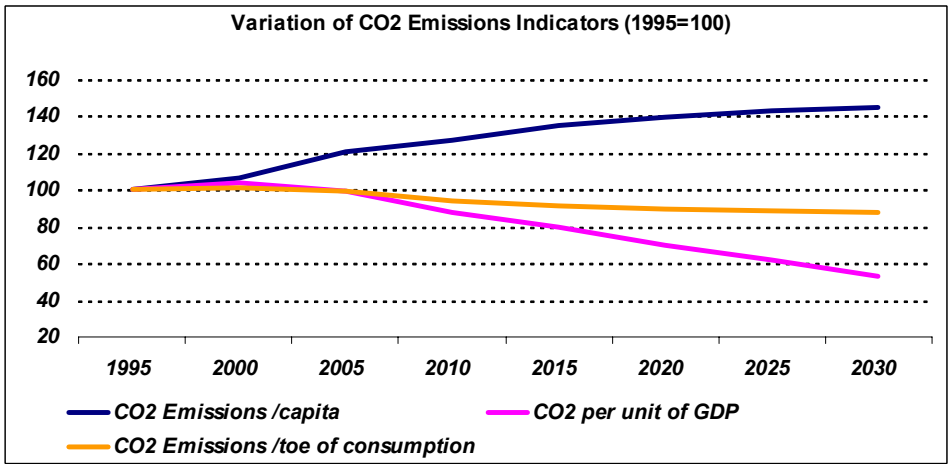
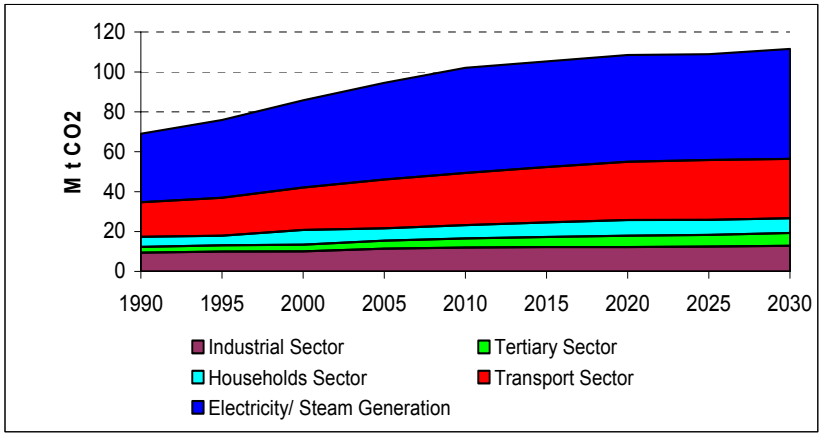


FIGURE 12 Variation of main CO2 Emissions Indicators



(1990=100)

	1990	1995	2000	2005	2010	2015	2020	2025	2030
Industrial Sector	100,0	110,0	125,4	137,5	148,5	153,2	157,8	158,5	162,3
Tertiary Sector	100,0	105,7	106,8	121,5	125,8	129,7	129,9	132,4	136,6
Households Sector	100,0	111,8	117,1	135,0	162,4	175,2	197,5	204,1	220,1
Transport Sector	100,0	93,1	145,4	123,1	132,3	143,9	152,9	147,4	145,2
Electricity/ Steam Generation	100,0	110,5	123,4	142,4	152,0	161,2	170,2	174,2	173,5
Energy Sector	100,0	109,9	159,9	155,4	163,9	171,0	176,4	179,9	181,3
Total	100,0	110,0	125,4	137,5	148,5	153,2	157,8	158,5	162,3

FIGURE 13 Increase of CO2 emissions per sector

3.3. Environmental Consequences – Baseline Scenario

The entry of natural gas into the energy consumption and the development of the renewable energy sources in power generation, in conjunction with the equivalent share decrease of conventional fuel, lead to a small decrease in the intensity of emissions of CO_2 per primary energy consumption unit and to a greater reduction of intensity of emissions in CO_2 per GDP unit as shown in Figure 12.

Despite this, it has not been possible to achieve the objective of decreasing the greenhouse gas emissions to +25%, in relation to the levels of 1990 levels, as the Kyoto Protocol implementation allows for Greece, within the framework of the existing agreement within the E.U. On the contrary, within the framework of the Baseline scenario, the CO2 emissions in 2010 display an increase of 48.5% in reference to those of 1990. The greatest consequence of this increase is evident in the tertiary sector, as well as in the electricity production, due to their great developmental activity as shown in Figure 13.

On the contrary, there is a reduction of emissions of SO_2 and NO_x mainly due to their substitutions and to the new technologies in power generation (Figure 14). The avoidance of CO_2 emissions in power generation sector due to the entry of natural gas entry and RES development is shown in Figure 15.

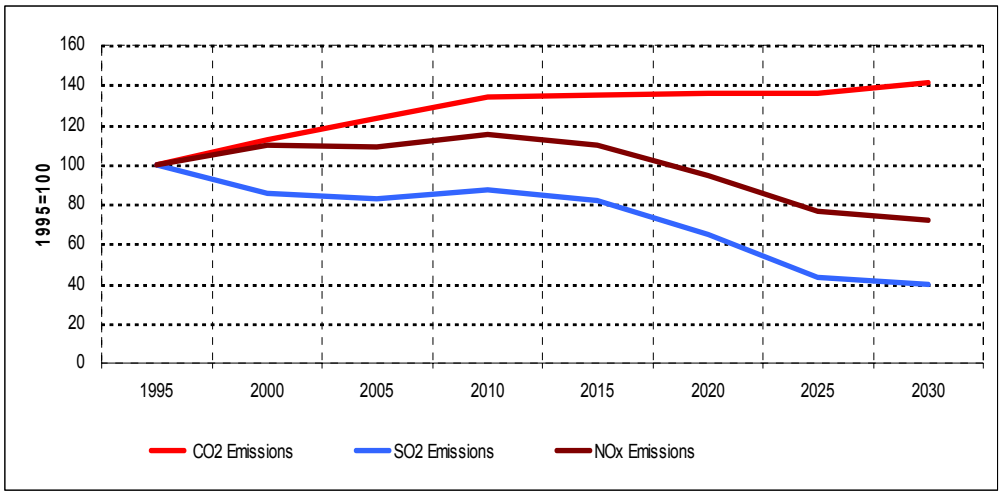


FIGURE 14 Variation of Gas Emissions in Power Generation Sector

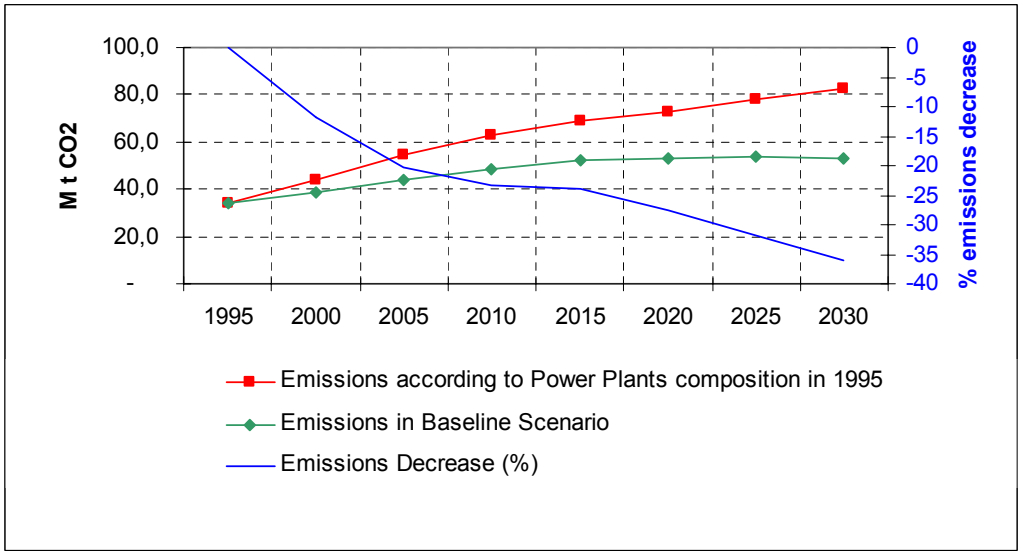


FIGURE 15 Avoidance of CO2 emissions in Power Generation Sector, due to then natural gas and RES entry.