HELLENIC REPUBLIC
MINISTRY OF DEVELOPMENT

ASSESSMENT OF THE NATIONAL POTENTIAL FOR COMBINED HEAT AND POWER IN GREECE

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Tigas Kostas
Prof. Frangopoulos Christos
Theofylactos Kostas

Damassiotis Marc
Spinakis Antonis
Kapiris Marc
Sakellaridis Nikos
Loumakis George

Giannakidis George
Kilias Vassilis
Siakkis Philip
Karystianos Michael

Komioti Niki
Georgiadis Tasos
Aggelis Kostas
Georgakopoulos Dinos
Malamatenios Babis
Zafiris Christos
Christou Mirsini
Karitsas Kostas
Mendrinos Dimitris

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1.1 OVERVIEW OF GREEK ENERGY POLICY

Energy policy in Greece is the responsibility of the Ministry of Development.

The main **targets of Greek Energy Policy** are:

- Ensuring the security of supply for the Greek energy market
- Enforcement of the regulatory and legal framework for the liberalization of the electricity and natural gas markets
- Upgrading the entire electricity sector, including generation, transmission and distribution sub-systems
- Diversification of energy sources through the penetration of natural gas. Extending the natural gas distribution networks
- Achievement of national environmental targets by increasing the shares of renewable energy sources, CHP and energy efficiency.
- Promoting productivity and competitiveness, through environmentally friendly energy investments
- Undertaking a number of initiatives related to the international energy networks that have a particular significance for the geographical areas in the vicinity of Greece.
- Establishing an Official Energy Planning Procedure, involving all the stakeholders.

The main **developments in the Greek energy sector** can be summarized as follows:

Market Reform

Law 2773/99 liberalized the electricity market in compliance with Directive 1996/92/EC. In addition, Law 3175/2003 set the initial basis for the liberalization of the gas market by introducing regulated third party access to the gas transmission system. Important changes have been made in energy legislation with new laws on the liberalization of the electricity and natural gas markets, leading to the incorporation of EU directives 2003/54/EC and 2003/55/EC into Greek legislation. The electricity market Law 3426/2005 and the gas market Law 3428/2005 established the framework for full market liberalization. In electricity, the new Grid and Power Exchanging Code, issued in May 2005, provided the necessary framework for both the efficient operation of the Greek Electricity Transmission System and the Daily Electricity Market. In addition, the new Law enables full account unbundling and the creation of an independent distribution system operator. In the gas sector, the network access tariffs were published in March 2006 in the form of ministerial decree 4955/2006. Special tariffs are granted to peak-load gas turbine power plants through ministerial decree D/23344/2006. Contracting procedures for third-party gas suppliers are defined in ministerial decree D1/1227/2007. Regarding the oil sector, the "Oil Market Law" 3054/2002 and its latest amendment, Law 3335/2005, allow all importers, which can be refineries, trading companies, supply co-operatives, major consumers, and retail stations, to import oil products directly.

Emissions Abatement

The Greek government agreed to the UN Framework Convention in 1994, and became a signatory to the Kyoto Protocol, ratifying the protocol in 2002 with Law 3017/2002. Under the EU burden sharing agreement from 1998, Greece has to restrict the increase of GHG emissions to no more than 25 per cent from base-year levels. The transposition of Directive 2001/80/EC into national legislation was completed in December 2004 with common ministerial decision 54409/2632/2004. In 2005, the European Emissions Trading System, which applies to those industrial and electricity generation plants which exceed specified capacity limits as described in the European directive 2003/87/EC, began operation. In Greece, the foundation and operation of a National Emissions Trading Office was established through the common ministerial decision 54409/2632/2004, based on the directive 2003/87/EC, regulation 2004/2216/EC and decision 2004/280/EC. The first National Allocation Plan (NAP for the period 2005-2007) under which CO_2 emission rights for the EU-ETS are assigned, was published in 2004, and was accepted by the EC in 2005.The second NAP for the period 2008-2012 was published in 2007.

Renewable Energy Sources, Energy Efficiency and CHP

The development of renewable energy sources, energy conservation and CHP are the top priority issues of European energy policy in the effort to reduce CO_2 emissions and safeguard energy supply. Greek energy policy includes the implementation of all the necessary policies in order to meet the targets set by the EU directives for energy conservation, CHP and electricity generation from renewable energy sources.

Concerning electricity generation from renewable energy sources, Greece is required to achieve a contribution of renewable energy sources to gross final electricity consumption of 20.1% for the year 2010 (including generation from large hydroelectric plants). Electricity generation from renewable energy sources is regulated through the legal framework for the liberalization of the electricity market in Greece. The same legal framework regulates CHP and gas Law 3175/2003 covers heat distribution networks (district heating). The new Law 3468/2006 governing renewable energy sources and high efficiency CHP is of special significance. The purpose of this law is the enactment of the use of modern instruments, procedures and means of carrying out energy policy, which promote energy generation from renewable energy sources and high efficiency CHP installations. Lastly, Law 3423/2005 transposed the EU target of 5.75 % biofuels into Greek legislation. Law 3661/2008 is transposing the EPBD into the greek legislation.

The Greek government's policy priorities are the promotion of energy efficiency in the industrial, residential and commercial sectors, with particular emphasis on increasing energy end-use efficiency and fuel substitution by natural gas. In the transport sector, the emphasis is on improving the transport infrastructure and on measures related to more efficient fuel use and less- polluting vehicle technology. In electricity, the focus of energy efficiency policy is on increasing power station efficiency, avoiding black-outs through high peak demand, and on the promotion of CHP and consumer awareness. Greek energy efficiency policy is primarily driven by EU directives. EU energy efficiency standards legislation have been transposed into Greek law. A target of 9% over the next nine years was set in Directive 2006/32/EC and the Member States are required to establish National Energy Efficiency Action Plans by the end of June 2007. A new Law has also been drafted leading to the incorporation of the CHP directive 2004/8/EC into Greek legislation.

National Energy Planning

Law 3438/2006 provides the legal framework for national energy planning. A National Energy Strategy Council has been established as the consultative body responsible for drafting long term energy policy.

Financial Support Measures

Over the last several years, the main financial support structures for energy investments were the Operational Programme for Energy (2nd CSF), the Development Law and the Operational Programme for Competitiveness (3rd CSF).

<u>Development Law 3299/2004</u>
Law 3299/2004 aims to strengthen economic development in Greece by providing fiscal incentives. Its implementation is managed by the Ministry of the Economy. It provides subsidies for industrial and tertiary sector investments in energy saving, for example, for the exploitation of agricultural, industrial and municipal wastes and effluents. The law also supports the creation of grant programmes for energy efficiency, and subsidies for the production of electricity through the exploitation of renewable energy sources, as well as CHP. The law was amended at the end of 2006 (article 37, law 3522/06) and the investment subsidies in the form of cash grants, leasing subsidies or tax exemptions, range from 20 to 60 per cent of the total investment, depending on the geographical location of the project (3 different investment zones across Greece) and the size of the enterprise making the application.

<u>Operational Programme for Competitiveness</u>
The OPC includes a programme of support for energy efficiency as well as for renewable energy, CHP, and the substitution of oil by natural gas. If the objectives of the programme are achieved, it will result in improved energy efficiency and reduced energy intensity. The total available budget for energy-related investment under the OPC is 1070 million € of which 367 million € is from Greek public funds, with a forecast of primary energy savings of 695 ktoe per year, equivalent to two per cent of Greek TPES, and CO_2 savings of 5 mt CO_2 per year. It is not expected that more than 70 per cent of the objective will be achieved. An additional 283 million €, including public funds of 114 million €, are available to further

increase the use of natural gas in all sectors of the economy.

Law 3468/2006

The new Law 3468/2006, for the Production of Electricity from Renewable Energy Sources and High-Efficiency Cogeneration of Electricity and Heat and Miscellaneous Provisions, is targeted to speed up the licensing procedures and to reform electricity generation from renewable energy sources and CHP. This new law creates a new reality and is a landmark in the generation of electricity from geothermal sources, wind farms, photovoltaic systems, hydroelectric stations and High Efficiency CHP.

Guaranteed market prices are provided as financial incentives for RES and CHP investments together with restructuring of the corresponding deadlines for installation & operation license permits in order to speed up the whole procedure.

Tax incentives for fuel switching

Law 3296/2004 provides for incentives to promote the use of natural gas and renewable energy sources through a 20 per cent reduction of taxable income on the expenses for the purchase and installation of domestic appliances or systems using natural gas or renewable energy sources. It applies to the whole residential and tertiary sector. This law has the secondary effect of modernising heating equipment at the time as the fuel switch, leading to higher energy efficiency.

ESCOs/Third Party Financing (TPF)

Third party financing has been discussed by the government as an effective market-oriented instrument. Current Greek legislation does not allow for the creation of energy service companies (ESCOs). A legal framework is now being developed by the Ministry of Development and is expected to be implemented in the near future, following the transposition of EU directive 2006/32/EC, on energy end-use efficiency and energy services. Preferential treatment is given to proposals for environmental and energy projects based on TPF which are submitted to the OPC, or under the development law 3299/2004.

1.2 THE GREEK ENERGY SYSTEM

1.2.1 Basic Statistics on the Greek Economy

Greece is a member of the Euro-Zone and is located on the farthest southeastern edge of the European Union. It has an area of 132,000 sq. km and geographically it is divided into the mainland and a total of 2000 islands, the largest of which are Crete and Rhodes.

The population of Greece is 11 million inhabitants, according to the 2001 census, 66% of which live in urban areas. In particular, 35.5% of the Greek population lives in Attica (4 million) and of these, 2.8 million live in Athens.

The special geomorphology of the country (many islands, large mountainous areas) with the resultant uneven distribution of the population creates additional difficulties in the development of energy infrastructure which is required for the achievement of the goals of the national energy policy.

Greece is located at a distance from the rest of the European Union, with the exception of Italy, and thus it has developed energy interconnections, mainly with non-European countries, such as Albania, the FYROM and Turkey.

The main economic activities in Greece are shipping and tourism. A large portion of the population is employed in the public sector and services, 20% in industry and 12% in the industrial sector.

Between 1990 and 2005, the GDP in Greece increased by 45%, showing an average yearly rate of increase of 2.5%. In the same period, the increase in added value for all the sectors of economic activity was also significant. Added value in the tertiary sector increased by 136%, and added value in the industrial and agricultural sectors increased by 48% and 14%. Consumption by households increased by 45% compared to the 1990 levels (Figures 1.2.1.1, 1.2.1.2).

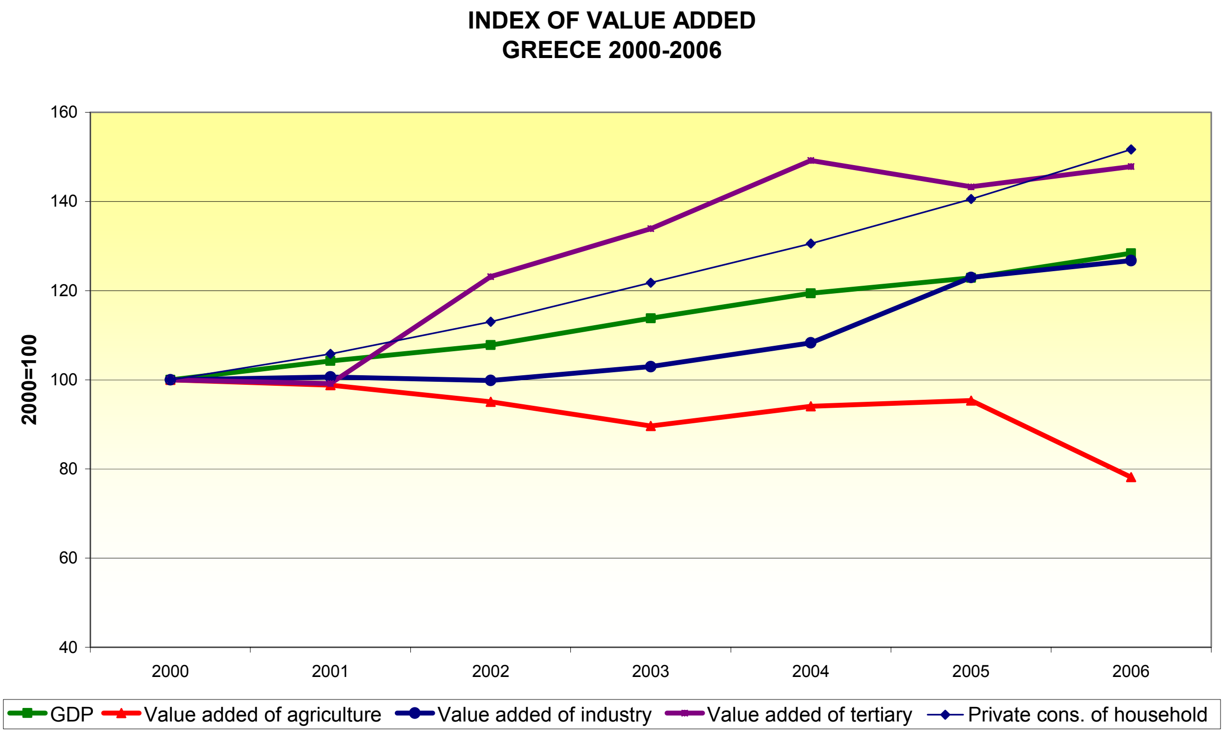


Figure 1.2.1.1: GDP and Value Added per Sector of Economic Activity 2000-2006 (M€ const. values **2000)**

1.2.2. Overview of the Energy Sector

In 2006, Total Primary Energy Supply (PES) in Greece reached 31.5 Mtoe (Figure 1.2.2.1). This is a 40% increase over the 1990 levels when gross national consumption was 22.3 Mtoe. Over the last decade (1995-2006), the average yearly rate of increase was 2.7%.

Lignite is the main domestic energy source which is used almost exclusively for electricity generation. Petroleum and lignite cover approximately 84.4% of the total primary energy supply, which shows a steady increase in recent years (Figure 1.2.2.1). Natural gas first appeared in 1995, and renewable energy sources started to be an important source of electricity generation at the end of the 1990s. Greece's energy dependency was about 72% in 2006, mainly due to imports of petroleum and natural gas.

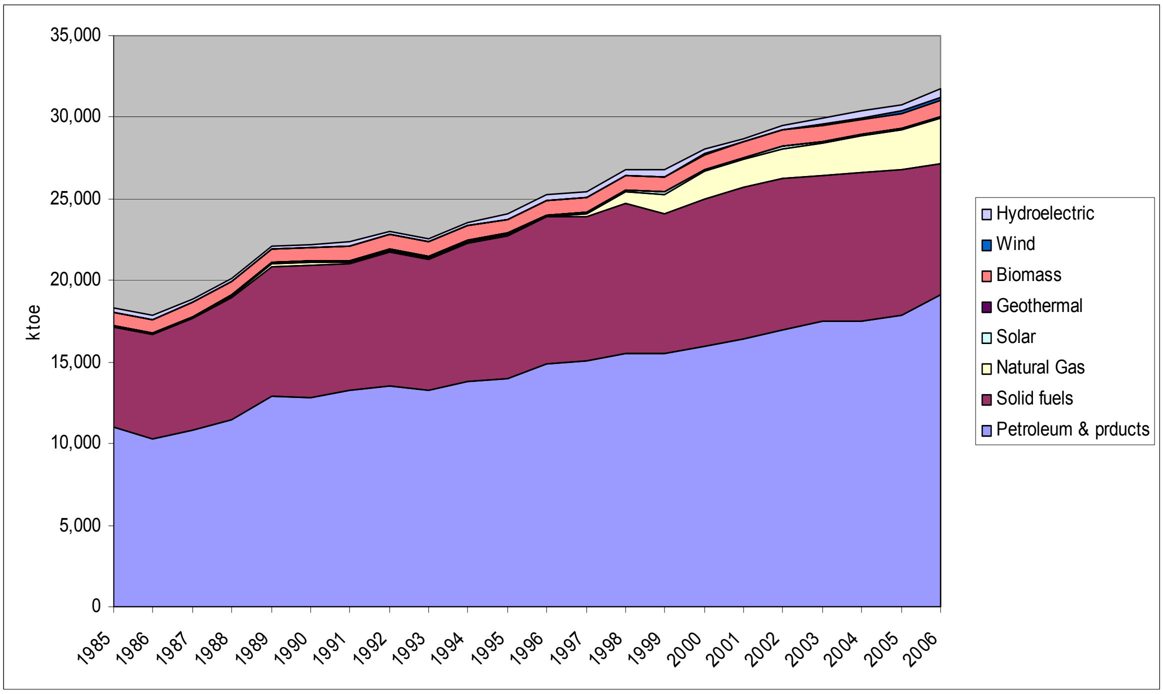


Figure 1.2.2.1 : Total Primary Energy Supply

Petroleum products cover 68.5% of final energy consumption, electricity 21%, while solid fuels account for smaller percentages, 1.87%, mainly in industry, renewable energy sources for 5% and natural gas for 3.2%.

The final consumption in the transport sector accounted for 39.6% of the total final consumption in 2006, equivalent to 8.5 Mtoe, and this is an increase of 2.7 Mtoe, over 1990. The percentage of household sector final consumption has increased significantly, and so has the tertiary sector, showing a large, steady increase in consumption. The combined tertiary, household, public and agricultural sectors consumed 46% of the energy in 2006, while the equivalent in 1990 was 40%. Industrial consumption, which was 4.2 Mtoe in 2006, representing an increase of 0.2 Mtoe or 5% compared to 1990, has remained steady in recent years. (Figure 1.2.2.2).

Primary energy intensity was 0.18 kgoe/ECU 00 in 2006, and the final energy intensity was 0.12kgoe/ECU 00 while the per capita energy consumption in 2006 was 2.14 Mtoe.

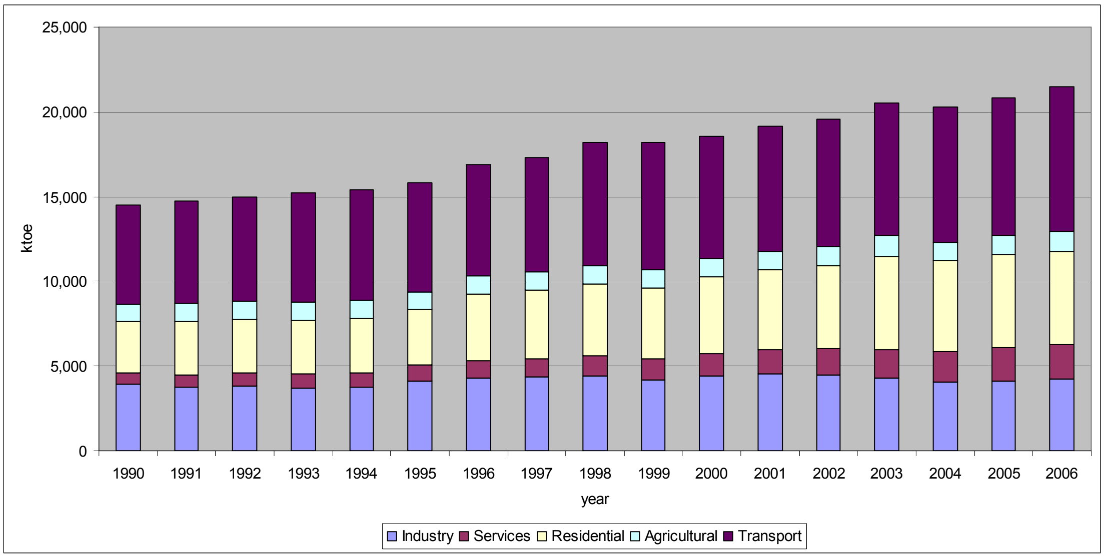


Figure 1.2.2.2: Final Energy Consumption

1.2.3. Solid Fuels

The main domestic energy source is low calorific value lignite with an output of 960-1300 kcal/kg and which is used almost exclusively for electricity generation. Small amounts are used in metal working industries, in handicraft industries, in greenhouses and for heating homes in areas near the deposits. Lignite is produced in mines owned by the PPC S.A. and a small percentage (3-5%) is produced by small, privately owned lignite mines. It is estimated that the total lignite reserves are around 3200 million tons, 90% of which are located in northern Greece. A small amount of coal is imported and is used mainly in the cement industry.

1.2.4 Petroleum Products

The Greek petroleum market consists of four refineries, around fifty wholesale companies and a large number of retail outlets. Crude petroleum is almost exclusively imported, except for small amounts produced by oil wells in northern Greece. The production capacity of the four refineries, about 20 million metric tons a year, is sufficient to cover demand in the domestic market and additional amounts are exported in the form of international sales or sales to airlines and ocean going vessels.

In 2006, petroleum products accounted for 18.2 Mtoe or 16789 TJ (Table 1.2.4) which corresponds to 57.8% of gross national consumption, which is almost 100% imported. The amount, 57.8%, was approximately the same in 1990 (the numbers refer to primary energy supply of crude, feedstocks and petroleum products).

In 2006, final consumption of petroleum products was 14.7 Mtoe or 68.5% and has remained at the same levels as 1990 (69%). The transportation sector consumed 57% of the petroleum products in final consumption, the residential sector 20%, the tertiary and agricultural sectors 10% and lastly, industry 13%.
The percentage of petroleum products in the Greek energy balance is very high, and this is due to the heavy use of petroleum products in transportation and also to the fact that the electricity generation system in the non-connected islands uses petroleum products as the main fuel source. However, it is anticipated that the increased penetration of natural gas in the coming years will reduce the usage of petroleum products.

1.2.5 Natural Gas

The introduction of natural gas into the Greek energy system was the most important energy project after the electrification of the country. The system is fed mainly by Russian reservoirs through the Greek-Bulgarian border and secondarily, in the form of liquefied natural gas from Algeria, with a present total capacity of 4.3 bcm/year. Before the end of 2007, the pipeline connection with Turkey will be completed and the pipeline connection with Italy is scheduled to be completed before 2010. Lastly, it is anticipated that the expansion of the terminal on the island of Revythousa will be completed before the end of 2007. It is expected that natural gas will penetrate into the electricity generation sector as well as into final consumption. Simultaneously, it will contribute to the reduction of CO_2 emissions from the electricity generation sector by replacing lignite and petroleum and in the consumption sector by substituting for petroleum products and electric power.

The supply of natural gas in Greece rose by 28% from 7,160 TJ in 1997 to 115,022 TJ in 2006. (Table 1.2.5). Natural gas covered 8.7% of gross domestic consumption in 2006 and it is anticipated to surpass 14% in 2010, due on the one hand, to consumption in all sectors of economic activity, and on the other, to heavy use for electricity generation (about 70% of the present gas consumption).

The penetration of natural gas in final energy consumption increased in 2006 by 132% over the 2000 levels. Industry accounts for 65% of the final consumption of natural gas. The rate of increase of the penetration of natural gas over the last five years is around 18%.

Table 1.2.4a : Balance of Oil Products 1990-2006 (ktoe)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total Inland Consumption	**12942**	**13373**	**13615**	**13411**	**13897**	**14006**	**14974**	**15122**	**15592**	**15627**	**16007**	**16499**	**17057**	**17619**	**17612**	**18063**	**18207**
Total Transformation Sector	**18398**	**17271**	**18150**	**16315**	**18545**	**20003**	**22548**	**22845**	**23198**	**21070**	**24588**	**23696**	**23595**	**24435**	**23133**	**23566**	**24684**
Independent power producers Ανεξάρτητοι	1677	1810	1783	1823	1786	1932	1907	1846	1794	1856	1950	1853	1921	1953	1796	1960	1997
Autoproducer electricity plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IP CHP plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	5
Autoproducer CHP plants	34	167	184	176	201	144	116	120	112	102	165	103	111	111	118	91	82
IP heat plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Autoproducer heat plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Refineries	16670	15279	16163	14295	16532	17901	20505	20858	21278	19112	22473	21740	21563	22371	21215	21510	22600
Gas Plants	17	15	20	21	26	26	20	21	14	0	0	0	0	0	0	0	0
Final Consumption	**10073**	**10135**	**10328**	**10466**	**10490**	**10837**	**11761**	**12066**	**12715**	**12683**	**12631**	**13042**	**13374**	**14303**	**13933**	**14278**	**14691**
Total transport	5809	5980	6151	6455	6445	6432	6561	6725	7293	7452	7193	7355	7447	7787	7946	8056	8425
Total industry	1683	1490	1624	1503	1517	1849	2042	2099	2069	1924	1943	1922	1976	1970	1718	1798	1938
Commercial and public services	160	209	197	188	194	211	255	246	249	240	245	317	318	343	365	442	451
Residential	1484	1476	1448	1437	1445	1519	2062	2156	2264	2226	2409	2596	2698	3203	3050	3108	2958
Agriculture/forestry	887	977	909	883	889	825	841	840	840	840	840	852	935	1000	854	874	919
Non-specified (other)	50	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Non-Energy Use	**487**	**433**	**446**	**429**	**427**	**452**	**463**	**477**	**419**	**428**	**598**	**640**	**677**	**694**	**748**	**633**	**777**

Table 1.2.4b : Oil Products-Analysis of Final Consumption 1990-2006 (GWh)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Final Consumption	**117048**	**117781**	**120024**	**121615**	**121895**	**125916**	**136663**	**140208**	**147750**	**147377**	**146762**	**151548**	**155406**	**166211**	**161912**	**165910**	**170710**
Total Transport	**67501**	**69488**	**71475**	**75007**	**74892**	**74741**	**76240**	**78145**	**84746**	**86604**	**83583**	**85464**	**86534**	**90495**	**92344**	**93610**	**97898**
International Aviation	14688	13514	14107	17012	15850	14479	14293	13793	13956	14920	15397	13839	13409	13502	14037	13723	15048
Road	45469	48665	49861	51058	51744	53406	55985	57287	60157	61226	61981	63352	65607	69557	70022	71916	74147
Rail	744	523	558	569	616	511	535	500	500	476	476	476	476	476	476	476	488
Domestic Navigation	6600	6786	6949	6368	6682	6345	5427	6565	10133	9982	5729	7797	7042	6960	7809	7495	8215
Total Industry	**19556**	**17314**	**18871**	**17465**	**17628**	**21485**	**23728**	**24390**	**24042**	**22357**	**22578**	**22334**	**22961**	**22891**	**19963**	**20893**	**22520**
Iron and Steel	1604	244	1313	1267	1197	732	407	465	546	593	604	616	627	651	302	58	70
Chemical and Petrochemical	1708	1174	1290	1127	1208	1162	1964	2324	2847	1766	1836	1720	1627	1569	1964	1929	2092
Non-Ferrous Metals	2057	1975	2068	2034	1917	2440	2777	2487	2719	3556	3091	3091	3137	3172	3044	2394	2615
Non-Metallic Minerals	3254	2940	3498	3846	3881	4462	4543	5334	4206	4021	4532	4880	5427	5415	6554	6763	6751
Transport Equipment	0	23	23	23	23	139	337	279	372	383	407	395	395	349	302	314	349
Machinery	755	302	627	616	639	1336	1406	1301	1197	1243	1255	1232	1290	906	779	767	767
Mining and Quarrying	3068	2963	3219	3312	3161	3312	3498	3184	3521	3021	3312	3114	3091	3323	2463	1789	1987
Food and Tobacco	1069	918	1011	953	895	755	1057	1243	1069	1127	1301	1127	1116	1127	674	627	720
Textile and Leather	1429	1092	1371	1243	1174	1185	1685	1569	1197	988	1150	964	953	860	720	662	558
Non-specified (Industry)	4602	5659	4450	3033	3416	5961	6054	6217	6379	5659	5090	5183	5299	5520	3172	5589	6600
Commercial and Public Services	**1859**	**2429**	**2289**	**2185**	**2254**	**2452**	**2963**	**2859**	**2893**	**2789**	**2847**	**3684**	**3695**	**3986**	**4241**	**5136**	**5241**
Residential	**17244**	**17151**	**16826**	**16698**	**16791**	**17651**	**23960**	**25053**	**26308**	**25866**	**27993**	**30166**	**31351**	**37219**	**35441**	**36115**	**34372**
Agriculture/Forestry	**10307**	**11353**	**10563**	**10260**	**10330**	**9587**	**9772**	**9761**	**9761**	**9761**	**9761**	**9900**	**10865**	**11620**	**9923**	**10156**	**10679**

Table 1.2.5a : Balance of Natural Gas 1990-2006 (TJ)

NCV (TJ)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total Inland Consumption	**5783**	**5713**	**5279**	**3893**	**1992**	**1837**	**2064**	**7160**	**30372**	**50994**	**71366**	**70466**	**75408**	**54835**	**93314**	**98538**	**115022**
Total Transformation	**756**	**743**	**653**	**636**	**622**	**584**	**689**	**2939**	**14758**	**36280**	**53598**	**52963**	**56429**	**62115**	**66951**	**67211**	**79089**
Independent Electricity Producers	0	0	0	0	0	0	0	1913	14267	35735	52324	51865	55058	61214	66404	66259	78354
Autoproducers Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	237	237
Autoproducers CHP	756	743	653	636	622	584	689	1027	491	545	1274	1098	1372	902	547	952	735
Energy Sector	**981**	**1103**	**950**	**887**	**1134**	**1094**	**1080**	**1065**	**1195**	**53**	**1397**	**1315**	**1462**	**1331**	**1535**	**1293**	**1351**
Total Final Consumption	**4046**	**3866**	**3677**	**2370**	**236**	**158**	**295**	**3071**	**14383**	**14629**	**15860**	**15768**	**17493**	**21331**	**24616**	**29736**	**34228**
TFC Energy Uses	**0**	**0**	**0**	**0**	**0**	**0**	**145**	**1390**	**5953**	**8431**	**10770**	**13289**	**14461**	**16140**	**19319**	**24474**	**28728**
TFC non Energy Uses	**4046**	**3866**	**3677**	**2370**	**236**	**158**	**150**	**1681**	**8430**	**6256**	**5072**	**2479**	**3032**	**5175**	**5495**	**5363**	**5427**

Table 1.2.5b : Natural Gas-Analysis of Final Consumption 1990-2006 (GWh)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Final Consumption	**0**	**0**	**0**	**0**	**0**	**0**	**35**	**383**	**1650**	**2336**	**2986**	**3684**	**4009**	**4474**	**5357**	**6798**	**7971**
Total Transport	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**70**	**116**	**128**	**128**	**139**	**151**
Road	0	0	0	0	0	0	0	0	0	0	0	70	116	128	128	139	151
Total Industry	**0**	**0**	**0**	**0**	**0**	**0**	**35**	**383**	**1499**	**2208**	**2835**	**3416**	**3591**	**3811**	**4334**	**4950**	**5171**
Iron and Steel	0	0	0	0	0	0	0	23	337	569	639	744	767	686	767	813	790
Chemical and Petrochemical	0	0	0	0	0	0	0	0	35	93	81	105	198	256	337	616	500
Non-Ferrous Metals	0	0	0	0	0	0	0	0	70	302	453	407	465	604	627	732	593
Non-Metallic Minerals	0	0	0	0	0	0	0	23	302	325	453	744	790	697	767	802	1081
Machinery	0	0	0	0	0	0	0	0	0	0	0	23	25	0	8	21	
Mining and Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Food and Tobacco	0	0	0	0	0	0	35	291	453	616	732	604	627	802	953	1267	1464
Paper, Pulp and Print	0	0	0	0	0	0	0	12	105	70	139	221	291	325	360	314	383
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textile and Leather	0	0	0	0	0	0	0	23	186	198	244	349	314	349	349	221	209
Non-specified (Industry)	0	0	0	0	0	0	0	0			58	198	139	105	151	163	128
Commercial and Public Services	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**151**	**81**	**105**	**139**	**209**	**325**	**511**	**860**	**1046**
Residential	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**46**	**58**	**58**	**105**	**221**	**407**	**848**	**1615**

1.2.6 Electricity

The Greek electricity system is divided into the grid connected system of the mainland and the island system consisting of Crete, Rhodes and the Autonomous Power Generation Plants of the other islands.. The systematic exploitation of lignite deposits in northern Greece and in the Peloponnese was a top priority of energy policy after the oil crises. Thus, demand in the grid connected system of the mainland is met by generation plants which use domestic energy sources, both lignite and hydroelectricity, and in the independent island systems, by autonomous petroleum combustion units, and more recently, by wind farms. In northern Greece, there are 17 units with an installed capacity of 4052 net MW and in the Peloponnese, there are 4 units with an installed capacity of 756 net MW.

Table 1.2.6.1 Analysis of Electricity Generation Capacity for the year 2006 (MW)

Fuel	Installed Capacity MW	Net Capacity MW	Mainland System (net) MW	Island of Crete (net) MW	Island of Rhodes (net) MW	Non-connected islands (net) MW
Wind	751,5	751,5	549,2	136	15,3	51
Biomass	30,7	30,7	30,3	0,4		
Hydroelectric	3135	3135	3134,4	0,6		
Natural Gas	2518	2454	2454	-	-	-
Oil Products	2317	2131,7	718	693,4	199	521,3
Lignite	5288	4808	4808	-	-	-
CHP	243	243	243	-	-	-
Total	**14283,2**	**13553,9**	**11936,9**	**830,4**	**214,3**	**572,3**

Table 1.2.6.2 Analysis of Electricity Generation for the year 2006 (MW)

Fuel	Net Generation Total (GWh)	Mainland System (GWh)	Island of Crete (GWh)	Island of Rhodes (GWh)	Non-connected islands (GWh)
Wind	1683,4	1199,4	348	24	112
Biomass	65,5	65	0,5	-	-
Hydroelectric	6484	6484	0,2	-	-
Natural gas	10169	10169	-	-	-
Oil Products	8045	3309	2472	674	1590
Lignite	29165	29165	-	-	-
CHP	983	983	-	-	-
Total	**56595**	**51374,4**	**2820,7**	**698**	**1702**

Lignite plants account for 36% of the total installed capacity in the year 2006, petroleum plants 16.3%, natural gas plants 18.4%, hydroelectric plants 23.4% and wind farms 5.6%.
In the year 2006, gross electricity generation was about 60 TWh, of which 54% was from lignite, 14.3% from petroleum products, 17.5% from natural gas, 11,3 % from hydroelectric power and 2.8% from wind power. Electricity generation has increased by 71% from 1990 when it was 35 TWh with an average yearly rate of increase of about 3.5%. The greatest increase was in the use of lignite, with a generation of 25 TWh in 1990 and 32 TWh in 2006. The most significant change over the last few years was the penetration of natural gas which was 10.5 TWh in 2006. The remaining electricity is generated by the use of petroleum products, hydroelectric power, and by the recent development of wind farms, while lately there has been an increase in imports.
The demand for electricity in Greece increased at a high rate after 1990 (Tables 1.2.6.3). The main increase occurred in the household and tertiary sectors. Specifically, the tertiary sector in 2006 was the largest electricity consumer in Greece with an annual consumption of 17.7 TWh. This is a percentage increase of approximately 216% compared to 1990 levels. While industry was the largest consumer in 1990, in 2006 it fell to 3rd place with a consumption of 14.1 TWh and a percentage increase of 14% in relation to 1990 levels. Hoysehold sector consumption as a share surpassed that of the industrial sector. It consumed 17.6 TWh in 2006, showing a 7.7% average yearly rate of increase and a total increase of 93%.

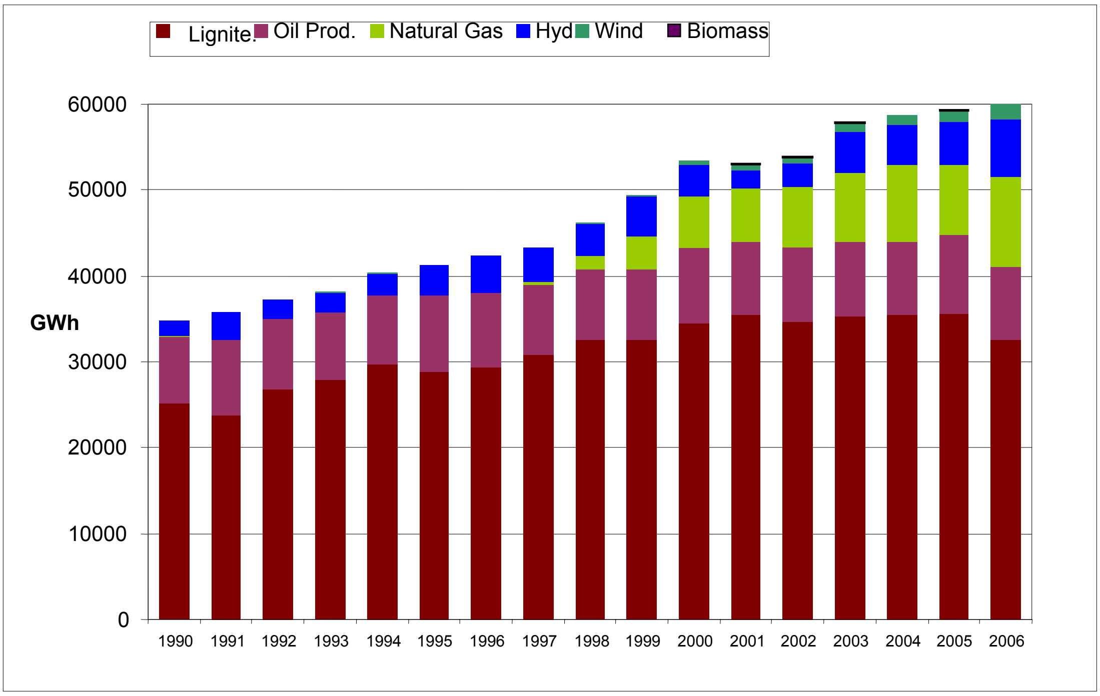


Figure 1.2.6 : Electricity Generation by Fuel (1990-2006)

Table 1.2.6.3 : Electricity Final Consumption by Sector 1990-2006 (TWh)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	28.5	29.3	30.7	31.2	32.7	34.1	35.6	37.2	39.3	40.6	43.2	44.5	46.6	48.6	49.7	50.8	52.4
Industry	12.1	11.9	11.7	11.4	11.7	12.1	12.1	12.4	12.9	12.9	13.5	13.8	14.1	14.2	14.0	14.4	14.1
Tertiary	5.6	6.0	6.6	7.2	7.9	8.4	8.8	9.8	10.8	11.5	12.3	13.2	14.0	15.0	15.9	16.5	17.7
Households	9.1	10.0	10.6	10.5	10.9	11.5	12.3	12.4	12.8	13.5	14.2	14.5	15.8	16.4	16.9	16.9	17.6
Agriculture	1.6	1.3	1.6	2.0	2.1	2.0	2.2	2.4	2.6	2.6	2.9	2.8	2.5	2.8	2.8	2.9	2.7
Transport	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2

The mainland system is well developed and is connected to all the neighbouring countries. However, the mainland system of electricity generation is not well distributed and 68% of the electricity is produced in northern Greece (lignite mines), while 33% is consumed in the region of Attica. A special feature of the Greek electricity system is the type of peak load of the mainland system which occurs in the middle of the day during the summer month of July. This transfer of the peak load from winter to the summer months began to be noticeable in 1992 and it is because of the use of a large number of air-conditioning units due to the rise in the average consumer’s income and the resulting demand for comfort. The yearly rate of increase in demand in Crete and Rhodes is greater than that of the grid-connected areas (5-6%, compared to 3-3.5% for grid-connected). Also, the load factor is smaller for the systems in Crete (approximately 54%) and in Rhodes (approximately 47%) than that of the grid-connected areas (approximately 62%). The non-connected systems of Crete and Rhodes have more pronounced peak load problems, which are essentially due to higher increased demand in the summer months because of tourism. The small load factor combined with the use of petroleum combustion units to meet demand in the islands, means that the electricity generated in the islands costs much more than that generated in the grid-connected areas (A marginal cost of 128 €/MWh was calculated by the Regulator). This cost, however, is not passed along to consumers due to the unified pricing policy scheme.

1.2.7 CHP

The first cogeneration units were installed in large Greek industries in the beginning of the 1970s. At present, cogeneration units operate in the sugar, pulp and paper industries, petroleum refineries, textile industries, etc. Also, power generation plants belonging to the PPC have been suitably modified to cover the heating requirements of urban areas with district heating networks, such as the networks in Kozani, Ptolemaida, Amyntaio and recently, Megalopolis.

After analysis of the statistics, it is apparent that the status of cogeneration units in Greek industries did not change substantially from the 1970s to 1990, with the exception of technical quality improvement in the industrial units. After the middle of the 1990's, the arrival of natural gas in Greece and the possibilities offered by CHP technology led to action by a significant number of businesses or organizations aimed at informing businesspeople, providing consultant services for the design and construction of complete cogeneration units, maintenance, operation and utilization of cogeneration installations. In spite of this, the cogeneration market, up to the present, despite all the positive steps taken by the State, remains cautious and is hesitant for the following reasons:

- Difficulty in the determination of the basic dimensions for economic and technical analyses in the energy sector.
- Lack of pricing policy for cogeneration in the tertiary sector.
- Lack of a competitive pricing policy for cogeneration in the industrial sector.
- Difficulties in the broader development of the natural gas distribution network.
- Difficulty of the Public Gas Corporation to comply with the specified timetable for the connection of large industries.
- Lack of experience in energy management and evaluation of alternative solutions.

Table 1.2.7.1 : Installed Capacity of CHP Installations per Sector of Economic Activity (2006)

Sector	***Electrical Capacity (MWe)***	***Thermal Capacity (MWth)***
Electricity, gas, steam and hot water supply		**316,0**
Collection, purification and distribution of water	7,10	9,60
Manufacture of refined petroleum products	133,00	159,22
Manufacture of food products and beverages	60,50	254,06
Manufacture of textiles	3,90	5,00
Manufacture of basic metals	13,70	54,18
Manufacture of other non-metallic mineral products	1,10	3,68
Hospital activities	0,80	0,89
Higher education	2,72	3,09
Growing of vegetables, horticultural specialities and nursery products	9,80	11,00
Manufacture of basic chemicals	21,60	
TOTAL	**255**	**816**

Table 1.2.7.2 : Fuel Consumption in CHP intallations (2006)

Fuel	**Consumption (MT)**	**Energy Content (TJ)**
LFO	8	334
HFO	5	186
Lignite	15094	77842
Refinary Gas	64	3000
Natural Gas		817
Biogas		394

Thus, even though many new installations have been constructed over the last decade, even financed by existing investment programmes, many CHP installations with natural gas have gone out of operation. This is due to the relatively high purchase price of natural gas and the low selling price for electricity, which means that these two parameters play a defining role in the viability of CHP investments. The total installed electrical capacity of the industrial and tertiary sector cogeneration units was 255 MW in 2006 and amounts to 1.5% of the total installed capacity in Greece, while the entire yearly electricity generated by the units, except the PPC's district heating networks, is approximately 1 TWh.

1.2.8 Renewable Energy Sources

The contribution of renewable energy sources to the energy balance is around 5-6% (the percentage fluctuates according to the availability of the hydroelectric plants) at the total primary energy supply level in Greece and is approximately 13-14%, at the domestic primary electricity generation level. Electricity generation from renewable energy sources in Greece has increased significantly in the last few years and is approximately 2-2.5% of the gross domestic electricity consumption. Production is mainly from wind energy and small hydropower and a small contribution from biomass. The installed capacity of electricity generation from renewable energy sources was 3.894 MW at the end of 2006, when the total net capacity of the Greek Electricity Generation System was 13.331,6 MW. Taking into consideration the large hydroelectric plants (with the exception of pumped storage), electricity generation from renewable energy sources is on the level of 12.4%.

Generation of thermal energy from renewable energy sources is derived mainly from thermal solar, heat uses of biomass and geothermal heat pumps. The significant development of the solar collector industry in recent decades has put Greece in the 2nd place for installed area of solar collectors at the European level. However, the majority of heat production from biomass is derived either from burning biomass in the household sector, or from biomass residues in industrial processing of wood, food, cotton, etc. units where it is used to cover the units' own energy needs. It could be said that the Greek market for heat generation from renewable energy sources is in the early stages. The use of biofuels in Greece is also in the initial phase, and at the present, around 15 biofuel production units in Greece are under construction or are being planned.

Table 1.2.8.1 : Installed Capacity of RES Installations (1990-2006)

RES Technology	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	2411	2515	2541	2552	2552	2552	2551	2757	2896	3068	3299	3369	3388	3473	3597	3622	3894
Hydroelectric	2408	2512	2523	2523	2523	2523	2522	2728	2856	2959	3072	3076	3078	3079	3099	3106	3125
Of which pumped storage	315	315	315	315	315	315	315	520	615	615	699	699	699	699	699	699	699
< 1 MW*	2	2	2	2	3	3	3	4	5	8	14	15	17	19	23	26	31
1-10 MW*	28	28	39	39	39	39	39	39	40	42	42	45	45	50	56	63	77
> 10 MW*	2063	2167	2167	2167	2166	2166	2165	2165	2197	2294	2317	2317	2317	2311	2317	2318	2318
Geothermal	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
Photovoltaics	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1,3
Wind Energy	1	1	16	27	27	27	27	27	38	109	226	270	287	371	472	491	745
Biogas	0	0	0	0	0	0	0	0	0	0	1	22	22	22	25	24	24
** pumped storage excluded*																	

Table 1.2.8.2 : Electricity Generation from RES Installations (1990-2006)

RES Technology	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	1999.1	3173.1	2397.1	2588.2	2880.2	3817.2	4542.2	4132.1	3937.1	4992.2	4562.2	3553.2	4205.5	6431.6	6420.2	6971.3	8558.7
Hydroelectric	1997.0	3171.0	2389.0	2541.0	2843.0	3783.0	4504.0	4096.0	3867.0	4829.0	4111.0	2725.0	3463.0	5332.0	5205.0	5610.2	6773.8
Of which pumped storage	228.0	72.0	186.0	259.0	243.0	253.0	156.0	214.0	149.0	237.0	418.0	628.0	663.0	566.0	533.0	593.0	610.0
< 1 MW*	6.0	5.0	5.0	5.0	8.0	7.0	7.0	11.0	8.0	9.0	26.0	40.0	58.0	76.0	91.0	105.8	118.0
1-10 MW*	54.0	71.0	43.0	77.0	97.0	89.0	119.0	138.0	138.0	160.0	140.0	95.0	92.0	169.0	212.0	218.4	250.0
< 10 MW*	1709.0	3023.0	2155.0	2200.0	2495.0	3434.0	4222.0	3733.0	3572.0	4423.0	3527.0	1962.0	2650.0	4521.0	4369.0	4693.0	5795.8
Wind	2.0	2.0	8.0	47.0	37.0	34.0	38.0	36.0	70.0	162.0	451.0	756.0	651.0	1021.0	1121.0	1266.4	1691.5
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	72.0	91.0	78.0	93.4	93.8	92.0
Photovoltaics	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.5	0.6	0.8	0.9	1.4

Table 1.2.8.3 : Heat Generation from RES Installations (1990-2006)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Θερμότητα ΑΠΕ Σύνολο (ktoe)	952	963	971	977	977	983	998	1003	1004	1011	1047	1073	1096	1046	1057	1093	1084
Βιομάζα Σύνολο	893	897	897	898	893	897	908	911	907	911	945	938	948	910	917	957	931
Βιομάζα Βιομηχανία	191	195	195	196	191	195	206	209	205	209	243	236	246	208	215	255	229
Βιομάζα Οικιακός	702	702	702	702	702	702	702	702	702	702	702	702	702	702	702	702	702
Βιοαέριο	-	-	1	1	1	1	1	1	1	1	1	33	48	36	38	33	33
Ηλιακή Ενέργεια	56	63	70	75	79	82	86	89	93	97	99	100	99	99	101	102	109
Γεωθερμία	3	3	3	3	4	3	3	2	3	2	2	2	1	1	1	1	11

1.2.9 Final Energy Consumption

The total final energy consumption in Greece was almost steady between 1990 and 1994 and amounted to around 15 Mtoe, after deducting the non-energy uses. Between the years 1995 and 1996, final energy consumption rose by 6.5% approximately, while from that time onwards, the average yearly rate of increase has been around 2.5%.

The consumption of natural gas has tripled since 1998 when natural gas was introduced to the Greek Energy System and this rate of penetration is anticipated to continue. The final energy consumption from renewable energy sources has remained almost constant and is due mainly to the use of biomass in the residential sector, chiefly non commercial.

The share of petroleum products was reduced slightly by 1.7% in comparison to 1990 levels, however, petroleum products remain the main energy source consumed in end use. (Figure 1.2.9.1). The market share of petroleum products was reduced mainly by the penetration of natural gas in the energy market in 1998.

The share of electricity rose by 4.6% and renewable energy sources retained a small percentage in final consumption, while coal likewise has a small share which, however, is steadily decreasing.

The final consumption in the transport sector accounted for 39.6% of the total final consumption in 2006 (Figure 1.2.9.2). The percentage of household sector was 26 % in 2005 while the equivalent in 1990 was 19.4 %.

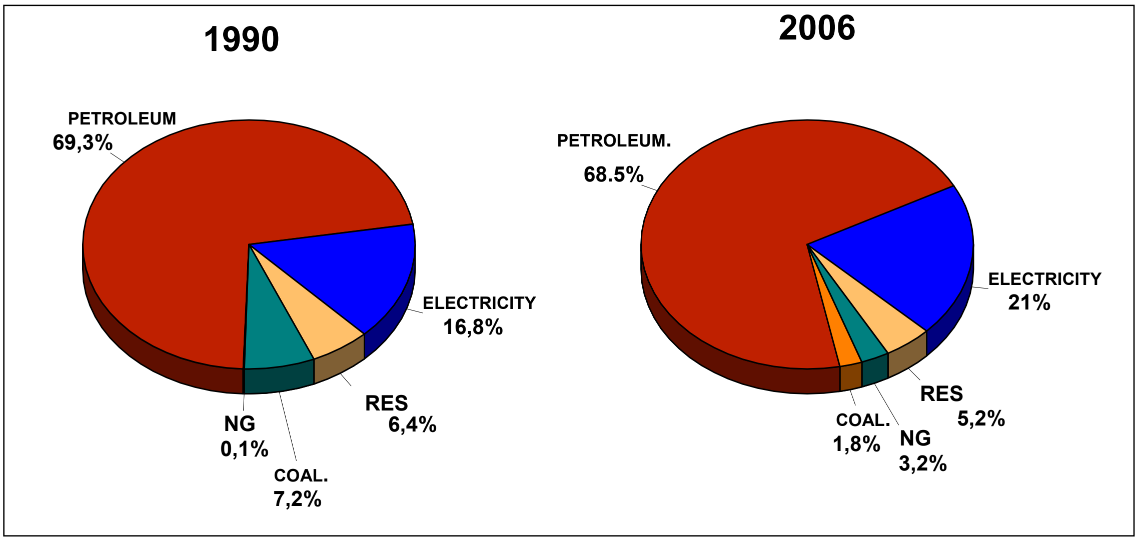


Figure 1.2.9.1 : Final Energy Consumption by Fuel (1990-2006)

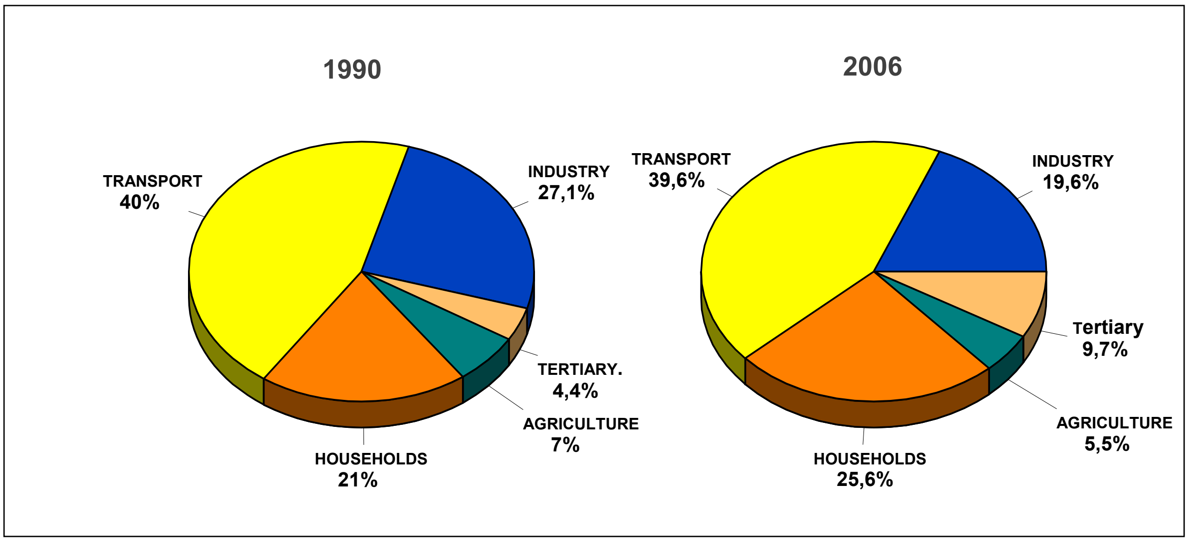


Figure 1.2.9.2 : Final Energy Consumption by Sector (1990-2005)

1.2.10 Greenhouse Gases Emissions

In accordance with European Union policy on climate change agreed upon by the European Ministers' Council in 1998, greenhouse gases emissions in Greece for the years 2008-1012 are allowed to increase by 25% in relation to the 1990 levels. The total goal for the European Union is an 8% reduction for the same period. The emissions per unit of gross domestic energy consumption are among the highest in the European Union. The reason is the dominant role of lignite and petroleum in Greece's energy mix. Around half of CO_2 emissions in Greece are produced by the generation of electricity while 83% are due to lignite combustion. Therefore, the main issue in Greece's emissions reduction policy is the diversification of the present energy mix through the importation of fuels with lower emissions (natural gas) and the penetration of renewable energy sources, combined with energy conservation. In the year 2006, the emission levels of 6 gases were 24.4% greater than those of the base year (1990 for CO_2, CH_4, N_2O – 1995 for the remaining gases). Specifically, CO_2 emissions from the energy industry increased by 29% between 1990 and 2006, while emissions from transportation increased by 62%.

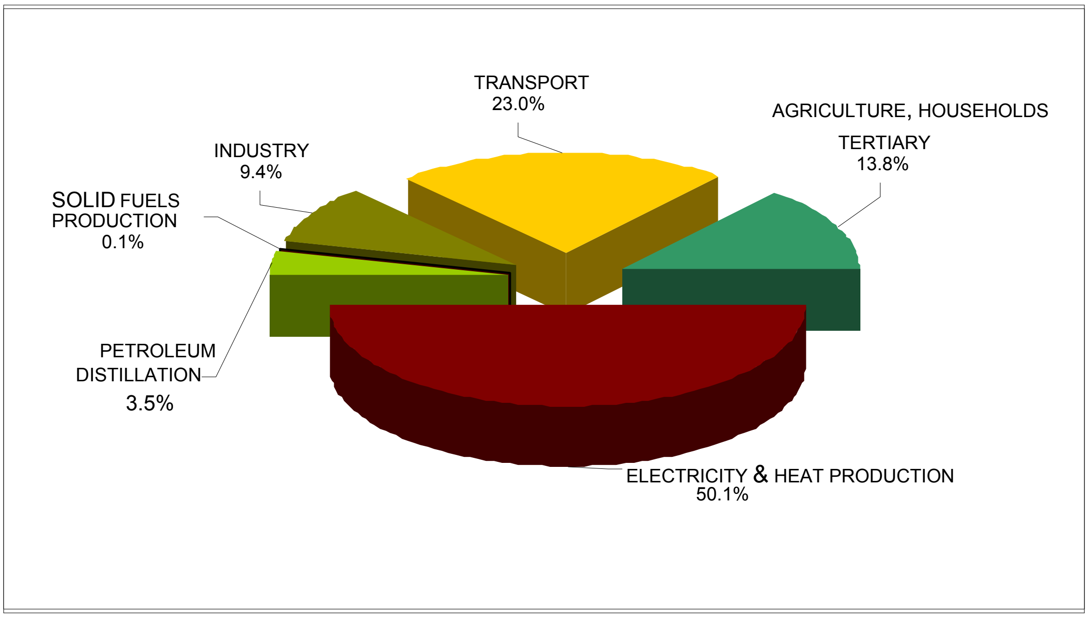


Figure 1.2.10 : Greenhouse Gases Emissions by Sector 2006

1.2.11 Pricing of Fuels and Energy Products

Prices for energy products in Greece are set in each case either by the market, by the government or by the Regulatory Authority for Energy, depending on the type of the products and the way the corresponding specific market operates. Prices for fuels and heating oil are freely set by the market. A daily wholesale market for electricity operates at the start of each day where prices are set by the competition. Electricity prices are set for the majority of consumers by the government, given that the PPC's market share is over 70% of the amount of the electricity sold. Unified pricing, regardless of geographical location is applied throughout the whole of Greece and is adjusted according to the voltage need of the consumer's connection. Prices for natural gas in areas with a network are set by the local Gas Supply Company. Prices for access to the grids are set by the government after consultation with the Regulatory Authority for Energy. Prices for energy products in Greece are given in detail in Table 1.2.11.

Table 1.2.11 : Prices of Fuels and Energy Products

OIL PRODUCT PRICES

	Low Sulphur Fuel Oil for Industry (per tonne)					Light Fuel Oil for Industry (per 1000 litres)					Light Fuel Oil for Households (per 1000 litres)				
	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price
2000	211.29	38.15	-	38.15	249.44	296.05	130.78	-	130.78	426.83	296.05	130.78	76.83	207.61	503.66
2001	197.52	38.15	-	38.15	235.67	268.32	156.84	-	156.84	425.16	268.32	156.84	76.53	233.37	501.69
2002	203.02	19.00	-	19.00	222.02	261.97	112.59	-	112.59	374.56	261.97	112.59	67.42	180.01	441.98
2003	216.94	19.00	-	19.00	235.94	279.84	133.00	-	133.00	412.84	279.84	133.00	74.31	207.31	487.16
2004	204.73	19.00	-	19.00	223.73	337.50	133.00	-	133.00	470.50	337.50	133.00	84.69	217.69	555.19
2005	269.97	19.00	-	19.00	288.97	458.54	133.00	-	133.00	591.54	458.54	133.00	106.48	239.48	698.02
2Q2006	323.90	19.00	-	19.00	342.90	543.25	245.00	-	245.00	788.25	543.25	245.00	149.77	394.77	938.02
3Q2006	313.24	19.00	-	19.00	332.24	574.46	260.00	-	260.00	834.46	574.46	260.00	158.55	418.55	993.01

NATURAL GAS PRICES

	Natural Gas for Industry (per 10^7 kilocalories GCV)					Natural Gas for Households (per 10^7 kilocalories GCV)				
	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price
2000	211.00	-	-	-	211.00	256.00	-	20.48	20.48	276.48
2001	206.00	-	-	-	206.00	267.00	-	21.36	21.36	288.36
2002	192.00	-	-	-	192.00	298.00	-	23.84	23.84	321.84
2003	196.00	-	-	-	196.00	320.00	-	27.00	27.00	347.00
2004	187.00	-	-	-	187.00	316.00	-	25.00	25.00	341.00
2005	251.00	-	-	-	251.00	444.75	-	38.92	38.92	483.67

ELECTRICITY PRICES

	Electricity for Industry (per kilowatt hour)					Electricity for Households (per kilowatt hour)				
	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price	Ex-Tax Price	Excise Tax	VAT	Total Tax	Total Price
2000	0.0452	-	-	-	0.0452	0.0701	-	0.0056	0.0056	0.0757
2001	0.0482	-	-	-	0.0482	0.0726	-	0.0058	0.0058	0.0784
2002	0.0487	-	-	-	0.0487	0.0755	-	0.0060	0.0060	0.0815
2003	0.0493	-	-	-	0.0493	0.0786	-	0.0063	0.0063	0.0849
2004	0.0510	-	-	-	0.0510	0.0800	-	0.0060	0.0060	0.0860
2005	0.0539	-	-	-	0.0539	0.0830	-	0.0073	0.0073	0.0903

HEAT DEMAND & TECHNICAL POTENTIAL FOR CHP

The objective of this chapter is to define heat markets for suited to CHP applications and to determine their technical CHP potential. For this purpose, heat markets are divided into different categories and criteria are created for choosing those markets which are realistically suited to CHP technologies. These criteria are based on geographic location, are related to fuel supply, or are based on type of business activity. The technical potential of CHP is then assessed where it is considered that the demand for heat and electrical loads can be met by suitable CHP technologies and with examination of their economic feasibility. Also, the potential for energy conservation (primary energy savings), in relation to the separate generation of electricity – heat and lastly, the primary energy savings ratio are calculated.

The data which are used in this chapter are derived from energy energy audits or market surveys through questionnaires. The potential applications for cogeneration have been ranked as follows by sector, based on the methodology recommended by the European Commission.

- TECHNICAL POTENTIAL FOR HEATING IN THE RESIDENTIAL SECTOR
    - District Heating Applications from the Electricity Generation System
    - Potential for District Heating Applications by Autoproducers and for Small CHP Applications in the Residential Sector with Natural Gas
    - Potential for small CHP applications in buildings in the residential sector
    - Potential for small CHP applications in buildings in the residential sector using natural gas as a fuel
- TECHNICAL CHP POTENTIAL IN INDUSTRY
- TECHNICAL POTENTIAL FOR TRIGENERATION IN THE TERTIARY SECTOR
    - Hotels
    - Hospitals
    - University Campuses
    - Airports
    - Tertiary Sector CHP Potential (office buildings excluded)
    - Office Buildings
- POTENTIAL FOR BIOMASS APPLICATIONs OF CHP
- BIOGAS POTENTIAL
    - Sewage Treatment Plants
    - Sanitary Landfills
    - Potential of the main organic wastes in Greece
    - Technical potential of biogas for CHP applications
- DESALINATION NEAR ISLAND GENERATION PLANTS
- GLASS GREENHOUSES
- GEOTHERMAL ENERGY

Tables 2.1 and 2.2 are presenting the analysis of the final consumptions of electricity and heat in Greece between the years 1990-2005. These data have been used for most of the calculations that follow.

Table 2.1 : Electricity-Analysis of Final Consumption 1990-2006 (GWh)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Electricity-Total Final Consumption	**28.471**	**29.332**	**30.701**	**31.179**	**32.703**	**34.087**	**35.564**	**37.213**	**39.312**	**40.616**	**43.151**	**44.535**	**46.564**	**48.598**	**49.719**	**50.904**	**52.524**
Total Industry Sector	**12.109**	**11.896**	**11.746**	**11.353**	**11.652**	**12.066**	**12.127**	**12.447**	**12.908**	**12.900**	**13.547**	**13.762**	**14.130**	**14.156**	**13.987**	**14.419**	**14.156**
Iron and Steel	1.002	932	821	824	785	856	742	833	868	821	975	1.101	1.416	1.550	1.506	1.683	1.776
Non-Ferrous Metals	3.315	3.262	3.424	3.087	3.240	3.215	3.203	3.300	3.446	3.520	3.861	3.898	3.929	3.752	4.237	4.615	4.111
Chemical and Petrochemical	1.381	1.214	1.050	968	956	1.058	1.150	1.162	1.246	1.221	1.212	1.094	1.154	627	524	569	529
Non-Metallic Minerals	1.783	1.807	1.802	1.801	1.818	1.906	1.936	1.947	2.016	1.979	2.068	2.063	2.049	2.072	2.240	2.407	2.311
Mining and Quarrying	282	214	231	253	269	273	281	285	277	281	276	270	276	89	294	264	319
Food and Tobacco	710	740	797	820	894	942	984	1.017	1.041	1.107	1.210	1.231	1.285	1.875	1.899	1.896	2.006
Textile and Leather	1.072	998	952	978	965	974	987	982	980	951	996	996	965	1.013	941	759	739
Paper, Pulp and Print	505	471	469	461	494	534	512	458	444	475	512	491	473	576	584	543	583
Engineering and other metal industry	572	575	534	572	585	627	645	663	713	754	790	785	808	1052	720	691	721
Non-specified (Industry)	1.375	1.566	1.533	1.432	1.475	1.503	1.505	1.609	1.685	1.580	1.432	1.595	1.527	1.269	767	766	1.061
Total Transport Sector	**125**	**123**	**130**	**125**	**138**	**149**	**159**	**167**	**180**	**197**	**227**	**214**	**222**	**237**	**238**	**199**	**217**
Rail	125	123	70	64	64	67	70	69	68	73	98	107	103	106	109	144	217
Commercial and Public Services	**5.605**	**5.979**	**6.590**	**7.180**	**7.896**	**8.373**	**8.826**	**9.793**	**10.840**	**11.482**	**12.260**	**13.233**	**13.954**	**14.978**	**15.853**	**16.479**	**17.757**
Residential	**9.074**	**10.014**	**10.612**	**10.481**	**10.932**	**11.508**	**12.253**	**12.423**	**12.786**	**13.484**	**14.207**	**14.546**	**15.775**	**16.444**	**16.852**	**16.875**	**17.676**
Agriculture/Forestry	**1.558**	**1.320**	**1.623**	**2.040**	**2.085**	**1.991**	**2.199**	**2.383**	**2.598**	**2.553**	**2.910**	**2.780**	**2.483**	**2.783**	**2.789**	**2.932**	**2.717**

Table 2.2 : Thermal Energy-Analysis of Final Consumption 1990-2006 (GWh)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Electricity-Total Final Consumption	140,521	141,752	143,426	145,866	145,947	149,979	160,867	163,923	172,220	170,663	172,557	178,169	180,598	189,999	186,152	190,835	196,820
Total Industry Sector	33,744	31,862	32,768	31,967	31,932	35,755	38,021	38,218	38,567	35,511	38,114	38,602	37,800	35,999	33,129	33,733	34,814
Iron and Steel	1,604	244	1,313	1,255	1,208	732	407	488	872	1,162	1,255	1,360	1,394	1,336	1,069	860	860
Non-Ferrous Metals	3,800	3,509	3,707	4,009	4,079	4,543	5,252	4,265	4,485	5,078	5,554	5,380	5,984	5,903	5,624	5,113	5,136
Chemical and Petrochemical	1,999	1,325	1,313	1,406	1,394	1,360	2,150	2,510	2,905	1,859	1,929	1,824	1,824	1,813	2,301	2,545	2,603
Non-Metallic Minerals	13,003	13,351	13,340	13,630	13,433	14,002	13,584	13,828	13,433	11,655	12,887	13,874	12,236	10,900	11,783	10,621	10,493
Mining and Quarrying	755	314	616	604	639	1,336	1,406	1,290	1,197	1,243	1,255	1,232	1,290	906	779	755	779
Food and Tobacco	3,207	3,091	3,370	3,451	3,312	3,393	5,520	5,798	5,845	5,554	6,368	5,996	6,170	6,170	5,554	5,543	5,682
Textile and Leather	1,464	1,104	1,394	1,267	1,185	1,208	1,836	1,743	1,522	1,313	1,487	1,418	1,348	1,208	1,069	883	755
Paper, Pulp and Print	1,081	953	1,023	964	918	767	1,069	1,290	1,174	1,255	1,453	1,360	1,406	1,453	1,034	941	1,116
Engineering and other metal industry	46	81	58	58	58	186	360	325	418	395	407	465	430	395	360	372	372
Non-specified (Industry)	6,821	7,913	6,716	5,310	5,624	8,215	6,449	6,647	6,740	5,984	5,520	5,682	5,717	5,891	3,579	6,101	7,042
Total Transport Sector	67,512	69,488	71,486	75,007	74,891	74,740	76,239	78,156	84,745	86,592	83,571	85,535	86,650	90,613	92,460	93,750	98,572
Rail	744	523	569	569	616	511	535	511	500	476	465	476	476	476	476	476	476
Road transport	45,469	48,665	49,861	51,058	51,744	53,406	55,985	57,287	60,157	61,226	61,981	63,422	65,723	69,674	70,150	72,056	74,821
Air transport	14,688	13,514	14,107	17,012	15,850	14,479	14,293	13,793	13,956	14,920	15,397	13,839	13,409	13,502	14,037	13,723	15,048
Inland navigation	6,600	6,786	6,949	6,368	6,682	6,345	5,427	6,565	10,133	9,982	5,729	7,797	7,042	6,960	7,809	7,495	8,215
Commercial and Public Services	1,859	2,429	2,278	2,185	2,254	2,452	2,963	2,859	3,056	2,882	2,963	3,858	3,928	4,381	4,799	6,066	6,368
Residential	26,459	26,424	26,168	26,226	26,331	27,214	33,628	34,721	35,976	35,732	37,928	40,089	41,344	47,305	45,690	46,922	46,143
Agriculture/Forestry	10,365	11,434	10,644	10,423	10,481	9,749	9,947	9,889	9,889	9,935	9,970	10,086	10,888	11,713	10,040	10,353	10,923

2.1 TECHNICAL POTENTIAL FOR HEATING IN THE RESIDENTIAL SECTOR

Technical potential for heating in the residential sector is defined as the total demand for useful energy for space heating and hot water, corresponding to different categories of buildings (apartment buildings, duplexes, single family dwellings), year of construction and the climate zone where they are located. The potential for heat, defines the total *heating market* for the specific sector and is illustrated by geographic location areas, cities and settlements in the whole country. For the calculation, the data from the census of buildings (Greek National Statistical Service, 2001) were entered into a geographical information system (GIS), where, combined with degree days, they give the seasonal demand for heating loads per settlement.

The sections of the heating market which can be covered by cogeneration technologies include, in order of importance:

- District heating applications in cities near existing electricity generating plants.
- District heating applications from new cogeneration plants using natural gas in cities which are connected or planned to be connected to the natural gas grid.
- Small CHP applications in residential sector buildings with natural gas as a fuel, which can be developed in buildings located in cities and settlements, to the extent that there exists, or is planned a natural gas supply.

Even if district cooling applications are scarce at the moment, it was considered worthwhile to investigate to what extent the cooling load of hotels in Crete and Rhodes located near steam electricity generation plants could be covered by absorption chillers.

Assessment of thermal loads for buildings in the residential sector by settlement and administrative regions

Thermal loads – uses of energy which are investigated in the chapter that follows include space heating (SH) and hot water production (HWP) for the residential sector.

Given the possibility of meeting the above needs with thermal energy from *heat networks*, (small heating networks or large district heating facilities), the useful energy which is connected with space heating and hot water is calculated over the long term, in a unified way for the whole country. By using these calculations in selected geographical locations (settlements and administrative regions), the feasibility of developing district heating networks is assessed, in areas where it is possible to produce and supply heat and specifically, in settlements near thermal electricity generation plants.

Analysis of climate data by zone

As the following figure shows, Greece is divided into four climate zones (A, B, C, D). This distribution (source: Regulations for Energy Efficiency in Buildings) provides a basic indication of energy demand for space heating in conjunction with external climate conditions. The basic indicator which is widely used to evaluate this effect is the Heating Degree-Hours (HDH) and they are arrived at by processing data on external air temperatures (at each location) relative to a typical value – threshold which determines the thermal comfort inside a building (18 C)

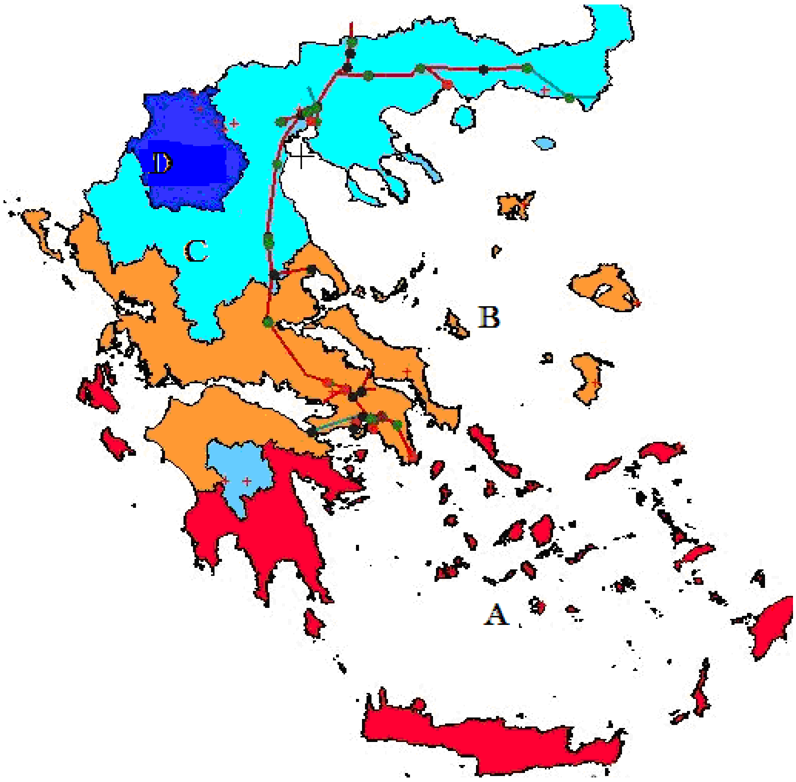


Figure 2.1 : Climate Zones in Greece

To the extent that the aim of the present study is the assessment of typical values for the distribution of loads for space heating in large areas (four climate zones), the relevant data were used (monthly and yearly values for HDH), such as those published by NASA (National Aeronautics and Space Administration (http://eosweb.larc.nasa.gov/sse/)) and are general meteorological data analyzed on a 1 X 1 grid.

2.1.1 District Heating Applications from the Electricity Generation System

Investigation of the demand for useable energy near existing thermal plants

Based on the method which was described in the previous paragraphs, it is possible to estimate the entire load (for household space heating and hot water production) for settlements and cities which are located near existing thermal plants in the mainland system (including Crete).

The areas where the thermal plants under study are located are the following:

- Lignite centre of Western Macedonia (PPC plants in Kardia, Agios Dimitrios, Liptol, Ptolemaida, Amyntaio, Florina) – Zone D
- Megalopolis area (PPC) – Zone C
- Komotini (PPC) – Zone C
- Area of Western Thessaloniki (Greek Petroleum Company) – Zone C
- Region of Viotia (IRON) – Zone B
- Area of Lavrio (PPC) – Zone B
- Aliveri (PPC) – Zone B
- Crete (Linoperamata and Hania – PPC) – Zone A

The areas which have been chosen correspond to settlements which are located at a distance of 25 km, for areas in northern Greece, and 15 km for areas in southern Greece, and also do not have a significant difference in altitude compared to the areas of the plants near which they are located.

Table 2.1.1. shows the total yearly energy required for heating and hot water production for households located in zones near electricity generation plants which could also cover heating loads through a district heating network.

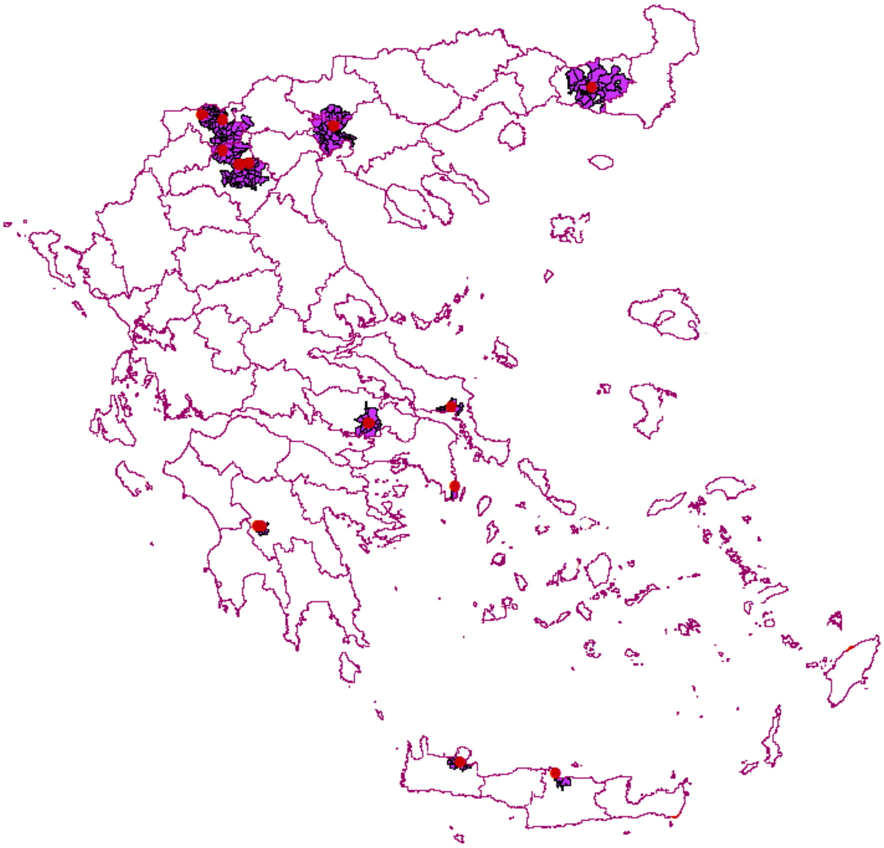


Figure 2.1.1. : Settlements near Thermal Electricity Plants

Table 2.1.1. : Thermal Energy and Peak Load Demand in Settlements Near Electricity Generation Plants

Region		Western Macedonia	Western Thessaloniki	Lavrio	Komotini	Megalopoli	Viotia
Space Heating	GJ/year	2710927	8810277	104979	1154252	80000	343281
Hot Water	GJ/year	163836	788302	12056	98396	6499	39799
Total Thermal Energy	**GJ/year**	**2874763**	**9598579**	**117035**	**1252648**	**86499**	**383080**
Climate Zone		**D**	**C**	**B**	**C**	**C**	**B**
Degree Days		2827	2238	1546	2238	2238	1546
Minimum temperature	°C	-7	-3	0	-5	-4	-1
Heating Months		9	8	6	8	8	6
Heating Hours	h	16	16	12	16	16	12
Thermal Peak Load	**MWth**	**441,36**	**1563,66**	**31,54**	**223,49**	**14,76**	**108,98**

2.1.2 Potential for District Heating Applications by Autoproducers and for Small CHP Applications in the Residential Sector with Natural Gas

Based on the method already described in chapter 2.1.1, it is possible to estimate the total load (for space heating and hot water production) for cities where it is possible to develop, according to priority, district heating applications with small or large cogeneration units which use natural gas as fuel. The general estimate of the technical potential corresponds to the estimate of the required thermal loads for the total of the existing buildings in the cities located in Zones B and C and have access, or will have, in the near future to the natural gas network.

The following have been excluded from the above estimates:

- Areas in Zones A and D where there is no natural gas network
- The area of the prefecture of Athens, which requires a special study
- Cities and settlements with a population of less than 5000 inhabitants.

In the following tables (2.1.2.1., 2.1.2.2), the technical potential of independent production units is shown, which could be used for CHP installations in combination with the district heating of the municipalities which were studied.

Table 2.1.2.1 : Technical Potential for District Heating from Independent Producers

Municipal Ward		**Karditsa**	**Sofades**	**Palamas**	**Larisa**	**Tirnavos**	**Farsala**	**Trikala**	**Drama**	**Kavala**
Space Heating	GJ/year	457209	73029	96990	1518282	181209	129276	718183	567652	820262
Hot Water	GJ/year	34412	6515	6196	133146	13285	10531	55336	46398	64875
Total Thermal Energy	**GJ/year**	**491621**	**79544**	**103186**	**1651428**	**194494**	**139807**	**773519**	**614050**	**885137**
Climate Zone		**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**
Degree Days		2238	2238	2238	2238	2238	2238	2238	2238	2238
Minimum Temperature	°C	-3	-3	-3	-3	-3	-3	-3	-4	-4
Heating Months		8	8	8	8	8	8	8	8	8
Heating Hours	h	16	16	16	16	16	16	16	16	16
Thermal Peak Load	**MWth**	**80,1**	**13,0**	**16,8**	**269,0**	**31,7**	**22,8**	**126,0**	**104,8**	**151,1**
CHP Overall Efficiency		0,82	0,85	0,85	0,88	0,85	0,85	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,37	0,37	0,55	0,37	0,37	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,48	0,48	0,33	0,48	0,48	0,47	0,47	0,47
Total Peak Load	MW	139,7	22,9	29,8	717,4	56,1	40,3	219,8	182,8	263,6
Electric peak Load	**MWe**	**49**	**8**	**11**	**395**	**21**	**15**	**77**	**64**	**92**
Suggested Technology		Industrial GT	Diesel/NG Engines	Diesel/NG Engines	CCPP GT/ST	Diesel/NG Engines	Diesel/NG Engines	Industrial GT	Industrial GT	Industrial GT
ne,ref		51,70%	49,60%	49,60%	51,70%	49,60%	49,60%	51,70%	51,70%	51,70%
nth,ref		84,99%	84,99%	84,99%	84,99%	84,99%	84,99%	84,99%	84,99%	84,99%
PES	**MWh/year**	**188.516**	**36.159**	**46.906**	**1.391.204**	**88.413**	**63.554**	**296.613**	**246.675**	**355.576**
PESR	**%**	**18,70%**	**23,70%**	**23,70%**	**31,13%**	**23,70%**	**23,70%**	**18,70%**	**18,70%**	**18,70%**

Municipal Ward		**Crisoupoli**	**Kilkis**	**Katerini**	**Litochoro**	**Seres**	**Sidirokastro**	**Alexandroupoli**	**Xanthi**	**Mikis**
Space Heating	GJ/year	134428	201723	693789	97430	674533	95089	597980	536100	82591
Hot Water	GJ/year	8540	20228	56240	7480	58328	6774	52470	48140	7854
Total Thermal Energy	**GJ/year**	142968	221951	750029	104910	732861	101863	650450	584240	90445
Climate Zone		C	C	C	C	C	C	C	C	C
Degree Days		2238	2238	2238	2238	2238	2238	2238	2238	2238
Minimum Temperature	°C	-4	-4	-3	-3	-4	-4	-4	-4	-4
Heating Months		8	8	8	8	8	8	8	8	8
Heating Hours	h	16	16	16	16	16	16	16	16	16
Thermal Peak Load	**MWth**	24,4	37,9	122,2	17,1	125,1	17,4	111,0	99,7	15,4
CHP Overall Efficiency		0,85	0,82	0,82	0,85	0,82	0,85	0,82	0,82	0,85
CHP Electric Efficiency		0,37	0,39	0,35	0,37	0,35	0,37	0,35	0,35	0,37
CHP Thermal Efficiency		0,48	0,43	0,47	0,48	0,47	0,48	0,47	0,47	0,48
Total Peak Load	MW	43,2	72,2	213,2	30,3	218,2	30,8	193,7	174,0	27,3
Electric peak Load	**MWe**	16	28	75	11	76	11	68	61	10
Suggested Technology		Diesel/NG Engines	Aeroderivative GT	Industrial GT	Diesel/NG Engines	Industrial GT	Diesel/NG Engines	Industrial GT	Industrial GT	Diesel/NG Engines
ne,ref		49,60%	49,60%	51,70%	49,60%	51,70%	49,60%	51,70%	51,70%	49,60%
nth,ref		84,99%	84,99%	84,99%	84,99%	84,99%	84,99%	84,99%	84,99%	84,99%
PES	**MWh/year**	68.085	111.852	287.605	47.690	294.404	48.510	261.298	234.700	43.072
PESR	**%**	23,70%	22,61%	18,70%	23,70%	18,70%	23,70%	18,70%	18,70%	23,70%

Municipal Ward		Elefsina	Nea Peramos	Megara	Aspropyrgos	Livadia	Schimatary	Inofyta	Chalkida
Space Heating	GJ/year	245110	75079	305332	221429	212454	62858	55763	566128
Hot Water	GJ/year	27596	7981	30084	29600	22161	8637	6736	57174
Total Thermal Energy	**GJ/year**	272706	83060	335416	251029	234615	71496	62499	623302
Climate Zone		B	B	B	B	B	B	B	B
Degree Days		1546	1546	1546	1546	1546	1546	1546	1546
Minimum Temperature	°C	0	0	0	0	-1	-1	-1	-1
Heating Months		6	6	6	6	6	6	6	6
Heating Hours	h	12	12	12	12	12	12	12	12
Thermal Peak Load	**MWth**	73,5	22,4	90,4	67,7	66,7	20,3	17,8	177,3
CHP Overall Efficiency		0,82	0,85	0,82	0,82	0,82	0,85	0,85	0,82
CHP Electric Efficiency		0,35	0,37	0,35	0,35	0,35	0,37	0,37	0,35
CHP Thermal Efficiency		0,47	0,48	0,47	0,47	0,47	0,48	0,48	0,47
Total Peak Load	MW	128,2	39,6	157,7	118,0	116,4	36,0	31,5	309,4
Electric peak Load	**MWe**	45	15	55	41	41	13	12	108
Suggested Technology		Industrial GT	Diesel/NG Engines	Industrial GT	Industrial GT	Industrial GT	Diesel/NG Engines	Diesel/NG Engines	Industrial GT
ne,ref		51,48%	49,39%	51,48%	51,48%	51,48%	49,39%	49,39%	51,48%
nth,ref		84,76%	84,76%	84,76%	84,76%	84,76%	84,76%	84,76%	84,76%
PES	**MWh/year**	98.635	35.569	121.317	90.795	89.572	32.318	28.251	237.967
PESR	%	18,99%	23,98%	18,99%	18,99%	18,99%	23,98%	23,98%	18,99%

Municipal Ward		Lamia	Korinthos	Ag.Theodoroi	Volos	N.Ionia	Almiros	N.Agchialos
Space Heating	GJ/year	578247	299484	57225	1137554	317963	114961	75951
Hot Water	GJ/year	49515	31783	6359	87962	33730	8452	6838
Total Thermal Energy	**GJ/year**	627762	331267	63585	1225516	351693	123413	82790
Climate Zone		B	B	B	B	B	B	B
Degree Days		1546	1546	1546	1546	1546	1546	1546
Minimum Temperature	°C	-1	0	0	-1	-1	-1	-1
Heating Months		6	6	6	6	6	6	6
Heating Hours	h	12	12	12	12	12	12	12
Thermal Peak Load	**MWth**	178,6	89,3	17,1	348,6	100,1	35,1	23,6
CHP Overall Efficiency		0,82	0,82	0,85	0,88	0,82	0,82	0,85
CHP Electric Efficiency		0,35	0,35	0,37	0,55	0,35	0,39	0,37
CHP Thermal Efficiency		0,47	0,47	0,48	0,33	0,47	0,43	0,48
Total Peak Load	MW	311,6	155,8	30,3	929,7	174,6	67,0	41,7
Electric peak Load	**MWe**	109	55	11	511	61	26	15
Suggested Technology		Industrial GT	Industrial GT	Diesel/NG Engines	CCPP GT/ST	Industrial GT	Aeroderivative GT	Diesel/NG Engines
ne,ref		51,48%	51,48%	49,39%	51,48%	51,48%	49,39%	49,39%
nth,ref		84,76%	84,76%	84,76%	84,76%	84,76%	84,76%	84,76%
PES	**MWh/year**	239.670	119.816	27.229	1.025.840	134.271	59.052	37.423
PESR	%	18,99%	18,99%	23,98%	31,40%	18,99%	22,90%	23,98%

Table 2.1.2.2 : Technical CHP Potential for District Heating Applications by Independent Producers

Climate Zone	MWe	MWth	PES (GWh/year)
C	1088	1385	4111
B	1119	1328	2378

2.1.3 Potential for small CHP applications in buildings in the residential sector

The technical potential of CHP for single houses and apartment buildings in four climate zones is determined. The calculations are based on data contained in [25].

The results are shown in Table 2.1.3

Table 2.1.3 : Technical Potential of CHP for Buildings in the Residential Sector

		Single Houses, Climate Zone A			
Year of Construction		Before 1980	1981-2001	2002-2010	Total
Surface	**s.m.**	**24010738,00**	**16535476,00**	**13226145,00**	**53772359,00**
Specific Thermal Consumption	kWh/s.m./year	94,00	89,10	66,90	
Total Thermal Consumption	**MWh / year**	**2257009,37**	**1473310,91**	**884829,10**	**4615149,38**
Degree Days		921,00	921,00	921,00	
Minimum Temperature	°C	0,00	0,00	0,00	
Heating Months		5,00	5,00	5,00	
Heating Hours	h	8,00	8,00	8,00	
Thermal Peak Load	**MWth**	**5513,87**	**3599,29**	**2161,63**	**11274,79**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	9619,94	6279,62	3771,36	19670,92
Electric Peak Load	**MWe**	**3366,98**	**2197,87**	**1319,98**	**6884,82**
ne,ref		0,38	0,38	0,38	0,38
nth,ref		0,84	0,84	0,84	0,84
PES	**MWh / year**	**4.537.883**	**2.962.200**	**1.779.014**	**9.279.097**
PESR	**%**	**0,33**	**0,33**	**0,33**	**0,33**

		Single Houses, Climate Zone B			
Year of Construction		Before 1980	1981-2001	2002-2010	Total
Surface	**s.m.**	**59222241,00**	**30665932,00**	**18726225,00**	**108614398,00**
Specific Thermal Consumption	kWh/s.m./year	134,00	115,20	88,30	
Total Thermal Consumption	**MWh / year**	**7935780,29**	**3532715,37**	**1653525,67**	**13122021,33**
Degree Days		1546,00	1546,00	1546,00	
Minimum Temperature	°C	0,00	0,00	0,00	
Heating Months		6,00	6,00	6,00	
Heating Hours	h	12,00	12,00	12,00	
Thermal Peak Load	**MWth**	**7699,66**	**3427,60**	**1604,33**	**12731,59**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	13433,44	5980,07	2799,04	22212,55
Electric Peak Load	**MWe**	**4701,71**	**2093,03**	**979,66**	**7774,39**
ne,ref		0,45	0,45	0,45	0,45
nth,ref		0,85	0,85	0,85	0,85
PES	**MWh / year**	**6.831.194**	**3.040.995**	**1.423.370**	**11.295.560**
PESR	%	**0,25**	**0,25**	**0,25**	**0,25**

		Single Houses, Climate Zone C			
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**45250489,00**	**23051218,00**	**16257744,00**	**84559451,00**
Specific Thermal Consumption	kWh/s.m./year	159,40	145,10	107,70	
Total Thermal Consumption	**MWh / year**	**7212927,95**	**3344731,73**	**1750959,03**	**12308618,71**
Degree Days		2238,00	2238,00	2238,00	
Minimum Temperature	°C	-1,00	-1,00	-1,00	
Heating Months		7,00	7,00	7,00	
Heating Hours	h	14,00	14,00	14,00	
Thermal Peak Load	**MWth**	**4373,98**	**2028,27**	**1061,80**	**7464,05**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	7631,20	3538,69	1852,50	13022,39
Electric Peak Load	**MWe**	**2670,92**	**1238,54**	**648,37**	**4557,84**
ne,ref		0,45	0,45	0,45	0,45
nth,ref		0,85	0,85	0,85	0,85
PES	**MWh / year**	**5.165.458**	**2.395.292**	**1.253.930**	**8.814.680**
PESR	%	**0,25**	**0,25**	**0,25**	**0,25**

		Single Houses, Climate Zone D			
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**5193004,00**	**3184299,00**	**2475032,00**	**10852335,00**
Specific Thermal Consumption	kWh/s.m./year	186,90	175,70	129,20	
Total Thermal Consumption	**MWh / year**	**970572,45**	**559481,33**	**319774,13**	**1849827,92**
Degree Days		2827,00	2827,00	2827,00	
Minimum Temperature	°C	-3,00	-3,00	-3,00	
Heating Months		8,00	8,00	8,00	
Heating Hours	h	16,00	16,00	16,00	
Thermal Peak Load	**MWth**	**450,61**	**259,75**	**148,46**	**858,83**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	786,17	453,18	259,02	1498,38
Electric Peak Load	**MWe**	**275,16**	**158,61**	**90,66**	**524,43**
ne,ref		0,38	0,38	0,38	0,38
nth,ref		0,84	0,84	0,84	0,84
PES	**MWh / year**	**1.136.399**	**655.071**	**374.409**	**2.165.879**
PESR	%	**0,32**	**0,32**	**0,32**	**0,32**

		Apartment Buildings, Climate Zone A			
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**2987390,00**	**6309271,00**	**6119221,00**	**15415882,00**
Specific Thermal Consumption	kWh/s.m./year	65,30	61,90	52,10	
Total Thermal Consumption	**MWh / year**	**195076,57**	**390543,87**	**318811,41**	**904431,86**
Degree Days		921,00	921,00	921,00	
Minimum Temperature	°C	0,00	0,00	0,00	
Heating Months		5,00	5,00	5,00	
Heating Hours	h	8,00	8,00	8,00	
Thermal Peak Load	**MWth**	**476,57**	**954,10**	**778,86**	**2209,52**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	831,47	1664,60	1358,85	3854,91
Electric Peak Load	**MWe**	**291,01**	**582,61**	**475,60**	**1349,22**
ne,ref		0,38	0,38	0,38	0,38
nth,ref		0,84	0,84	0,84	0,84
PES	**MWh / year**	**392.216**	**785.217**	**640.994**	**1.818.427**
PESR	**%**	**0,33**	**0,33**	**0,33**	**0,33**

		Apartments Buildings, Climate Zone B			
Year of Construction		Before 1980	1981-2001	2002-2010	Total
Surface	**s.m.**	**52591634,00**	**38614093,00**	**35037293,00**	**126243020,00**
Specific Thermal Consumption	kWh/s.m./year	93,70	91,40	70,50	
Total Thermal Consumption	**MWh / year**	**4927836,11**	**3529328,10**	**2470129,16**	**10927293,36**
Degree Days		1546,00	1546,00	1546,00	
Minimum Temperature	°C	0,00	0,00	0,00	
Heating Months		6,00	6,00	6,00	
Heating Hours	h	12,00	12,00	12,00	
Thermal Peak Load	**MWth**	**4781,21**	**3424,32**	**2396,63**	**10602,16**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	8341,69	5974,34	4181,36	18497,39
Electric Peak Load	**MWe**	**2919,59**	**2091,02**	**1463,48**	**6474,09**
ne,ref		0,45	0,45	0,45	0,45
nth,ref		0,85	0,85	0,85	0,85
PES	**MWh / year**	**4.241.928**	**3.038.079**	**2.126.310**	**9.406.317**
PESR	%	**0,25**	**0,25**	**0,25**	**0,25**

		Apartment Buildings, Climate Zone C			
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**18500091,00**	**19554006,00**	**18483636,00**	**56537733,00**
Specific Thermal Consumption	kWh/s.m./year	110,80	109,00	90,40	
Total Thermal Consumption	**MWh / year**	**2049810,08**	**2131386,65**	**1670920,69**	**5852117,43**
Degree Days		2238,00	2238,00	2238,00	
Minimum Temperature	°C	-1,00	-1,00	-1,00	
Heating Months		7,00	7,00	7,00	
Heating Hours	h	14,00	14,00	14,00	
Thermal Peak Load	**MWth**	**1243,02**	**1292,49**	**1013,26**	**3548,78**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	2168,68	2254,99	1767,82	6191,48
Electric Peak Load	**MWe**	**759,04**	**789,24**	**618,74**	**2167,02**
ne,ref		0,45	0,45	0,45	0,45
nth,ref		0,85	0,85	0,85	0,85
PES	**MWh / year**	**1.467.949**	**1.526.369**	**1.196.611**	**4.190.928**
PESR	**%**	0,25	0,25	0,25	0,25

		Apartment Buildings, Climate Zone D			
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**527809,00**	**1248487,00**	**1145100,00**	**2921396,00**
Specific Thermal Consumption	kWh/s.m./year	129,80	124,50	114,90	
Total Thermal Consumption	**MWh / year**	**68509,61**	**155436,63**	**131571,99**	**355518,23**
Degree Days		2827,00	2827,00	2827,00	
Minimum Temperature	°C	-3,00	-3,00	-3,00	
Heating Months		8,00	8,00	8,00	
Heating Hours	h	16,00	16,00	16,00	
Thermal Peak Load	**MWth**	**31,81**	**72,17**	**61,09**	**165,06**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	55,49	125,90	106,57	287,97
Electric Peak Load	**MWe**	**19,42**	**44,07**	**37,30**	**100,79**
ne,ref		0,38	0,38	0,38	0,38
nth,ref		0,84	0,84	0,84	0,84
PES	**MWh / year**	**80.215**	**181.994**	**154.052**	**416.260**
PESR	**%**	**0,32**	**0,32**	**0,32**	**0,32**

2.1.4 Potential for small CHP applications in buildings in the residential sector using natural gas as a fuel

Based on the method used, it is possible to estimate the total load (for space heating and hot water production) using natural gas as a fuel, as a first priority. The general calculation of the technical potential corresponds to the calculation of the required thermal loads for total of existing buildings by groups of dwellings (apartment buildings) as well as duplexes in cities and settlements which are included in the tables of paragraph 2.1.1.3.

Included in the following table are:

- Areas where there is a natural gas network in place.
- Areas where such a network is planned for development in the near future (Kilkis, Trikala, Karditsa).
- The city of Lamia, as long as the climate conditions (more than 1400 HDH per year) define the coldest area of Zone B,

while out of the total number of buildings, only apartment buildings have been chosen.

Table 2.1.4 : Technical Potential for Apartment Buildings Located Near Natural Gas Pipelines

Total Thermal Consumption	**MWh / year**	**3101586,71**
Degree Days		2238,00
Minimum Temperature	°C	-1,00
Heating Months		7,00
Heating Hours	H	14,00
Thermal Peak Load	**MWth**	**1880,83**
CHP Overall Efficiency		0,82
CHP Electric Efficiency		0,35
CHP Thermal Efficiency		0,47
Total Peak Load	MW	3281,45
Electric Peak Load	**MWe**	**1148,51**
ne,ref		0,45
nth,ref		0,85
PES	**MWh / έτος**	**2221105,802**
PESR	**%**	**0,25**

2.2 TECHNICAL CHP POTENTIAL IN INDUSTRY

The heating-cooling and electricity demand for industry was analyzed statistically with questionnaires by industry sectors and sub-sectors. The sampling research process was chosen to be done through a stratified sampling method, in one stage. The research population was composed of the total number of the industrial units as recorded in the ICAP industry handbook. The total number is 2583 units, distributed into the following categories of activity:

- Food and Beverages (41%)
- Textiles (2%)
- Pulp and paper (5%)
- Chemicals (6%)
- Non-metallic minerals (21%)
- Basic metalworking industries (steelworks, aluminum producers, etc.) (21%)
- Woodworking (4%)

The unit's category of activity and its size were used as stratification variables, corresponding to three size groups: Group 1, which includes the first 1/3 of the units, based on their turnover (the largest ones), Group 2, which includes the next 1/3 (medium sized), and Group 3, which includes the remaining 1/3 of the units based on their turnover (small size). This separation was judged to be necessary in order to ensure equal weight of participation for businesses of all sizes in the sample. The sample was distributed proportionately in the layers, according to the percentage of "participation" of the units in the population and the choice of units in the layers was made with the random sampling method. The **total size** of the sample was set at 130-150 units with the intention that the statistical error rate would be around 5%.

For each industrial unit, for which we received a completed questionnaire, a preliminary feasibility study for the installation of a cogeneration system was made. The components of the CHP installation were calculated which would meet the load demand (heating, cooling, electrical) which were recorded. Then, the primary energy savings that a CHP installation would provide in relation to the separate production of electricity and heating/cooling were calculated. Next, the synthesis of the results for different categories of the sample was done according to the EUROSTAT NACE classification. Lastly, the total values for each NACE category were derived from the conversion of the results of the sample to the total of each category, based on the consumption totals from the EUROSTAT balances.

Table 2.2 : Technical CHP Potential in industry by sector (based on questionnaire data analysis)

SECTOR	Heat Demand (GWh/year)	Technical CHP Potential (MWe)	Technical CHP Potential (MWth)	PES (GWh/year)
Food, beverages & tobacco	6200	629,14	1222,36	5108,52
Paper, pulp and printing	1420	82,78	189,93	637,40
Wood and Products	320	25,01	249,71	185,42
Textile, leather and clothing	1360	108,74	236,66	760,04
Chemical & petrochemical	2940	106,36	166,50	643,07
Iron & steel+non-ferrous metals	7070	955,06	1697,83	3373,45
Non-metallic minerals	1340	98,52	171,55	900,08
TOTAL INDUSTRY	**20650**	**2005,64**	**3934,54**	**11607,97**

2.3 TECHNICAL POTENTIAL FOR TRIGENERATION IN THE TERTIARY SECTOR

In order to estimate the technical CHP potential in the tertiary sector, the collection of questionnaires was concentrated on the following types of buildings/facilities:

- Hotels
- Hospitals
- University campuses
- Airports
- Office buildings

Thus, the heating-cooling and electricity demand in the tertiary sector was also analyzed by sector and unit.

For each building/facility for which we received a completed questionnaire, a preliminary feasibility study for the installation of a cogeneration system was made. The components of the CHP facility which meets the load demand (heating, cooling, electricity), were calculated. Then, the primary energy savings, which the CHP facility would provide, in relation to the separate generation of electricity and heating/cooling, were calculated. Finally, conversion of the sample for each branch of the tertiary sector was done on the total sector. For Greece, the possibility of promoting trigeneration in hotels is of special significance, mainly on the large islands. Thus, the influence of the possible penetration of trigeneration on the demand for electrical capacity on those islands during the summer months was studied.

2.3.1 Hotels

The research population is composed of all the hotels in Greece of all types, except campgrounds. As the data of the Greek National Statistical Service show, (Hotel Database, Greek National Statistical Service, 2003), the number of hotels is comprised of 8899 units which form the sampling framework of the research.

The sampling method chosen was stratified sampling, which was done in two stages due to the large number of units in the whole of the country.

The stratification variable for the first stage of the research was the climate zones (4 zones) into which all the regions of Greece were divided using geographic and climate criteria. For the second stage, the stratification variables were the seasonal operation of the unit, the category and type of hotel. The distribution of the sample was made corresponding to the four zones according to which percentages the units "participate" in the population and the choice of the units in the layers was done with the random sampling method.

The total size of the sample was 50 units, proportionately distributed in the aforementioned layers in order to ensure a statistical error of around 5%.

- Continuous operation, which belong to the grid connected system
- Seasonal operation, which belong to the grid connected system
- Seasonal operation, which belong to the non-connected island systems.
- Continuous operation of units, which belong to the non-connected island systems

Based on the replies which were received from the sample and after the conversion to the total, the total heating, cooling and electricity loads were estimated as well as the total technical potential for hotel units on the grid connected and non-connected island systems.

The results are shown in Table 2.3.1:

Table 2.3.1 : Technical CHP Potential in Hotel Sector (based on questionnaire data analysis)

HOTELS	Heat Demand For Heating (GWh/year)	Heat Demand For Cooling (GWh/year)	TECHNICAL POTENTIAL (MWe)	TECHNICAL POTENTIAL (MWth)	PES (GWh/year)
Grid-Connected	1070	190	147,79	200,58	736,3
Non-connected islands	110	120	26,48	33,18	99,55
TOTAL	**1180**	**310**	**174,3**	**233,76**	**835,85**

2.3.2 Hospitals

The research population was composed of the total number of hospital units in Greece according to the data of the Ministry of Health and Welfare (www.mohaw.gr). The total number of hospitals in Greece is 324 units, divided into 133 public hospitals and 191 private clinics. However, for the purposes of this research, the small hospitals (units with less than 50 beds) were excluded as it was judged that the objectives of the research (investigation of cogeneration potential), were not relevant to them. Therefore, the number of hospitals was reduced to 223 units (116 public and 117 private).

Next, the units were divided into three sizes corresponding to their number of beds:
Specifically, into:

- Small units (50 to 250 beds)
- Medium units (250 to 500 beds)
- Large units (more than 500 beds)

The sampling method chosen was stratified sampling done in one stage as, in general, it leads to a higher level of accuracy in the results and as a representative sample of the population in question.

The stratification variables used were the legal form of the unit (public-private) as well as size, according to the three size categories referred to above (small medium, large). The sample was distributed correspondingly to the layers, according to the percentages at which the units "participate" in the population and the choice of the units in the layers was made using the random sampling method. However, for this specific research, the special characteristics of the sector had to be taken into consideration (small number of units, difficulties in locating those responsible for filling in the questionnaires, "bureaucratic" difficulties in approval for filling them in, etc.) and which had a significant effect on the time and cost involved for the research. For this reason, the choice of a relatively small sample size was preferred (about 15% of the total) and the 'focus" of the research on specific sample units in order to achieve a high rate of response (the usual percentage of response in similar research is 20-30%, with especially time consuming rates of response). In accordance with all the above, but also taking into consideration the confidentiality rules of the sample (at least 3 sampled units in each layer), the total size of the sample was set at 16 units, distributed correspondingly to the layers, as they were defined above. The statistical error for the specific sample size is under 3 %.

Based on the replies received from the sample, and after conversion to the total number of hospital in Greece, it was calculated that the total energy consumption for **covering heating and cooling loads** in hospitals is **1.182,9 and 221,1 GWh** correspondingly and energy consumption for **electricity loads in hospitals** is **792,1 GWh.** Based on these loads, it is calculated that the **technical potential** for cogeneration in hospitals is **164,41 MWth** and **109,18 MWe**. The **conservation of primary energy (PES)** amounts to **290,78 GWh.**

2.3.3 University Campuses

The collection of the required data was done through a field survey at university facilities. From the replies received, the required thermal energy per student is estimated at 953,7 kWh/year, and the required electricity per student is 886,5 kWh/year. According to these data, the technical potential for cogeneration is estimated at 0,26kWe/student or 0,37 kWth/student. Expressed as a fraction of the total

number of students in Greece's universities, the following are derived: **cooling load 62,92 GWh, heating load 251,37 GWh, total electricity load 233,65 GWh.**
The **technical potential for cogeneration is 67,339 MWe and 97,257 MWth**. The primary energy savings **(PES) amount to 118,71 GWh.**

2.3.4 Airports

The collection of the necessary data was done through a field survey at Greece's airports. From the replies received, energy consumption to **cover thermal and electricity loads amounts to 75,5 GWh and 25,34 GWh,** correspondingly. Consumption for **cooling loads is in the order of 9 GWh.** The **technical potential for cogeneration in the sample** amounts to **2,5 MWe** or **3,99 MWth.** The **primary energy savings (PES) amount to about 10,292 GWh.**

2.3.5 Tertiary Sector CHP Potential (office buildings excluded)

The Technical Potential of CHP in the Tertiary sector is presented in Table 2.3.5

Table 2.3.5 : Technical CHP Potential in the Tertiary Sector (office buildings are excluded)

Subsector	Heat Demand For Heating (GWh/year)	Heat Demand For Cooling (GWh/year)	CHP Potential (MWe)	CHP Potential (MWth)	PES (GWh/year)
Hotels, Mainland	1070	190	147,72	200,58	736,3
Hotels, Islands	110	120	26,48	33,18	99,55
Hotels Total	**1180**	**310**	**174,3**	**233,76**	**835,85**
Hospitals	**1185**	**220**	**109,18**	**164,42**	**290,78**
Universities	**250**	**65**	**67,34**	**97,26**	**118,71**
Airports	**75**	**9**	**2,5**	**3,99**	**10,292**
Total Tertiary	***2690***	***604***	***353,32***	***499,43***	***1255,632***

2.3.6 Office Buildings

The calculations for office buildings were made based on data in [2] and [24]. The buildings are divided among four climate zones and by date of construction. The calculations of the technical potential are shown in Table 2.3.6.

Table 2.3.6. : Office Buildings – CHP Technical Potential

Office Buildings, Climate Zone A					
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**2057998,00**	**2773066,00**	**2641015,00**	**7472079,00**
Specific Thermal Consumption	kWh/s.m./year	67,00	52,00	48,00	
Total Thermal Consumption	**MWh / year**	**137885,87**	**144199,43**	**126768,72**	**408.854**
Degree Days		921,00	921,00	921,00	
Minimum Temperature	°C	0,00	0,00	0,00	
Heating Months		5,00	5,00	5,00	
Heating Hours	h	12,00	12,00	12,00	
Thermal Peak Load	**MWth**	**224,57**	**234,85**	**206,46**	**665,89**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	391,80	409,74	360,21	1161,76
Electric Peak Load	**MWe**	**137,13**	**143,41**	**126,07**	**406,62**
ne,ref		0,41	0,41	0,41	0,41
nth,ref		0,84	0,84	0,84	0,84
PES	**MWh / year**	**231.260**	**241.849**	**212.614**	**685.723**
PESR	**%**	**0,30**	**0,30**	**0,30**	**0,30**

Office Buildings, Climate Zone B					
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**19908653,00**	**18313115,00**	**14004147,00**	**52225915,00**
Specific Thermal Consumption	kWh/s.m./year	85,00	69,00	65,00	
Total Thermal Consumption	**MWh / year**	**1692235,51**	**1263604,94**	**910269,56**	**3866110,00**
Degree Days		1546,00	1546,00	1546,00	
Minimum Temperature	°C	0,00	0,00	0,00	
Heating Months		6,00	6,00	6,00	
Heating Hours	h	14,00	14,00	14,00	
Thermal Peak Load	**MWth**	**1407,33**	**1050,86**	**757,02**	**3215,21**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	2455,34	1833,42	1320,75	5609,51
Electric Peak Load	**MWe**	**859,37**	**641,70**	**462,26**	**1963,33**
ne,ref		0,48	0,48	0,48	0,48
nth,ref		0,85	0,85	0,85	0,85
PES	**MWh / year**	**1.118.107**	**834.899**	**601.440**	**2.554.445**
PESR	**%**	0,22	0,22	0,22	0,22

Office Buildings, Climate Zone C					
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**11800285,00**	**10854575,00**	**8513392,00**	**31168252,00**
Specific Thermal Consumption	kWh/s.m./year	107,00	89,00	83,00	
Total Thermal Consumption	**MWh / year**	**1262630,50**	**966057,18**	**706611,54**	**2935299,21**
Degree Days		2238,00	2238,00	2238,00	
Minimum Temperature	°C	-1,00	-1,00	-1,00	
Heating Months		7,00	7,00	7,00	
Heating Hours	h	16,00	16,00	16,00	
Thermal Peak Load	**MWth**	**669,96**	**512,60**	**374,93**	**1557,49**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	1168,87	894,32	654,14	2717,33
Electric Peak Load	**MWe**	**409,10**	**313,01**	**228,95**	**951,06**
ne,ref		0,49	0,49	0,49	0,49
nth,ref		0,85	0,85	0,85	0,85
PES	**MWh / year**	**690.239**	**528.112**	**386.282**	**1.604.633**
PESR	**%**	**0,21**	**0,21**	**0,21**	**0,21**

Office Buildings, Climate Zone D					
Year of Construction		**Before 1980**	**1981-2001**	**2002-2010**	**Total**
Surface	**s.m.**	**409721,00**	**420633,00**	**385581,00**	**1215935,00**
Specific Thermal Consumption	kWh/s.m./year	134,00	110,00	103,00	
Total Thermal Consumption	**MWh / year**	**54902,61**	**46269,63**	**39714,84**	**140887,09**
Degree Days		2827,00	2827,00	2827,00	
Minimum Temperature	°C	-3,00	-3,00	-3,00	
Heating Months		8,00	8,00	8,00	
Heating Hours	h	16,00	16,00	16,00	
Thermal Peak Load	**MWth**	**25,49**	**21,48**	**18,44**	**65,41**
CHP Overall Efficiency		0,82	0,82	0,82	0,82
CHP Electric Efficiency		0,35	0,35	0,35	0,35
CHP Thermal Efficiency		0,47	0,47	0,47	0,47
Total Peak Load	MW	44,47	37,48	32,17	114,12
Electric Peak Load	**MWe**	**15,57**	**13,12**	**11,26**	**39,94**
ne,ref		0,41	0,41	0,41	0,41
nth,ref		0,84	0,84	0,84	0,84
PES	**MWh / year**	**53.296**	**44.915**	**38.552**	**136.763**
PESR	**%**	**0,29**	**0,29**	**0,29**	**0,29**

2.4 POTENTIAL FOR BIOMASS APPLICATIONS OF CHP

The applications which are considered in the chapter that follows include combustion technologies using biomass products to produce heat and electricity. The heat produced is used either to cover the needs of the producer, such as they may be, or to cover neighbouring heating loads in the residential sector by developing a heat distribution network.

The types of biomass fuel which were investigated are:

- Byproducts associated with processing of agricultural and forestry residues (wood working industry, food, etc.)
- Agricultural residues as well as forestry residues which can be used after being preprocessed and transported from harvest areas to proposed processing facilities.

Such facilities for energy production could be located:

- In places where there is already production or use of biomass byproducts (agricultural industry plants or woodworking industries which in many instances use biomass byproducts to cover their heating needs).
- In places near small or larger urban centres which are located in areas with a large supply of biomass (agricultural areas, forests) and have heating loads which could be covered by small scale district heating.
- In places where the above two conditions are met.

The calculations refer to:

1. The assessment of the heating loads of the industrial units with biomass byproducts.
2. The assessment of heating loads in the residential sector which can be covered at a short distance from the candidate facilities.
3. The assessment of the available biomass potential available for energy production, and finally
4. The potential of CHP to meet the above heating loads and this forms the evaluation of the biomass potential for CHP applications.

Based on the assessments from processing the data and the models used, this potential amounts to 373 MWe, out of which:

- **290** MWe can be installed in locations where there is already proven industrial activity related to the agricultural or wood working sectors.
- **83** MWe can be installed at locations without proven activity in these sectors, but which are located next to areas with a potential supply and residential sector loads.

The total biomass used, based on the existing data and the estimates of the model, amounts to **25 674 TJ** (6 393 TJ to cover industrial loads and 8 367 TJ for district heating of neighbouring settlements). The thermal energy produced amounts to **4 100 $GW_{th}h$** (14 760 TJ) without the calculation of losses during end use.

2.4.1 Investigation of the possibility for the development of CHP projects using biomass as a fuel

In the following table, the basic categories of facilities are shown which produce and consume (or could consume) biomass products to cover their heating needs as well as the number of units for which data is recorded.

Table 2.4.1.1 : Basic categories of facilities which produce or consume biomass products to cover their heating needs

Kind of Industry	Residue	Mass
1. Cotton Factories	Cotton residues	18 – inventory
2. Woodworking	Wood residues	60 – inventory
3. Olive kernel processing	Olive kernel	38 – inventory
4. Rice mills	Rice residues	8 – inventory
5. Poultry farms	Poultry litter	Sampling

In the cases of facilities 1-4, data were collected for all the facilities, while for category 5, data were collected from a representative sample.

The development phases of the methodology followed include:

1. Collection of the data (yearly heating load and total demand for thermal energy) for the categories of facilities in the preceding table.
2. Calculation of the residential heating loads which could be covered at a short distance from the facilities.
3. Calculation of the biomass (wood, branches pruned from orchards…) which could be collected at a short distance from the facilities.
4. Evaluation of the energy characteristics of likely facilities.

Table 2.4.1.2 : Distribution of heating and electricity loads of cogeneration units with biomass at locations of manufacturing plants by using biomass products

Area	Thermal capacity (MWth)	Electrical capacity (MWe)	Biomass Used (TJ)
Central Greece Peloponnese	284.08	132.08	8559.58
Ipiros –Thessaly	71.9	33.14	2460.42
Makedonia – Thrace	138.48	64.19	4596.77
Islands - Attica	130.37	60.68	4340.94
Total	**624.80**	**290.09**	**19 958**

Table 2.4.1.3 : Distribution of the thermal and electrical capacity of CHP units using biomass exclusively from agricultural and forest residues, for use in the residential and tertiary sectors with district heating

Area	Thermal capacity (MWth)	Electrical capacity (MWe)	Biomass Used (TJ)
Central Greece - Thessalia	67.36	31.08	2022.66
Makedonia - Thraki	87.28	40.19	2820.37
Peloponnese	26.05	11.85	872.79
Total	**180.7**	**83.1**	**5716**

The thermal and electrical capacity shown is the maximum capacity which could be installed with the basic prerequisite that ***the costs calculated in each case do not exceed the expected revenue.*** In this sense and to the extent that factors such as financial support measures, cost of loans and profitability indicators (return on the investment) are not taken into consideration in the calculations, these estimates define the ***technical potential of agricultural and forest biomass which could be used in CHP units.***

In any event, and taking into consideration the total of the potential supply, either from industrially processed products or from agriculture, the amount of biomass which could be used is maximized.

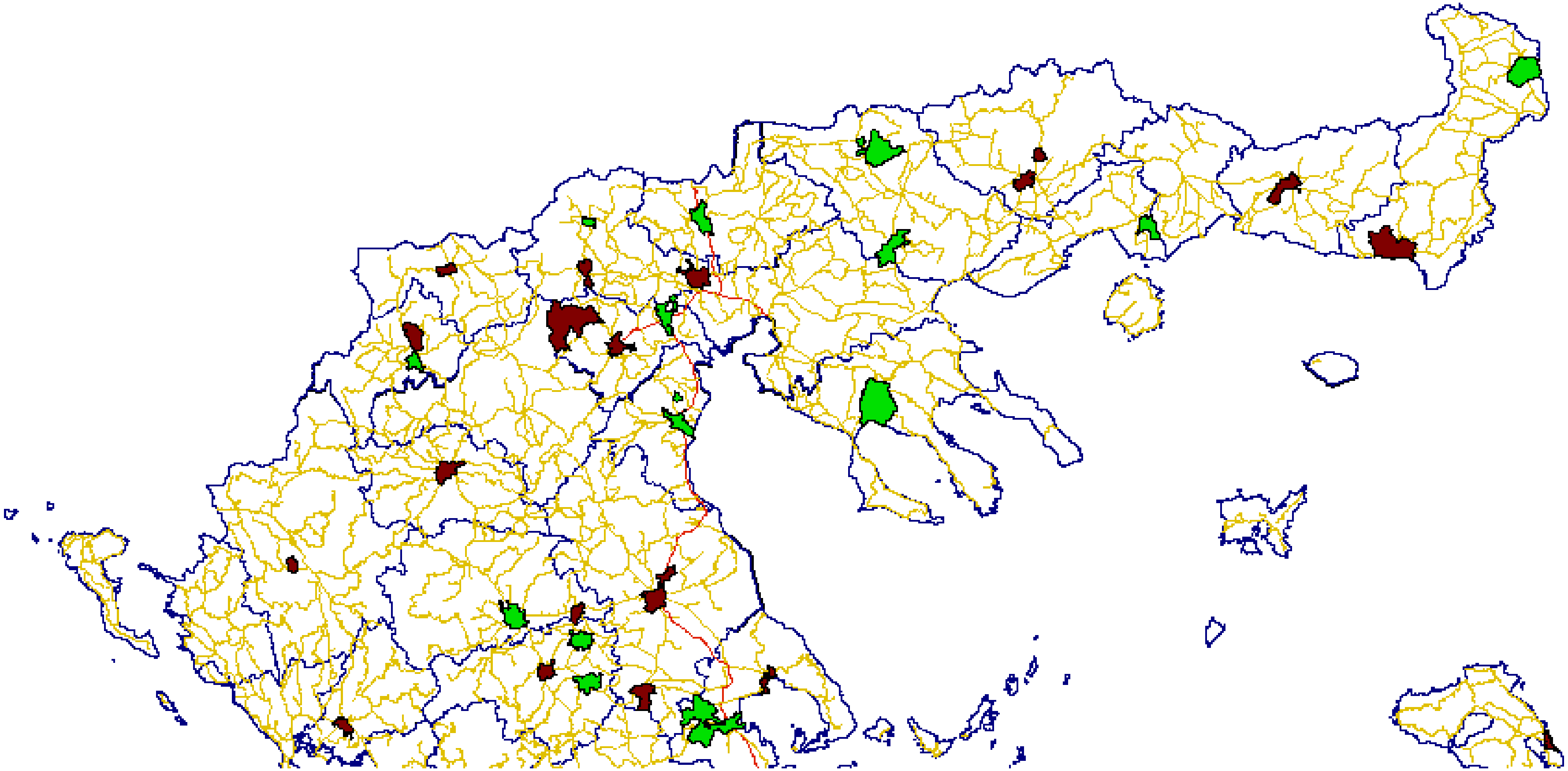


Figure 2.4.1.1 : Distribution of locations of facilities evaluated for CHP from biomass – northern Greece

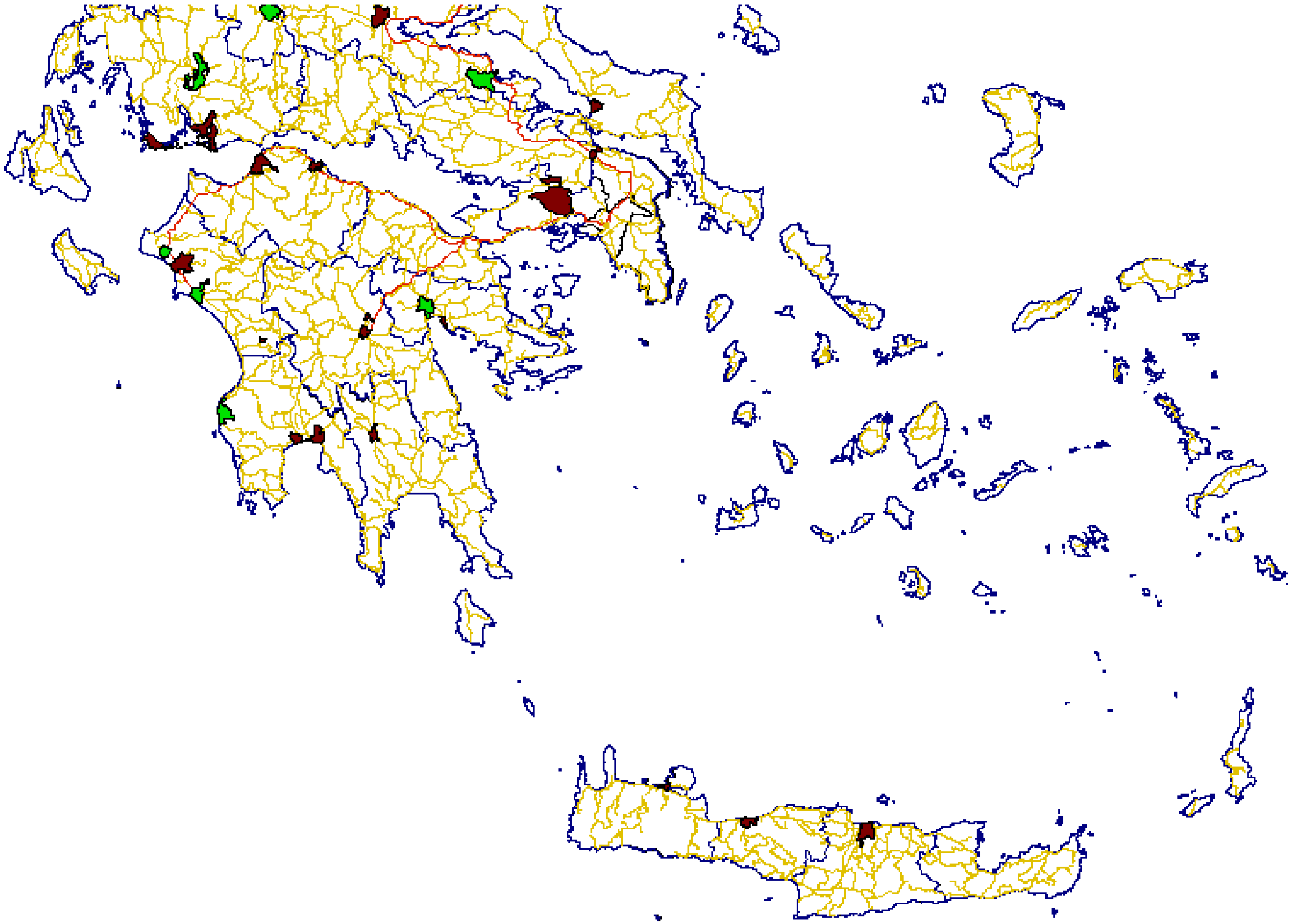


Figure 2.4.1.2 : Distribution of locations of facilities evaluated for CHP from biomass – southern Greece

Table 2.4.1.4 : Energy characteristics of cogeneration units with biomass, at locations of manufacturing plants with use of biomass products

Area	Heat Production (TJ)	Electricity Production (TJ)	Primary Energy Savings (TJ)	Primary Energy Savings (GWh/year)
Central Greece Peloponnese	5066	2355	4911	1365
Ipiros -Thessaly	1421	658	1303	361
Makedonia – Thrace	2652	1227	2438	677
Islands - Attica	2581	1201	2526	703
Total	**11720**	**5440**	**11178**	**3107**

Table 2.4.1.5 : Energy characteristics of cogeneration units with biomass, exclusively from agricultural and forestry residues for use in the residential and tertiary sectors with district heating

Area	Heat Production (TJ)	Electricity Production (TJ)	Primary Energy Savings (TJ)	Primary Energy Savings (GWh/year)
Central Greece - Thessaly	1167.2	538.4	1067	297
Makedonia - Thrace	1618.1	745.2	1466	406
Peloponnese	479.8	218.2	389	108
Total	**3266**	**1503**	**2921**	**812**

2.5 BIOGAS POTENTIAL

2.5.1 Sewage Treatment Plants

The collection of the required data was done through a country wide field survey at sewage treatment plants in Greece, for biogas production. From the replies received, the energy consumption was **138,73 GWh and 33,92 GWh,** respectively. There is also a small consumption for cooling loads at 0,1 GWh. The **technical potential for cogeneration** amounts to **18,1 MWth** and **11,93 MWe.** Of this, based on the replies and the national statistics, **16,7 MWth** and **10,93 MWe** have already been installed. The primary energy savings **(PES) amount to approximately 108 GWh/year.**

2.5.2 Sanitary Landfills

The biogas produced at sanitary landfills could be used for CHP and to cover the heating loads at a very short distance (< 5 k) from the locations of the sanitary landfills, which mainly concern space heating of buildings and hot water production. Loads are given and described for the 4 more important sanitary landfills.

Sanitary Landfill of Attica

The sanitary landfill of Attica serves the greater area of the capital and is located at the boundaries of the Municipality of Liosia. The technical potential of the sanitary landfill of Attica is 23,5 MWe and 31,3 MWth. The capacity which corresponds to the technical potential can yield 185274 MW_eh and 247032 MW_{th}h (889 TJ).

Sanitary Landfill of Thessaloniki

The sanitary landfill of Thessaloniki is within the boundaries of the municipal district of Tagarades. The technical potential of the sanitary landfill of Thessaloniki is presently 5 MWe and 6.7 MWth; out of this 5 MWe are installed for power production. The capacity which corresponds to the technical potential can yield 39420 MW_eh and 52 560 MW_{th}h (189 TJ).

Other sanitary landfills which possibly have biogas potential for CHP or electricity generation are:

Sanitary Landfill of Volos

The sanitary landfill of Volos is located on the boundaries of the municipal district of Diminio, at a distance of less than 10km from both the city centre of Volos and from the Industrial Park of Volos. The technical potential of the sanitary landfill of Volos is 5 MWe and 6,7 MWth. The capacity which corresponds to the technical potential can yield 3940 MW_eh and 52560 MW_{th}h (189 TJ).

Sanitary Landfill of Larissa

The sanitary landfill of Larissa is located at the boundaries of the municipal district of Makryhori and its distance from the urban centre of the area (Larissa) is fairly large (more than 15 km). The technical potential can give 31536 MW_eh and 42048 MW_{th}h (189 TJ).

Table 2.5.2 : Technical potential of sanitary landfills for CHP applications

Area	Electric Capacity (MW_e)	Thermal Capacity (MW_{th})	Electricity Production (MW_eh)	Heat Production (MW_{th}h)	Heat Production (TJ)
Liosia 1	13.8	18.4	108799	145066	522
Liosia 2	9.7	12.93	76475	101966	367
Tagarades	5	6.67	39420	52560	189
Volos	5	6.67	39420	52560	189
Larisa	4	5.33	31536	42048	151
TOTAL	**37.5**	**50**	**295650**	**394200**	**1419**

2.5.3 Potential of the main organic wastes in Greece

In Greece today, there are around 33,000 cattle farms with 723,000 head, 36000 pig farms with 970,000 head, 2700 olive oil presses, 25 olive kernel oil presses and a significant number of food industries.

According to estimates made by CRES, **17.000.000** tons of organic waste are produced yearly in Greece which, through the process of anaerobic digestion, could produce biogas sufficient to supply CHP units with a total installed capacity of **350 MWe and 467 MWth.**

Table 2.5.3 : Technical potential of organic wastes

	Electric Capacity (MW_e)	Thermal Capacity (MW_{th})	Electricity Production (MW_eh)	Heat Production ($MW_{th}h$)	Heat Production (TJ)
Cattle farms	278	370.7	2191752	2922336	10520.41
Pig farms	37	49.3	291708	388944	1400.19
Slaughterhouses	28	37.3	220752	294336	1059.61
Cheese factories (milk processing)	7.21	9.6	56844	75792	272.85
TOTAL	**350.21**	**466.94**	**2761056**	**3681407.52**	**13253.07**

2.5.4 Technical potential of biogas for CHP applications

According to the above calculations, we derive the technical potential for biogas in Greece in the Table 2.5.4 which follows:

Table 2.5.4 : Technical potential of biogas

	Electric Capacity (MW_e)	Thermal Capacity (MW_{th})	Electricity Production (MW_eh)	Heat Production ($MW_{th}h$)	PES (MWh)
Sludge	11,93	18,1	33920	138730	108000
Landfill gas	37,50	50,00	295650	394200	447297
Organic waste	350,21	466,94	2761056	3681407	4177277
TOTAL	**399,64**	**535,04**	**3090626**	**4214337**	**4732574**

2.6 DESALINATION NEAR ISLAND GENERATION PLANTS

The calculation of the technical potential of CHP for water desalination in the Greek islands is based on the assumption that in each non-connected plant a desalination system is installed which utilizes the total heat produced. The desalination system uses the waste thermal energy and not mechanical energy or by extension, electricity.

Using typical values found in the literature for the required special heat for each method, it is easy to calculate the corresponding amount of desalinated water for each plant which could be produced on a daily basis. This amount obviously concerns the maximum possible production provided that the plant functions at 100% of its capacity. Also, it was considered that there was a power to heat ratio of 0,75, a value which is quite typical both for diesel engines as well as for small sized steam turbine units.

Table 2.6 : Technical CHP Potential for Desalination Applications near Island Generation Plants

Name of Island	Installed Electrical Capacity	Estimated Thermal Capacity	Production of Drinking Water (daily-c.m.)		Electricity Generated Per Day	Equivalent Population	
	kWe	kWth	MSF (1)	MED (2)	kWh,e/day	MSF	MED
Agathonisi	440	587	282	469	563,2	1877	3129
Agios Efstratios	580	773	371	619	742,4	2475	4124
Amorgos	4470	5960	2861	4768	5721,6	19072	31787
Anafi	470	627	301	501	601,6	2005	3342
Andros	14600	19467	9344	15573	18688	62293	103822
Antikythira	350	467	224	373	448	1493	2489
Astypalea	4425	5900	2832	4720	5664	18880	31467
Donoussa	293	391	188	313	375,04	1250	2084
Erikousa	440	587	282	469	563,2	1877	3129
Zakynthos	3400	4533	2176	3627	4352	14507	24178
Thera	35146	46861	22493	37489	44986,88	149956	249927
Ikaria	11360	15147	7270	12117	14540,8	48469	80782
Ios	2160	2880	1382	2304	2764,8	9216	15360
Kalymnos	15000	20000	9600	16000	19200	64000	106667
Karpathos	12027	16036	7697	12829	15394,56	51315	85525
Kefallonia	14800	19733	9472	15787	18944	63147	105244
Kythnos	1600	2133	1024	1707	2048	6827	11378
Kos	77600	103467	49664	82773	99328	331093	551822
Lesbos	63360	84480	40550	67584	81100,8	270336	450560
Lemnos	20450	27267	13088	21813	26176	87253	145422
Megisti	1390	1853	890	1483	1779,2	5931	9884
Milos	11450	15267	7328	12213	14656	48853	81422
Myconos	27450	36600	17568	29280	35136	117120	195200
Nissiros	640	853	410	683	819,2	2731	4551
Othoni	440	587	282	469	563,2	1877	3129
Paros	68020	90693	43533	72555	87065,6	290219	483698
Patmos	4965	6620	3178	5296	6355,2	21184	35307
Samothraki	1300	1733	832	1387	1664	5547	9244
Samos	30700	40933	19648	32747	39296	130987	218311
Serfios	4550	6067	2912	4853	5824	19413	32356

Name of Island	Installed Electrical Capacity	Estimated Thermal Capacity	Production of Drinking Water (daily-c.m.)		Electricity Generated Per Day	Equivalent Population	
Sifnos	5800	7733	3712	6187	7424	24747	41244
Skyros	2140	2853	1370	2283	2739,2	9131	15218
Simi	4350	5800	2784	4640	5568	18560	30933
Syros	25750	34333	16480	27467	32960	109867	183111
Tilos	265	353	170	283	339,2	1131	1884
Chios	41980	55973	26867	44779	53734,4	179115	298524
Psara	345	460	221	368	441,6	1472	2453
Marathi	40	53	26	43	51,2	171	284
Arkii	260	347	166	277	332,8	1109	1849
Gavdos	90	120	58	96	115,2	384	640

2.7 GLASS GREENHOUSES

The determination of the technical potential of cogeneration for heating glass greenhouses rests on the following two main assumptions:

The heat requirements of a greenhouse result from thermal losses through its surfaces only. These losses are calculated in relation to the expected typical minimum temperatures, average temperatures and degree days. The average load in relation to the peak load is estimated based on the average number of degree days in each month.

The CHP unit is sized so that it covers a base heating load which allows it to operate for a significant number of hours during its period of operation, a number which is estimated to be over 80%. However, determining this number requires complete meteorological data which do not exist for such a preliminary study. The electricity produced is always absorbed entirely either by the unit itself or by the grid.

Very small heating loads as well as thermal peak loads are covered by a conventional boiler which also functions as a 100% reserve for the occasions when there is no supply from the CHP unit.

Table 2.7 : Technical CHP Potential for Glass Greenhouses

Area	Agricultural District	Thermal Capacity for the Aver. Day (MWth)	Electrical Capacity (MWe)	Thermal Energy for Period of Operation ($MW_{th}h$)	Electricity for Period of Operation (MW_eh)	PES (MWh/year)
BE	Drama	0,6	0,4	105,9	79,5	124,6
BE	Serres	1,7	1,3	331,1	248,3	389,5
BE	Xanthi	0,2	0,2	41,3	30,9	48,5
BE	Preveza	0,6	0,5	107,9	80,9	126,9
KE	Corfu	0,2	0,2	37,4	28,0	44,0
KE	Magnisia	1,0	0,8	175,4	131,5	206,3
KE	Karditsa	0,2	0,2	41,3	30,9	48,5
NE	Argolida	0,1	0,0	8,1	6,1	9,5
NE	Corinth	0,8	0,6	127,4	95,5	149,8
NE	Lakonia	1,1	0,8	159,2	119,4	187,3
NE	Aetoloakarnania	0,6	0,5	107,9	80,9	126,9
NE	East Attika	1,8	1,3	298,0	223,5	350,6
NE	Piraeus	0,3	0,2	55,0	41,3	64,7
NE	Cyclades	0,6	0,4	83,5	62,6	98,2
NE	Dodekanissa	0,2	0,2	31,1	23,3	36,6
NE	Iraklio	1,8	1,4	263,2	197,4	309,7
NE	Lassithi	0,2	0,2	31,1	23,3	36,6
NE	Chania	0,2	0,1	25,6	19,2	30,1
NE	Rethymno	0,2	0,2	31,1	23,3	36,6
	TOTAL	**12,4**	**9,5**	**2061,4**	**1546,0**	**2425,2**

2.8 GEOTHERMAL ENERGY

Table 2.8 which follows, shows the geothermal potential in Greece for CHP applications, according to CRES' estimates. It is noted that for cogeneration applications, the potential of medium and mainly high enthalpy is more suitable where the geothermal fluid has a temperature above 120 C.

In the cases of Milos and Nisyros, the thermal capacity is calculated based on the demand for heating load which is anticipated on these islands. Thus, the potential 20 and 2 **MWth which is shown is severely limited in thermal capacity which could be used locally for the requirements of these islands.**

Table 2.8 : Technical Potential of Geothermal Energy for CHP in Greece
Middle (120 C – 150 C) – High (150 C – 350 C) Enthalpy

Area of Geothermal field	Temperature	Thermal Capacity (MWth)	Electrical Capacity (MWe)	Heat Produced ($MW_{th}h$*)	Electricity Produced (MW_eh**)
Milos	120 ºC -350 ºC	20	4	70080	28032
Nisiros	120 ºC -350 ºC	2	0,4	7008	3154
Possible potential (not investigated) in areas like Lesvos, Chios, plains in North Greece)	120 ºC -150 ºC	1000	100	3504000	788400
TOTAL		**1022**	**104,4**	**3581088**	**819586**

* load factor 40%
** load factor 90%

EVALUATION OF THE ECONOMIC POTENTIAL OF CHP IN GREECE

3.1 EXISTING CHP INSTALLATIONS AND INSTALLATIONS UNDER DEVELOPMENT

In Table 3.1, the CHP installations which operate at present in Greece are shown, projects under construction (installation permit) and projects which have been granted generation permits. The data are from the Electricity Generation Division of the Ministry of Development and accordingly show that the total cogeneration capacity of CHP installations which are in operation at present amounts to 255 MWe and projects with a total capacity of 95 MWe are under construction and projects with a total of a further 355 MWe have been granted generation permits. The total cogeneration capacity amounts to 714 MWe and substantially, this is the expected level of penetration of CHP over the coming years (until 2010). It is worthy of note that even if the functioning installations concern only CHP applications in industry and district heating in the electricity generation system, the permits for projects under construction also concern hotels, hospitals and buildings in the tertiary sector and lastly CHP from autoproducers with district heating and glass greenhouses uses. Also, the presence of small CHP systems as well as systems using biomass for fuel is typical. Finally, it is noted that of the 500 MWe of the installations under construction, 320 MWe are destined for the Aluminum of Greece SA.

The increase in installed capacity of CHP which is anticipated from the installations under construction in reality is a result of the application of current policies of support for CHP investments. However, it is noted that for the time being, the influence of the new Law 3468 on renewable energy sources and high efficiency cogeneration is not yet apparent.

Table 3.1 : CHP Installations in Greece

	OWNING COMPANY	LOCATION	TYPE OF ACTIVITY	CHP TECHNOLOGY	FUEL	YEAR OF OPERATION	Electrical Capacity (MWe)	Thermal Capacity (MWth)
1	GREEK SUGAR INDUSTRY - LARISA, unit. 1&2	Larisa	Manufacture of food products and beverages	Steam Backpressure Turbine	Natural gas	1961	5	24
2	GREEK SUGAR INDUSTRY PLATY, unit. 1- 2	Platy	Manufacture of food products and beverages	Steam Backpressure Turbine	Natural gas	1962	12	53,3
3	GREEK SUGAR INDUSTRY SERRES, unit. 1-2	Serres	Manufacture of food products and beverages	Steam Backpressure Turbine	Natural gas	1962	6	25,7
4	GREEK SUGAR INDUSTRY-XANTHI	Xanthi	Manufacture of food products and beverages	Steam Backpressure Turbine	Natural gas	1972	16	51,4
5	GREEK SUGAR INDUSTRY - LARISA, unit. 3	Larisa	Manufacture of food products and beverages	Steam Backpressure Turbine	Natural gas	1972	7	37
6	GREEK SUGAR INDUSTRY ORESTIADA, unit 1-2	Orestiada	Manufacture of food products and beverages	Steam Backpressure Turbine	Heavy Fuel Oil	1974	10	51,4
7	Greek Aluminum unit 1	Viotia	Aluminium production	Steam Backpressure Turbine	Natural gas	1981	3,7	17,5
8	Greek Aluminum, unit. 2	Distomo Viotias	Manufacture of other non-metallic mineral products	Steam Backpressure Turbine	Heavy Fuel Oil	1981	7,9	33,7
9	ELPE	Aspropirgos	Manufacture of refined petroleum products	Combined-Cycle Gas Turbine with Heat Recovery	Refinery Gas, Heavy Fuel Oil, Light Fuel OIl	1990	50	50,1
10	KAVALA OIL	Kavala	Manufacture of refined petroleum products	Combined-Cycle Gas Turbine with Heat Recovery	Natural gas	1995	17,67	11

11	VFL	Kavala	Manufacture of basic chemicals	Internal Combustion Engine	Natural gas	1997	21,3	
12	MOTOR OIL (units1&2)	Korinthos	Manufacture of refined petroleum products	Gas Turbine with Heat Recovery	Refinery Gas	1997	32,1	47,1
13	AMYLO SA (Tate & Lyle), unit Kentavros	Thessaloniki	Manufacture of food products and beverages	Gas Turbine with Heat Recovery	Natural gas	1999	4,5	11,3
14	EXALCO SA	Larisa	Manufacture of textiles	Internal Combustion Engine	Natural gas	2000	2,7	3,6
15	EYDAP	Psitalia	Collection, purification and distribution of water	Internal Combustion Engine	Biogas	2001	7,1	9,6
16	MAILIS	Oinofyta	Non Metallic Minerals	Internal Combustion Engine	Natural gas	2001	2,1	3
17	KOTHALIS SA	Thessaloniki	Manufacture of other non-metallic mineral products	Gas Turbine with Heat Recovery	Natural gas	2001	1,1	3,7
18	MOTOR OIL (unit.3)	Korinthos	Manufacture of refined petroleum products	Gas Turbine with Heat Recovery	Refinery Gas	2002	17	25
19	GENESIS HOSPITAL SA	Thessaloniki	Hospital activities	Internal Combustion Engine	Natural gas	2006	0,8	0,9
20	NATIONAL UNIVERSITY OF ATHENS	Athens	Higher education	Internal Combustion Engine	Natural gas	2006	2,7	3,1
21	MOTOR OIL SA	Ag. Theodoroi	Manufacture of refined petroleum products	Gas Turbine with Heat Recovery	Refinery Gas	2006	17	25
22	ELFIKO	Schimatari-Viotia	Manufacture of textiles	Internal Combustion Engine	Natural gas	2007	1,2	1,4
23	ARCHITEK ENERGIAKH SA	Imathia	Growing of vegetables, horticultural specialities and nursery products	Internal Combustion Engine	Natural gas	2007	5	6,1

24	GREENHOUSES OF DRAMA SA	Drama	Growing of vegetables, horticultural specialities and nursery products	Internal Combustion Engine	Natural gas	2007	4,8	4,9
	OPERATING CAPACITY						**255**	**500**

1	EYDAP	Psitalia	Collection, purification and distribution of water	Internal Combustion Engine	Natural gas	IP	12,9	17,3
2	DEPA SA	Revithousa	Electricity, gas, steam and hot water supply	Internal Combustion Engine	Natural gas	IP	13	12,27
3	P.A.P. HOTELS CORPORATION SA	Thessaloniki	Hotel	Internal Combustion Engine	Natural gas	IP	0,07	0,11
4	BRIGHT SA	Menidi-Attica	Manufacture of lighting equipment and electric lamps	Internal Combustion Engine	LPG	IP	0,13	0,24
5	ETEM	Magoula-Attica	Manufacture of basic chemicals	Internal Combustion Engine	Natural gas	IP	0,23	0,34
6	FYSIS SA	Tympaki-Xanthi	Recycling	Internal Combustion Engine	Natural gas-Biomass	IP	9,5	45
7	AEE CHALIVA	Ionia-Thessaly	Manufacture of basic chemicals	Combined-Cycle Gas Turbine with Heat Recovery	Natural gas	IP	11,5	25
8	THERMI SERRON SA	Thermi Serron	Growing of vegetables, horticultural specialities and nursery products	Internal Combustion Engine	Natural gas	IP	16,5	70
9	THERMI DRAMAS SA	Drama	Growing of vegetables, horticultural specialities and nursery products	Internal Combustion Engine	Natural gas – Light Fuel Oil	IP	18	93
10	VFL	N.Karvali Kavalas	Manufacture of basic chemicals	Internal Combustion Engine	Steam	IP	2,35	
11	BIOGAS ANO LIOSIA	A.Liosia	General (overall) public service activities	Internal Combustion Engine	Biomass	IP	9,69	4,9
	CAPACITY UNDER CONSTRUCTION						**93,87**	**268,16**

1	ATHINAION	Athens	Hotel	Internal Combustion Engine	Natural gas	PP	0,41	0,61
2	MITERA HOSPITAL SA	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	0,49	0,62
3	ALFA WOOD	Larisa	Manufacture of wood and of products	Organic Rankine Cycle	Biomass	PP	0,75	4,9
4	COCA COLA	Schimatari - Viotia	Manufacture of food products and beverages	Internal Combustion Engine	Natural gas	PP	0,7	2,38
5	INSTITOUTO VIOLOGIKON EREUNON	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	0,54	0,78
6	EKPEDEFTHRIA DOUKA	Athens	Higher education	Internal Combustion Engine	Natural gas	PP	0,4	0,4
7	GENERAL AVIATION HOSPITAL	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	1,4	1,86
8	MARINE HOSPITAL	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	0,5	0,65
	PLANTS < 1MW, WITH A PRODUCTION PERMIT						**5,19**	**12,2**

1	VEAK SA	Komotini	Non-Metallic Minerals	Gas Turbine with Heat Recovery	Natural gas	PP	1,06	2,52
2	SISMANOGLIO	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	1,2	1,61
3	HOSPITAL KAT	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	1,2	1,56
4	HOSPITAL GENIMATAS	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	1,3	1,64
5	ACADEMY OF ATHENS	Athens	Higher education	Internal Combustion Engine	Natural gas	exemption	1,49	1,45
6	GENERAL HOSPITAL EUAGELISMOS	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	1,5	3,28
7	ATTIKON HOSPITAL	Athens	Hospital activities	Internal Combustion Engine	Natural gas	PP	1,65	2,03
8	DELTA SA	Ag.Stefanos	Manufacture of food products and beverages	Internal Combustion Engine	Natural gas	PP	2,05	2,42
9	SAKELLARAKOS	Tripoli	Manufacture of other non-metallic mineral products	Internal Combustion Engine	Biomass - LPG	PP	5	14,5
10	PAPER INDUSTRY OF THRAKI	Magana Xanthis	Manufacture of pulp, paper and paper products	Combined-Cycle Gas Turbine with Heat Recovery	Natural gas	PP	9,9	12
11	GREEK ALUMINUM SA	Ag. Nikolaos Viotias	Manufacture of basic metals	Combined-Cycle Gas Turbine with Heat Recovery	Natural gas	PP	334	302
	PLANTS > 1MW WITH A PRODUCTION PERMIT						**360,35**	**345**
	TOTAL CAPACITY						**715**	**1125**

3.2 ECONOMIC VIABILITY OF INVESTMENTS FOR THE APPLICATION OF CHP SYSTEMS IN THE RESIDENTIAL SECTOR

In this chapter, the economic potential of applications of CHP in the residential sector is assessed. The types of application which were examined for economic viability are:

- District heating applications for settlements by existing steam electricity generating plants
- Installation of new CHP units for district heating of settlements
- Application of small CHP systems (micro-CHP) in housing

3.2.1 District heating applications by existing electricity generation plants – planned by the PPC S.A.

After examining the load curves for the 4 climate zones, it was decided that steam electric generation plants for district heating, should be sought mainly in Zones D and C and less in Zone B, while in Zone A, the heating-cooling potential is examined on one hand, close to steam electricity generating plants in the islands and on the other hand, near hotels which have high cooling loads in the summer months.

In climate zone D, the following plants are located:
1. Agios Dimitrios – Steam condensing extraction turbine
2. Ptolemaida – Steam condensing extraction turbine
3. LKDM – Steam condensing extraction turbine
4. Kardia – Steam condensing extraction turbine
5. Melitis – Steam condensing extraction turbine

In climate Zone C the following plants are located:
1. Megalopolis – Steam condensing extraction turbine
2. Komotini – Combined cycle gas turbine
3. Greek Petroleum – Thessaloniki area – Combined cycle gas turbine

In climate zone A, the following plants are located:
1. Linoperamata – Steam condensing extraction turbine
2. Chania – Steam condensing extraction turbine
3. Rhodes – Steam condensing extraction turbine

For most of the plants which were identified, there are already district heating applications or they are in the planning stage. Specifically, **the PPC SA has built or plans to build district heating plants at the following electricity generation plants:**

In climate zone D:
1. For units 3,4 and 6 of the Steam Electricity Generating Plant Agios Dimitrios, there is the possibility for alternative supply of 70 MWth from each unit at the maximum, to the district heating system of the city of Kozani. At the same time, there is a project ***in the process of being implemented*** which will ensure the increase of thermal capacity to 140 MWth to the district heating network of the city of Kozani with the combined operation of the above units.
2. For units 1 and 2 of the **Steam Electricity Generation Plant at Amyntaio**, there is a possibility for alternatively supplying the maximum thermal capacity of 25 MWth to the district heating network of the city of Amyntaio.
3. From unit 3 of the **Steam Electricity Generation Plant of Ptolemaida**, thermal capacity is supplied to the district heating network of the city of Ptolemaida at a maximum of 50 MWth.
4. Unit 1 of the **Steam Electricity Generation Plant of LKDM** supplies a maximum thermal capacity of 25 MWth to the district heating network of the city of Ptolemaida.
5. The PPC S.A. **is studying** the means of satisfying the request of the Municipality of Ptolemaida for a supply of additional thermal energy to the district heating network of the city, with a capacity of up to 40 MWth alternatively from two units of the **Steam Electricity Generation Plant of Kardia.**
6. The PPC S.A. **has signed an agreement** with the Municipality of Florina on the supply of thermal energy for district heating with a maximum capacity of 104 MWth for the city of Florina from the **Steam Electricity Generation Plant at Melitis.**

In climate Zone C:

1. From unit 3 of the **Steam Electricity Generation Plant at Megalopolis**, a maximum thermal capacity of 20 MWth is supplied to the district heating network of Megalopolis.

3.2.2 Studies on the Viability Of New CHP District Heating Applications

The methodology used for the assessment of the economic potential is as follows:

For each of the four climate zones of Greece, preliminary viability studies for CHP installations in typical applications were made. Based on the results of the feasibility analysis, the corresponding categories of applications were taken or not taken into consideration in the economic potential.

3.2.2.1 Climate Zone D

District Heating for the Municipality of Grevena with LFO

The possibility of district heating was studied for the Municipality of Grevena, which belongs to Climate Zone D (colder) by means of a cogeneration system with diesel combustion (there is no natural gas in the area). From the results of the parametric analysis, it was concluded that only with an exceptionally high price for electricity and a similarly high price for heating, would the investment be even marginally profitable. In addition, due to the high operating cost, and even with a subsidy of the capital cost, the situation would not improve much.

3.2.2.2 Climate Zone C

District Heating for the Cities of Komotini and Sapes from the Steam Electricity Generation Plant of Komotini (Combined Cycle – Natural Gas)

The application of a district heating system for the cities of Komontini and Sapes by the Steam Generation Plant of Komotini was studied.

The analysis found that the production cost is € 19,96/MW_{th}h. This result is important, as in conjunction with the policy for the sale of heat and the sale price which will be set, the corresponding profit of the project is derived. The price per MWh generated is considered satisfactory for the realization of such a project, however there is no technical possibility for the plant to provide thermal load under the present electric load conditions of the mainland electricity generation system.

District Heating for the Municipality of Koufalia – Natural Gas Fuel

The possibility of district heating for the Municipality of Koufalia, which is located in Climate Zone C, was studied. Taking into consideration the 35% grant, the investment was considered to be economically profitable with a DPBP of about 8 years. The investment was chosen over others because it represented the lowest limit for economic viability of district heating CHP plants in Zone C.

3.2.2.3 Climate Zone B

District Heating for the Municipality of Thebes – Natural Gas Fuel

The possibility of district heating for the municipality of Thebes, which is located in Climate Zone B, was studied. Taking into consideration the 35% grant, the investment is evaluated as economically profitable with a DPBP of about 8 years. The investment was chosen over others because it represented the lowest limit for economic viability of district heating CHP plants in Zone B.

3.2.2.4 Climate Zone A

District Heating-Cooling for the Area of Iraklio in Crete by the Steam Electricity Generation Plant at Linoperamata

The application of a district heating system for the area of Iraklio in Crete from the Steam Electricity Plant at Linoperamata was studied. The analysis found the cost per thermal MWh generated to be **€ 21,31/MWh.**

Despite the much smaller distance and concentrated consumption, the cost is greater than that of Komotini. The reason is the shorter period of use, however there is no technical possibility for the plant to provide thermal load under the present electric load conditions of the electricity generation system of Crete.

Study for the District Heating/Cooling of the Area of Iraklion in Crete by a Hypothetical CHP Plant of an Independent Producer

Despite the high sale price of a thermal MWh, the investment shows a negative financial projection. Even with strong economic support for the cost of the investment, it appears that it is of doubtful viability, and this in spite of the fact that the use of heat by hotels to cover their needs is not at all certain with this price for heat, as due to the ratio of COP electric chillers to absorption chillers, the pricing of heat must be much more competitive.

3.2.3 Studies on the Viability of Applications for Very Small CHP Systems in Single Family Dwellings

3.2.3.1 Single Family Dwelling (Zone A)

A representative single family home in Zone A was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid for a supply of additional capacity to it. The operational result is negative. The investment is not justified for Zone A because of the limited hours of operation.

3.2.3.2 Single Family Dwelling (Zone B)

A representative single family home in Zone B was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid. The operational result is negative. The investment is not justified for Zone B because of the limited hours of operation.

3.2.3.3 Single Family Dwelling (Zone C)

A representative single family home in Zone C was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid. The operational result is positive although a 90% subsidy for the equipment is needed for the investment to be profitable. The scenario is judged to be impractical. In the parametric analyses of the non-subsidized investments, based on the price for electricity and assuming that the price of natural gas stays the same and doubling the price of a kWh of electricity, the investment is still considered to be not profitable. For a parametric analysis of an investment with a 50% equipment subsidy and doubling the price of electricity, the investment is still not attractive. Lastly, even with the price for natural gas at as low as 1/5th of current prices, it is still uneconomical.

3.2.3.4 Single Family Dwelling (Zone D)

A representative single family home in Zone D was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid. The operational result is positive, but an equipment subsidy of 77.5% is needed in order for the investment to be profitable.

3.2.4 Studies on the Viability of Very Small CHP Systems in Apartment Buildings

3.2.4.1 Apartment Building using Diesel (Zone A)

A representative apartment building in Zone A was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid for a supply of additional capacity to it. Even with any type of subsidy of the cost of the investment, it is not economically viable. The substitution of diesel with natural gas, which is not available in Zone A however, would be an improvement, but even then, the problem of the very short period of operation remains.

3.2.4.2 Apartment Building using Natural Gas (Zone B)

A representative apartment building in Zone B was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid. In Zone B, and for a typical apartment building, the cost of the investment without a subsidy would be paid off in 20 years. The investment is not considered profitable. **With a 65% subsidy, the interest bearing payback time falls to 9.5 years and the return on the investment is worthwhile.**

3.2.4.3 Apartment Building using Natural Gas (Zone C)

A representative apartment building in Zone C was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid. In Zone C, for a typical apartment building with a 50% subsidy the payback period is 10.5 years.

3.2.4.4 Apartment Building using Diesel Fuel (Zone D)

A representative apartment building in Zone D was chosen for the installation of a CHP unit to cover part of the dwelling's requirements and which will be connected to the grid. In Zone D and for a typical apartment building the cost of the investment without a subsidy would be paid back in over 20 years. With a 50% subsidy the payback period is 10.5 years.

3.2.5 Economic Potential of the Residential Sector

3.2.5.1 District Heating-Cooling Applications

Beyond the PPC's programme for lignite plants, the company does not have plans for combined cycle plants or gas turbines. Even though the cases of Komotini and Linoperamata are acceptably economical, they incur a large loss of electrical capacity of 16,5 MWe and 13 MWe respectively, and thus, with the current status of operation of the plants, any modification for district heating is not considered technically acceptable by the PPC. Perhaps the possibility could be discussed for the Linoperamata Steam Electricity Generation Plant to be modified for cogeneration instead of being closed in 2016. Regarding district heating investments by independent producers, the lowest limits of the investments have been calculated for the examples of the Municipalities of Koufalia and Thebes, which correspond to a payback period of around 8,5 years with a 35% subsidy. These limits are 7,5 MWe and 12,5 MWth for Zone C (Municipality of Koufalia) and 10 MWe and 16 MWth for Zone B (Municipality of Thebes). The investments should not, in any event surpass 35 MWe.

Thus, based on the above, we conclude with the following tables:

Table 3.2.5.1.1 : Economic Potential for District Heating from Neigbouring Steam Electricity Generation Plants

Power Plant	District Heating Network	Existing Thermal Capacity (MW_{th})	Planned Thermal Capacity (MW_{th})
Ag. Dimitrios	Kozani	70	70
Aminteo	Aminteo	25	
Ptolemaida	Ptolemaida	50	
LKDM	Ptolemaida	25	
Kardia.	Ptolemaida		40
Melitis	Florina		104
Megalopoli	Megalopoli		20
TOTAL		**170**	**234**

Table 3.2.5.1.2 : Economic Potential of District Heating Applications by Independent Producers

CLIMATE ZONE	ELECTRICAL CAPACITY (MWe)	THERMAL CAPACITY (MWth)	PES (GWh)
C	132	196	554
B	92	136	220
TOTAL	224	332	774

3.2.5.2 Applications for Very Small CHP Systems in Single Family Dwellings in the Residential Sector

No purchase of equipment for single family dwellings brings an acceptable financial return.

3.2.5.3 Applications of Very Small CHP Systems in Apartment Buildings in the Residential Sector

No purchase of equipment brings an acceptable financial return in Zone A.

In climate zone B with natural gas and a 65% subsidy the payback period is 9.5 years.

In climate zone C with natural gas and a 50% subsidy the payback period is 10.5 years

In climate zone D with diesel and a 50% subsidy the payback period is 10.5 years.

Residential cogeneration, in order to be a profitable investment, requires a subsidy of over 50% and only for large consumption (apartment buildings) and long hours of operation.

3.3 ECONOMIC VIABILITY OF INVESTMENTS FOR THE APPLICATION OF COGENERATION SYSTEMS IN INDUSTRY

3.3.1 Methodology

In the framework of the project, preliminary feasibility studies were made for the installation of a cogeneration system in more than 130 companies in the Greek industrial sector. Thus, we can state that the results of the study, always based on data given the by companies, express the real technical and economic potential of cogeneration in our sample. The evaluation of the financial viability of an investment in cogeneration systems was done from the point of view of the investor.

The economic viability of cogeneration investments was studied based on:

- The yearly operational benefits which would be derived from the conservation of fuel from the production of thermal energy with a conventional boiler, substitution of the purchase of electricity and capacity, as well as the revenue from the sale of surplus electricity.
- The cost of construction and operation of the cogeneration system.

The choice of the system was based on:

- The type of processes and the quality of thermal energy required by the individual company.
- The need for electricity compared to heat.
- The time distribution of loads.
- The fuel supply.
- The size and cost of the system

The sizing of the proposed cogeneration system was made strictly on the basis of the thermal loads of the individual company (100% coverage) and then with the electrical loads. In many instances, the coverage of the total or part of the cooling loads was examined. All the cases examined in the industrial and tertiary sectors, concern autoproducers. The electricity generated is consumed by them and where there is a surplus of up to 20% of the electricity generated by the cogeneration system, it is sold to the grid at the competitive prices set by current legislation.

The most commonly used economic indicators for the study of the feasibility of a cogeneration system are the Net Present Value (NPV), the internal rate of return (IRR) and the discounted payback period (interest bearing DPBP or simple SPB). The basic data and the results of the study are shown in the following table.

Table 3.3.1 : Data – Results of Preliminary Feasibility Studies

<table>
<tr><td>Economic Data (Input)
• Economic life of the investment
• Desired rate of return
• Depreciation
• Anticipated worth
• Investor’s taxation factor
• Subsidies
• Loans –loan terms
• Construction Time
• Cost of equipment, operation and maintenance of the cogeneration system
• Fuel costs
• Data on the market and sale of electricity
• Economic life, desired rate of return</td><td>Results (for the private investor)
• Benefits from the generation of the proposed system (coverage of thermal, cooling and electrical loads, sale of electricity)
• Costs of operation and maintenance
• Cost – benefit table
• Capital structure table
• Payment schedule for the investment
• Basic economic indicators of viability, (net present value, internal rate of return, cost – benefit ration, potential payback period)</td></tr>
<tr><td colspan="2">Technical Data (Input)
• Thermal, cooling and electrical loads
• Data on the operation of the existing system
• Data on the operation of the cogeneration system
• Data on the operation of the cooling absorption cycle</td></tr>
</table>

Assumptions

The most important assumptions which were made in the preliminary feasibility studies for the installation of a cogeneration system in companies of the sample are the following:

1. The studies were made based on the consumption of thermal and electrical energy which were given by the companies. The investigation of the possibility of energy conservation at the companies before the installation of the cogeneration system is not an objective of the present study.
2. The studies were based on monthly thermal and electrical loads.
3. The costs of the cogeneration system are not derived from specific offers but from published data and limited research in the Greek market. For certain systems, it is likely that the offer prices would be substantially lower. In each case, the parametric analysis of the viability in relation to the capital subsidy of the cogeneration system investment, which is part of the study, helps us to draw conclusions for the economic potential of cogeneration.
4. The studies were based on values for economic parameters which are shown in the following table:

The results of the study

The financial potential for cogeneration in the industrial sector was derived mainly from processing all results of the preliminary feasibility studies on the installation of a cogeneration system in the companies of the sample.

The extension of the potential for cogeneration in the companies of the sample to the whole of their sectors was done on the basis of thermal energy consumption (data available from energy balances). The results are given in the form of the parametric analysis of the installed capacity in industrial sectors in relation to the percentage of subsidy of the investment, fuel costs, the cost of electricity and the potential payback period of the investment.

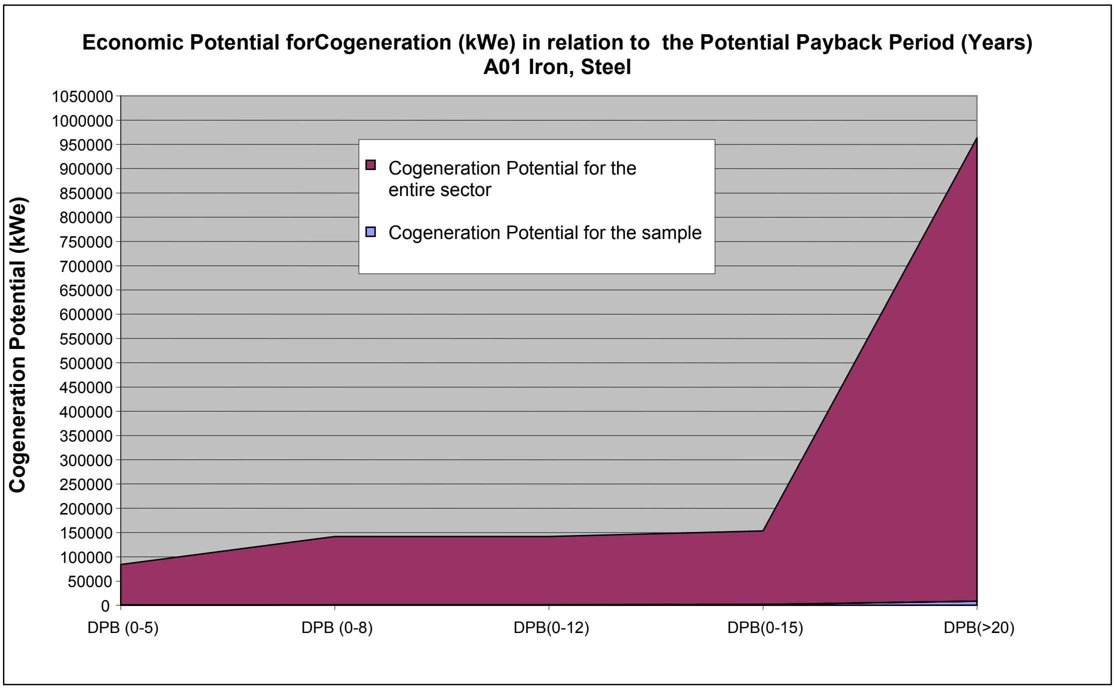
3.3.2 Parametric Analysis of the Economic Potential of Cogeneration in Industrial Sectors

3.3.2.1 Iron, Steel and non-ferrous Metals

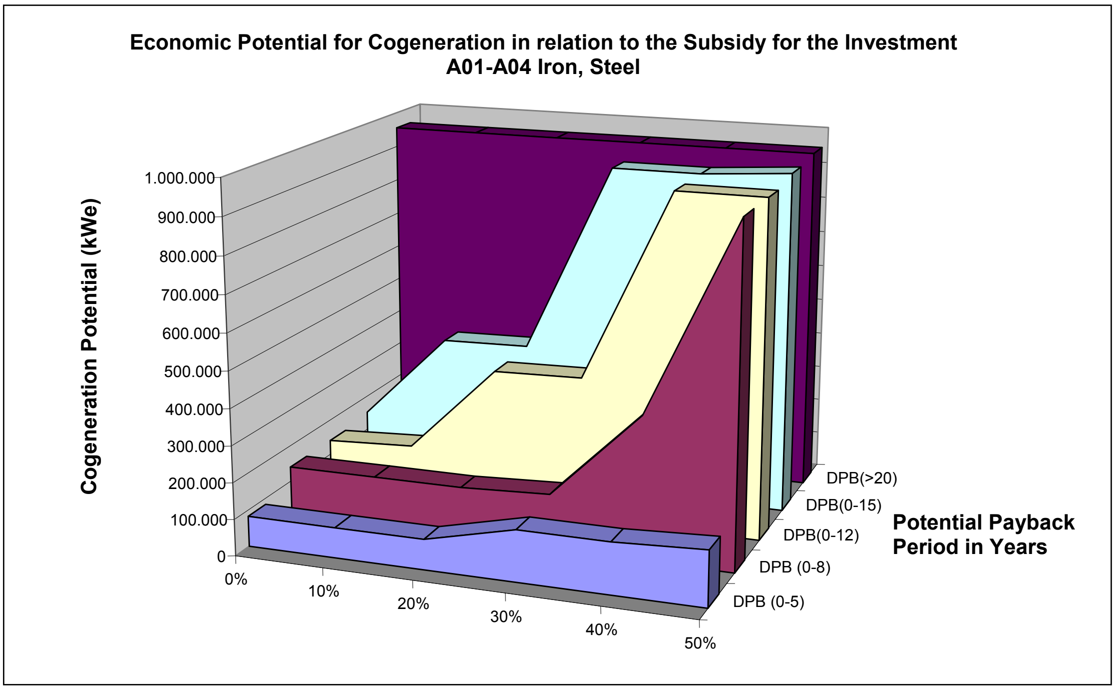
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	83146	140489	140489	151957	955095
10%	83146	140489	151957	393139	955095
20%	83146	140489	393139	398874	955095
30%	140489	151957	398874	926424	955095
40%	140489	393139	926424	926424	955095
50%	151957	926424	926424	943627	955095

Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	146223	398874	943627	943627	955095
-30%	83146	398874	398874	943627	955095
-20%	83146	387405	398874	398874	955095
-10%	83146	140489	398874	398874	955095
0%	83146	140489	140489	151957	955095
10%	83146	83146	140489	140489	955095
20%	57342	83146	140489	140489	955095
30%	57342	83146	83146	140489	955095
40%	0	83146	83146	83146	955095

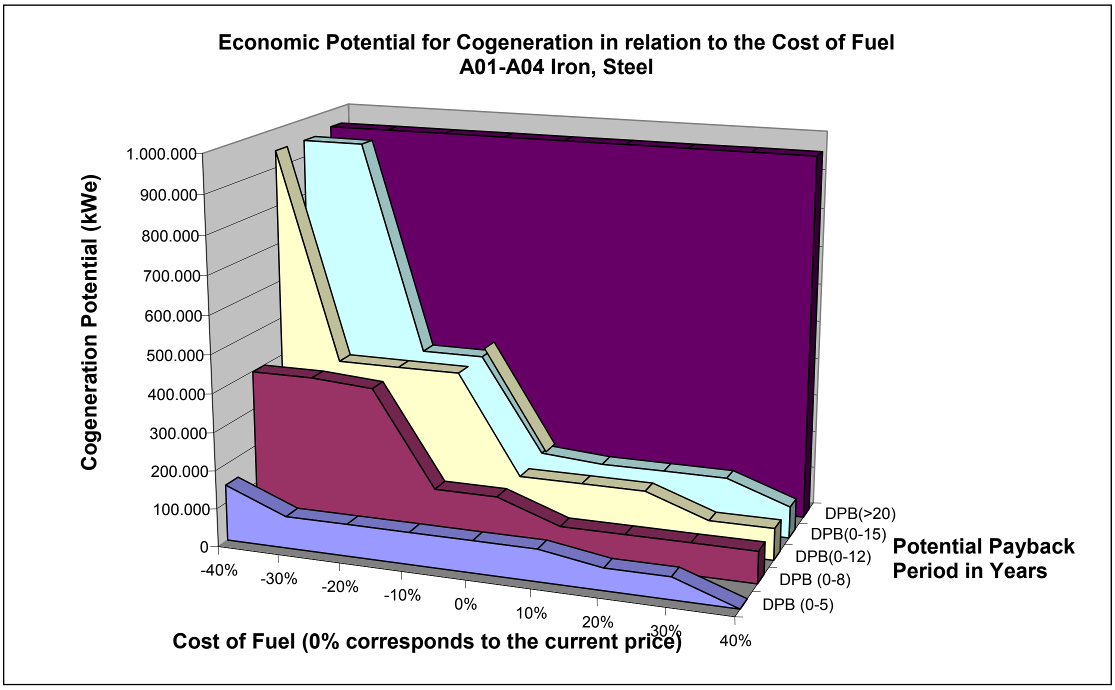
Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	57342	83146	83146	83146	955095
-20%	57342	83146	83146	140489	955095
-10%	83146	83146	140489	140489	955095
0%	83146	140489	140489	151957	955095
10%	83146	140489	393139	398874	955095
20%	83146	140489	398874	398874	955095
30%	140489	387405	398874	398874	955095
40%	140489	398874	398874	398874	955095
50%	140489	398874	398874	398874	955095

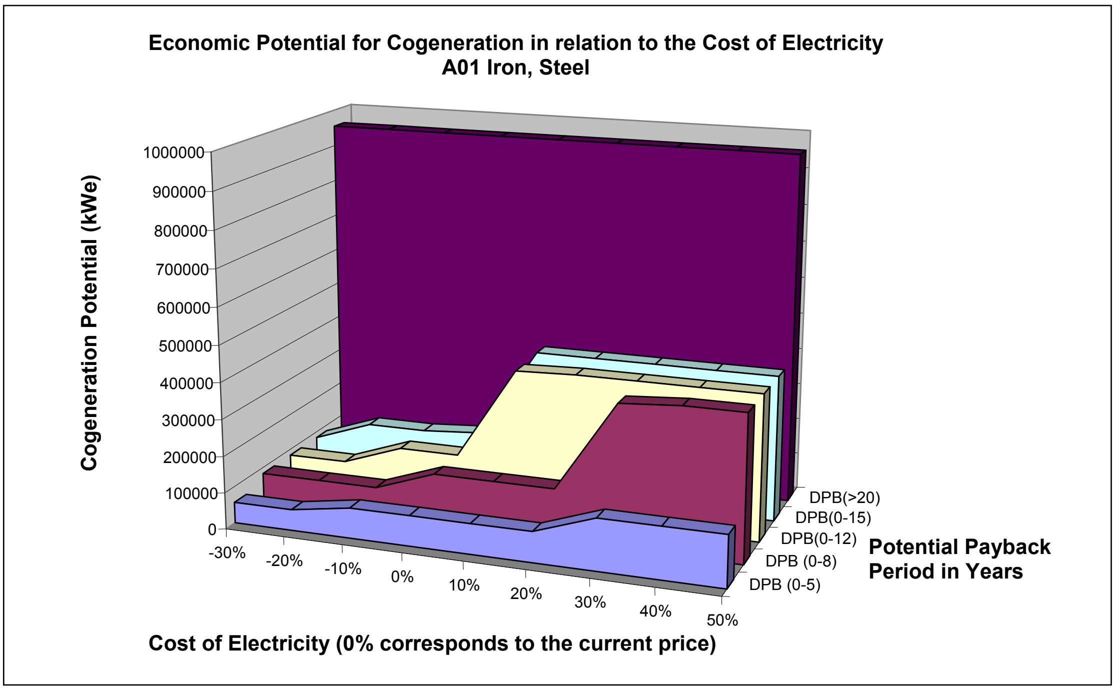


Economic Potential forCogeneration (kWe) in relation to the Potential Payback Period (Years)
A01 Iron, Steel
Cogeneration Potential (kWe)
1050000
1000000
950000
900000
850000
800000
750000
700000
650000
600000
550000
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)



Economic Potential for Cogeneration in relation to the Subsidy for the Investment
A01-A04 Iron, Steel
Cogeneration Potential (kWe)
1.000.000
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Cost of Fuel
A01-A04 Iron, Steel
Cogeneration Potential (kWe)
1.000.000
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
Cost of Fuel (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

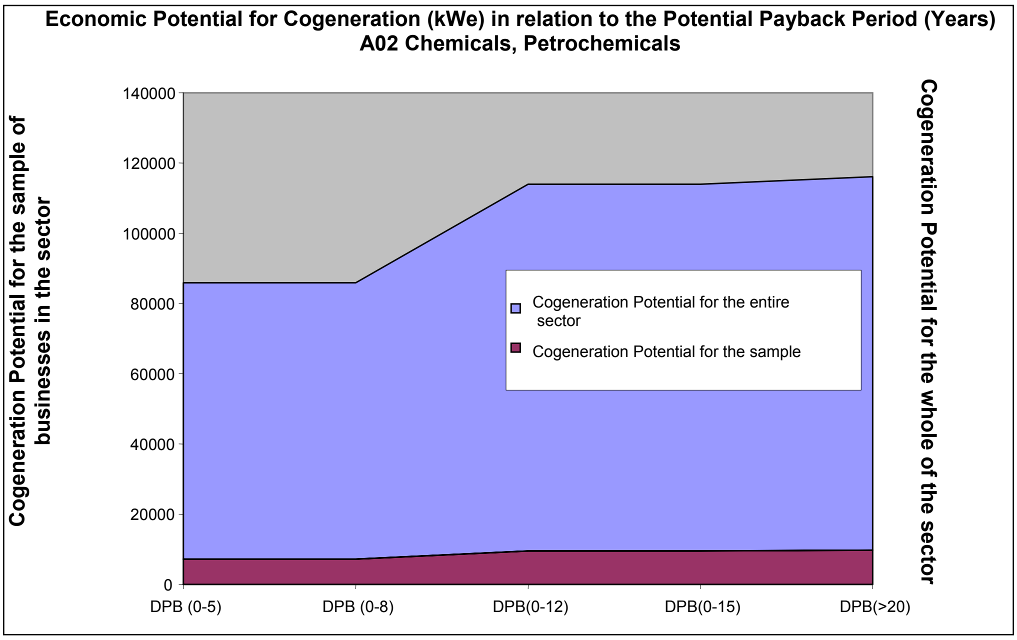

Economic Potential for Cogeneration in relation to the Cost of Electricity
A01 Iron, Steel
Cogeneration Potential (kWe)
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
Cost of Electricity (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

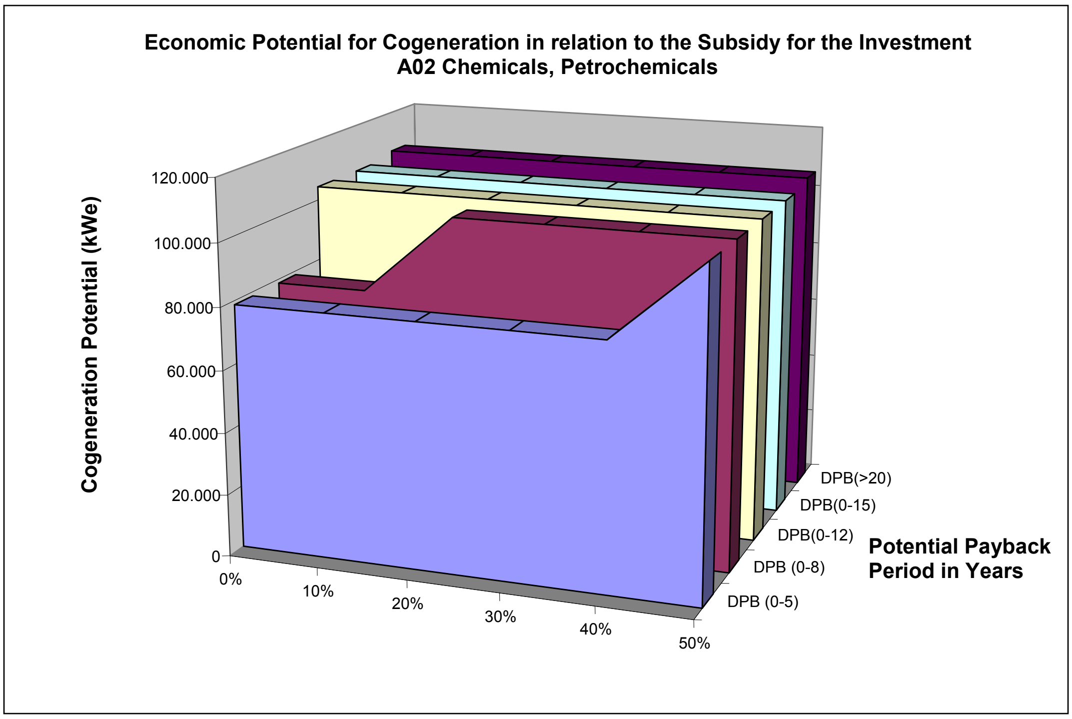
3.3.2.2 Chemicals, Petrochemicals

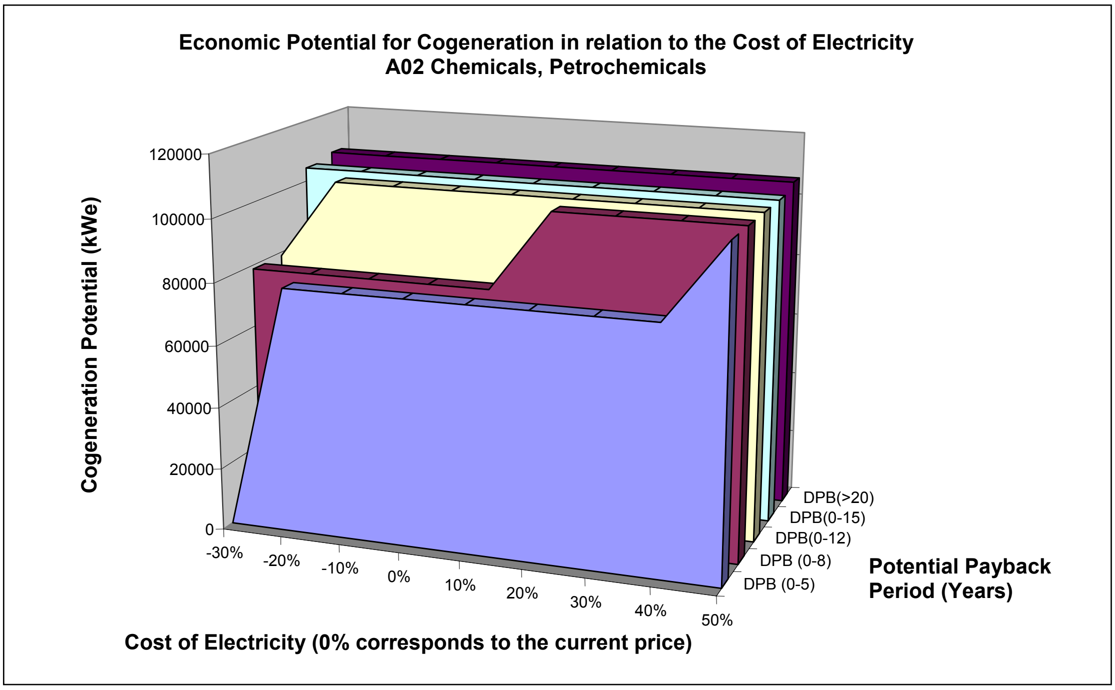
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	78701	78701	104388	104388	106355
10%	78701	78701	104388	104388	106355
20%	78701	104388	104388	104388	106355
30%	78701	104388	104388	104388	106355
40%	78701	104388	104388	104388	106355
50%	104388	104388	104388	104388	106355

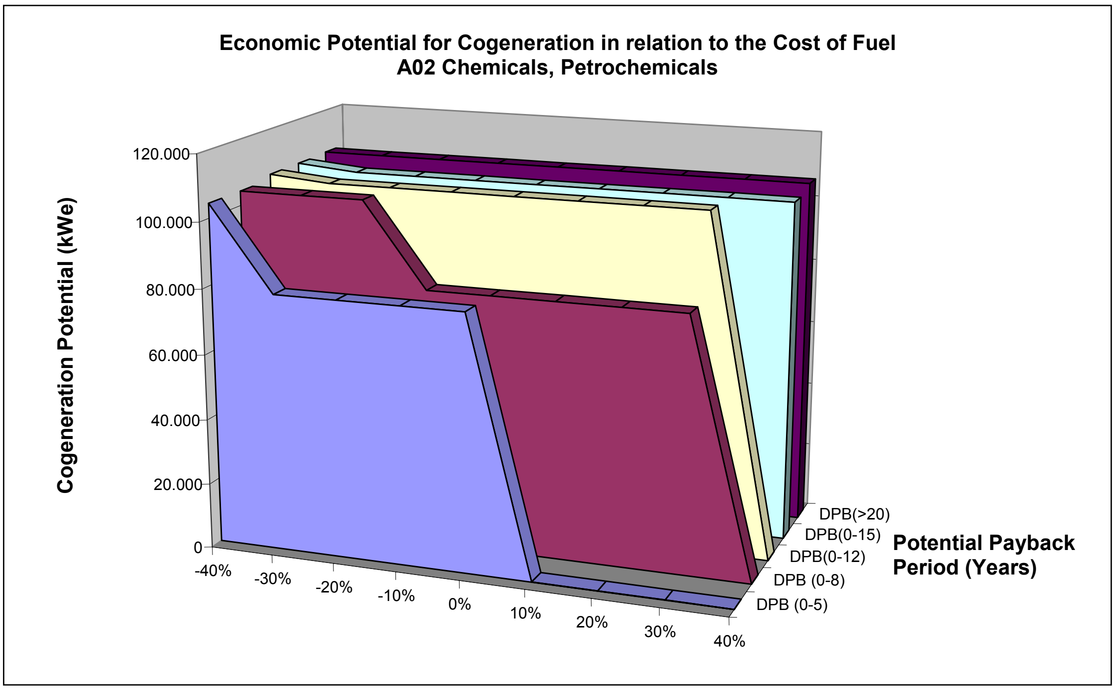
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	104388	104388	106027	106027	106355
-30%	78701	104388	104388	104388	106355
-20%	78701	104388	104388	104388	106355
-10%	78701	78701	104388	104388	106355
0%	78701	78701	104388	104388	106355
10%	0	78701	104388	104388	106355
20%	0	78701	104388	104388	106355
30%	0	78701	104388	104388	106355
40%	0	0	0	104388	106355

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	0	78701	78701	104388	106355
-20%	78701	78701	104388	104388	106355
-10%	78701	78701	104388	104388	106355
0%	78701	78701	104388	104388	106355
10%	78701	78701	104388	104388	106355
20%	78701	104388	104388	104388	106355
30%	78701	104388	104388	104388	106355
40%	78701	104388	104388	104388	106355
50%	104388	104388	104388	104388	106355


Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years)
A02 Chemicals, Petrochemicals
Cogeneration Potential for the sample of businesses in the sector
Cogeneration Potential for the whole of the sector
140000
120000
100000
80000
60000
40000
20000
0
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample


Economic Potential for Cogeneration in relation to the Subsidy for the Investment
A02 Chemicals, Petrochemicals
Cogeneration Potential (kWe)
120.000
100.000
80.000
60.000
40.000
20.000
0
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Cost of Electricity
A02 Chemicals, Petrochemicals
Cogeneration Potential (kWe)
120000
100000
80000
60000
40000
20000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period (Years)
Cost of Electricity (0% corresponds to the current price)

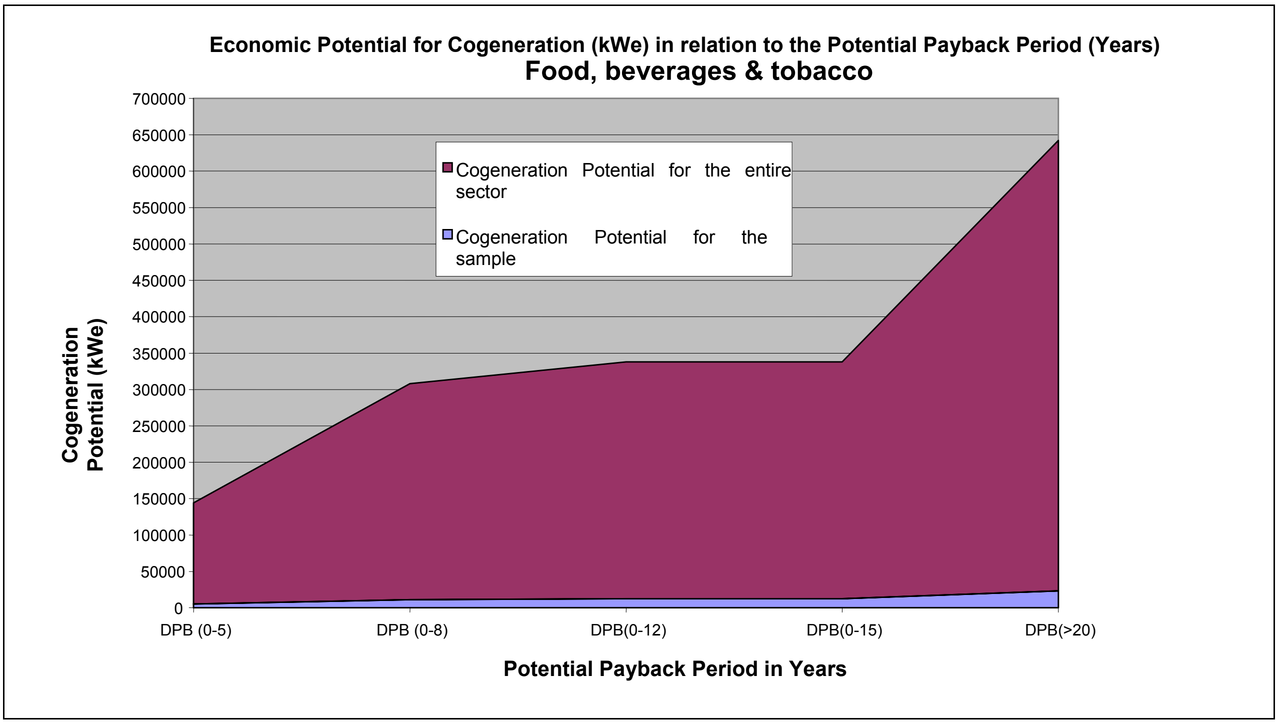

Economic Potential for Cogeneration in relation to the Cost of Fuel
A02 Chemicals, Petrochemicals
Cogeneration Potential (kWe)
120.000
100.000
80.000
60.000
40.000
20.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period (Years)

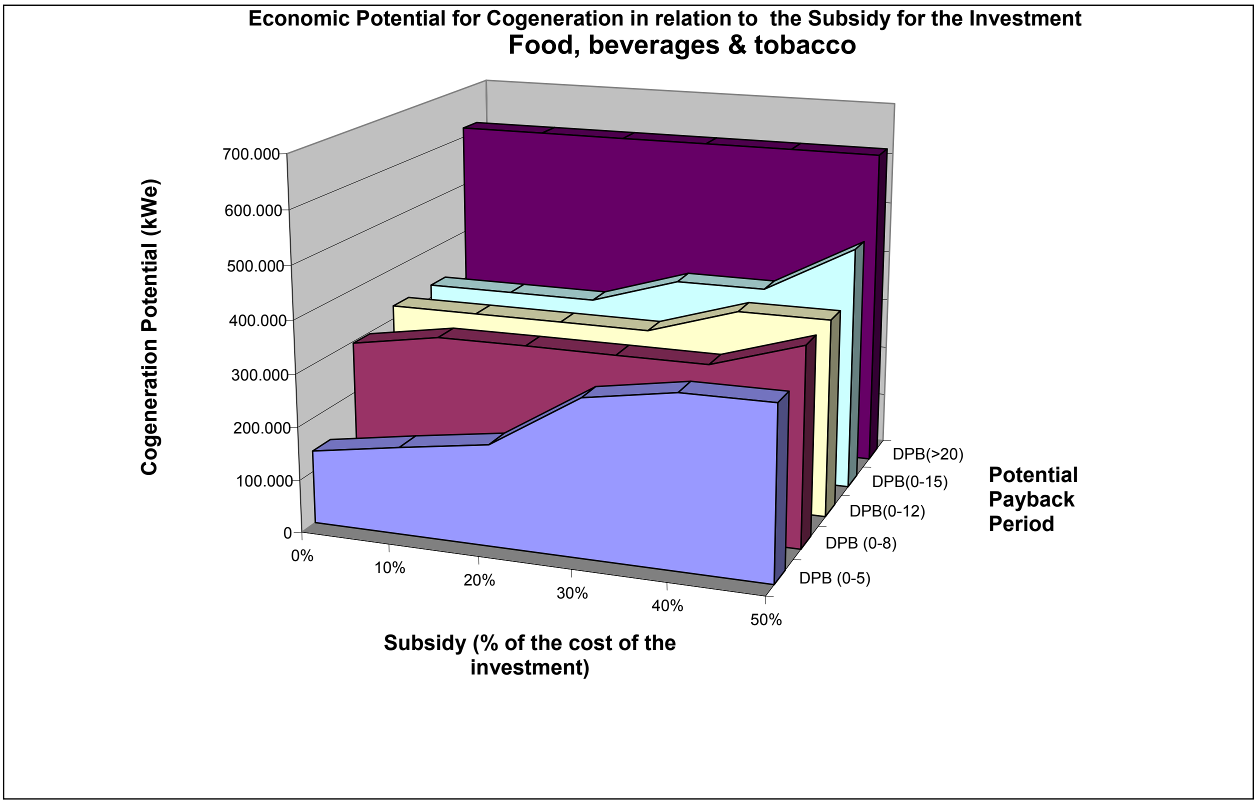
3.3.2.3 Food, Beverages and Tobacco

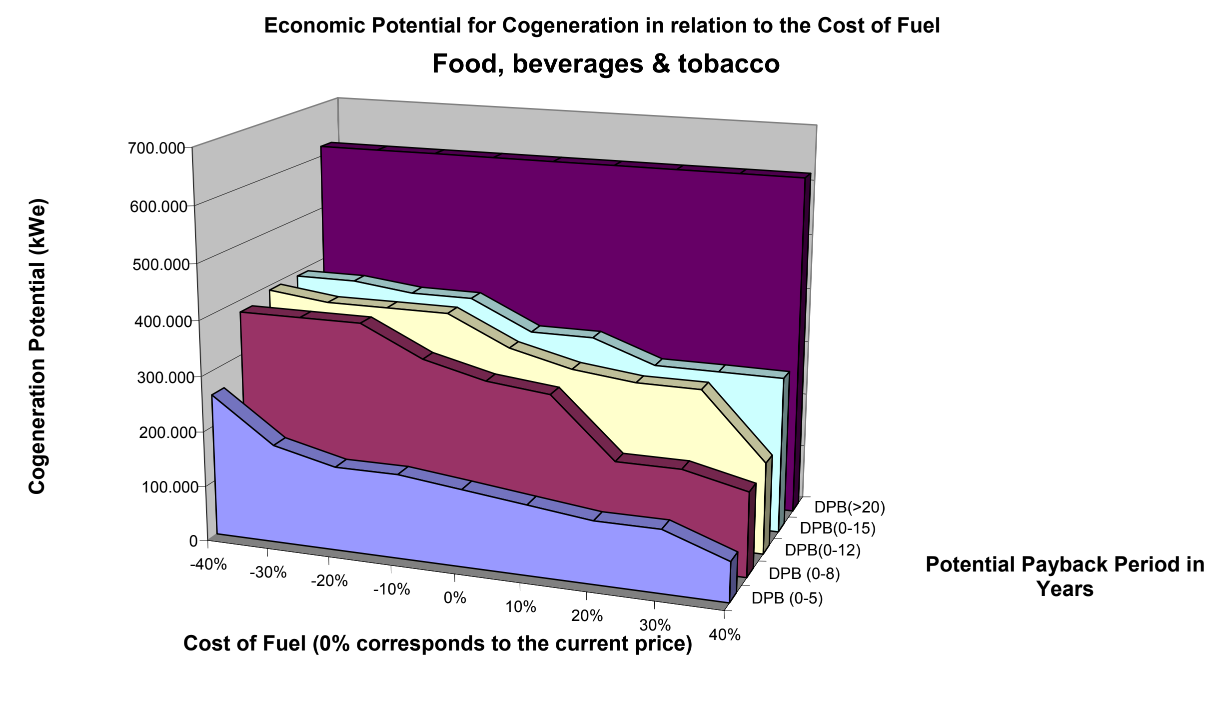
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	136486	291951	320028	320028	629138
10%	163264	319248	320028	320028	629138
20%	187961	320028	320028	320028	629138
30%	291951	320028	320028	392821	629138
40%	319248	320028	392821	392821	629138
50%	320028	372023	392821	483812	629138

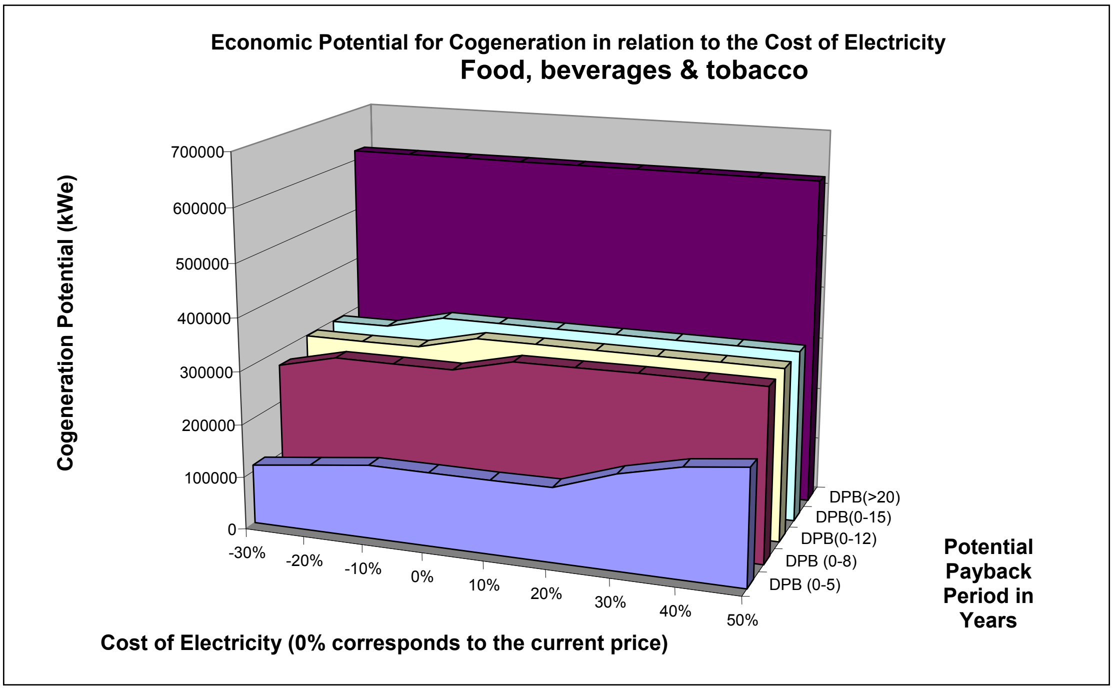
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	252955	372023	405820	405820	629138
-30%	174963	372023	372023	405820	629138
-20%	148965	372023	372023	372023	629138
-10%	148965	319248	372023	372023	629138
0%	136486	291951	320028	320028	629138
10%	123488	280252	293251	320028	629138
20%	110489	175483	280252	280252	629138
30%	110489	175483	280252	280252	629138
40%	70193	149485	162484	279472	629138

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	110489	266474	293251	293251	629138
-20%	123488	291951	293251	294031	629138
-10%	136486	291951	294031	320028	629138
0%	136486	291951	320028	320028	629138
10%	136486	317949	320028	320028	629138
20%	137266	318728	320028	320028	629138
30%	174963	320028	320028	340826	629138
40%	200960	320028	340826	340826	629138
50%	213959	320028	340826	340826	629138


Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years)
Food, beverages & tobacco
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
Cogeneration Potential (kWe)
700000
650000
600000
550000
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Subsidy for the Investment
Food, beverages & tobacco
Cogeneration Potential (kWe)
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
0%
10%
20%
30%
40%
50%
Subsidy (% of the cost of the investment)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period


Economic Potential for Cogeneration in relation to the Cost of Fuel
Food, beverages & tobacco
Cogeneration Potential (kWe)
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
Cost of Fuel (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

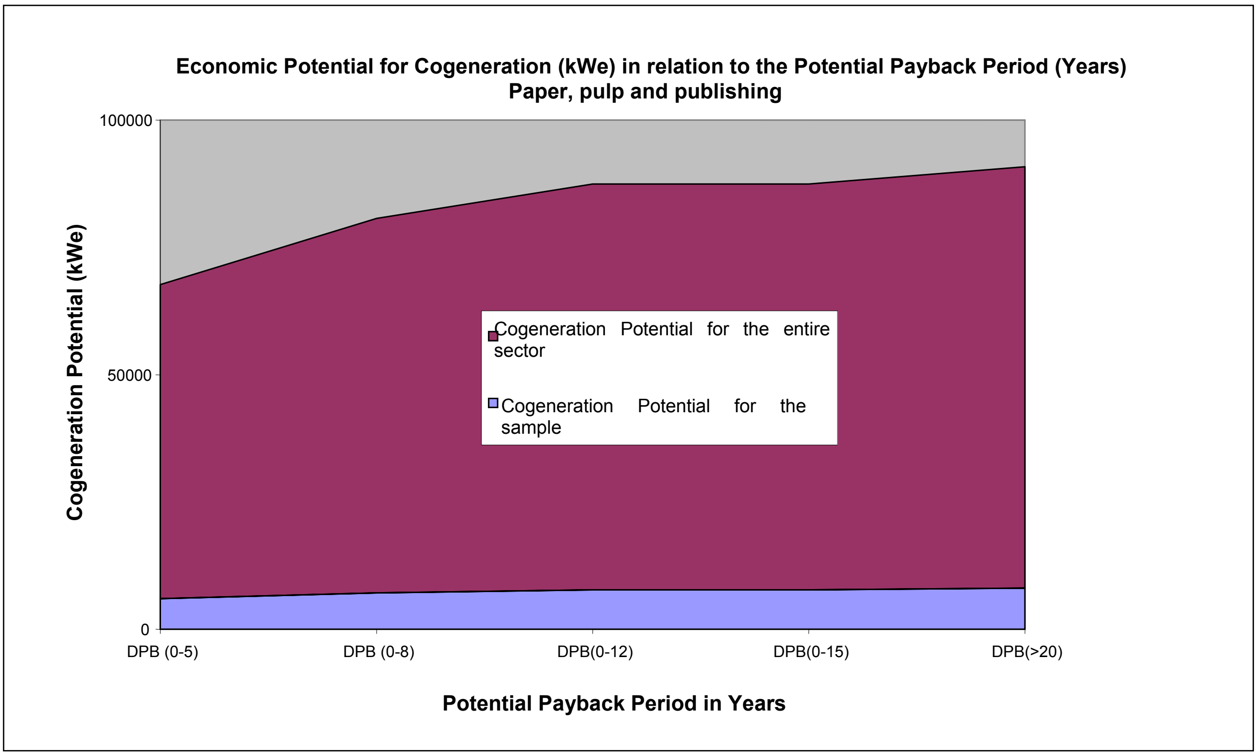

Economic Potential for Cogeneration in relation to the Cost of Electricity
Food, beverages & tobacco
Cogeneration Potential (kWe)
700000
600000
500000
400000
300000
200000
100000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
Cost of Electricity (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

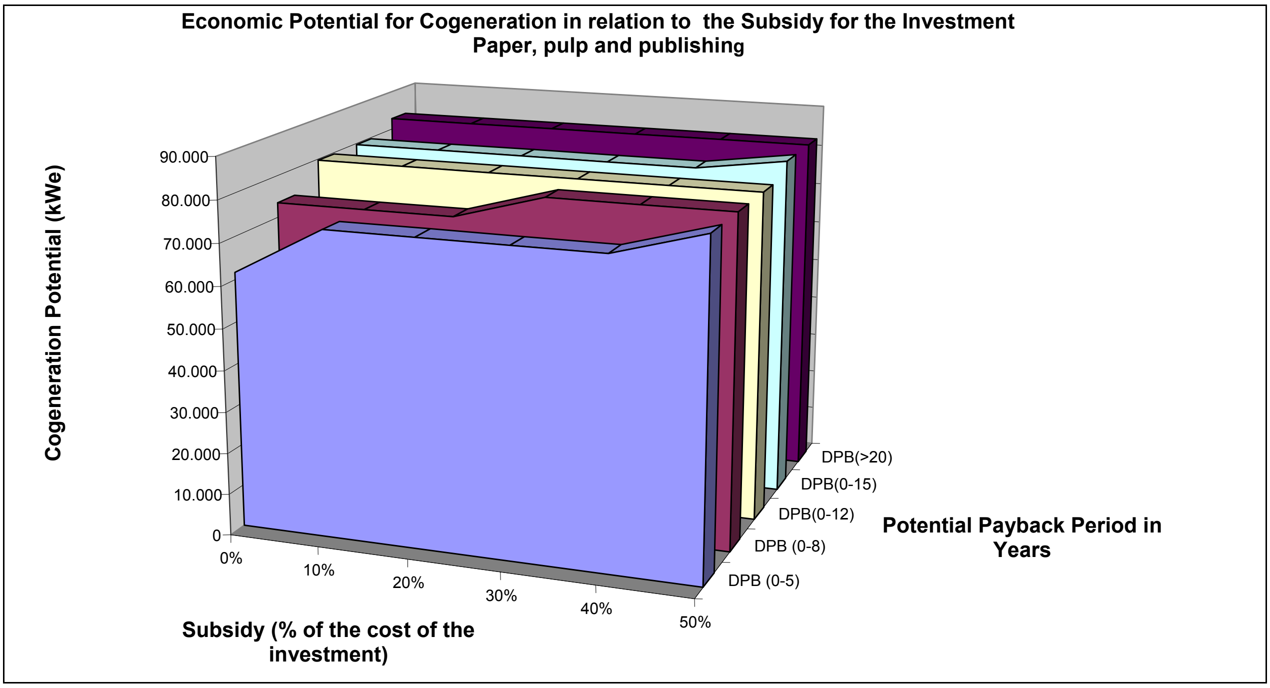
3.3.2.4 Paper, Pulp and Publishing

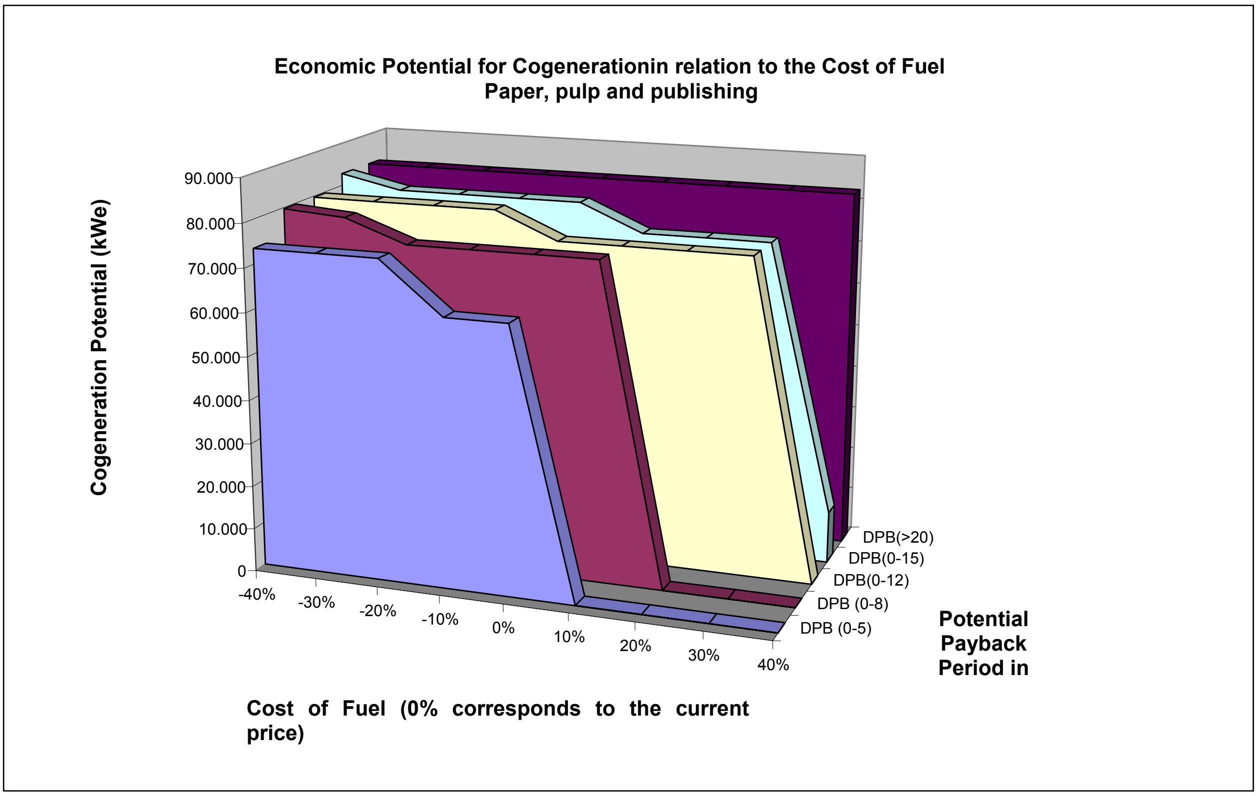
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	61701	73527	79697	79697	82782
10%	73527	73527	79697	79697	82782
20%	73527	73527	79697	79697	82782
30%	73527	79697	79697	79697	82782
40%	73527	79697	79697	79697	82782
50%	79697	79697	79697	82782	82782

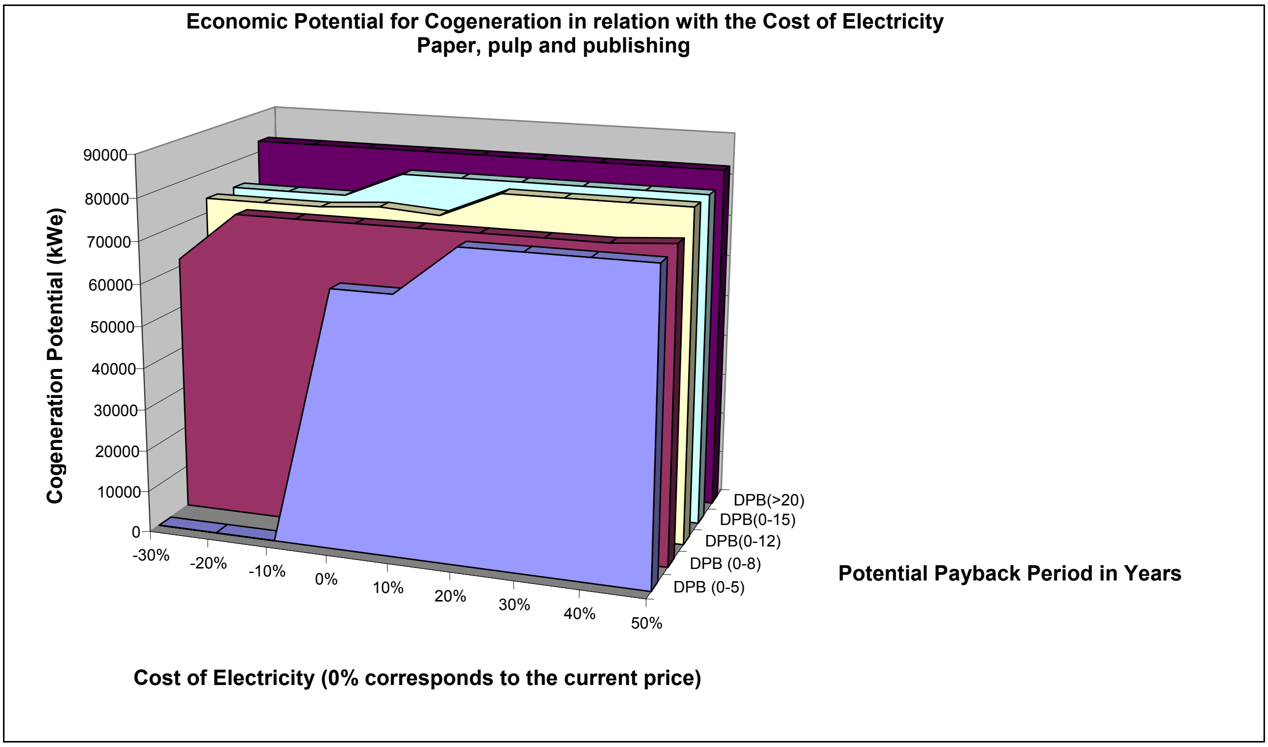
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	73527	79697	79697	82782	82782
-30%	73527	78668	79697	79697	82782
-20%	73527	73527	79697	79697	82782
-10%	61701	73527	79697	79697	82782
0%	61701	73527	73527	79697	82782
10%	0	73527	73527	73527	82782
20%	0	0	73527	73527	82782
30%	0	0	73527	73527	82782
40%	0	0	0	11826	82782

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	0	61701	73527	73527	82782
-20%	0	73527	73527	73527	82782
-10%	0	73527	73527	73527	82782
0%	61701	73527	74555	79697	82782
10%	61701	73527	73527	79697	82782
20%	73527	73527	79697	79697	82782
30%	73527	73527	79697	79697	82782
40%	73527	73527	79697	79697	82782
50%	73527	74555	79697	79697	82782


Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years)
Paper, pulp and publishing
Cogeneration Potential (kWe)
100000
50000
0
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Subsidy for the Investment
Paper, pulp and publishing
Cogeneration Potential (kWe)
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
0%
10%
20%
30%
40%
50%
Subsidy (% of the cost of the investment)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years


Economic Potential for Cogenerationin relation to the Cost of Fuel
Paper, pulp and publishing
Cogeneration Potential (kWe)
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in
Cost of Fuel (0% corresponds to the current price)

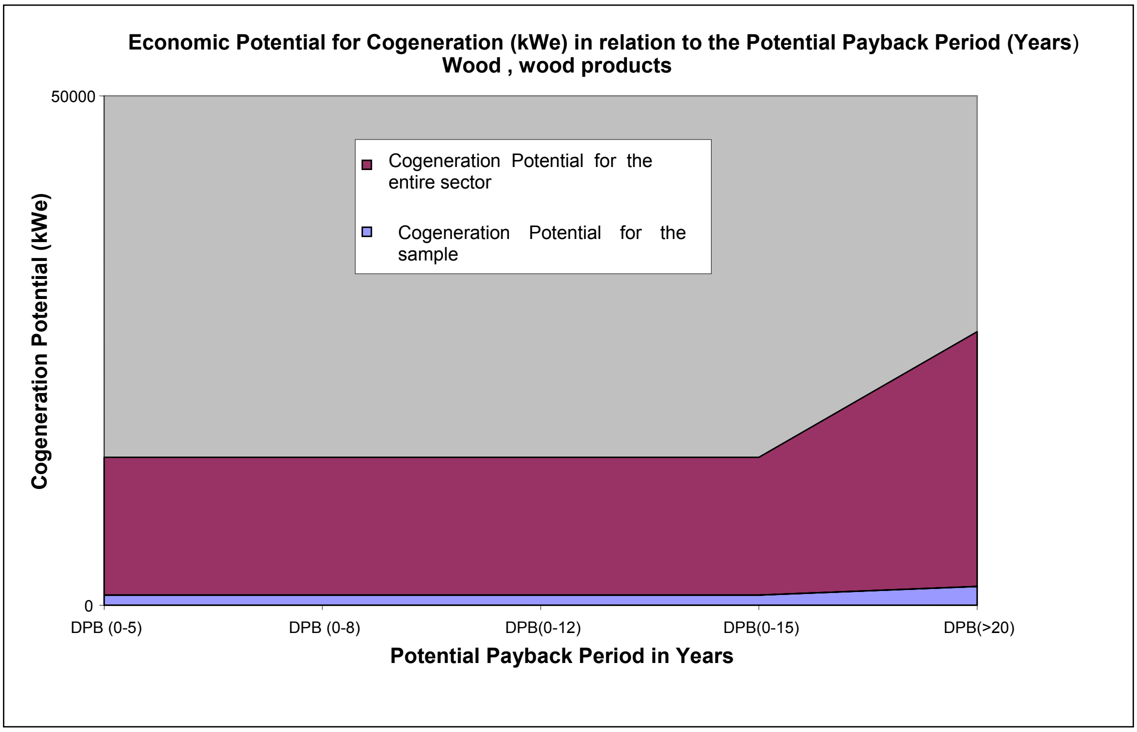

Economic Potential for Cogeneration in relation with the Cost of Electricity
Paper, pulp and publishing
Cogeneration Potential (kWe)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
Cost of Electricity (0% corresponds to the current price)

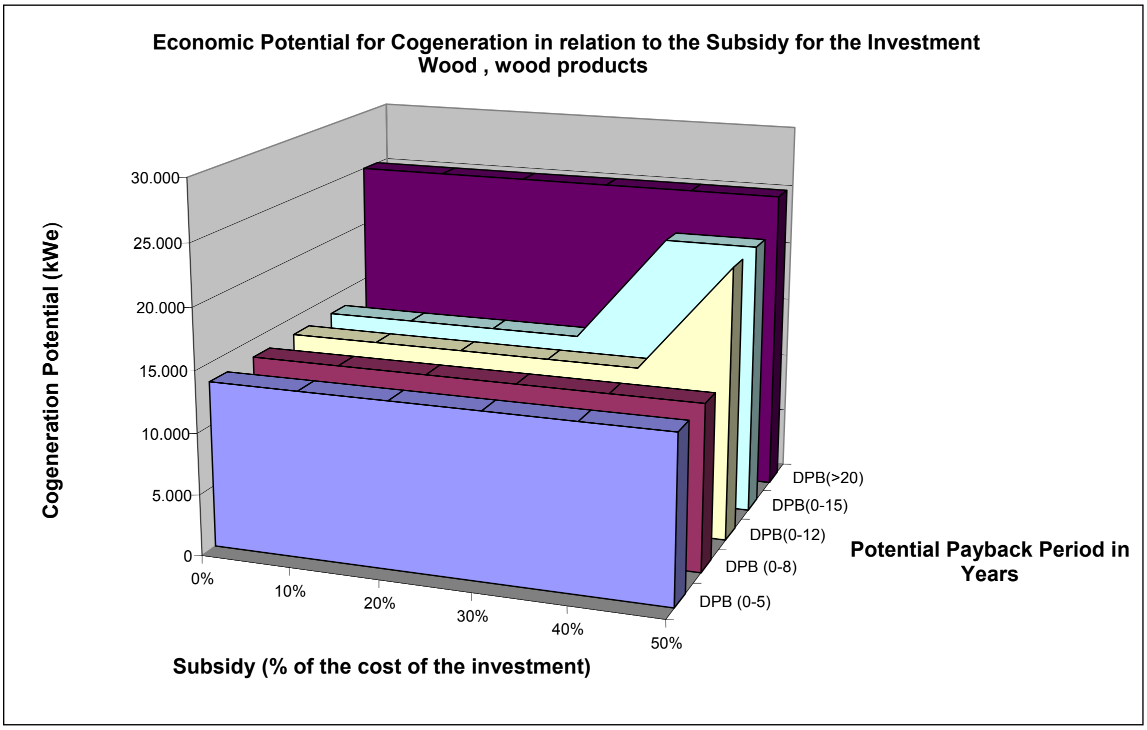
3.3.2.5 Wood, Wood Products

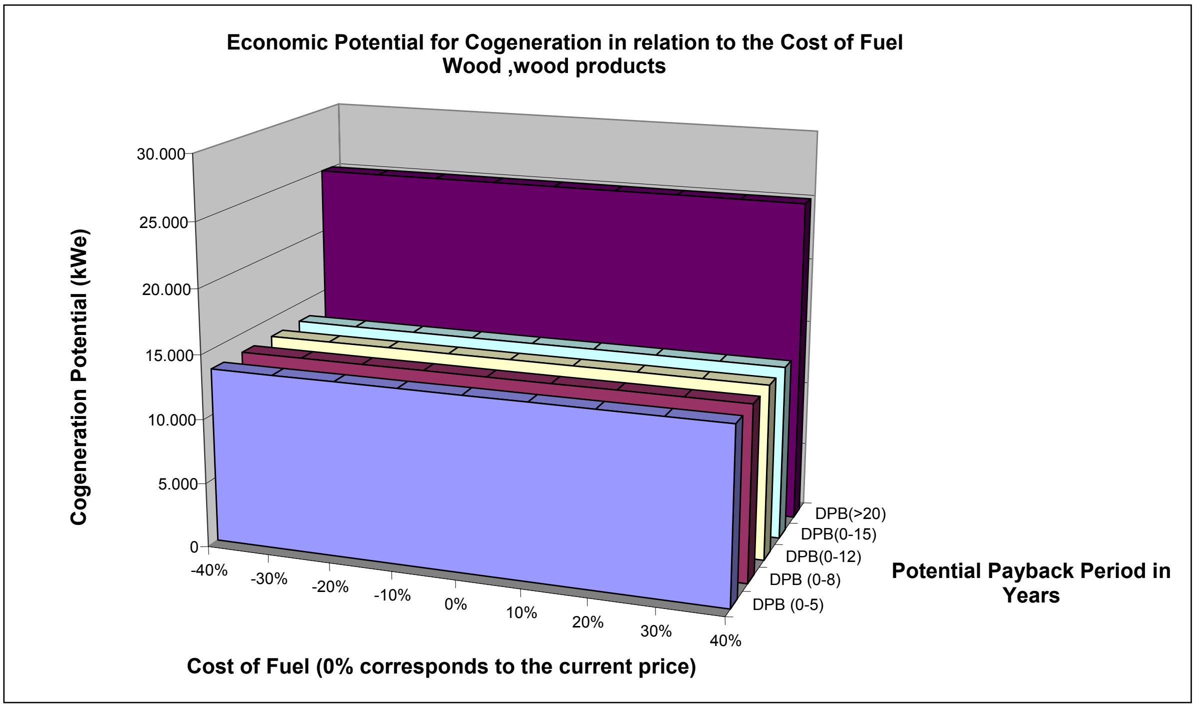
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	13520	13520	13520	13520	25013
10%	13520	13520	13520	13520	25013
20%	13520	13520	13520	13520	25013
30%	13520	13520	13520	13520	25013
40%	13520	13520	13520	22309	25013
50%	13520	13520	22309	22309	25013

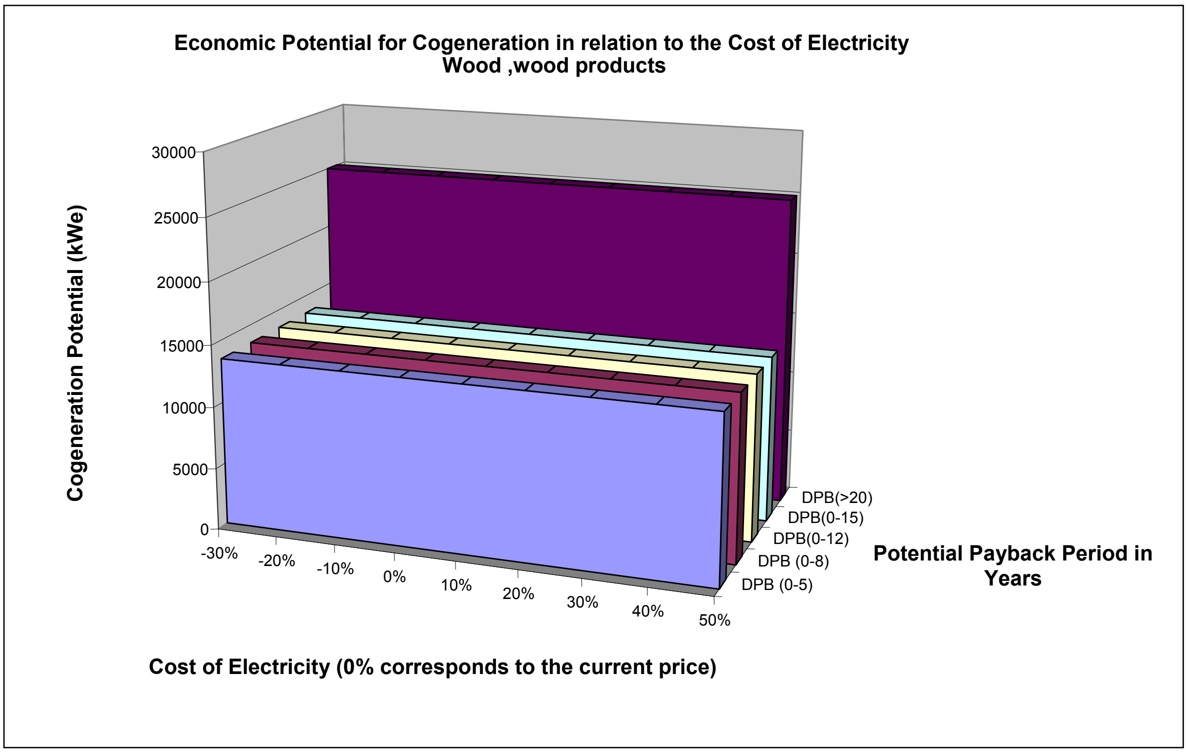
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	13520	13520	13520	13520	25013
-30%	13520	13520	13520	13520	25013
-20%	13520	13520	13520	13520	25013
-10%	13520	13520	13520	13520	25013
0%	13520	13520	13520	13520	25013
10%	13520	13520	13520	13520	25013
20%	13520	13520	13520	13520	25013
30%	13520	13520	13520	13520	25013
40%	13520	13520	13520	13520	25013

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	13520	13520	13520	13520	25013
-20%	13520	13520	13520	13520	25013
-10%	13520	13520	13520	13520	25013
0%	13520	13520	13520	13520	25013
10%	13520	13520	13520	13520	25013
20%	13520	13520	13520	13520	25013
30%	13520	13520	13520	13520	25013
40%	13520	13520	13520	13520	25013
50%	13520	13520	13520	13520	25013


Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years)
Wood , wood products
50000
0
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
Cogeneration Potential (kWe)
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Subsidy for the Investment
Wood , wood products
Cogeneration Potential (kWe)
30.000
25.000
20.000
15.000
10.000
5.000
0
0%
10%
20%
30%
40%
50%
Subsidy (% of the cost of the investment)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Cost of Fuel
Wood ,wood products
Cogeneration Potential (kWe)
30.000
25.000
20.000
15.000
10.000
5.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
Cost of Fuel (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

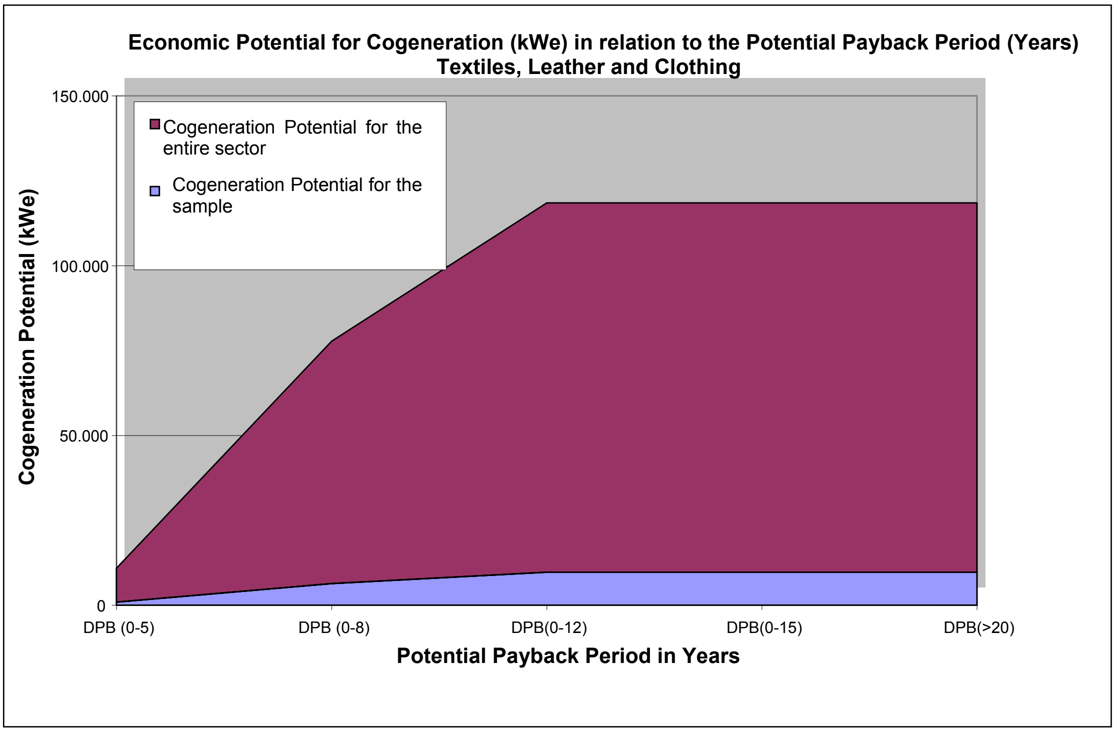

Economic Potential for Cogeneration in relation to the Cost of Electricity
Wood ,wood products
Cogeneration Potential (kWe)
30000
25000
20000
15000
10000
5000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
Cost of Electricity (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

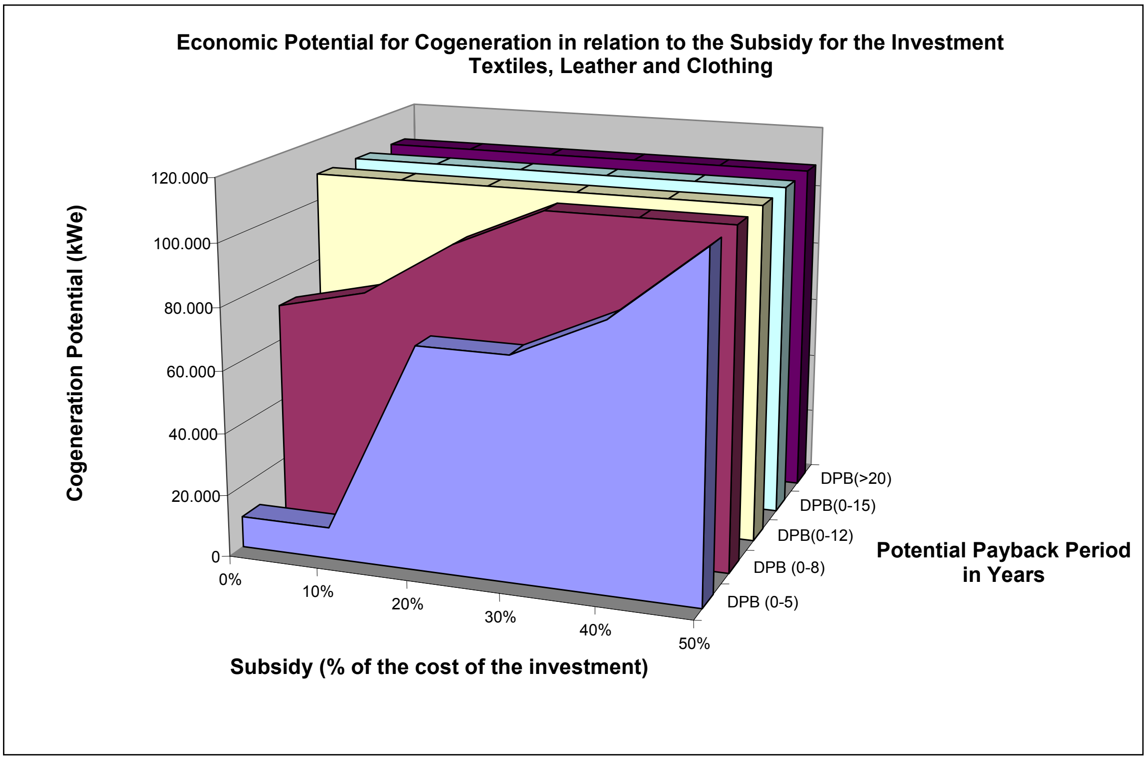
3.3.2.6 Textiles, Leather and Clothing

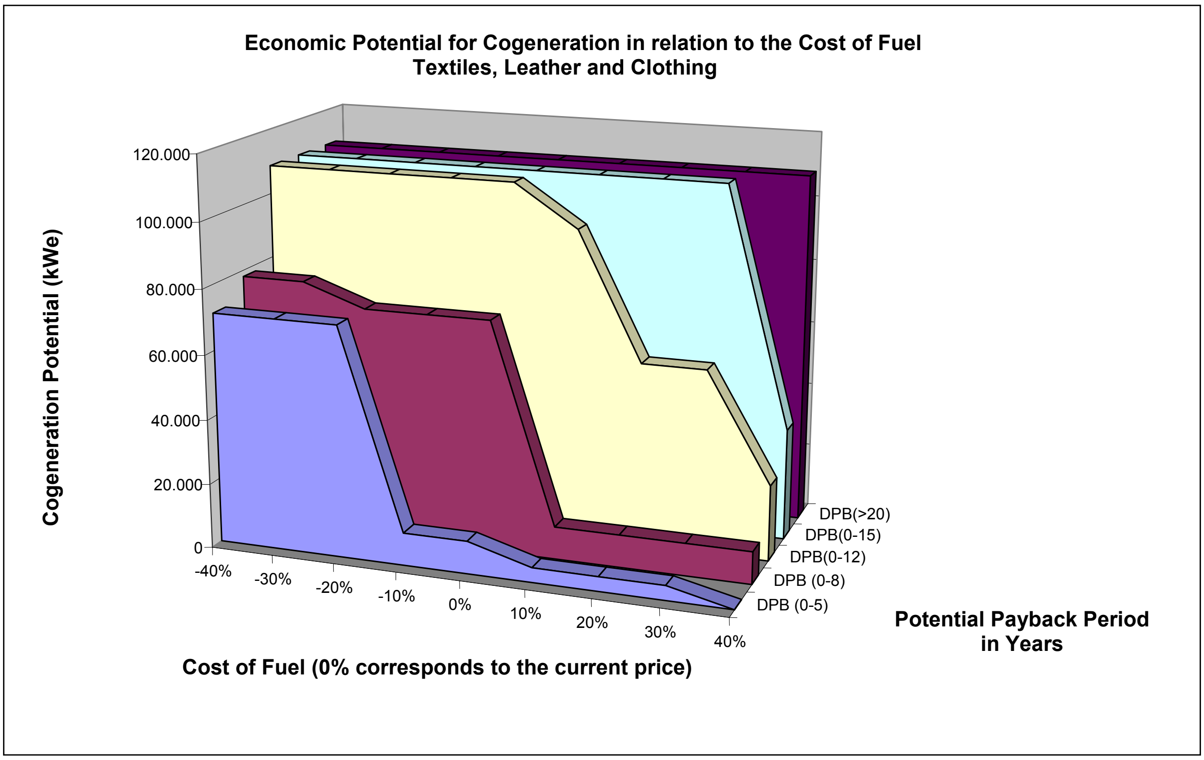
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	10037	71376	108737	108737	108737
10%	10037	78067	108737	108737	108737
20%	71376	95911	108737	108737	108737
30%	71376	108737	108737	108737	108737
40%	84759	108737	108737	108737	108737
50%	108737	108737	108737	108737	108737

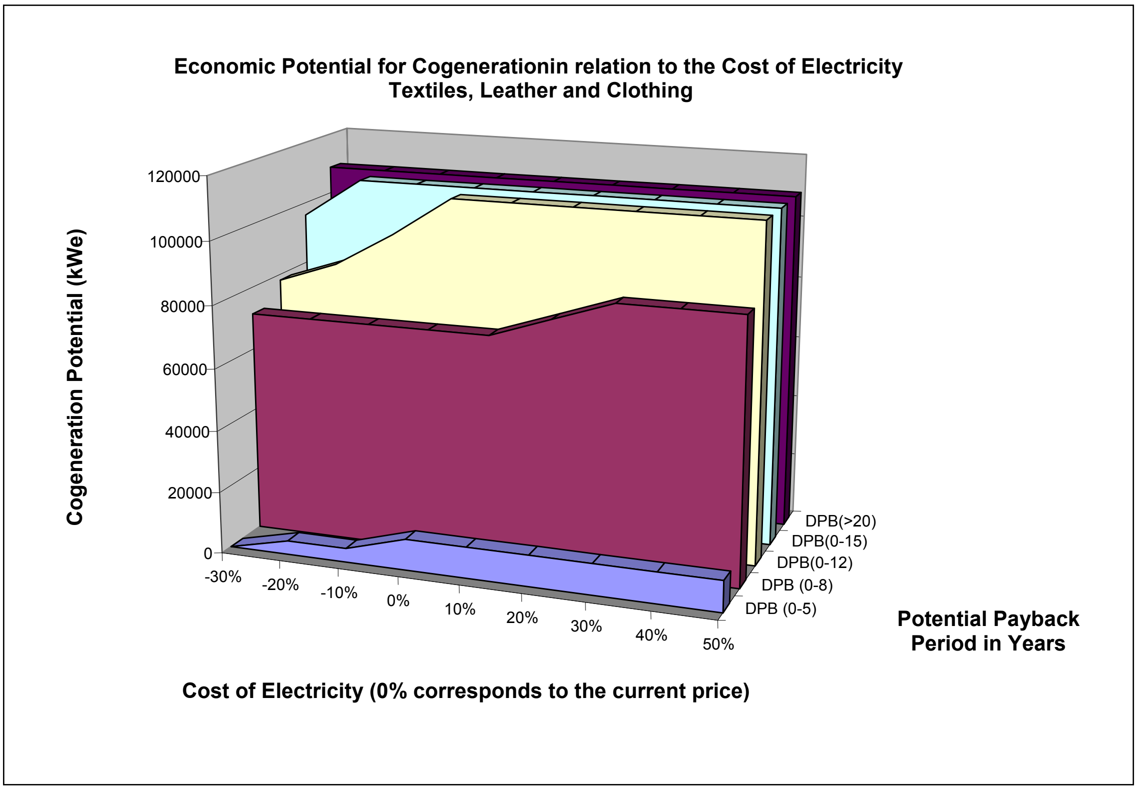
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	71376	78067	108737	108737	108737
-30%	71376	78067	108737	108737	108737
-20%	71376	71376	108737	108737	108737
-10%	10037	71376	108737	108737	108737
0%	10037	71376	108737	108737	108737
10%	4461	10037	95911	108737	108737
20%	4461	10037	56878	108737	108737
30%	4461	10037	56878	108737	108737
40%	0	10037	23420	34573	108737

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	0	71376	78067	95911	108737
-20%	4461	71376	84759	108737	108737
-10%	4461	71376	95911	108737	108737
0%	10037	71376	108737	108737	108737
10%	10037	71376	108737	108737	108737
20%	10037	78067	108737	108737	108737
30%	10037	84759	108737	108737	108737
40%	10037	84759	108737	108737	108737
50%	10037	84759	108737	108737	108737


Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years)
Textiles, Leather and Clothing
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
Cogeneration Potential (kWe)
150.000
100.000
50.000
0
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Subsidy for the Investment
Textiles, Leather and Clothing
Cogeneration Potential (kWe)
120.000
100.000
80.000
60.000
40.000
20.000
0
0%
10%
20%
30%
40%
50%
Subsidy (% of the cost of the investment)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Cost of Fuel
Textiles, Leather and Clothing
Cogeneration Potential (kWe)
120.000
100.000
80.000
60.000
40.000
20.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
Cost of Fuel (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

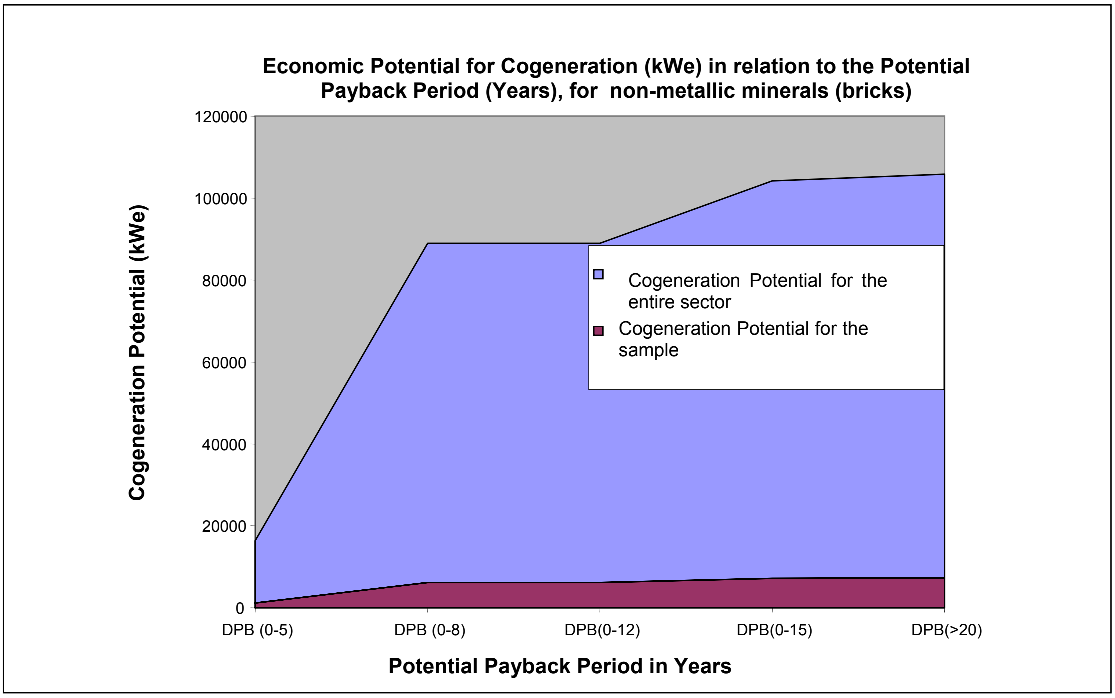

Economic Potential for Cogenerationin relation to the Cost of Electricity
Textiles, Leather and Clothing
Cogeneration Potential (kWe)
120000
100000
80000
60000
40000
20000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
Cost of Electricity (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

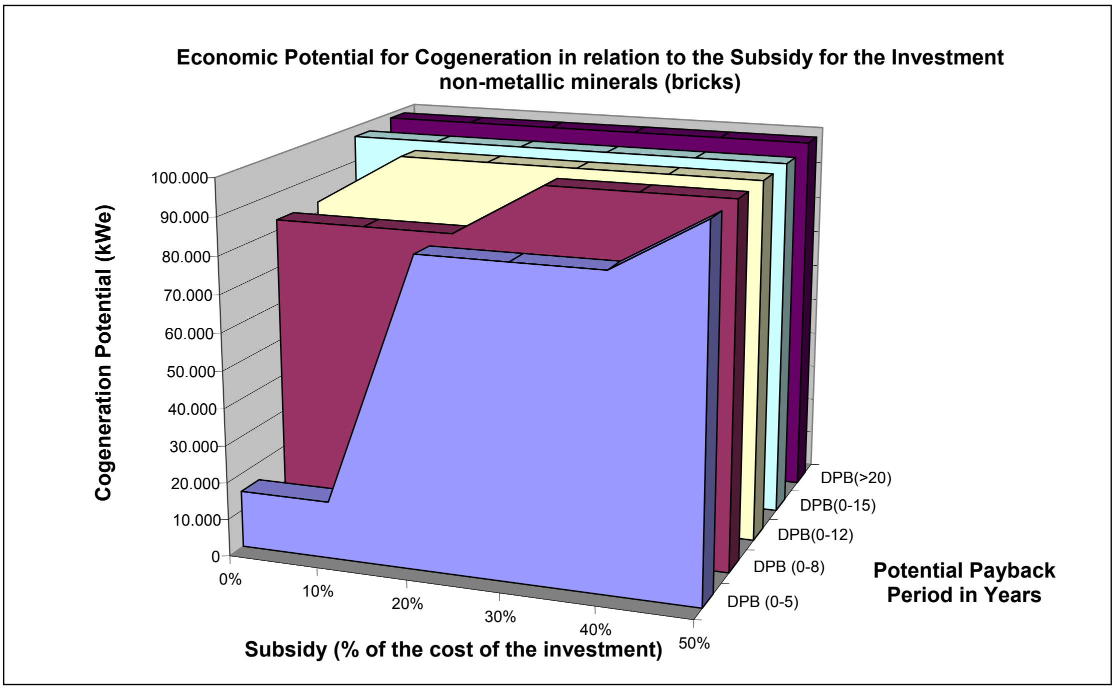
3.3.2.7 Non-Metallic Minerals

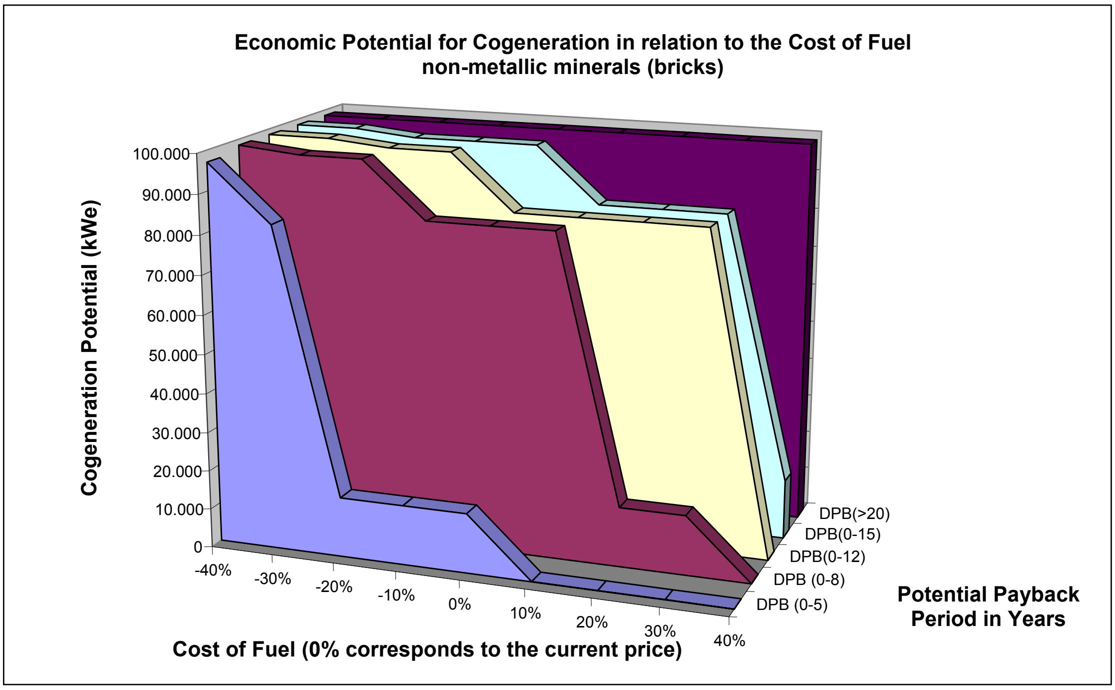
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	15261	82789	82789	97037	98523
10%	15261	82789	97037	97037	98523
20%	82789	82789	97037	97037	98523
30%	82789	97037	97037	97037	98523
40%	82789	97037	97037	97037	98523
50%	97037	97037	97037	97037	98523

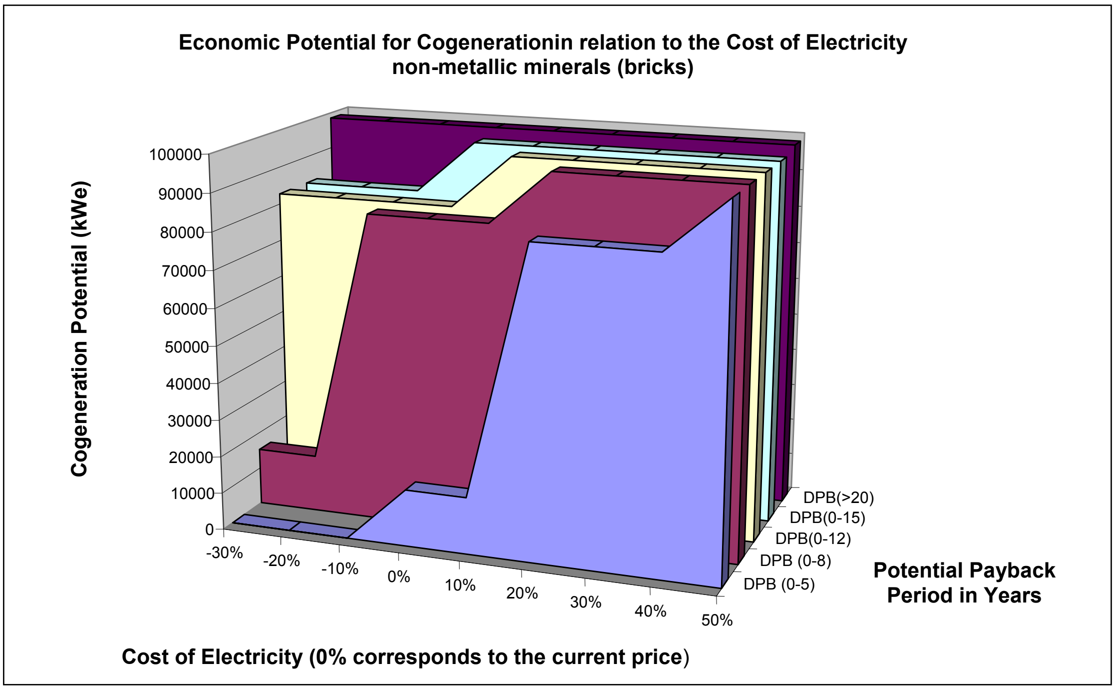
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	97037	98523	98523	98523	98523
-30%	82789	97037	98523	98523	98523
-20%	15261	97037	97037	97037	98523
-10%	15261	82789	97037	97037	98523
0%	15261	82789	82789	97037	98523
10%	0	82789	82789	82789	98523
20%	0	15261	82789	82789	98523
30%	0	15261	82789	82789	98523
40%	0	0	0	15261	98523

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	0	15261	82789	82789	98523
-20%	0	15261	82789	82789	98523
-10%	0	82789	82789	82789	98523
0%	15261	82789	82789	97037	98523
10%	15261	82789	97037	97037	98523
20%	82789	97037	97037	97037	98523
30%	82789	97037	97037	97037	98523
40%	82789	97037	97037	97037	98523
50%	97037	97037	97037	97037	98523


Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years), for non-metallic minerals (bricks)
120000
100000
80000
60000
40000
20000
0
Cogeneration Potential (kWe)
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Subsidy for the Investment non-metallic minerals (bricks)
100.000
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
Cogeneration Potential (kWe)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
0%
10%
20%
30%
40%
50%
Subsidy (% of the cost of the investment)


Economic Potential for Cogeneration in relation to the Cost of Fuel
non-metallic minerals (bricks)
Cogeneration Potential (kWe)
100.000
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
Cost of Fuel (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

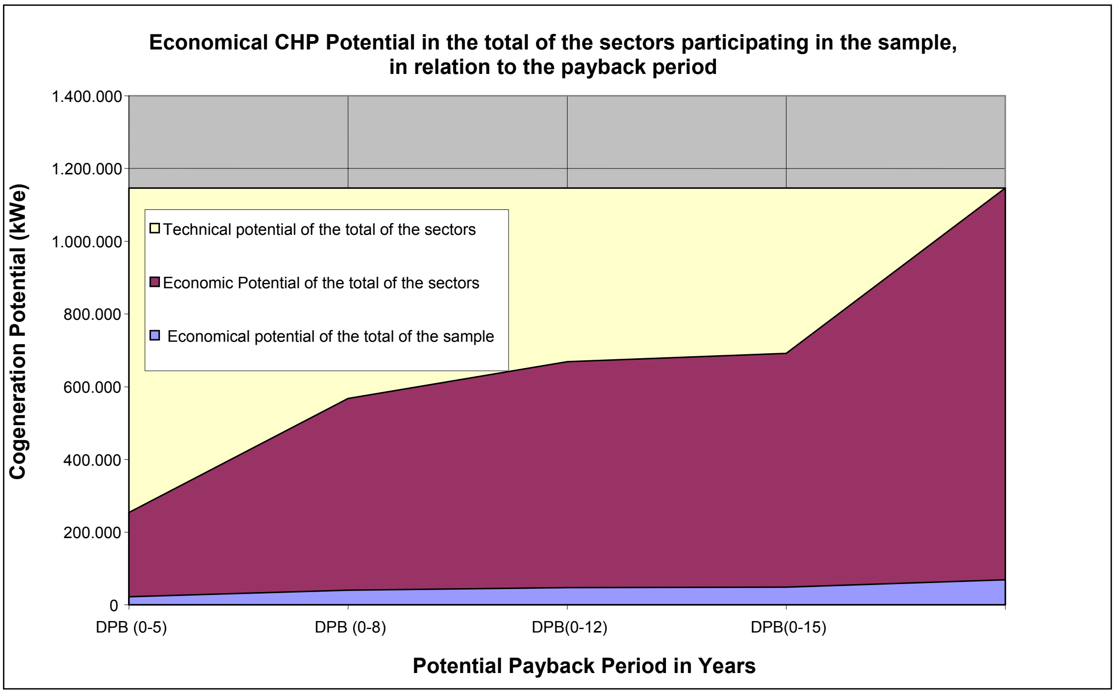

Economic Potential for Cogenerationin relation to the Cost of Electricity
non-metallic minerals (bricks)
Cogeneration Potential (kWe)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
Cost of Electricity (0% corresponds to the current price)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years

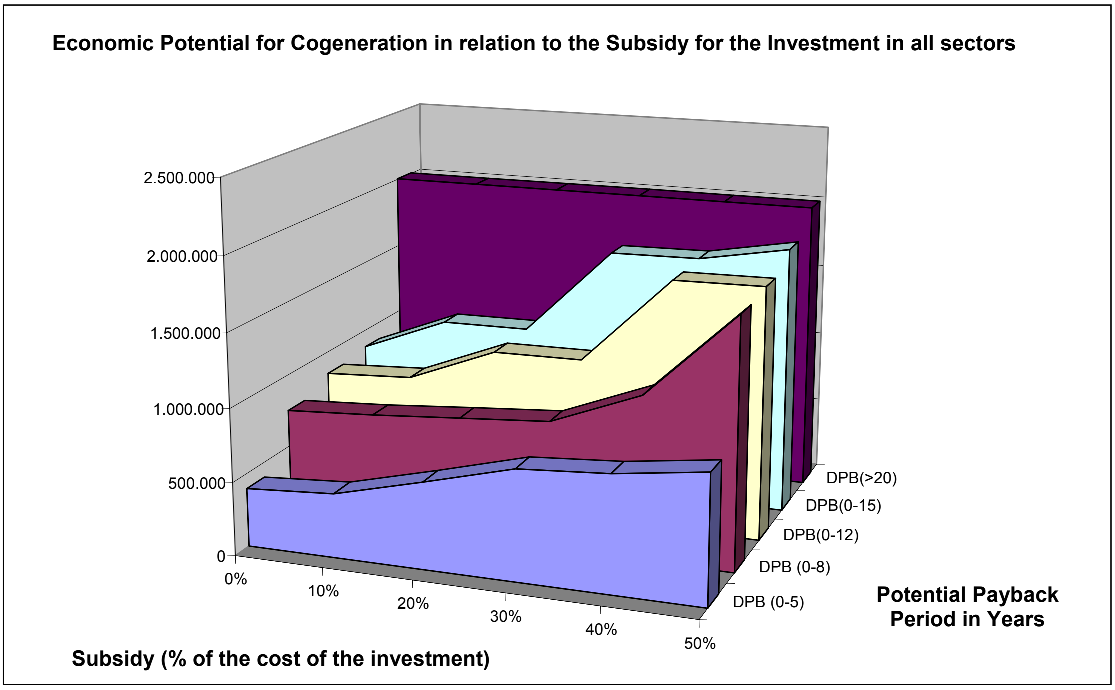
3.3.2.8 Total Industry

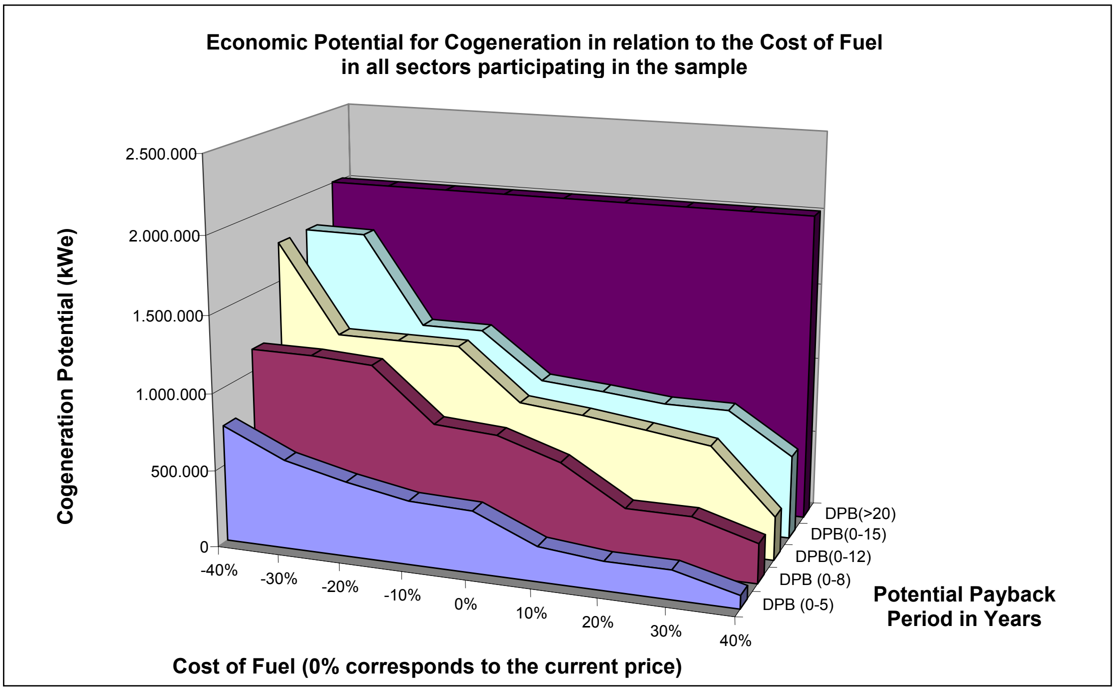
Impact of the subsidy on the economic potential of cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	398853	752352	843478	875364	2005642
10%	437457	786341	875364	1116547	2005642
20%	591020	830652	1116547	1122281	2005642
30%	752352	875364	1122281	1722624	2005642
40%	793033	1116547	1722624	1731412	2005642
50%	875364	1701826	1731412	1842691	2005642

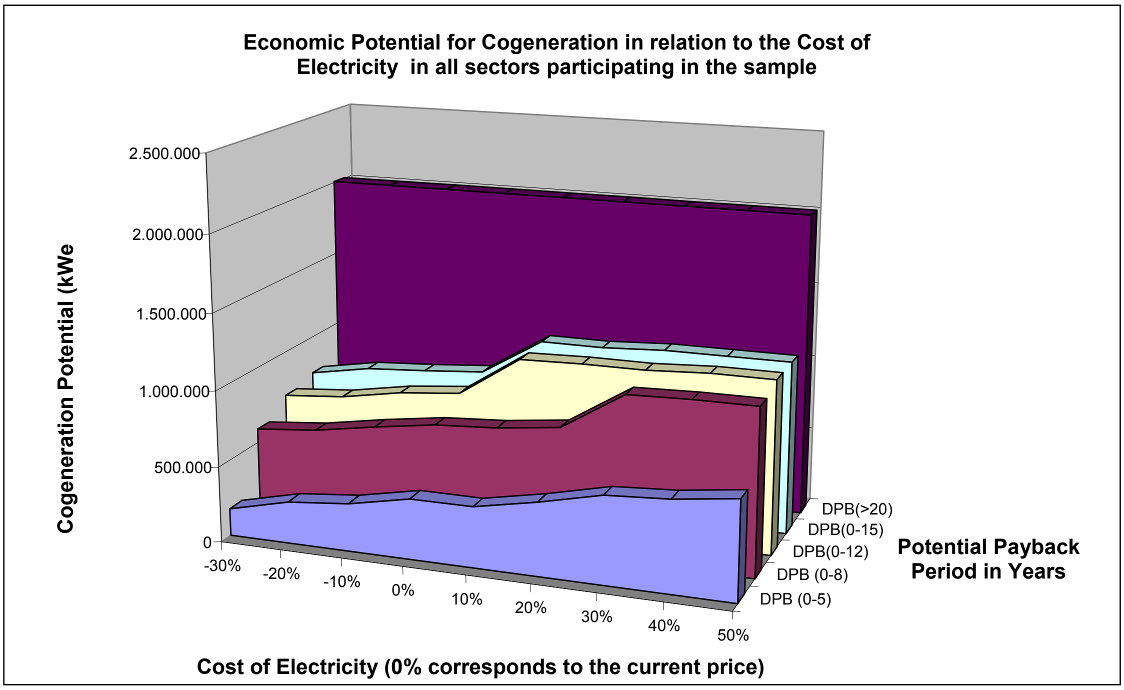
Impact of the cost of fuel on the economic potential of cogeneration (prices in kWe)					
Price change for fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	759026	1145092	1755950	1759035	2005642
-30%	578022	1142578	1175761	1754311	2005642
-20%	484497	1119276	1174276	1174276	2005642
-10%	411332	779650	1174276	1174276	2005642
0%	398853	752352	843478	875364	2005642
10%	224616	621973	803875	843478	2005642
20%	185813	376149	751842	803701	2005642
30%	185813	376149	694500	803701	2005642
40%	83713	256189	282571	542187	2005642

Impact of the cost of electricity on the financial potential of cogeneration (prices in kWe)					
Price change in the market for electricity	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	181352	590179	703001	746532	2005642
-20%	277512	627483	735380	817480	2005642
-10%	316315	695010	804655	843478	2005642
0%	398853	752352	843478	875364	2005642
10%	398853	778350	1111405	1122281	2005642
20%	478987	825757	1122281	1122281	2005642
30%	574025	1080664	1122281	1143079	2005642
40%	600023	1092133	1143079	1143079	2005642
50%	652957	1093161	1143079	1143079	2005642


Economical CHP Potential in the total of the sectors participating in the sample, in relation to the payback period
1.400.000
1.200.000
1.000.000
800.000
600.000
400.000
200.000
0
Cogeneration Potential (kWe)
Technical potential of the total of the sectors
Economic Potential of the total of the sectors
Economical potential of the total of the sample
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
Potential Payback Period in Years


Economic Potential for Cogeneration in relation to the Subsidy for the Investment in all sectors
2.500.000
2.000.000
1.500.000
1.000.000
500.000
0
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
Subsidy (% of the cost of the investment)


Economic Potential for Cogeneration in relation to the Cost of Fuel in all sectors participating in the sample
Cogeneration Potential (kWe)
2.500.000
2.000.000
1.500.000
1.000.000
500.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
Cost of Fuel (0% corresponds to the current price)


Economic Potential for Cogeneration in relation to the Cost of Electricity in all sectors participating in the sample
Cogeneration Potential (kWe
2.500.000
2.000.000
1.500.000
1.000.000
500.000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
Cost of Electricity (0% corresponds to the current price)

3.4 ECONOMIC VIABILITY OF INVESTMENTS FOR THE APPLICATION OF COGENERATION IN THE TERTIARY SECTOR

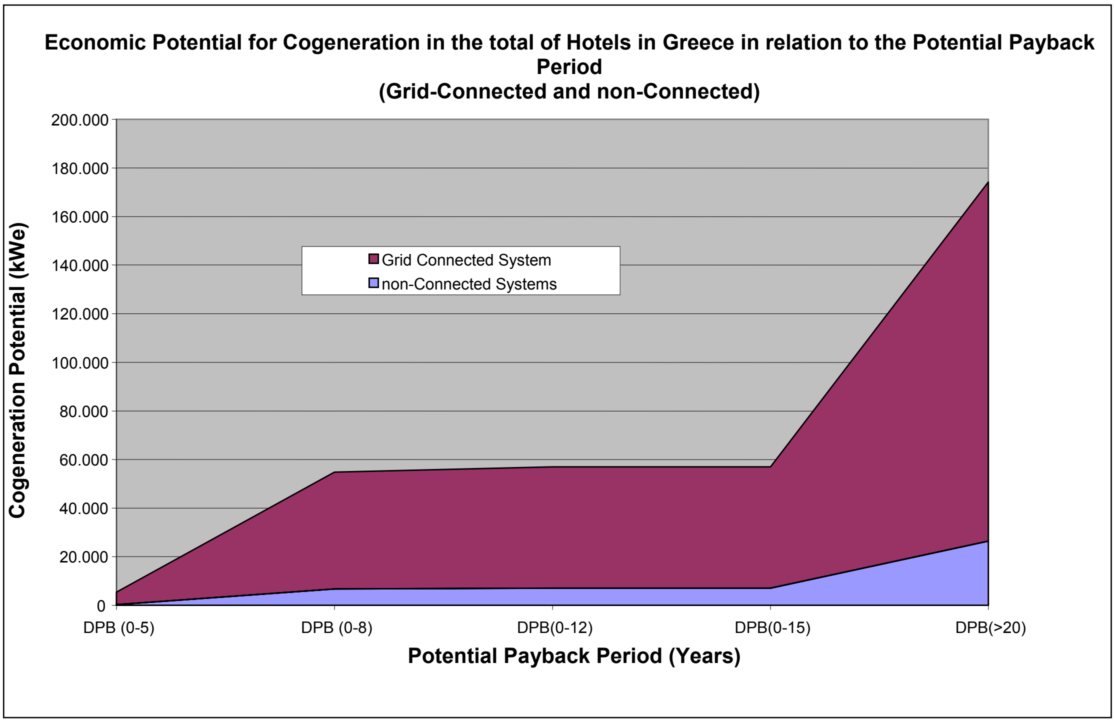
For the evaluation of the technical potential in the tertiary sector, approximately 100 questionnaires were collected from the following types of buildings/facilities:

- Hotels
- Hospitals
- University Campuses
- Airports

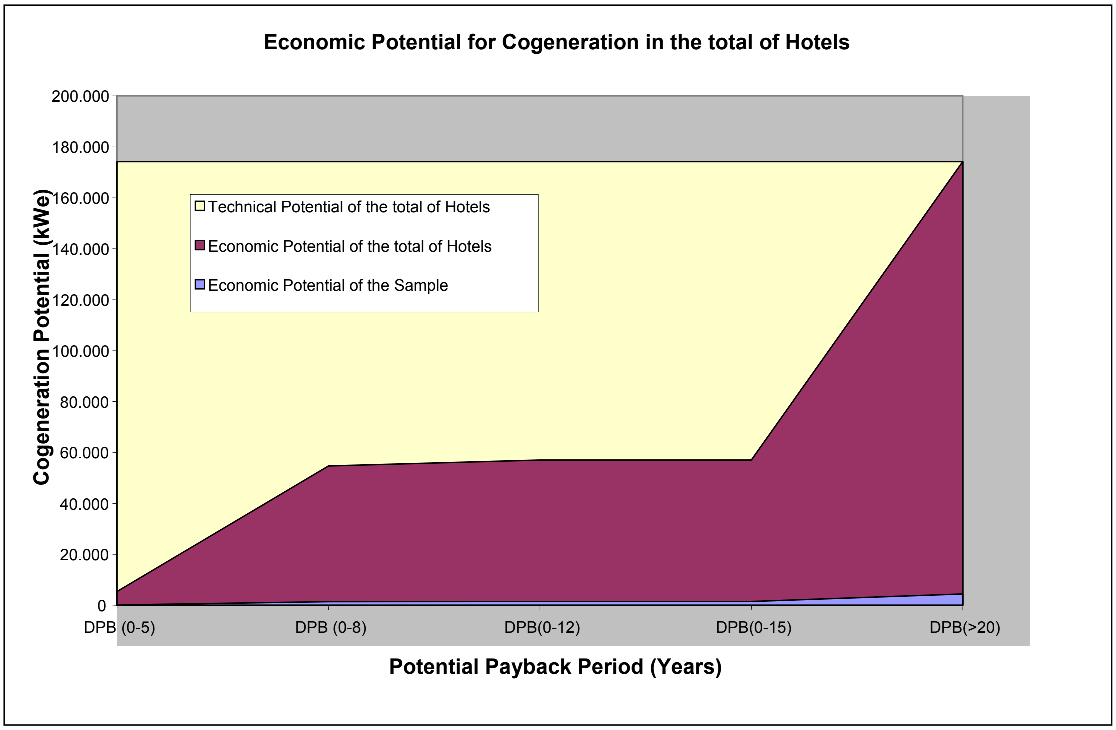
The same method used in preparing preliminary feasibility studies in the industrial sector was used for the above sectors.

3.4.1 Parametric Analysis of the Economic Potential for Cogeneration in Hotels

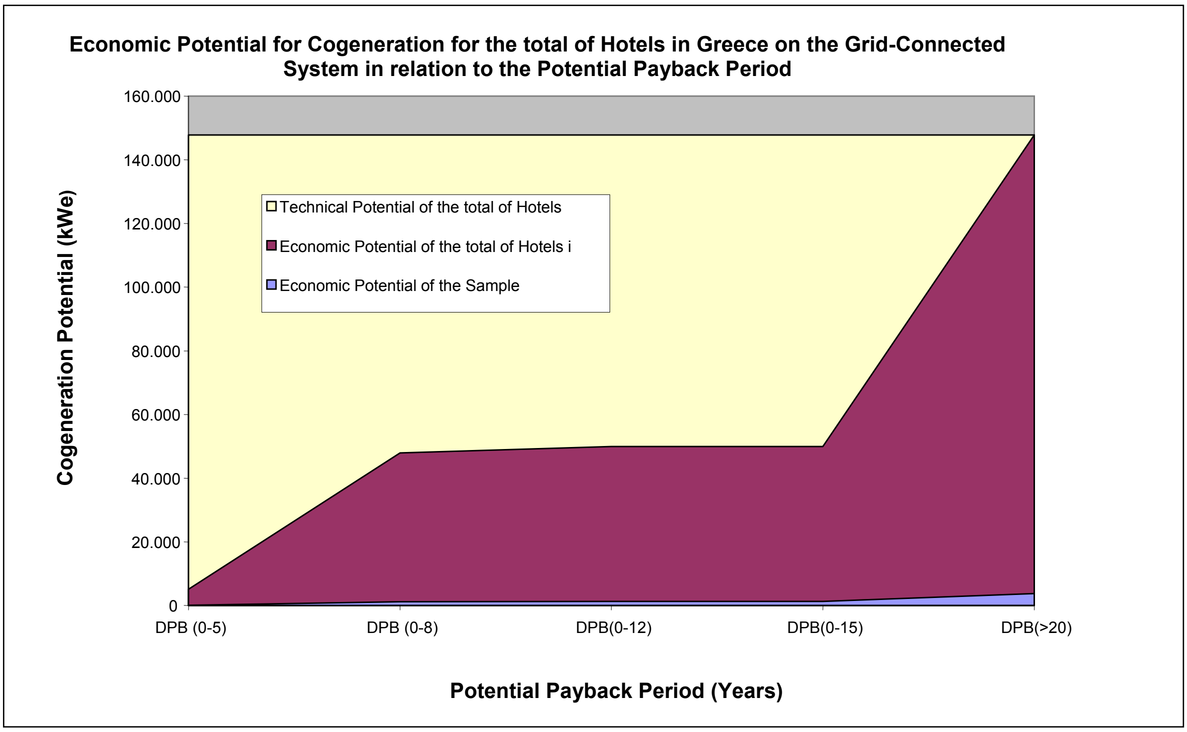
Economic Potential for Cogeneration in Hotels					
	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
Economic Potential for the total of Hotels in Greece in the Grid-Connected System	5110	47953	49919	49919	147791
Economic Potential for the total of Hotels in Greece in the non-Connected Systems	306	6786	7064	7064	26415
Economic Potential for all the Hotels in Greece	5415	54739	56982	56982	174206



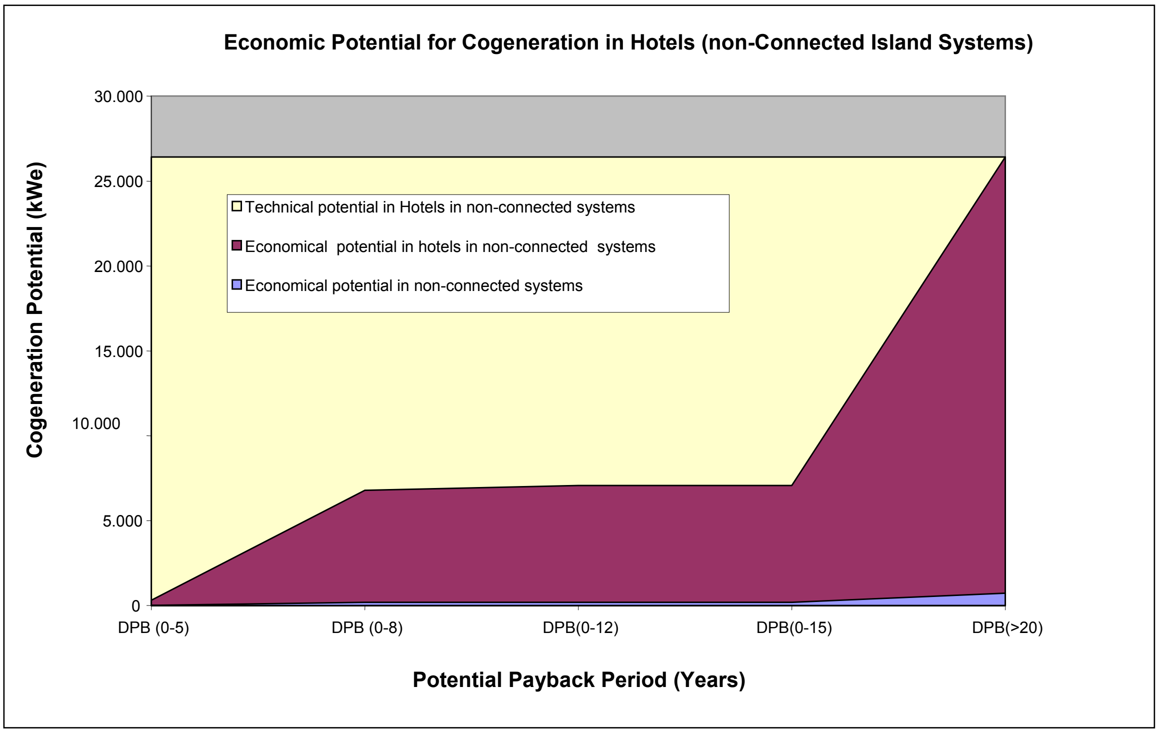
Economic Potential for Cogeneration in Hotels					
	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
Economic Potential of the Sample	138	1405	1463	1463	4480
Economic Potential of the total of Hotels in Greece	5415	54739	56982	56982	174206
Technical Potential of the total of Hotels in Greece	174206	174206	174206	174206	174206



Economic Potential for Cogeneration in Hotels (Grid-Connected System)					
	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
Economic Potential for the Sample in the Grid-Connected System	130	1220	1270	1270	3760
Economic Potential for the total of Hotels in Greece in the Grid-Connected System	5110	47953	49919	49919	147791
Technical Potential for the total of Hotels in Greece in the Grid-Connected System	147791	147791	147791	147791	147791

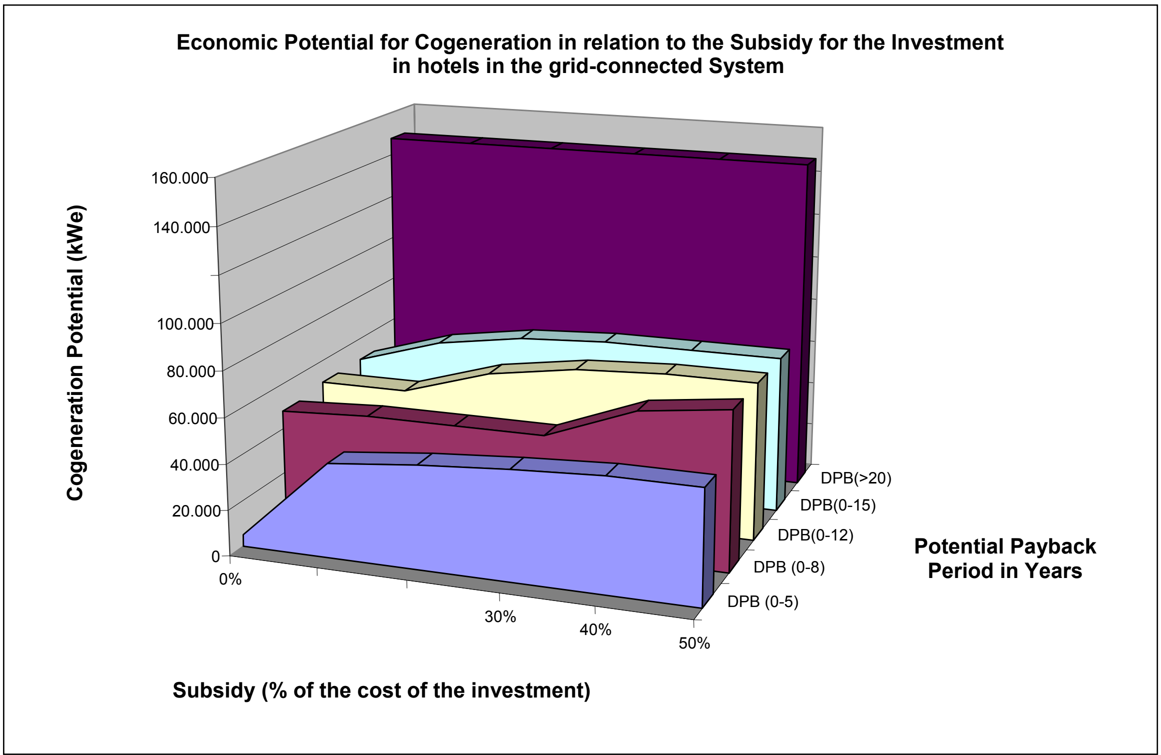


Economic Potential for Cogeneration in Hotels (non-Connected Island Systems)					
	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
Economic Potential for the Sample in the non-Connected Systems	8	185	193	193	720
Economic Potential for the total of Hotels in Greece in the non-Connected Systems	306	6786	7064	7064	26415
Technical Potential for the total of Hotels in Greece in the non-Connected Systems	26415	26415	26415	26415	26415

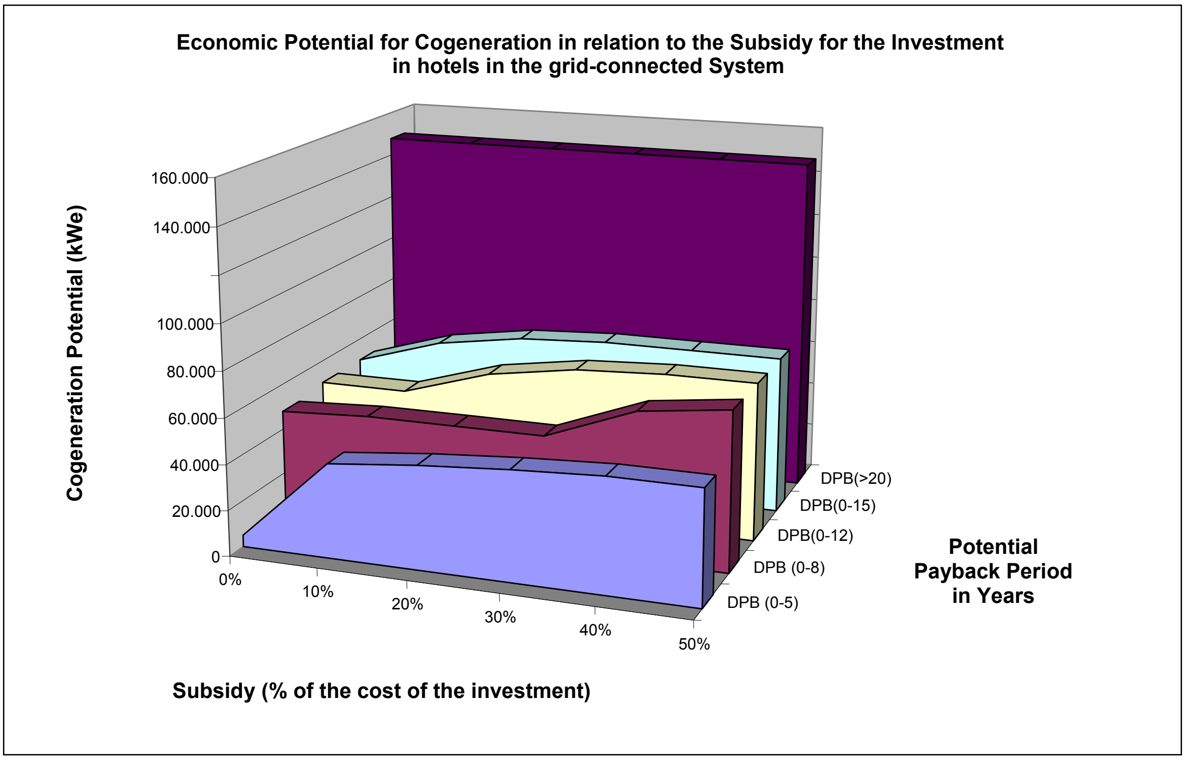


Impact of the Subsidy on the Economic Potential for Cogeneration in kWe (Grid-Connected and non-Connected Systems)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	5415	54739	56982	56982	174206
10%	48648	58841	58841	72740	174206
20%	53281	58841	72740	79690	174206
30%	56153	58841	79107	82007	174206
40%	58841	76447	83072	83072	174206
50%	58841	82007	83572	85072	174206

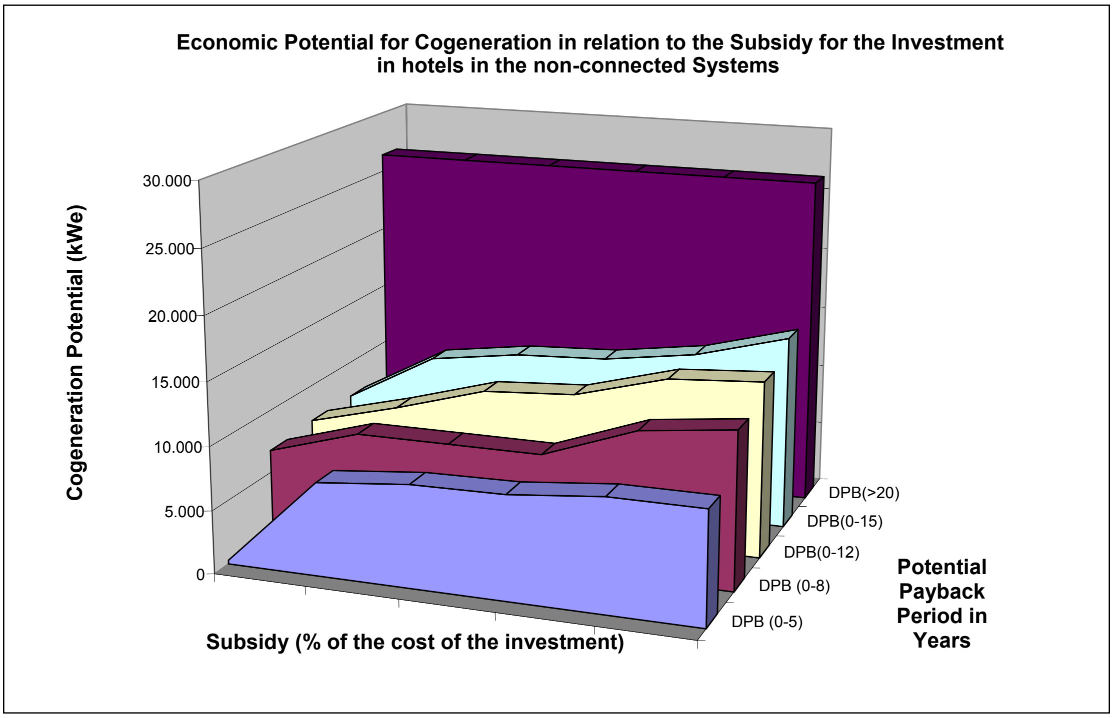
Impact of the Subsidy on the Economic Potential for Cogeneration in kWe (Grid-Connected System)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	5110	47953	49919	49919	147791
10%	41271	49919	49919	61711	147791
20%	45202	49919	61711	67607	147791
30%	47953	49919	67607	69572	147791
40%	49919	64855	69572	69572	147791
50%	49919	69572	69572	69572	147791



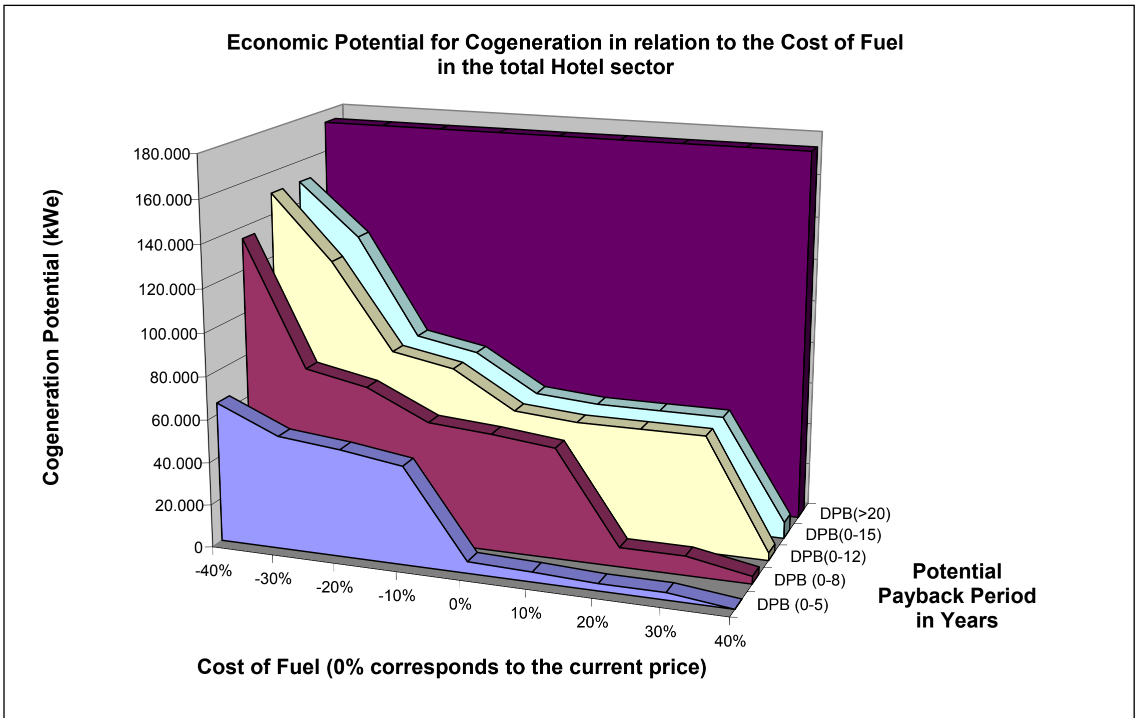
Impact of the Subsidy on the Economic Potential for Cogeneration in kWe (Grid-Connected System)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	5110	47953	49919	49919	147791
10%	41271	49919	49919	61711	147791
20%	45202	49919	61711	67607	147791
30%	47953	49919	67607	69572	147791
40%	49919	64855	69572	69572	147791
50%	49919	69572	69572	69572	147791



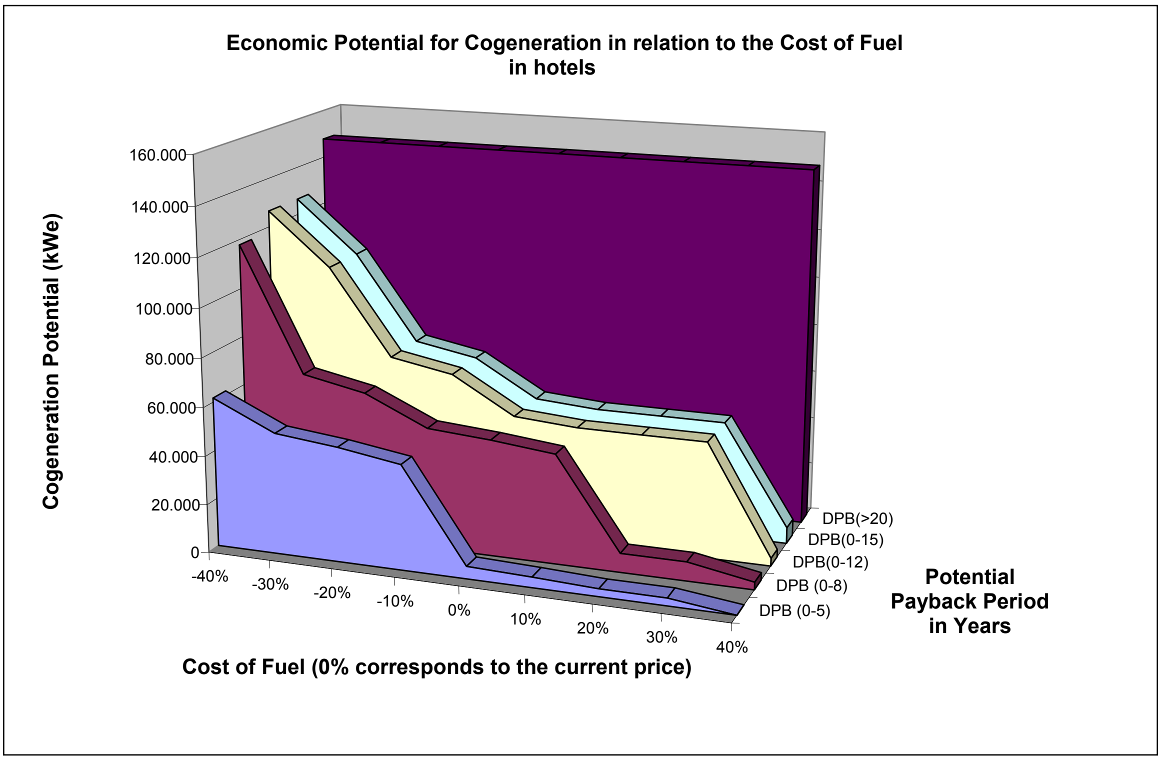
Impact of the Subsidy on the Economic Potential for Cogeneration in kWe (non-Connected Systems)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	306	6786	7064	7064	26415
10%	7377	8922	8922	11030	26415
20%	8079	8922	11030	12084	26415
30%	8200	8922	11500	12435	26415
40%	8922	11592	13500	13500	26415
50%	8922	12435	14000	15500	26415



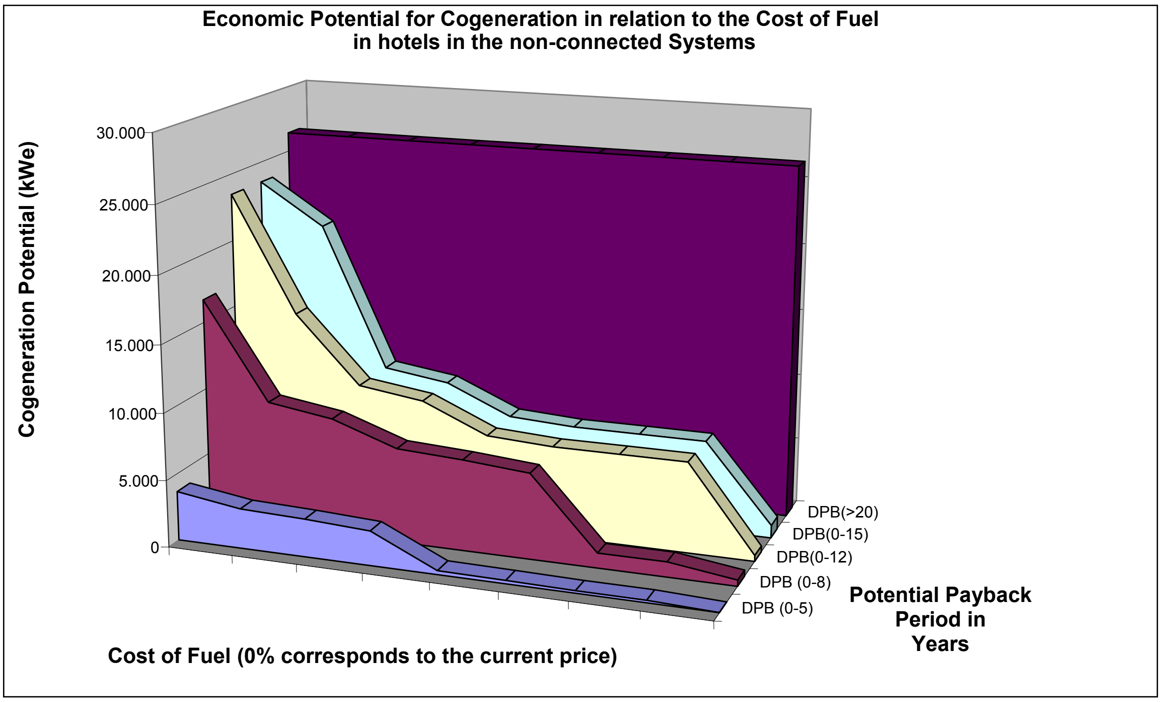
Impact of the fuel cost on the Economic Potential for Cogeneration in kWe (Grid-Connected and non-Connected Systems)					
Μεταβολή κόστους καυσίμου	DPB (0-5)	DPB (0-8)	DPB (0-12)	DPB (0-15)	DPB (>20)
-40%	65402	134604	150052	150052	174206
-30%	52905	76276	119798	125375	174206
-20%	49989	70443	79416	79416	174206
-10%	45823	56982	74032	74032	174206
0%	5415	54739	56982	56982	174206
10%	4582	51598	54739	54739	174206
20%	3333	8974	54739	54739	174206
30%	3333	8974	54739	54739	174206
40%	0	3589	3589	7628	174206



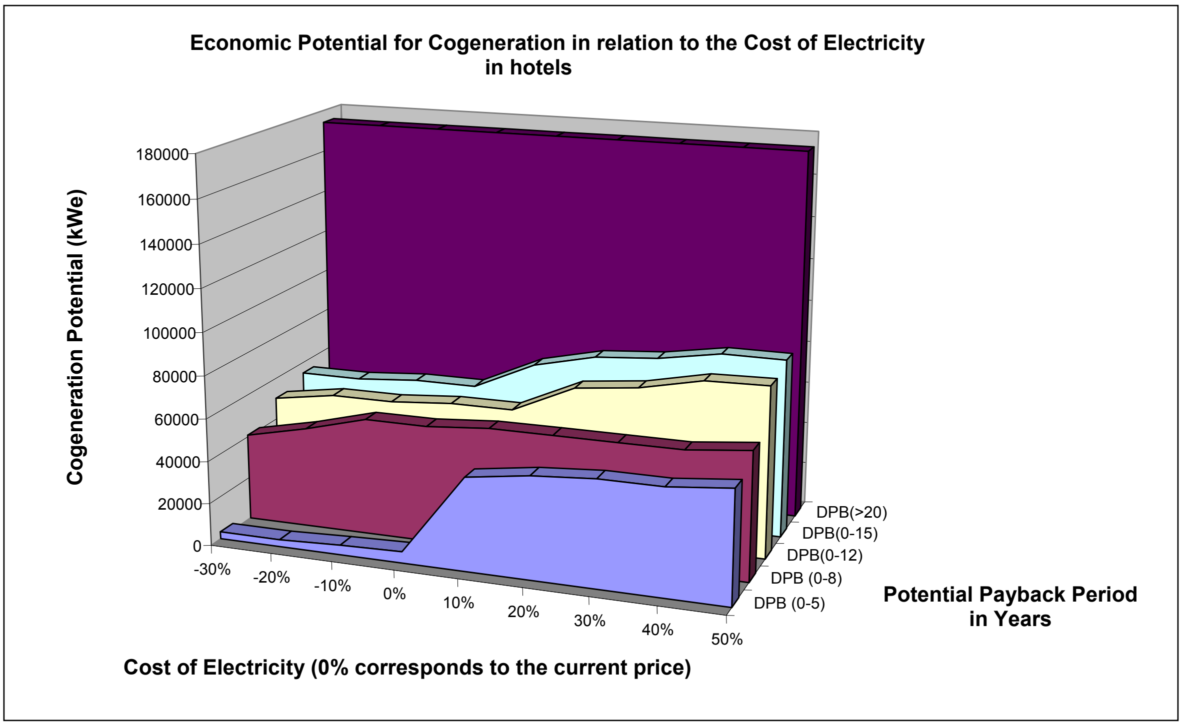
Impact of the fuel cost on the Economic Potential for Cogeneration in kWe (Grid-Connected and non-Connected Systems)					
Change in Fuel Price	DPB (0-5)	DPB (0-8)	DPB (0-12)	DPB (0-15)	DPB (>20)
-40%	61711	117918	126566	126566	147791
-30%	49919	66820	104947	104947	147791
-20%	47167	61711	69572	69572	147791
-10%	43237	49919	64855	64855	147791
0%	5110	47953	49919	49919	147791
10%	4324	45202	47953	47953	147791
20%	3144	7861	47953	47953	147791
30%	3144	7861	47953	47953	147791
40%	0	3144	3144	6682	147791



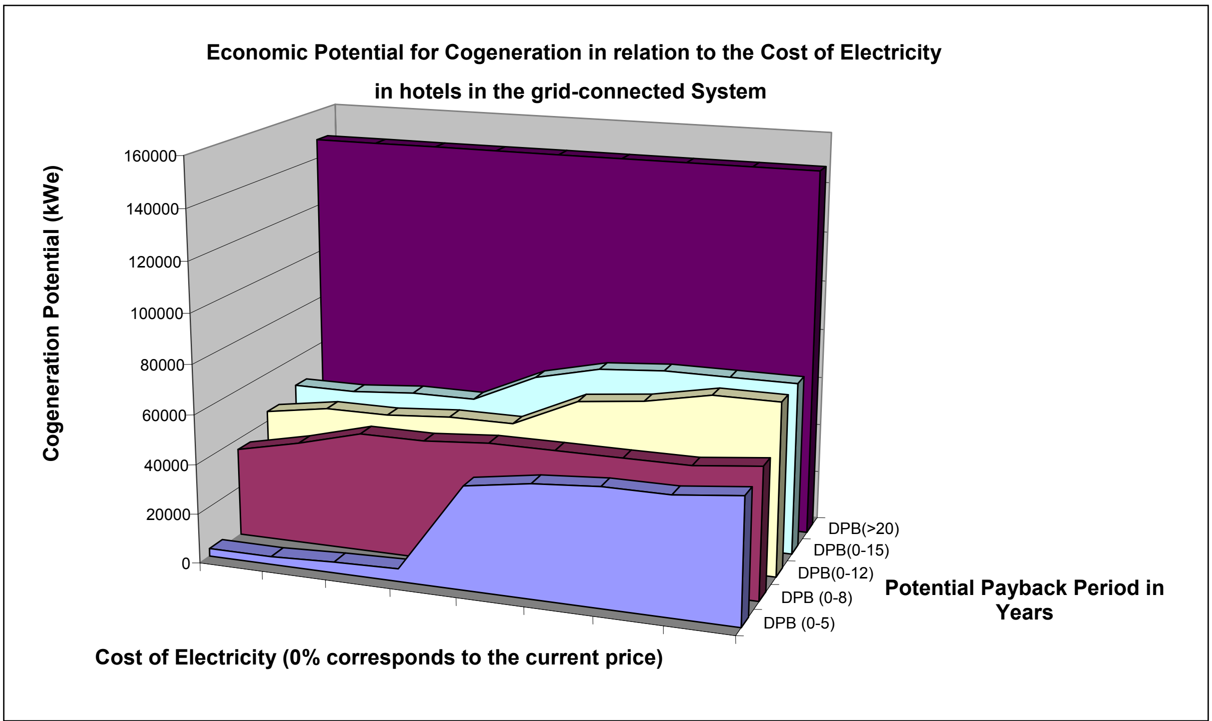
Impact of the fuel cost on the Economic Potential for Cogeneration in kWe (non-Connected Systems)					
Change in Fuel Price	DPB (0-5)	DPB (0-8)	DPB (0-12)	DPB (0-15)	DPB (>20)
-40%	3691	16686	23486	23486	26415
-30%	2986	9455	14850	20427	26415
-20%	2821	8732	9845	9845	26415
-10%	2586	7064	9177	9177	26415
0%	306	6786	7064	7064	26415
10%	259	6396	6786	6786	26415
20%	188	1112	6786	6786	26415
30%	188	1112	6786	6786	26415
40%	0	445	445	946	26415



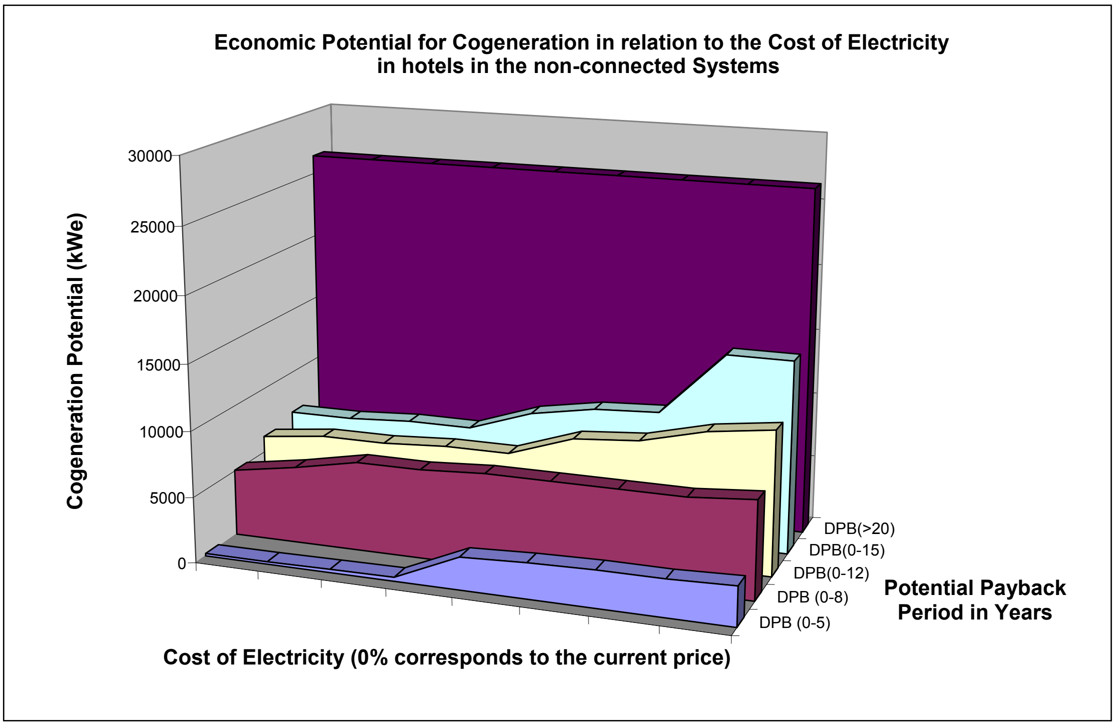
Impact of the fuel cost on the Economic Potential for Cogeneration in kWe (Grid-Connected and non-Connected Systems)					
Change of electricity price	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	3333	40830	50252	54739	174206
-20%	3333	47111	54739	54739	174206
-10%	4582	54739	54739	56982	174206
0%	5415	54739	56982	56982	174206
10%	43740	56982	56982	70443	174206
20%	47906	56982	70443	77173	174206
30%	49989	56982	73584	79416	174206
40%	49989	56982	79904	84296	174206
50%	52905	60123	80555	84296	174206



Impact of the fuel cost on the Economic Potential for Cogeneration in kWe (Grid-Connected System)					
Change of electricity price	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	3144	35769	44023	47953	147791
-20%	3144	41271	47953	47953	147791
-10%	4324	47953	47953	49919	147791
0%	5110	47953	49919	49919	147791
10%	41271	49919	49919	61711	147791
20%	45202	49919	61711	67607	147791
30%	47167	49919	64462	69572	147791
40%	47167	49919	69572	69572	147791
50%	49919	52670	69572	69572	147791



Impact of the fuel cost on the Economic Potential for Cogeneration in kWe (non-Connected Systems)					
Change of electricity price	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%	188	5061	6229	6786	26415
-20%	188	5840	6786	6786	26415
-10%	259	6786	6786	7064	26415
0%	306	6786	7064	7064	26415
10%	2469	7064	7064	8732	26415
20%	2704	7064	8732	9567	26415
30%	2821	7064	9122	9845	26415
40%	2821	7064	10333	14724	26415
50%	2986	7453	10983	14724	26415

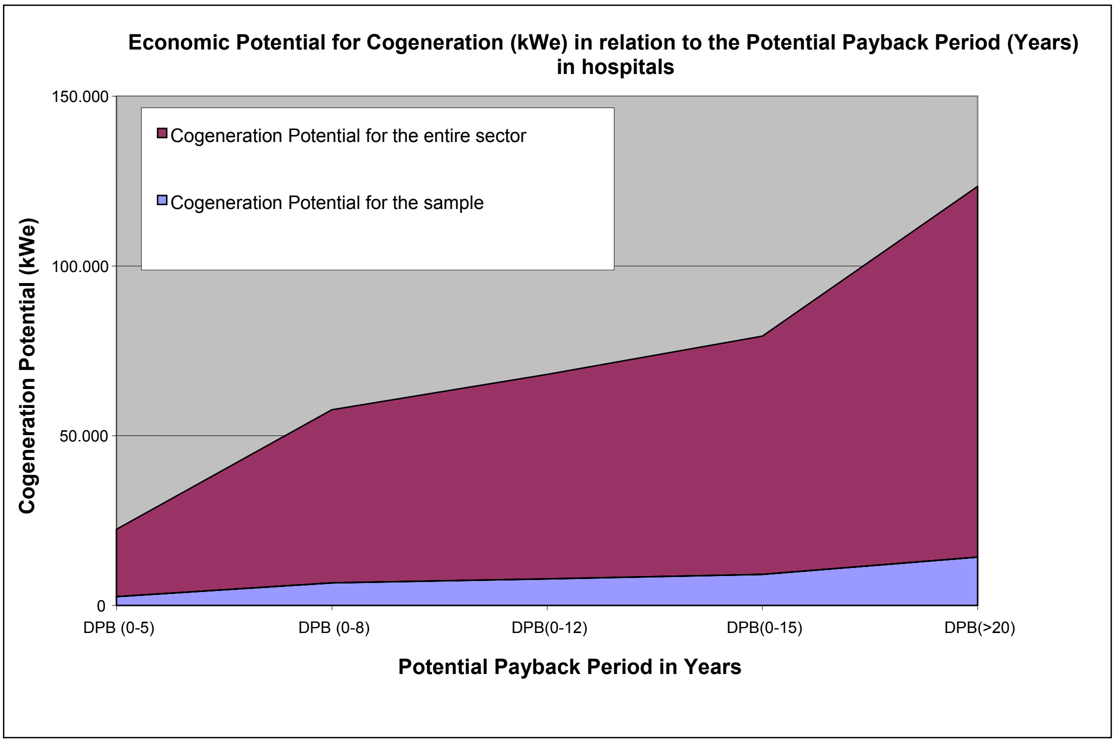


3.4.2 Parametric Analysis of the Economic Potential for Cogeneration in Hospitals

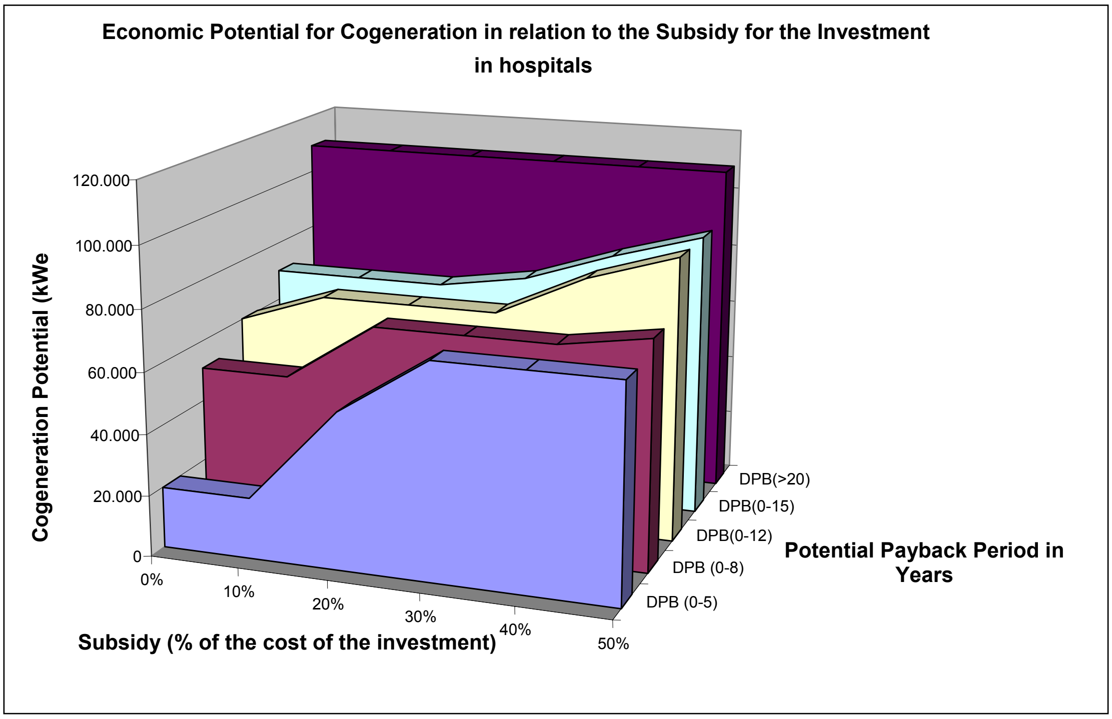
Impact of the Subsidy on the Economic Potential for Cogeneration (prices in kWe)					
Subsidy	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
0%	19824	51014	60199	70149	109184
10%	19824	51014	70149	70149	109184
20%	51014	70149	70149	70149	109184
30%	70149	70149	70149	74741	109184
40%	70149	70149	83926	84691	109184
50%	70149	74741	93111	93111	109184

Impact of the cost of fuel on the economic potential for cogeneration (prices in kWe)					
Change in the cost of fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-40%	49674	72445	109184	109184	109184
-30%	29009	72445	104592	104592	109184
-20%	29009	60199	91580	96172	109184
-10%	19824	51014	69383	79333	109184
0%	19824	51014	60199	70149	109184
10%		29009	51014	60199	109184
20%		29009	51014	60199	109184
30%		29009	51014	60199	109184
40%			29009	51014	109184

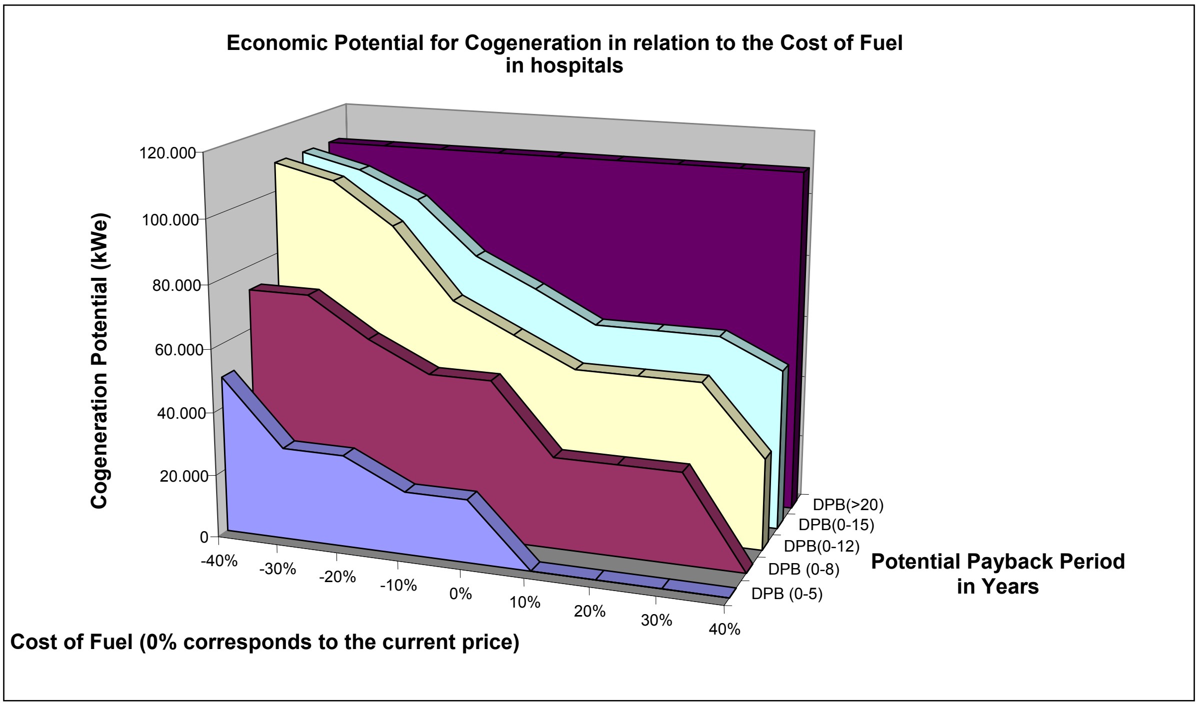
Impact of the cost of electricity on the economic potential for cogeneration (prices in kWe)					
Change in the cost of fuel	DPB (0-5)	DPB (0-8)	DPB(0-12)	DPB(0-15)	DPB(>20)
-30%		19824	51014	51014	109184
-20%		29009	51014	60199	109184
-10%	13241	41638	60199	70149	109184
0%	19824	51014	60199	70149	109184
10%	19824	51014	60199	70149	109184
20%	29009	51014	79333	79333	109184
30%	29009	51014	79333	83926	109184
40%	29009	51014	79333	83926	109184
50%	51014	79333	103826	103826	109184



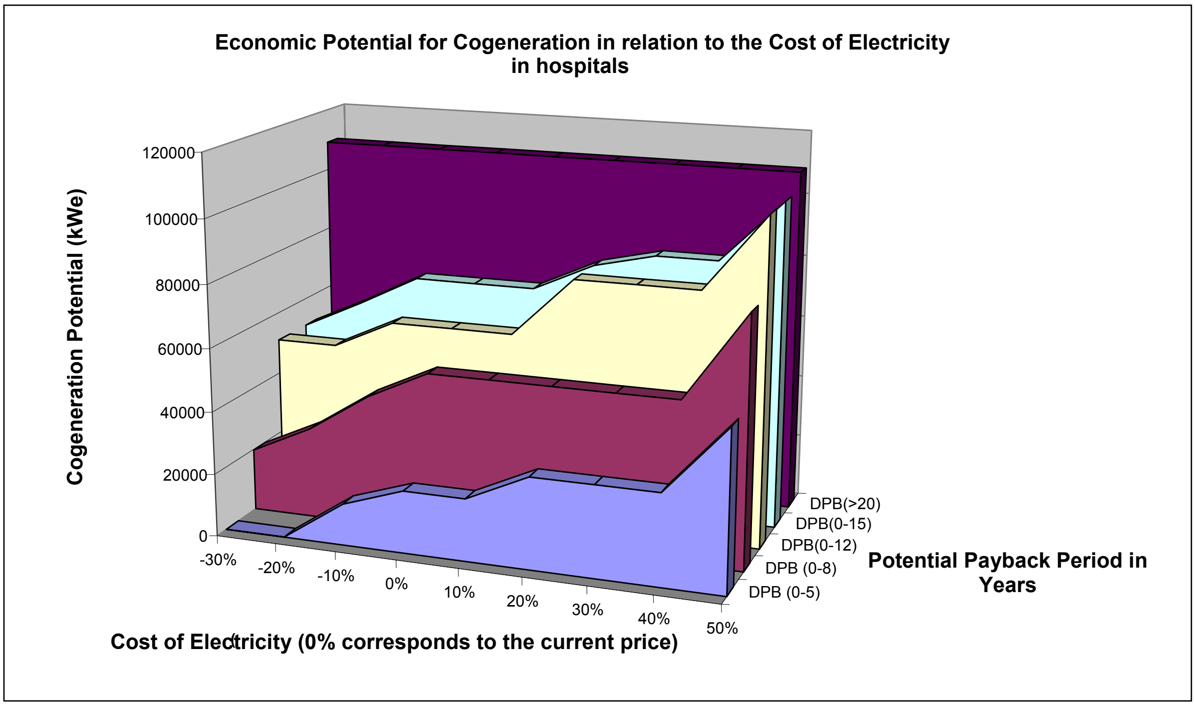
Economic Potential for Cogeneration (kWe) in relation to the Potential Payback Period (Years) in hospitals
Cogeneration Potential for the entire sector
Cogeneration Potential for the sample
Cogeneration Potential (kWe)
150.000
100.000
50.000
0
DPB (0-5)
DPB (0-8)
DPB(0-12)
DPB(0-15)
DPB(>20)
Potential Payback Period in Years



Economic Potential for Cogeneration in relation to the Subsidy for the Investment in hospitals
Cogeneration Potential (kWe
120.000
100.000
80.000
60.000
40.000
20.000
0
0%
10%
20%
30%
40%
50%
Subsidy (% of the cost of the investment)
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years



Economic Potential for Cogeneration in relation to the Cost of Fuel in hospitals
Cogeneration Potential (kWe)
120.000
100.000
80.000
60.000
40.000
20.000
0
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
Cost of Fuel (0% corresponds to the current price)



Economic Potential for Cogeneration in relation to the Cost of Electricity in hospitals
Cogeneration Potential (kWe)
120000
100000
80000
60000
40000
20000
0
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
DPB(>20)
DPB(0-15)
DPB(0-12)
DPB (0-8)
DPB (0-5)
Potential Payback Period in Years
Cost of Electricity (0% corresponds to the current price)

3.4.3. Economic Potential of CHP Applications in Office Buildings

Using the same method as the one used for the economic potential in the residential sector, typical investments were analyzed for each one of the four climate zones. The final conclusions are:

In climate zone A, with a subsidy of 50%, the interest bearing payback period is 9 years.

In climate zone B, with natural gas and a 35% subsidy, the payback period is 8 years. According to [2] and [24], the percentage of buildings with high consumption due to high air conditioning loads is about 20%. After further analysis of the calculations of the technical potential of chapter 2, we calculated that in zone B, 20% of the buildings account for a **power capacity of 393 MWe**, **thermal capacity of 643 MWth** and **PES of 511 GWh/year.**

In climate zone C, with natural gas and a 50% subsidy, the payback period is 9 years.

In climate zone D, with diesel and a 50% subsidy, the payback period is 10 years.

3.4.4 Economic Potential of CHP in the Remainder of the Tertiary Sector

3.4.4.1 University Campuses

The economic potential for cogeneration in university campuses is zero for the Discounted Payback Period (DPBP) < 20 years. **For DPBP > 20 years CHP investments in university campuses of 36,94 MWe or 62.6 MWth are being carried out.**

3.4.4.2 Airports

The economic potential for cogeneration in the airports of the sample is zero for the Discounted Payback Period (DPBP) < 20 years. **For DPBP > 20 years, CHP investments of 2,5 MWe or 3.99 MWth are being carried out.**

3.5 ECONOMIC POTENTIAL OF BIOMASS

The potential which was calculated in chapter 2 concerns investments which have a positive current value. Taking into consideration that the investments will be subsidized by 40% by current policies, this potential is economically profitable.

Table 3.5.1: Distribution of the thermal and power capacity of cogeneration units with biomass at manufacturing installations with the use of biomass products

Area	Thermal capacity (MWth)	Electrical capacity (MWe)	PES (GWh/year)
Central Greece Peloponnese	284.04	132.08	1365
Ipiros -Thessaly	71.9	33.14	361
Makedonia - Thrace	138.48	64.19	677
Islands - Attica	130.37	60.68	702.6
Total	**624.80**	**290.09**	**3107**

Table 3.5.2: Distribution of the thermal and power capacity of cogeneration units with biomass exclusively from agricultural and forest residues, for use in the residential and tertiary sectors with district heating

Area	Thermal capacity (MWth)	Electrical capacity (MWe)	PES (GWh/year)
Central Greece - Thessaly	67.36	31.08	297
Makedonia - Thrace	87.28	40.19	406
Peloponnese	26.05	11.85	108
Total	**180.7**	**83.1**	**812**

3.6 BIOGAS

3.6.1 Sewage Sludge

In the evaluation of the economic potential for cogeneration, it is noted that **the sum of the technical potential, 11,93 MWe, with a Discounted Payback Period (DPBP) lesser or equal to 8 years is being realized.**

3.6.2 Landfill Gas

The installations at Liosia and Tagarades are expected to supply heat for the heating needs in their surrounding areas, and thus the economic potential from sanitary landfills is:

Table 3.6.2: Economic CHP Potential from Sanitary Landfills

Area	Electrical Capacity (MW_e)	Thermal Capacity (MW_{th}*)	Electricity Production (MWh_e**)	Heat Production (MWh_{th}**)	Electricity Production (TJoule)	Heat Production (TJoule)
Liosia 1	13.8	18.4	108799.2	145065.6	391.677	522.236
Liosia 2	9.7	12.93	76474.8	101966.4	275.309	367.079
Tagarades	5	6.67	39420	52560	141.912	189.216
TOTAL	**28.5**	**38**	**224694**	**299592**	**808.898**	**1078.531**

It is not clear at the present whether sanitary landfills will be built at Volos and Larisa.

3.6.3 Biogas from Organic Waste

Table 3.6.3 : Technical Potential for Biogas from Organic Wastes

	Electrical Capacity (MW_e)	Thermal Capacity (MW_{th})	Electricity Production (MW_eh)	Heat Production ($MW_{th}h$)	Heat Production (TJoule)
Cattle farms	278	370.7	2191752	2922336	10520.41
Pig farms	37	49.3	291708	388944	1400.19
Slaughterhouses	28	37.3	220752	294336	1059.61
Cheese factories (milk processing)	7.21	9.6	56844	75792	272.85
TOTAL	**350.21**	**466.94**	**2761056**	**3681407.52**	**13253.07**

According to the table above, **8 central units** could be created **in Greece** at locations where there is a proven high organic waste potential and also serious environmental problems from the unregulated disposal of such waste. It is encouraging that these sites are located in a 2-25 k diameter, so that the cost of transporting the waste to a central biogas unit(s) is rather small. Despite this, at present, there is uncertainty over the economic potential of the installations, which, according to crude estimates, might be around 30-40 MWe. The fact that this potential is site-specific requires detailed prefeasibility studies which so far, have not been done.

3.6.4 Confirmed Economic Potential of Biogas

Table 3.5.2: Economic CHP Potential from Biogas

	Electrical Capacity (MW_e)	Thermal Capacity (MW_{th})	Electricity Production (MW_eh)	Heat Production ($MW_{th}h$)	PES (MWh)
Sewage Sludge	11,93	18,1	33920	138730	108000
Sanitary Landfills	28,5	38	224694	299592	339946
TOTAL	**40,43**	**56,1**	**258614**	**438322**	**447946**

3.7 GLASS GREENHOUSES

Glass greenhouses which were referred to in chapter 2 are economically viable investments and have CHP economic potential. Therefore, they could be included in a National Policy for CHP and are shown in the following table:

Table 3.7: Economic CHP Potential from Glass Greenhouses

Area	Agricultural District	Thermal Capacity for the Average Day MWth	Electric Capacity (MWe)	Thermal Energy for Period of Operation (MWth,th)	Electricity for Period of Operation (MWh,e)	PES (MWh/year)
BE	Drama	0,6	0,4	105,9	79,5	124,6
BE	Serres	1,7	1,3	331,1	248,3	389,5
BE	Xanthi	0,2	0,2	41,3	30,9	48,5
BE	Preveza	0,6	0,5	107,9	80,9	126,9
KE	Corfu	0,2	0,2	37,4	28,0	44,0
KE	Magnisia	1,0	0,8	175,4	131,5	206,3
KE	Karditsa	0,2	0,2	41,3	30,9	48,5
NE	Argolida	0,1	0,0	8,1	6,1	9,5
NE	Corinth	0,8	0,6	127,4	95,5	149,8
NE	Lakonia	1,1	0,8	159,2	119,4	187,3
NE	Aetoloakarnania	0,6	0,5	107,9	80,9	126,9
NE	East Attika	1,8	1,3	298,0	223,5	350,6
NE	Piraeus	0,3	0,2	55,0	41,3	64,7
NE	Cyclades	0,6	0,4	83,5	62,6	98,2
NE	Dodekanissa	0,2	0,2	31,1	23,3	36,6
NE	Iraklio	1,8	1,4	263,2	197,4	309,7
NE	Lassithi	0,2	0,2	31,1	23,3	36,6
NE	Chania	0,2	0,1	25,6	19,2	30,1
NE	Rethymno	0,2	0,2	31,1	23,3	36,6
	TOTAL	**12,4**	**9,5**	**2061,4**	**1546,0**	**2425,2**

3.8 DESALINATION UNITS NEAR ISLAND POWER GENERATION PLANTS

The proposed desalination units which were shown in Table 2.6.1 have technical potential only, given that the PPC is not at the present planning desalination projects near island power generating plants.

3.9 GEOTHERMAL ENERGY

The confirmed geothermal potential which is economically exploitable is shown in the following table. This potential has been calculated based on the local requirements of Milos and Nisyros. However, it is noted that the PPC, although it is doing geothermal research in these areas, is not planning to construct power generation plants using geothermal energy.

Table 3.9 : Economic Geothermal Potential for CHP in Greece

Middle (120 ºC -150 ºC) - **High** (150 ºC - 350 ºC) **Enthalpy**

Location of Geothermal Field	Temperature	Thermal Capacity (MWth)	Electrical Capacity (MWe)	Heat Production ($MW_{th}h$)	Electricity Generation ($MW_{e}h$)
Milos	120 ºC -350 ºC	20	4	70080	28032
Nisyros	120 ºC -350 ºC	2	0,4	7008	3153
TOTAL		**22**	**4,4**	**77088**	**31185**

3.10 ECONOMIC POTENTIAL OF CHP FROM THE POINT OF VIEW OF THE INVESTOR

The following table 3.10.1 summarizes the results of chapter 3 up to this point concerning the economic potential of CHP in Greece from the point of view of the investor. Investments here have a discounted payback period of 8 years. Table 3.10.2 is giving an overview of the potential CHP market in Greece. Table 3.10.2 includes information derived from a sample of 100 economically viable installations.

Table 3.10.1 : ECONOMIC POTENTIAL OF CHP (INVESTMENTS VIABILITY)

Sector	Economic Potential of CHP (MWe)	Economic Potential of CHP (MWth)	PES (GWh/year)	Required Percentage of Subsidy %
INDUSTRY	***998,5***	***1993,2***	***6552,8***	***35***
Food, Beverages and Tobacco	320	622	2599	35
Paper, Pulp and Printing	80	183	614	35
Wood & Products	13,5	135	100	35
Textile, Leather and Clothing	109	237	760	35
Chemicals and Petrochemicals	104	163	631	35
Iron and Steel	275	484	963	35
Construction Materials	97	169	887	35
TERTIARY SECTOR	***531***	***840***	***1023***	***35***
Hotels-Grid Connected	58	78	286	35
Hotels-Non Connected	10	13	39	35
Hospitals	70	106	187	35
Office Buildings*	393	643	511	35
RESIDENTIAL SECTOR	***224***	***332***	***774***	
District Heating from IPs*	224	332	774	35
Micro CHP-Residential Sector				**DPBP=10 years > 50**
BIOMASS & AGRICULTURE	***423,5***	***874,4***	***4369,3***	***40***
Biomass in Industry	291	625	3107	40
District Heating with Biomass	83	181	812	40
Biogas	40	56	447,9	40
Glass Greenhouses	9,5	12,4	2,4	40

*uncertain data

Table 3.10.2 : ASSESMENT OF THE CHP MARKET IN GREECE BASED ON A SAMPLE OF 100 ECONOMICALLY VIABLE INSTALLATIONS

Economic Activity	***Technology***	***Fuel***	***Electrical Capacity (KWe)***	***Thermal Capacity (KWth)***
Public Thermal Power Plants	Steam Backpressure Turbine	Lignite, Briquettes, Heavy Fuel Oil	10000	56000
Public Thermal Power Plants	Steam Condensing Extraction Turbine	Lignite	7600	70000
Public Thermal Power Plants	Steam Condensing Extraction Turbine	Lignite	9500	70000
Public Thermal Power Plants	Steam Condensing Extraction Turbine	Lignite	4600	70000
Public Thermal Power Plants	Steam Condensing Extraction Turbine	Lignite, Heavy Fuel Oil	6100	50000
Natural gas supply and transmission	Internal Combustion Engine	Natural Gas	15500	19000
Refineries	Combined Cycle Gas Turbine with Heat Recovery	Refinery Gas, Heavy Fuel Oil	43400	50100
Refineries	Combined Cycle Gas Turbine with Heat Recovery	Natural Gas	11800	11000
Refineries	Gas Turbine with Heat Recovery	Refinery Gas	26400	47100
Refineries	Gas Turbine with Heat Recovery	Refinery Gas	14000	25020
Refineries	Gas Turbine with Heat Recovery	Oil Feedstocks	17000	(26000)
Non Ferrous metals	Combined Cycle Gas Turbine with Heat Recovery	Natural Gas	334000	302000
Non Ferrous metals	Gas Turbine with Heat Recovery	Natural Gas	500	828
Non Ferrous metals	Internal Combustion Engine	Natural Gas	2100	3000
Non Ferrous metals	Steam Backpressure Turbine	Heavy Fuel Oil	7900	33670
Non Ferrous metals	Steam Condensing Extraction Turbine	Heavy Fuel Oil	500	833
Chemical Industry	Gas Turbine with Heat Recovery	Natural Gas	7200	9741
Chemical Industry	Steam Turbine	Steam	2350	N/A
Non Metallic Mineral Products	Gas Turbine with Heat Recovery	Natural Gas	1100	3680
Non Metallic Mineral Products	Gas Turbine with Heat Recovery	Natural Gas	1060	2520
Non Metallic Mineral Products	Steam Backpressure Turbine + Internal Combustion Engine	Biomass, LPG	5000	(14500)
Food Beverage and Tobacco	Gas Turbine with Heat Recovery	Natural Gas	3700	11260
Food Beverage and Tobacco	Gas Turbine with Heat Recovery	Natural Gas	1800	3960
Food Beverage and Tobacco	Gas Turbine with Heat Recovery	Natural Gas	1000	1424
Food Beverage and Tobacco	Gas Turbine with Heat Recovery	Natural Gas	1000	1353
Food Beverage and Tobacco	Gas Turbine with Heat Recovery	Natural Gas	1500	2364
Food Beverage and Tobacco	Internal Combustion Engine	LPG	450	415

Economic Activity	Technology	Fuel	Electrical Capacity (KWe)	Thermal Capacity (KWth)
Food Beverage and Tobacco	Internal Combustion Engine	LPG	30	43
Food Beverage and Tobacco	Internal Combustion Engine	LPG	50	79
Food Beverage and Tobacco	Internal Combustion Engine	Natural Gas	700	2380
Food Beverage and Tobacco	Internal Combustion Engine	Natural Gas	2050	2420
Food Beverage and Tobacco	Microturbines	LPG	30	50
Food Beverage and Tobacco	Microturbines	Natural Gas	50	87
Food Beverage and Tobacco	Steam Backpressure Turbine	Heavy Fuel Oil	10000	51400
Food Beverage and Tobacco	Steam Backpressure Turbine	Natural Gas	16000	51400
Food Beverage and Tobacco	Steam Backpressure Turbine	Natural Gas	5000	24000
Food Beverage and Tobacco	Steam Backpressure Turbine	Natural Gas	7000	37000
Food Beverage and Tobacco	Steam Backpressure Turbine	Natural Gas	12000	53300
Food Beverage and Tobacco	Steam Backpressure Turbine	Natural Gas	6000	25700
Food Beverage and Tobacco	Steam Condensing Extraction Turbine	Biomass	1000	2810
Food Beverage and Tobacco	Steam Condensing Extraction Turbine	Biomass	4000	8800
Food Beverage and Tobacco	Steam Condensing Extraction Turbine	Heavy Fuel Oil	500	1100
Food Beverage and Tobacco	Steam Condensing Extraction Turbine	Heavy Fuel Oil	500	929
Food Beverage and Tobacco	Steam Condensing Extraction Turbine	Biomass	500	643
Textile, Leather and Clothing	Internal Combustion Engine	Natural Gas	2100	3600
Textile, Leather and Clothing	Internal Combustion Engine	Natural Gas	1200	1400
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Biomass	1150	2530
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Biomass	500	981
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Biomass	1000	1963
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Biomass	600	1178

Economic Activity	***Technology***	***Fuel***	***Electrical Capacity (KWe)***	***Thermal Capacity (KWth)***
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Biomass	600	855
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Biomass	400	880
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Natural Gas	2500	5833
Textile, Leather and Clothing	Steam Condensing Extraction Turbine	Natural Gas	3000	7000
Paper and Printing	Combined Cycle Gas Turbine with Heat Recovery	Natural Gas	9900	12000
Paper and Printing	Microturbines	Natural Gas	100	173
Paper and Printing	Steam Condensing Extraction Turbine	Biomass	1200	2640
Paper and Printing	Steam Condensing Extraction Turbine	Heavy Fuel Oil	500	929
Paper and Printing	Steam Condensing Extraction Turbine	Natural Gas	6000	14500
Engineering and Other Metal Industry	Combined Cycle Gas Turbine with Heat Recovery	Natural Gas	11500	(25000)
Engineering and Other Metal Industry	Internal Combustion Engine	Propane	130	240
Engineering and Other Metal Industry	Internal Combustion Engine	Natural Gas	230	340
Other Industry	Internal Combustion Engine	Natural Gas, Biomass	9500	45000
Other Industry	Organic Rankine Cycle	Biomass	750	4900
Other Industry	Steam Condensing Extraction Turbine	Biomass	1000	2636
Health and Social Work	Internal Combustion Engine	Natural Gas	750	890
Health and Social Work	Internal Combustion Engine	Natural Gas	490	620
Health and Social Work	Internal Combustion Engine	Natural Gas	540	780
Health and Social Work	Internal Combustion Engine	Natural Gas	1200	1610
Health and Social Work	Internal Combustion Engine	Natural Gas	1200	1560
Health and Social Work	Internal Combustion Engine	Natural Gas	1300	1640

Economic Activity	***Technology***	***Fuel***	***Electrical Capacity (KWe)***	***Thermal Capacity (KWth)***
Health and Social Work	Internal Combustion Engine	Natural Gas	1400	1860
Health and Social Work	Internal Combustion Engine	Natural Gas	1500	3280
Health and Social Work	Internal Combustion Engine	Natural Gas	1650	2030
Health and Social Work	Internal Combustion Engine	Natural Gas	300	411
Hotels	Internal Combustion Engine	Light Fuel Oil	50	50
Hotels	Internal Combustion Engine	Light Fuel Oil	30	30
Hotels	Internal Combustion Engine	Light Fuel Oil	50	50
Hotels	Internal Combustion Engine	Light Fuel Oil	20	20
Hotels	Internal Combustion Engine	Natural Gas	70	110
Hotels	Internal Combustion Engine	Natural Gas	410	610
Hotels	Internal Combustion Engine	Natural Gas	800	1143
Hotels	Internal Combustion Engine	Natural Gas	50	75
Hotels	Internal Combustion Engine	Natural Gas	70	90
Hotels	Internal Combustion Engine	Natural Gas	80	93
Hotels	Internal Combustion Engine	Natural Gas	50	58
Hotels	Internal Combustion Engine	Natural Gas	70	90
Education	Gas Turbine with Heat Recovery	Natural Gas	1490	1450
Education	Internal Combustion Engine	Natural Gas	2720	3090
Education	Internal Combustion Engine	Natural Gas	400	400
Sewage and refuse disposal, sanitation and similar activities	Gas Turbine with Heat Recovery	Biogas	193	275
Sewage and refuse disposal, sanitation and similar activities	Internal Combustion Engine	Biogas	5600	9600
Sewage and refuse disposal, sanitation and similar activities	Internal Combustion Engine	Biogas	14000	17300
Sewage and refuse disposal, sanitation and similar activities	Internal Combustion Engine	Biogas	350	498
Sewage and refuse disposal, sanitation and similar activities	Internal Combustion Engine	Biogas	200	285
Sewage and refuse disposal, sanitation and similar activities	Internal Combustion Engine	Biogas	200	285
Sewage and refuse disposal, sanitation and similar activities	Internal Combustion Engine	Biogas	250	356
Sewage and refuse disposal, sanitation and	Internal Combustion Engine	Biogas	9690	4900

Economic Activity	***Technology***	***Fuel***	***Electrical Capacity (KWe)***	***Thermal Capacity (KWth)***
similar activities				
Greenhouses	Internal Combustion Engine	Natural Gas	4970	6100
Greenhouses	Internal Combustion Engine	Natural Gas	4800	4900
Greenhouses	Internal Combustion Engine	Natural Gas	16500	70000
Greenhouses	Internal Combustion Engine	Natural Gas, Light Fuel Oil	18000	93000

3.11 USE OF THE MARKAL MODEL FOR THE EVALUATION OF THE ECONOMIC POTENTIAL OF COGENERATION IN THE YEARS 2010, 2015 AND 2020

3.11.1 Using the MARKAL model for calculating CHP penetration in the years 2010, 2015 and 2020

MARKAL is a model for the simulation-optimization of the energy market. It meets the demand for useful energy in the sectors of economic activity and final uses which are defined by the user, with the aim of minimizing the total cost of the energy system for the time period under consideration. The model requires as basic input data, the demand for useful energy, categorized by sector and by final use . In the present application, the analysis corresponds to the sectors which were discussed in the previous chapters.

Along with the development of the demand for useful energy/sector of activity/final use (i.e. space heating-cooling, lighting, etc.), the model uses as input data, the technical and economic data of the energy technologies(technology roadmaps) together with the future energy prices of the different fuels. Thus, the development of the installed capacity of cogeneration is calculated within the time period of the solution (minimizing the total cost), taking into consideration the market competition. The economic viability of CHP installations is examined with investment factors (defined anticipated internal interest rate or subsidy), in order to incorporate the point of view of the private investor in the model output.

For the time period of the solution, the model includes the forecast of the IEA regarding the development of international prices for petroleum, natural gas and coal, as they were published in November of 2007. The forecast takes into consideration the average and high fuel price scenario as shown in the following and in the graph of Figure 3.11.1.1.

3.11.2 Energy Demand Assumptions

The MARKAL model is useful energy demand driven, with the forecast given exogenously. For the future development of energy demand, hypotheses are made for the development of factors which influence demand for useful energy. The main factors are population development, the GDP and the value added for each sector of economic activity. The industrial sector is anticipated to show a small increase in energy demand in the next decade, based on the fact that the indicators do not forecast a significant increase in industrial activity. Thus, industrial sectors with a low energy intensity are expected to show an increase of around 2% a year in final energy demand between 2000 and 2015, which corresponds to a similar increase in added value in the sector. The heavy energy consuming sectors, which produce cement, bricks, steel and aluminum, are analyzed separately in the model. Thus, cement production increases by 1% a year by 2005 due to the increased demand in the domestic market and after that with an average yearly increase of 0.2% due to saturation of the domestic and international markets. Brick production is estimated to follow a similar trend with an average yearly increase of 0.2%. Ammonia production is anticipated to show an average yearly increase of 0.2%, following the trend in the petrochemical sector. Steel production is expected to stay flat during the period of the study and aluminum production will continue its yearly increase of around 0.22% between 2000 and 2015.

3.11.3 Energy Policy Assumptions

The calibration of the present model is based on the Energy and Climate Change Package energy policy constraints. The cost of the CO_2 emissions after the year 2013 is considered at 40 €/tn for electicity generation plants. The RES penetration target for Greece is 18 % of the final consumption. Non-ETS emissions reduction is -4 %. Energy efficiency targets are in conformity with Directive 2006/32/EC and an additional 20% in the primary energy is considered.

Finally, the limits on greenhouse gases emissions for the energy sector according to the Kyoto protocol influence energy policy in recent years and are taken into consideration in the model. Thus, the estimate of the National Observatory of Athens, which is included in the Ministerial Council Decision (PYS 5/27.2.2003, Govt. Gazette 58A/5.3.2003) are adopted. According to the National Observatory, the limits imposed by Kyoto on the energy sector correspond to an increase of about +35% over the 1990 emissions levels in accordance with the “scenario with additional measures”.

IEA Reference Senario (€2005/GJ)

	2005	2010	2015	2020
Crude Oil	7.71	7.95	7.71	7.93
Natural Gas	3.61	4.84	4.86	5.04
Coal	1.64	1.47	1.48	1.52

IEA High Prices Senario (€2005/GJ)

	2005	2010	2015	2020
Crude Oil	7.71	8.63	8.99	11.13
Natural Gas	3.61	5.28	5.64	7.08
Coal	1.64	1.51	1.58	1.81

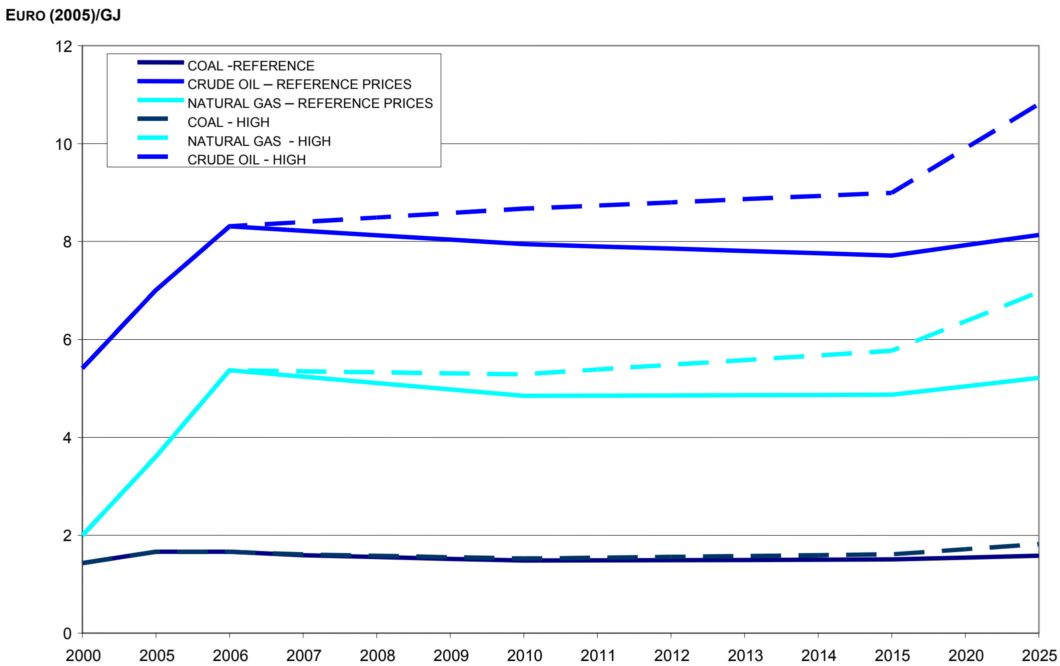


Figure 3.11.1.1 International Fuel Prices forecasting according to the IEA (November 2007)

3.11.4 Results

The results of the present exercise are compatible with the National Energy Planning Study in view of the Energy and Climate Change Package and the National Energy Efficiency Allocation Plan submitted to the EC.

3.11.5 Economic Potential for CHP in 2010, 2015, 2020

The goal of this study is to calculate the economic potential of CHP on the national economy under different assumptions. Thus in Table 3.11.5.1 (and respevtively in Figure 3.11.5.1), the development of the economic potential of CHP according to MARKAL model is presented.

In Table 3.11.5.4, the development of the share of CHP in the natural gas market is shown, while in Table 3.11.5.5, the indicative heat and power generation from CHP is presented.

For the year 2015, there is a possibility of a potential (at the level of the National Economy) for the penetration of CHP, in total, of around 1600 MW (Table 3.11.5.1). Of these, 370 MW is in the tertiary sector of which 30 MWe is in hotels, 30 MWe in hospitals, 200 MWe in big office buildings and 110 MWe in other buildings of the tertiary sector. In industry, the potential in 2015 is estimated to be around 1100 MWe.

For the year 2020, it appears that there is a possibility of significant potential for the penetration of CHP, in total, of around 1450 MW. Of these, 90 MW is in the tertiary sector of which 12 MWe is in hotels, 12 MWe in hospitals, 11MWe in office buildings and 37 MWe in other buildings of the tertiary sector. In the residential sector in 2020, about 24 MWe can be used, the effect of which will appear after 2015. Lastly, in industry, the potential in 2020 is estimated to be around 1270 MWe.

Table 3.11.5.1: Development of Installed Capacity (Economic Potential) of CHP According to the MARKAL Model

	2010	2015	2020
Tertiary Sector	22	61	90
Hotels – Grid Connected	2	5	12
Hotels – Island Systems	2	5	12
Hospitals	2	5	12
University Campuses	2	4	5
Office Buildings	10	11	11
Other Tertiary – Grid Connected	2	29	31
Other Tertiary – Island Systems	1	3	6
Residential Sector	0	0	24
Industry	608	1110	1271
Food, Beverages and Tobacco	58	175	186
Textile, Leather and Clothing	0	40	40
Pulp, Paper and Printing	0	2	2
Chemical Industry	120	171	222
Wood & Products	150	180	200
Aluminum	213	223	211
Iron & Steel	8	110	110
Non-Metallic Minerals	60	210	300
Refineries	70	70	70
Total	701	1241	1455

Table 3.11.5.2: Development of Electrical and Heat Capacity of CHP

	2010	2010	2015	2015	2020	2020
	MWe	**MWth**	**MWe**	**MWth**	**MWe**	**MWth**
Tertiary Sector	22	***39***	61	***93***	90	***133***
Hotels – Grid Connected	2	4	5	8	12	20
Hotels – Island Systems	2	3	5	6	12	15
Hospitals	2	4	5	8	12	20
University Campuses	2	4	4	6	5	8
Office Buildings	10	19	11	21	11	21
Other Tertiary – Grid Connected	2	4	29	41	31	44
Other Tertiary – Island Systems	1	1	3	3	6	6
Residential Sector	***0***	***0***	***0***	***0***	***24***	***39***
Industry	608	***1136***	1110	***1841***	1271	***2020***
Food, Beverages and Tobacco	58	123	175	288	186	289
Textile, Leather and Clothing	0	0	40	89	40	89
Pulp, Paper and Printing	0	0	2	4	2	4
Chemical Industry	120	192	171	269	222	326
Wood & Products	150	360	180	432	200	480
Aluminum	213	382	223	396	211	368
Iron & Steel	8	9	110	124	110	124
Non-Metallic Minerals	60	70	210	239	300	340
Refineries	***70***	107	***70***	107	***70***	107
Total	701	***1282***	1241	***2041***	1455	***2299***

Table 3.11.5.3: Development of the Total Consumption of Fuel, Total Power Generation, Total Thermal Energy Generation and Conservation of Primary Energy from CHP

(GWh)	CHP Fuel Consumption			Power Generation from CHP			Generation of Useful Heat from CHP			PES		
	2010	**2015**	**2020**	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**
Tertiary Sector	***346***	***939***	***1247***	***112***	***325***	***437***	***186***	***487***	***653***	***90***	***257***	***384***
Hotels– Grid Connected	42	96	114	14	32	37	22	50	65	15	34	41
Hotels – Island Systems	25	56	137	9	21	53	11	26	64	9	21	55
Hospitals	37	83	205	12	28	69	20	45	111	13	30	77
University Campuses	48	90	127	15	29	41	26	49	71	10	20	31
Office Buildings	160	174	172	49	54	54	90	99	99	33	39	41
Other Tertiary – Grid Connected	19	406	408	6	146	148	11	203	207	4	98	104
Other Tertiary – Island Systems	15	34	84	6	14	35	6	14	35	6	14	35
Residential Sector	0	0	328	0	0	107	0	0	173	0	0	67
Industry	***11276***	***19172***	***19986***	***3109***	***6012***	***6287***	***5948***	***9842***	***10300***	***2384***	***4571***	***4895***
Food, Beverages and Tobacco	1164	2778	2621	297	911	878	713	1518	1440	199	675	682
Textile, Leather and Clothing	0	503	497	0	137	137	0	306	306	0	97	103
Pulp, Paper and Printing	0	24	24	0	6	6	0	14	14	0	5	6
Chemical Industry	1800	2446	3064	542	744	955	1070	1470	1855	486	699	923
Wood & Products	3365	3992	4385	514	616	685	1233	1479	1644	41	56	69
Aluminum	3740	3954	3954	1280	1351	1351	2346	2476	2476	1305	1369	1369
Iron & Steel	137	1871	560	56	774	234	63	871	263	40	571	179
Non Metallic Minerals	1070	3602	4881	421	1473	2041	523	1707	2301	313	1099	1564
Refineries	906	1330	1315	311	491	491	549	751	751	414	624	640
Total	**12528**	**21441**	**22876**	**3532**	**6827**	**7321**	**6682**	**11080**	**11876**	**2888**	**5452**	**5985**

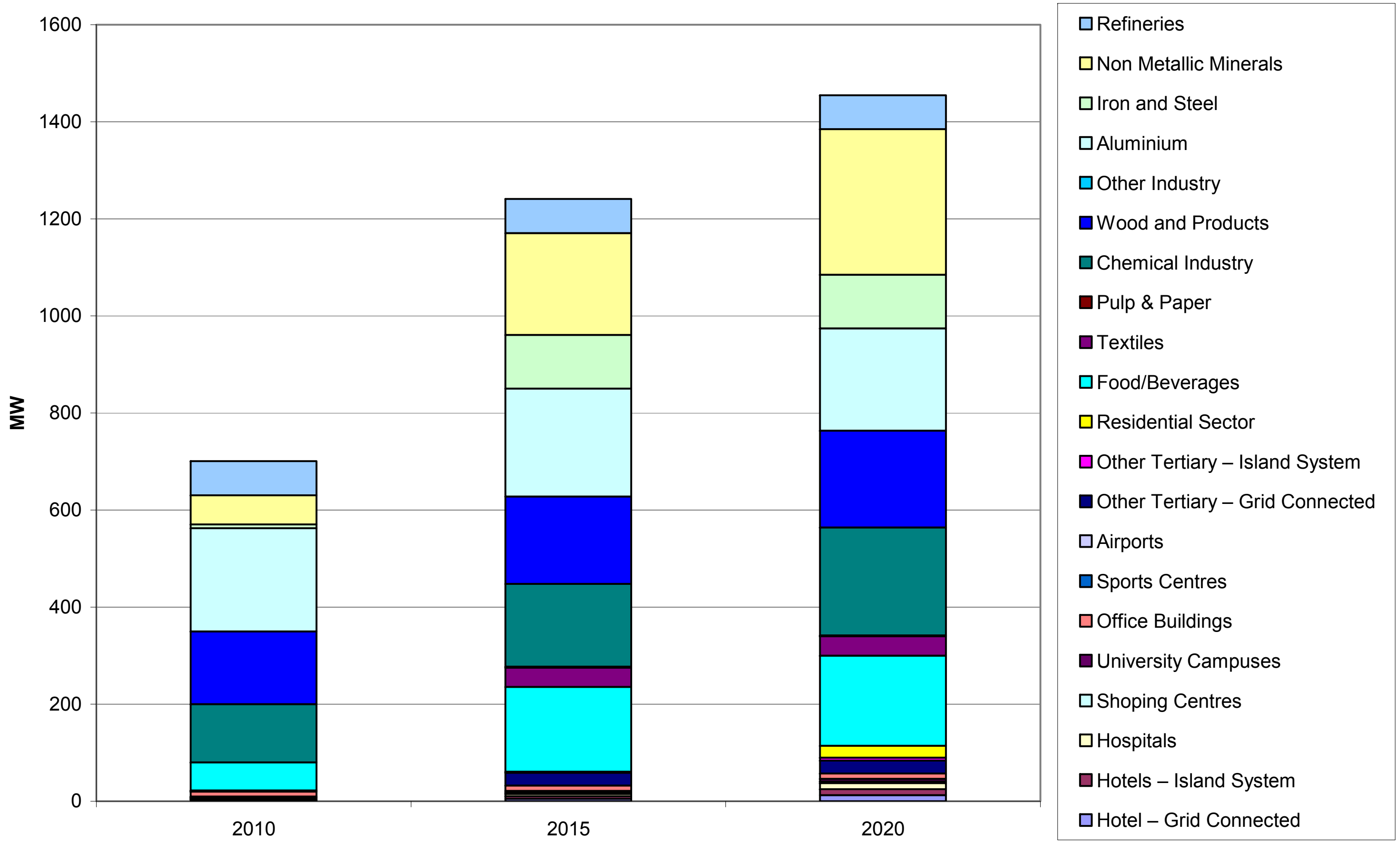


Figure 3.11.5.1 Development of CHP by Sector

Table 3.11.5.4: Development of Fuel Consumption for Cogeneration

	PJ/year		
	2010	**2015**	**2020**
Petroleum and Products (Grid-Connected)	5	13	15
Petroleum and Products (Non-Connected Islands)	2	3	4
Natural Gas	23	34	30
Biomass	12	14	16

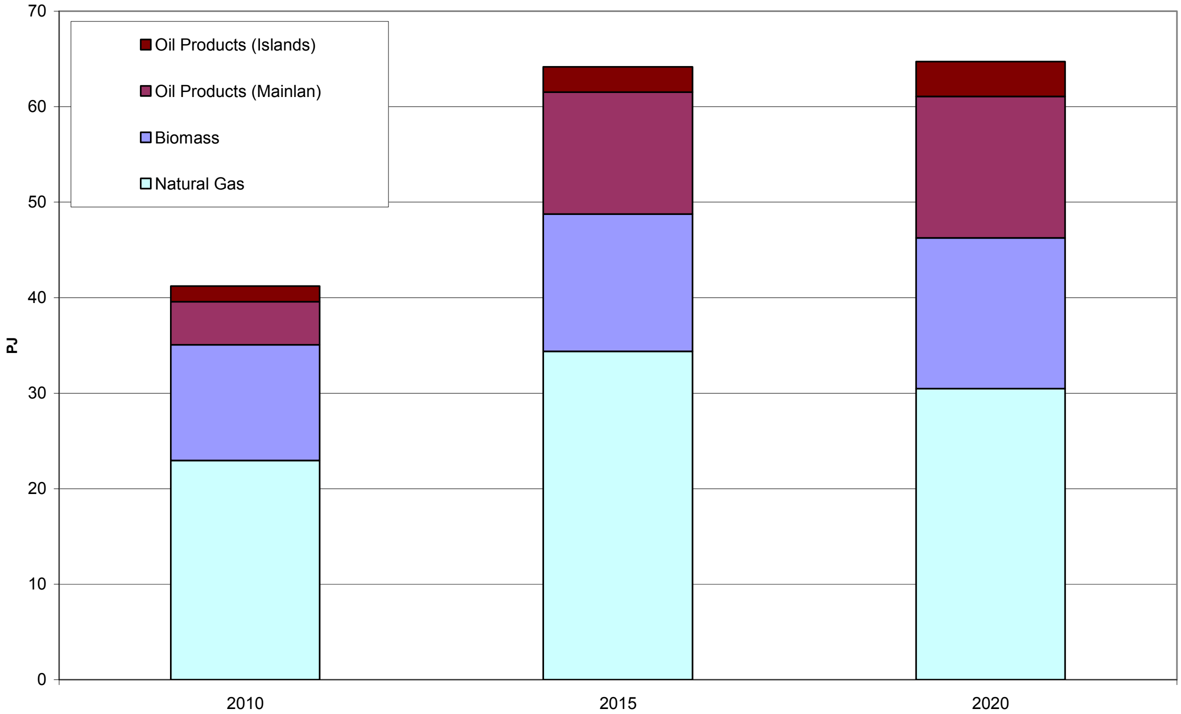


Figure 3.11.5.2 Development of Fuel Consumption for CHP

Table 3.11.5.5: Development of Power and Heat Generation from CHP

	GWh/year		
	2010	**2015**	**2020**
Electricity (Grid Connected)	3619	6860	7233
Electricity (Islands)	15	35	88
Heat (Grid Connected)	7113	11204	11776
Heat (Islands)	18	40	100

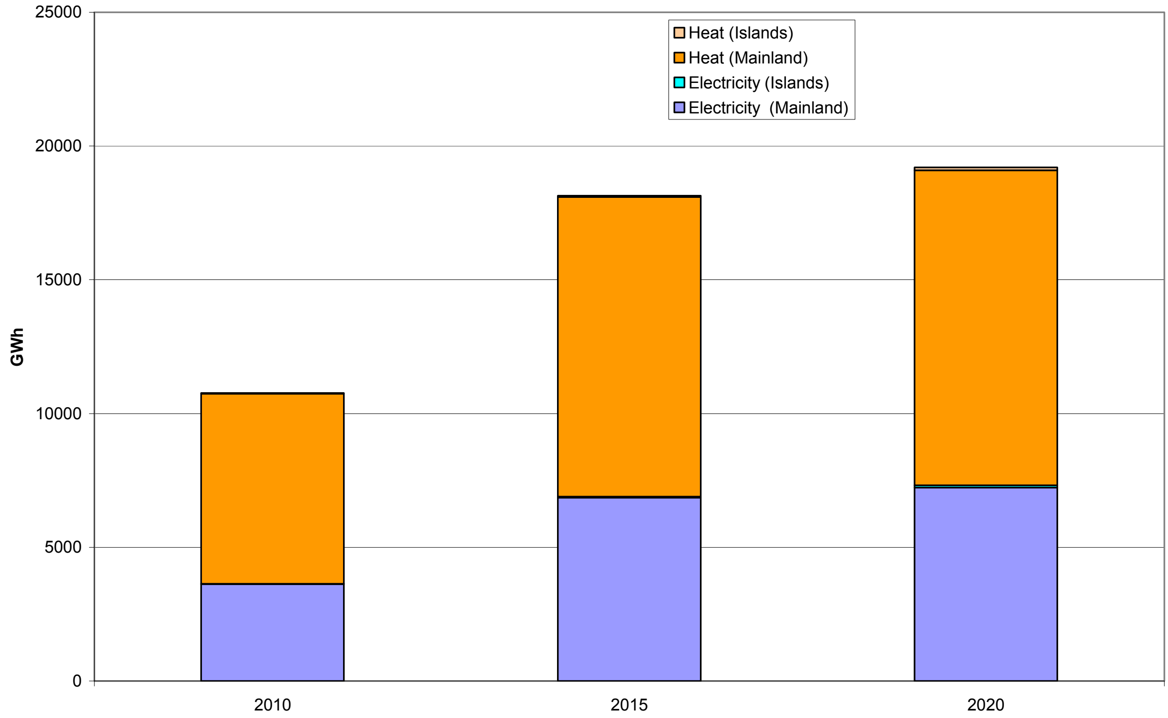


Figure 3.11.5.3 : Development of Power and Heat Generation from CHP

THE EXISTING LEGAL AND FINANCIAL SUPPORT FRAMEWORK FOR CHP

4.1 THE LEGAL FRAMEWORK FOR THE PROMOTION OF CHP IN GREECE

In 1994, Law 2244 (Govt. Gazette 68/A/7.10.1994) was the first substantial step in the development of renewable energy sources and CHP. It partially liberalized electrically generation for generating units with a capacity of up to 50 MW, which used renewable energy sources or were CHP units. Cogeneration was defined by this law as "power generation" :

a) From the combination of heating and cooling generation using conventional fuels
b) Through the energy use of non-toxic and non-environmentally harmful industrial byproducts (byproducts are understood to be products/residues of a specific industry which are released during production)
c) From the recovery of waste heat

In addition, the purpose of the law was to promote cogeneration by providing incentives and by attempting to simplify the procedures. Law 2244 regulated matters concerning the energy supply and installation and operation permits for RES and CHP power generation plants. Relatively adequate market prices were set for electricity from RES and CHP sold to the PPC and ten year contracts were provided.

Ministerial Decision 8907/96 (Govt. Gazette 449 B) provides planning contracts between organizations or consortia with the PPC for the creation and operation of cogeneration units so that the electricity generated can be sold to the PPC at agreed upon terms.

With Law 2773/99 (Govt. Gazette 286/A/20) for the liberalization of the electricity market, matters concerning CHP were regulated, in the context of Directive 96/92/EC, which was incorporated by this law into the national energy legislation framework. Law 2273/99 set special regulations for independent producers and autoproducers, some of whom use CHP. Also, it provides the right of priority in distribution to electricity generated by CHP units. In *Article 2 – Definitions* of the law, the definition of cogeneration is repeated, with the addition that "as long as cogeneration is produced exclusively using renewable energy sources, the relation of the potentials of electrical and heat capacity of the cogeneration installation and the technology applied are obliged to ensure a total yearly coefficient of efficiency in the generation plant, of at least 65% and especially in cases where combined cycle technology is used, 75%. Especially in the case of autoproducers in the tertiary sector, the minimum limit for the above defined yearly coefficient of efficiency is set at 60%". Consequently, for the first time, minimum output criteria were defined in this law for cogeneration units.

In Law 2941/2001 (Govt. Gazette 201/A/12.9.2001, the permit procedures for power generation systems using renewable energy sources were simplified, and CHP systems were included, allowing such systems to be located in forest areas, reducing the number of approvals from regional planning departments, by treating renewable energy sources systems as industrial plants and defining which prior approvals for land use were required.

Law 3175/2003 (Govt. Gazette 207/A/29.8.2003 creates the prerequisites for the use of geothermal potential as well as for the distribution of thermal energy by heating networks. In Article 14, where the procedure for the distribution of thermal energy to third parties is described, the permission procedure is defined for the operation of district heating networks and specifically, those belonging to CHP installations.

Recently, the Ministry of Development tabled a new law in Parliament for renewable energy sources and CHP which was voted into legislation on June 6, 2006. When this Law 3468/2006 (Govt. Gazette 129/A/27.6.2003) "Generation of Electricity with Renewable Energy Sources and High Efficiency CHP and other Provisions", came into effect, a new legal framework was introduced for issuing generation, installation and operating permits for electricity generation using renewable energy sources and high efficiency CHP, for the purpose of supporting the implementation of investments in renewable sources of energy and high efficiency CHP sectors. This law came into effect on the 27th of June 2006.

4.2 FINANCIAL FRAMEWORK

4.2.1 The Operational Programme for Competitiveness (OPC)

The basic financing instrument in energy policy at present, is the Operational Programme for Competitiveness, in the framework of the 3rd Framework Programme. The programme, which is the responsibility of the Ministry of Development, runs from 2000 to 2008 and concerns the entire country. The total funding for the energy sector is as follows:

Table 4.2.1 : Subsidies of the 3rd Framework Programme

Total Budget	**6,392 M €**
EU Participation	1,977 M €
Public Investment	1,240 M €
Private Sector Participation	3,175 M €

In the framework of the Operational Programme for Competitiveness, there is a provision for a capital subsidy for CHP investments through action 2.1.3 and Measure 6.5. The projects which can be subsidized through the OPC must have a minimum total budget of over € 44,000. CHP investments eligible in the OPC are those which generate electricity from:

- Solid waste
- Non-toxic industrial waste
- In combination with the generation of thermal energy for required coverage of thermal loads. If the fuel is not renewable energy sources, a 65% efficiency must be ensured on a yearly basis and for combined cycle, 75%. Especially for autoproducers in the tertiary sector, the efficiency can be 60%.

If the fuel is not renewable energy sources, the subsidy is 35%. For CHP applications with geothermal energy and biomass, the subsidy is 40%.

4.2.2 Law 3468/2006

Pricing for electricity generated from renewable energy sources and high efficiency CHP is incorporated into this law, in order to make it independent of the PPC's pricing and to secure the investments. Thus, investments in high efficiency CHP are supported by guaranteed selling prices for electricity, where independent producers can sell electricity to the HTSO at € 75,82/MWh in the grid-connected system and € 87,42/MWh in the islands' non-connected systems. Also, autoproducers can sell up to 20% of the electricity they produce to the grid.

4.2.3 Development Law 3299/2004

National Development Law 3299/04 (after the Amendment by Article 37 of Law 3522/06): This is a financial instrument-umbrella, covering all private investments in Greece, in all sectors of economic activity. It has a strong regional character, in that the level of public support depends strongly on the particular geographic region where the given private investment is planned. Regions with high unemployment rates and low incomes per capita receive the highest investment subsidies from the State.

Investments in RES installations (both electricity- and heat-producing ones) have a favoured status also under the previous Law 3299/04, similar to the one bestowed to other selected categories of investments, such as investments in high technology, environmental protection, tourism, etc.

The following categories in the energy sector are eligible for incentives:

- Power generation, in the form of hot water, steam.
- Production of solid fuels from biomass.
- Cogeneration of electricity and heat.
- Energy production from renewables, and especially wind and solar, hydroelectric, geothermal energy and biomass.
- Environmental protection and waste disposal projects.

The kinds of incentives alternatively provided are:

- Cash grant and/or leasing subsidy; **or**
- Tax allowance; **or**
- Labour cost subsidy for new employment

For the purpose of investment incentives, Greece is divided into 3 zones:

Table 4.2.3 : Investment Incentives for the Energy Sector in the context of the new Development Law

Type of incentive	Investment zone Zone A	Zone B	Zone C
Cash grant and/or leasing subsidy	20%	30%	40%
Tax allowance	60%	100%	100%
Labour cost subsidy for new employment	20%	30%	40%

The level (%) of public subsidy is increased by 10 to 20 (bonus) percentage points in the following cases:

i) Very small and small-sized enterprises (less than 50 employees, and annual turnover less than 10M€): 20% bonus

ii) medium-sized enterprises (less than 250 persons, and annual turnover less than 50M€) : 10% bonus

In order to be eligible for the funding the following conditions must also be met :

- Required own capital: 25 % (min) of the total investment cost
- Minimum investment cost required: 100,000-500,000 € (depending on the size of the enterprise)
- Installation license is required for project application (grant proposal)

Figure 4.2.3 : Investment Incentives for the Energy Sector in the context of the new Development Law

4.2.4 Third Party Financing and Energy Service Companies

The term *"Third Party Financing – TPF or financing by third parties, financing on behalf of third parties"* refers to any kind of financing for the implementation of a project which comes from third parties and not from the main investor.

Up to the present, there are no CHP investments which have been implemented using these types of financial instruments. However, they could potentially aid in the development of CHP if problems involved with these instruments are solved. Lastly, the harmonization with Directive 2006/32/EC is anticipated to contribute to the development of an energy services market supporting further CHP applications which fall into this category, such as, for example, DH/CHP applications.

FORMULATION OF A NATIONAL CHP STRATEGY

5.1 ANALYSIS OF THE BARRIERS TO THE EXPLOITATION OF THE NATIONAL CHP POTENTIAL IN GREECE

5.1.1 Technical Barriers

5.1.1.1 Procedures for the Connection of Cogenerated Electricity to the Grid

The access of cogenerated electricity to the grid is a complex problem for cogenerators. Greater flexibility is required in connection procedures, and in connection costs, in order to create a clear environment for the promotion of CHP systems, especially for small and very small CHP.

As for the connection procedure, there is a need for set and agreed upon timetables, for preparation of the connection plans by HTSO. Therefore HTSO should submit binding connection reports, within a short deadline, mainly to owners of large CHP installations, including proposals for the distribution of costs for upgrading the grid.

CHP installations which are being developed in the tertiary sector (small CHP – up to 1 MWe) and residential sector (very small CHP – up to 50 kWe) should be able to take advantage of simplified access procedures to the grid. For very small CHP installations, it is necessary that even more simplified rules for connection and costs be enacted. At present, the lack of articulated and distinct regulations for connection, especially for very small CHP systems, has created serious barriers for small and very small cogenerators. Also, the charge for the PPC meter at small and very small CHP installations is judged to be very high.

5.1.1.2 The duration of thermal and cooling loads

We assume that for the operation of a CHP system to be economically viable, a minimum of hours of operation per year are required and a sufficient thermal and/or cooling load. Therefore, if the operation of the CHP system is limited only to covering heating loads and that the system is not in operation during the summer, the investment is not viable because it operates with only small thermal loads.
It is obvious, then, that the CHP system chosen must be suitable, from a technical standpoint, for covering both thermal and cooling loads, whether this concerns either the tertiary or the residential sector.

5.1.2 Financial Barriers

5.1.2.1 Fuel Prices, Cost of Purchasing Fuels and Supply of Fuels for CHP Installations

A significant issue related to the penetration of CHP systems in Greece is the pricing of the primary fuel used in CHP systems.

In particular, the problem concerns pricing for natural gas because natural gas prices are connected to those of crude oil, resulting in increased prices for natural gas when crude oil prices rise.

The problems are reflected both in the natural gas prices from the Public Gas Corporation and concern cogenerators in the industrial sector as well as prices from the Gas Supply Companies which concern cogenerators in the tertiary and residential sectors. According to the cogenerators, the present selling prices for natural gas for CHP systems are not attractive, and in addition, they create difficulties for the viability of these investments. This is the present situation, despite the efforts made by natural gas supply companies to improve their prices, especially for natural gas used in CHP systems and air conditioning.

The Public Gas Corporation (DEPA), which recognizes the problem, is trying, to offer a more advantageous unified pricing for electricity generation/cogeneration, especially for industrial high-pressure users of cogeneration, which will take into consideration only the load factor and the amounts consumed by each end user.

Up to the end of 2006, the Gas Supply Company of Thessaloniki and consequently, the Gas Supply Company of Thessaly, were selling natural gas for CHP at a 5% discount compared to the price for thermal use, and they already anticipate a positive response from the Regulatory Authority for Energy, in order to offer customers-cogenerators a larger discount, probably around 15%.

The Gas Supply Company of Attica, in its new pricing for 2007, offers various possibilities in order to make the prices for CHP/air conditioning more attractive, such as:

- Unified pricing for B2B (business to business) and B2C (business to customers). However, in the equation for calculating the final sale price for natural gas, the average price for crude oil in the preceding six months still plays a significant role.
- Creation of a discount system for subsidizing the cost of the investment which will range from €7.5 to €5.5/MWh. The system for conversion discounts, according to the Gas Supply Company of Attica, is inversely proportional to the capacity of the equipment so that the level of the conversion discount reflects the economy of scale in the cost of the investment.

As for access of the cogenerators to the natural gas system, the situation has vastly improved in recent years, but even today, there are areas where upgrading of the networks is required for the regular operation of CHP systems.

Where prices for electricity produced from CHP are concerned, the environment has changed significantly in recent months, after Law 3468/2006 came into effect, which especially concerns high efficiency CHP. Prices for the sale of cogenerated electricity from high efficiency CHP, to the system are now considered satisfactory, as they have been made equal to those of renewable energy sources, in compliance with Article 13 of Law 3468/2006. This equalization of the prices, on the one hand, has removed a long standing barrier, and on the other, has created a new competitive environment for the development of CHP at least.

5.1.2.2. Natural Gas Sale Contracts for CHP installations

a. Public Gas Corporation : Pricing Policy and Natural Gas Sale Contract for a CHP Unit

Cogenerators are complaining that the Public Gas Corporation, in order to reduce business risks, has adopted a rather complex contract, which in the end is a barrier to the promotion of CHP.

A detailed and systematic study of the contract reveals that the text is complicated in energy issues as well as in legal terms. It typically refers to many “conventional” amounts of natural gas, which the buyer, in other words, the cogenerator, should meet under the contract.

In discussions with industrial cogenerators, it was said that that the systematic compliance with the terms and conditions set by the contract requires, on their part, hiring a mechanical engineer, whose basic duty is managing the contract. This is an additional barrier to the development of CHP, since it increases the operating costs of the CHP system.

Lastly, as it was emphasized by cogenerators, a significant barrier is the fact that the Public Gas Corporation charges for monthly capacity – independent of the operation of the CHP system – while correspondingly, it does not charge capacity to natural gas consumers who use it in furnaces or in boilers to produce thermal energy.

b. Gas Supply Company of Attica : Pricing Policy and Natural Gas Sale Contract for a CHP Unit

The Contract which a very small cogenerator (mainly in the residential sector) signs with the Gas Supply Company of Attica, is the same as that which an ordinary consumer with individual heating signs, for using natural gas in central heating. The Contract has 22 Articles which concern payment and settlement of the bill and safety of the installation, and the capacity charge is designated as “fixed rate”, and it is of unlimited duration.

The Contract which the Gas Supply Company of Attica signs with the small cogenerator (mainly in the tertiary sector) is different from the above. The contract consists of 21 Articles and 4 Annexes and resembles in many ways the contract that the Public Gas Corporation signs with “large” cogenerators (i.e. definitions, abbreviations, etc.). The Contract has a three year duration, which is considered short, while the indicated duration should be longer, in order to create normal economic and management conditions for both cogenerators and the Gas Supply Company. Due to the low penetration of CHP in the tertiary sector in Greece at present, and also due to the pricing policy proposed by the Gas Supply Company, no serious objections to the contract were raised by cogenerators. Despite this, however, the contract has its bureaucratic side, which should be eliminated for the faster promotion of CHP in the tertiary sector.

5.1.3 Administrative Barriers

5.1.3.1 Permitting Procedure for CHP Systems

Various civil service branches are involved in different phases of the permit process, such as the prefectural and local authorities, offices of different ministries with differing structures, which for such complex projects create significant delays in evaluating a CHP investment, especially in its beginning stages.

In Phase B, a worth noting delay occurs, especially concerning the approval of the environmental impact study for CHP systems by the Ministry of the Environment, Physical Planning and Public Works. It is observed that the approval of the environmental impact study is a time consuming process, which in many cases, takes up to 6 months, mainly due to the concern of officials at the Ministry of the Environment that CHP can create an increase in pollution. In reality, CHP, due to the energy conservation of primary fuel that it provides and the simultaneous generation of electrical and heating/cooling energy, contributes to reduction of air pollution, which the National Plan for Distribution of Air Pollutants for Greece, approved by the European Commission, emphasizes.

In order to assist small or very small CHP, it would be useful to facilitate the permit process for such units, so that they will be exempted from submitting a Preliminary Environmental Impact Study as long as the proposed equipment has been tested for the amount of reduction in NOx in the manufacturer's specifications and is certified by laboratory measurements of the CHP system (test bed results).

This can be done, if the Ministry of the Environment recognizes and analyzes the two basic categories of CHP systems:

1) Those which require environmental assessment and a regular monitoring process, have an installed capacity of more that 1 MWe and are installed in industrial areas or in cities, mainly in the tertiary sector.
2) Those which require environmental assessment, once for each type of technology and thereafter a follow up sampling procedure is required. This concerns standardized small and very small CHP units up to 1 MWe.

The Ministry of the Environment if it accepts and qualifies the above mentioned key-arguments can begin without any further delay the process of evaluation and rating of CHP systems by category and set scientifically sound levels for air pollutant emissions from these systems. In this way, a longstanding problem in the environmental licensing of CHP systems will be solved, since all the organizations involved in licensing, both in Athens and the Regions, which now play an important role, according to the provisions of Law 3469/02, will have clear regulations for preliminary environmental assessments of CHP and high efficiency CHP.

Until Law 3468/06 came into effect, other permits, except for preliminary environmental assessment, which are approved by the Regulatory Authority for Energy and the Ministry of Development, had a fixed approval process and did not create any particular problems for the investor. However, the recently enacted Law 3468/06 transfers responsibilities to the Regions. Up to now there has been no experience with the time required for approval of permits for the operation of CHP systems by the Regions, as Law 3468/06 requires.

5.1.3.2 Other Institutional Barriers

There is a lack of ESCOs in the Greek market which could better promote certain CHP applications. It is anticipated that the harmonization of Greece with Directive 2006/32/EC will help in this direction.

The fact that the State has not enacted Third Party Financing (TPF) has also affected the promotion of cogeneration. The enactment of TPF will partially solve the problem of the ownership of the equipment during operation, but only for autoproducers. A corresponding regulation which will include independent producers will improve the situation so that time consuming procedures will not be required for safeguarding the ownership of the equipment of the independent investor, which is located on the premises of the consumer of the thermal energy generated.

The laws currently in force, require the constant presence of two foremen, one a heating technician and the other an electrician, in thermal energy generation plants. These laws also apply at present to CHP systems because they generate thermal and electrical energy simultaneously. Thus, the cogenerator is obliged to hire foremen for each shift that the CHP system is in operation, bearing the corresponding costs (salaries, social security, etc.) The legislation in force should be revised, taking into account new technologies in industrial automation where all the signals from the CHP system can be centralized in control panels or BMS and the plant engineer can communicate with them over the Internet, particularly in an emergency. In addition, the proposed new provisions, indicatively, should require the presence of an operator for each CHP system larger than 1 MWe.

5.1.4 Lack of Endo-Enterprise Assessment of the External Cost in Energy Prices

This is an especially significant matter on the European level, which, however, is not being dealt with at present in the laws in effect in Greece and concerns the environmental and social cost of energy. The adoption of an endo-enterprise assessment of the external cost in energy prices would show the importance of CHP systems and their environmental advantages compared to the conventional means of generating electricity and heat.

5.1.5 Barriers for the Promotion of CHP from Biomass

The uncertainty in cogeneration applications from biomass is increased by the fact that most of the solid forms of biomass are not yet a marketable product (with a steady quality and price). This has resulted in the continuously increasing interest in the "international biomass market" as well as the rapid drafting of standards and specifications for biomass fuels.

The data on the potential supply of biomass are not always accurate as there may be competing uses. For cogeneration investments to be economically worthwhile, the prices of raw materials must remain stable.

The seasonal availability of many types of biomass is a barrier to the planning and sizing of units and is also a risk for regular operation over the whole life of a project.

In comparison to mined fuels, biomass has a low energy intensity and the supplies are small, scattered, unequal in quality and seasonal. All these factors bring about additional costs: management contracts, transportation and storage.

A general rule for cogeneration investments are the relatively stable yearly requirements for heat. This is a difficult requirement for many possible cogeneration units in the agroindustrial sector.

The maximum size of cogeneration units with biomass is smaller than for those with conventional fuels due to limitations on biomass as a material and there are fewer opportunities for economies of scale. Thus, more productive technologies (i.e. gasification) are preferred, which however, have high technological risks.

5.2 NATIONAL STRATEGY FOR CHP – ACTION PLAN

5.2.1 Integrated Support Programme for CHP

The analysis in the framework of the present study, current developments in legislation and financial support lead to the view that what is really needed for the support of CHP is the adoption of supplementary measures in the existing policy framework.

There is a need for the creation of a programme which, besides policy measures, should include specific quantified goals for penetration on a short term and mid to long term outlook, as well as targeted actions which will remove the barriers which prevent the penetration of CHP. Also, it should include information for the responsible government organizations as well as actions for promotion and dissemination to investors.

5.2.2 Short Term Outlook for CHP Penetration

The short term outlook for CHP concerns the economic potential for CHP from the point of view of the investor and is presented in Table 5.2.2

In brief, the short term outlook for the penetration of CHP should be concentrated in the following basic directions:

- Further development of district heating applications, especially in combination either with the existing electricity generation plants or with natural gas.
- Further penetration of CHP in industry in combination with the development of natural gas networks.
- Development of trigeneration in the tertiary sector and especially:
    - Management of heating-cooling potential with CHP in the hotel sector
    - Penetration of CHP in large hospitals
    - Management of the heating-cooling potential with CHP in large office buildings.

The supply of natural gas to consumers in the industrial and tertiary sectors is anticipated to be an important incentive for the installation of new cogeneration units.

5.2.3 Mid to Long Term Outlook for Penetration

In the mid to long term outlook, the planning must take into consideration the optimal solutions for the national economy, which are shown in Tables 5.2.3.1 and 5.2.3.2

Thus, in the mid to long term outlook, the question of the penetration of small and very small CHP systems is focused particularly on the residential sector where such systems in Greece should cover heating and cooling loads due to the climate conditions. Therefore, it is obvious that a series of problems arises, which will accompany the beginning phase of the installation of such systems in the Greek market.

In addition, the possibility of changing the form of the energy system, is provided, through more rational energy generation and better load management. The anticipated gradual improvement in the output of absorption chillers will significantly boost the penetration of trigeneration systems.

Table 5.2.2 : Economic potential of CHP investments today (2008) from the investor's point of view (DPBP<8 years)

Capital Subsidy of 20% and 35%

Short Term outlook for Penetration of CHP in Greece Economic Potential of CHP Investments at Present

Sector	Economic CHP potential with a capital subsidy of 20% (MWe)	Economic CHP potential with a capital subsidy of 35% (MWe)
INDUSTRY	***837***	***998,5***
Food, Beverages and Tobacco	320	320
Paper, Pulp and Printing	80	80
Wood & Products	13,5	13,5
Textile, Leather and Clothing	96	109
Chemicals and Petrochemicals	104	104
Iron and Steel	140	275
Construction Materials	83	97
TERTIARY SECTOR	***128***	***138***
Hotels-Grid Connected	49	58
Hotels-Non Connected	9	10
Hospitals	70	70

Table 5.2.3.1 : Mid to Long term Outlook for the Penetration of CHP in Greece from the point of View of the National Economy

	2010	2010	2015	2015	2020	2020
	MWe	**MWth**	**MWe**	**MWth**	**MWe**	**MWth**
Tertiary Sector	22	***39***	61	***93***	90	***133***
Hotels – Grid Connected	2	4	5	8	12	20
Hotels – Island Systems	2	3	5	6	12	15
Hospitals	2	4	5	8	12	20
University Campuses	2	4	4	6	5	8
Office Buildings	10	19	11	21	11	21
Other Tertiary – Grid Connected	2	4	29	41	31	44
Other Tertiary – Island Systems	1	1	3	3	6	6
Residential Sector	***0***	***0***	***0***	***0***	***24***	***39***
Industry	608	***1136***	1110	***1841***	1271	***2020***
Food, Beverages and Tobacco	58	123	175	288	186	289
Textile, Leather and Clothing	0	0	40	89	40	89
Pulp, Paper and Printing	0	0	2	4	2	4
Chemical Industry	120	192	171	269	222	326
Wood & Products	150	360	180	432	200	480
Aluminum	213	382	223	396	211	368
Iron & Steel	8	9	110	124	110	124
Non-Metallic Minerals	60	70	210	239	300	340
Refineries	***70***	107	***70***	107	***70***	107
Total	701	***1282***	1241	***2041***	1455	***2299***

Table 5.2.3.2 : Mid to Long term Outlook for the Penetration of CHP in Greece from the point of View of the National Economy

(GWh)	CHP Fuel Consumption			Power Generation from CHP			Generation of Useful Heat from CHP			PES		
	2010	**2015**	**2020**	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**
Tertiary Sector	***346***	***939***	***1247***	***112***	***325***	***437***	***186***	***487***	***653***	***90***	***257***	***384***
Hotels– Grid Connected	42	96	114	14	32	37	22	50	65	15	34	41
Hotels – Island Systems	25	56	137	9	21	53	11	26	64	9	21	55
Hospitals	37	83	205	12	28	69	20	45	111	13	30	77
University Campuses	48	90	127	15	29	41	26	49	71	10	20	31
Office Buildings	160	174	172	49	54	54	90	99	99	33	39	41
Other Tertiary – Grid Connected	19	406	408	6	146	148	11	203	207	4	98	104
Other Tertiary – Island Systems	15	34	84	6	14	35	6	14	35	6	14	35
Residential Sector	0	0	328	0	0	107	0	0	173	0	0	67
Industry	***11276***	***19172***	***19986***	***3109***	***6012***	***6287***	***5948***	***9842***	***10300***	***2384***	***4571***	***4895***
Food, Beverages and Tobacco	1164	2778	2621	297	911	878	713	1518	1440	199	675	682
Textile, Leather and Clothing	0	503	497	0	137	137	0	306	306	0	97	103
Pulp, Paper and Printing	0	24	24	0	6	6	0	14	14	0	5	6
Chemical Industry	1800	2446	3064	542	744	955	1070	1470	1855	486	699	923
Wood & Products	3365	3992	4385	514	616	685	1233	1479	1644	41	56	69
Aluminum	3740	3954	3954	1280	1351	1351	2346	2476	2476	1305	1369	1369
Iron & Steel	137	1871	560	56	774	234	63	871	263	40	571	179
Non Metallic Minerals	1070	3602	4881	421	1473	2041	523	1707	2301	313	1099	1564
Refineries	906	1330	1315	311	491	491	549	751	751	414	624	640
Total	**12528**	**21441**	**22876**	**3532**	**6827**	**7321**	**6682**	**11080**	**11876**	**2888**	**5452**	**5985**

5.2.4 Proposed Support Measures for CHP

The analyses in chapters 2,3,4 and 5.1 led to the definition of policy measures which would support CHP in Greece and the implementation of specific quantitative goals which would be policy goals for CHP.

Industry:

- Create a competitive pricing policy for cogeneration in the industrial and handicraft sectors. The existing pricing of natural gas for CHP and the way in which it is calculated create problems. Also, it is suggested that the Public Gas Company's contract be simplified where at present, specialized personnel are required at the cogenerator just to cover the contract obligations.
- Investigate the possibility of increasing the subsidy of the operation(feed-in tariffs) of industrial CHP systems rather than subsidizing the capital.
- It is proposed that CHP equipment which is subsidized be certified for the following:
    - that it is current technology
    - that it has an emissions certificate based on test bed results
    - that it has a certificate of good operation
- Establish a better procedure for connection of the cogenerator to the grid, with clear regulations on the part of the HTSO and the PPC.
- Abolish legislation enacted based on old technology
- Training for the technical staff of the prefectures, regions, etc. on CHP. A regular, continuous training programme is also proposed for technicians in CHP.

Tertiary Sector:

- Create a competitive pricing policy for cogeneration in the tertiary sector. The existing natural gas pricing for CHP from the Gas Supply Companies could be improved, as well as the way the price is calculated. The Gas Supply Companies are aware of this and are trying to make reductions in the natural gas price. In this direction, it would be beneficial for the Public Gas Corporation to give the Gas Supply Companies a special discount for gas consumed by CHP.
- It is proposed that tax deductions should be given to investors in CHP systems up to 1 MW as well as giving them a lower VAT classification.
- Establish a better procedure for connection of the cogenerator to the grid, with clear regulations on the part of the HTSO and the PPC.
- Investigate the possibility of increasing the subsidy of the operation(feed-in tariffs) of small CHP systems for a five year period, instead of the capital subsidy.

Residential Sector:

District Heating Applications

- Create a policy for exploiting the significant potential for district heating/cooling applications which exists. Promotion of ESCOs and TPF in compliance with Directive 2006/32/EC for energy services will hasten the utilization of this potential.

Very Small CHP:

- The exemption of very small cogenerators from VAT is proposed due to the considerable difficulties they face in the Greek market.
- The PPC should avoid unreasonable charges for the meter and the connection costs which discourage autoproducers from selling to the grid.
- Simple rules should be laid down for the very small cogenerator on connection to the grid with clear rules on the part of the PPC. Basically, the rules set out in prEN50438, "Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks", should be followed.

5.2.5 Information and Coordination of the Responsible Organizations

The organizations responsible for the penetration of cogeneration and the development of related activity are mainly the Ministry of Development, the PPC, the Public Gas Corporation, RAE and HTSO, as well as the private sector of the economy in the form of prospective consumers and the companies which support the construction, installation, sale and maintenance of the mechanical equipment for cogeneration.

The Ministry of Development, as the national body for energy strategy and policy, is interested in reducing the dependence on imported fuels, increasing energy efficiency and meeting the environmental goals associated with the use of energy, especially in the framework of recent European legislation. Cogeneration covers these goals to a great extent and promoting it on a national level is justifiable. In addition, the transition from oil to natural gas which is a consequence of cogeneration in most cases is greatly desired for reducing dependence on petroleum.

The Public Gas Corporation, as the body responsible for transporting and, in part, distribution of gas, is the most interested in increasing the market share for gas, and consequently has a favourable view of the wider use of CHP, a technology which is based on the use of natural gas. This interest on the part of the Public Gas Corporation could be expressed even by active participation in investment schemes for cogeneration with the goal of supplying industrial zones or groups of consumers.

Lastly, RAE and HTSO are interested in supporting cogeneration given that it is the suitable technology for “distributed generation” which can solve problems of load management.

Besides the main responsible organizations, there are others, which if they are logically included in a National Action Plan, could contribute to its success. These are the entire banking system, leasing companies, local authorities and the Ministry of the Environment.

To ensure the implementation of a robust policy for CHP, the Ministry of Development, as the leading authority for energy, will take the initiative to inform all the bodies involved on the problems of CHP which are related to their responsibilities and coordinate them for the implementation of a programme to support CHP policy. This will be done by organizing a series of meetings of the responsible bodies with the investors, so that the problems are understood by all sides and a common effort at solving them will be organized.

5.2.6 Promotion and Dissemination to Prospective Investors

Actions for promotion and dissemination are as a rule a cornerstone of every coordinated intervention in the energy field. Increasing interest in CHP should be based to a great extent on intensive and specialized information for prospective investors, so that they will be persuaded of the technical advantage and the economic viability of related investment plans, and also to inform them of the broader parameters which are related to developments in the institutional and legal fields, existing financing opportunities, etc.

It is considered that a cohesive dissemination programme of approach be developed for different categories of prospective investors, with a basic unified body for all the categories and with specialization where needed. The goals for this programme are:

1. Informative, in the sense that it should provide prospective investors with integrated information on technical, technological, economic, financial, procedural, institutional and legal questions.
2. Supportive, in the sense that it provides for making available the necessary specialized personnel for practical support of interested investors and in particular, for small and medium sized enterprises in the secondary and tertiary sectors, throughout the development phase of their investment.
3. Communicative, in the sense that it should use the suitable communication tools in order to refute the present generalized unfavourable opinion in circles of possibly interested parties.

It is considered that the framework for the planning and implementation of the programme for approaching prospective investors in cogeneration be immediately incorporated into the coming 4th CSFP. The whole programme will take on the character of a nationwide coordinated effort, which will ensure a positive response to the basic goals and outlook for implementation. The cooperation, both in the planning phase and mainly in the implementation phase of the programme with the representatives of business community activity (the Association of Greek Industries, large industrial and handicraft chambers, etc. is necessary and vital for the final success and the uptake of the Greek CHP sector.

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