Mediterranean and National Strategies for Sustainable Development
Priority Field of Action 2: Energy and Climate Change

Energy Efficiency and Renewable Energy
Cyprus - National study

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Plan Bleu

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MEDITERRANEAN ACTION PLAN –MCSD

ENERGY EFFICIENCY AND RENEWABLE ENERGY IN CYPRUS

FINAL REPORT

Nicosia, Cyprus,

January 2007

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1. Introduction

This report has been prepared by Dr. Costas Papastavros, with the assistance of Theodoulos Mesimeris and Nicoletta Kythreotou, Environment Officers in Environment Service of the Ministry of Agriculture, Natural Resources and Environment. The Expert Service Provider Contract was signed between "Plan Bleu" and "The Consultant" (Dr Costas Papastavros).

The data presented in this report primarily concern the areas under the effective control of the Government of the Republic of Cyprus.

The main components of the report are:

PART I – The country's energy situation: indicators and basic data

- Share of the Energy Sector and Institutional Specifications
- Energy Supply, Demand and production: evolution and structure
- Impacts and risks of the observed and forecast evolutions
- Financing and investment needs

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- RUE and RE Policies
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2. PART I: The country's energy situation: indicators and basic data

2.1. Share of the Energy Sector and Institutional Specificities

2.1.1. The Sector's economic weight

The most recent data show that during 2005 there was an increase in the rate of economic growth in this sector[1], estimated at 5.3%, compared to 3.5% in 2004. Generation, transmission and distribution of electric energy is by far the most important industry of the sector and in 2005 contributed 80.0% to the sectoral value added. Sales of electricity rose by 5.4% and reached 3,930.7 million kWh in 2005 from 3,729.3 million kWh in 2004. The highest increases were recorded in the construction and health and social work. In the manufacturing sector, the largest increases in the usage of electricity were recorded in chemical and chemical products and metal products industries. Decreases were observed in the clothing and refined petroleum products industries. Consumption of electricity by households rose by 8.9%, for water pumping purposes by 2.9% and for public lighting by 13.9%.

Expenditure on fixed assets in the sector dropped to C£62.1 million from C£95.6 million in 2004. Construction works for the extension and reinforcement of the electricity transmission system and the water supply network accounted for 66.5% of total investment. Machinery and equipment accounted for 32.3% and transport equipment for the remaining 1.2%.

Employment in the sector increased from 1.6 thousand persons in 2004 to 1.7 thousand in 2005, which represents less than 0.5% of the total gainfully employed population for the production of the Gross Domestic Product.

[1] In Cyprus, *the sector* also includes gas and water in addition to electricity

2.1.2. National energy resources and potential saving

The energy system of Cyprus depends almost entirely on the imported fuels; 97% of Cyprus' primary energy supply needs originate from imported crude oil and final oil products. The transport sector consumes almost all the Gasoline and Kerosene imported, and 50% of diesel. Diesel is also used by all demand sectors. LPG is used in the domestic and services sectors, whereas coal and fuel oil are used only by industry. The principal fuel for electricity generation is heavy fuel oil. Concerning coal, there are no mining activities in Cyprus, but some small quantities are imported for cement production; no import restrictions are applied. In general, solid fuels are not important for Cyprus. No gas is used for energy production in Cyprus, but studies have been carried out for the examination of import scenarios for the harmonisation with the requirements of the European Union.

In terms of Renewable Energy Sources (RES), 4% of the country's energy originates from solar energy, and is mainly used for the heating of water. 1% of the energy supply comes from solids, and is used for industry. 50% of the energy supply is used for transportation, whereas industrial, residential and tertiary sectors use 27%, 15% and 8% respectively. Oil products, mainly used for transportation, contribute the most to the net domestic consumption per fuel (80%), with electricity, solar and coal providing 16%, 2% and 1% respectively. The net domestic consumption per fuel, gives a total of 1.66 Mtoe (according to 2000 data). With respect to the solar energy use, the EU Study "Sun in Action" ranks Cyprus first with approximately 1m^2 of installed solar collector per capita. Today, about 690,000 m^2 of solar collectors are installed in Cyprus. Approximately 90% of privately owned houses, 80% of apartments and 50% of hotels are equipped with solar water heating systems.

2.1.3. Institutional specificities and energy policies

The main institutional specificities regarding energy administrative organization, production and distribution, market structure the decision making process for energy process and users associations are the following:

Electricity Authority of Cyprus (EAC)

Even though the market has been liberalized, at the moment, the only energy provider in Cyprus is the Electricity Authority of Cyprus, with the exceptions of some industrial units that are directly consuming fuel for the production electrical energy.

The Electricity Authority of Cyprus is an independent, semi government corporation established under the Electricity Development Law Cap.171 of 1952 in order to exercise and perform functions relating to the generation and supply of electric energy in Cyprus.

Transmission System Operator (TSO)

The basic provisions of the Law regarding the establishment of the Transmission System Operator are the following:

- The Transmission System Operator Unit upon the issue of license by the Cyprus Energy Regulatory Authority (CERA), will be the Transmission System Operator
- The TSO is exclusively responsible for the operation of the Transmission System and has the responsibility for the credibility, security and its optimum economic operation and management. In order to be in a position to operate objectively, the TSO compiles Transmission and Distribution Rules that regulate the technical characteristics and the basic operation procedures of the Transmission System
- In the framework of operation and management of the electricity market, the TSO compiles and applies Trading and Settlement Rules, according to which all power trading is carried out
- The TSO prepares studies defining the charges for the connection and use of the Transmission System by the users. The users of the Transmission System are also obliged to sign protocols or enter into agreements with the TSO
- The TSO is responsible for the preparation of Demand Forecasts, Total Consumption Forecasts and Forecasts on the future behaviour of the Transmission System
- The TSO is responsible for securing the development and maintenance of the Transmission System, according to forecasts about its behaviour for the coming decade. For this reason it studies and prepares the Ten Year Development Plan of the Transmission System.

Cyprus Energy Regulatory Authority (CERA)

CERA in an independent authority of the Government of Cyprus with executive power and authorities in the field of energy. Among others, CERA has the power and authority to:

- Give, monitor, enforce, modify or recall permits
- Consult the Minister in all the issues relevant to electricity

- Ensure that the transfer, distribution, and electricity market regulations, are prepared and approved in accordance to the relevant legislation
- Ensure sufficiency in electric supply
- Control prices
- Determine quality levels

Energy Service (Ministry of Commerce, Industry and Tourism)

The Energy Service of the Ministry of Commerce, Industry and Tourism has the overall responsibility of Energy in Cyprus and specifically for:

- Monitoring and coordinating the supply and availability of sufficient energy capacity for domestic needs.
- Monitoring and participating in the formation of the European Policy for energy issues.
- Suggesting ways for the implementation of the European Acquis, assists in the preparation of Laws, Regulations, Rules etc and implements programmes for their promotion.
- Preparing and implementing programmes for energy conservation, the promotion of renewable energy sources (RES) and the developing of technologies for the utilization of RES
- Assisting the Government in the formation of the national energy policy for Cyprus in coordination with all other bodies involved

Recent evolution in energy policies

The first formulation of Renewable Energy and Energy Conservation Action Plan was completed in 1985 and revised in 1998. This included the first energy support Scheme for the sectors of manufacturing industry, hotels and agriculture. In year 2000, the Applied Energy Centre and the Cyprus Institute of Energy were established. Moreover,

- the Electricity Authority of Cyprus (EAC) agreed to purchase electricity generated from RES;
- the independent authority of Transmission System Operator (TSO) was set;
- procedures have been specified for licensing and interconnection of wind and photovoltaic installations to the national grid;
- an Action Plan (2002-2010) for RES was formulated;

- the legislative framework for the promotion of RES and conservation of energy (2003) was established;
- Cyprus Energy Regulatory Authority (CERA) (2004) was instituted;
- New support schemes have been initiated (2004); and
- New Enhanced Support Schemes for RES and RUE (2006) were created.

Support measures have been set and applied for RES (wind energy, biomass, and solar collectors) as measures of RES promotion.

2.2. Energy supply, demand and production: evolution and structure

2.2.1. Electricity access

The total of Electricity produced in the government controlled areas of the Republic of Cyprus (with the exception of those north of the confrontation line where the Cyprus Government does not exercise effective control) consists of:

1. The total electrical energy generated by the three Power Stations of EAC
2. The energy produced by Auto-producers
3. The power produced by Independent Power Producers by the use of:
    - Renewable Sources of Energy
    - Conventional Generating Units

During 2005, only Power Stations of cases 1 and 2 above operated. The total energy produced for 2005 increased to 4,376,042,038 kWh. The total energy imported in the Transmission System, excluding the losses in the Power Stations and the Transmission System, amounted to 4,102,483,700 kWh.

The overall production by the three Power Stations of the Electricity Authority of Cyprus was 4,347,942,740 kWh during 2005 against 4,176,149,000 kWh in 2004. This corresponds to an increase of 4.1% compared to the previous year, covering the total energy demand of the residential, urban, industrial and rural areas under the effective control of the Government of the Republic of Cyprus. The Gross Production of 1990 was 1,974,480 MWh, of which 1,445,452 MWh was the actual consumption.

2.2.2. Evolution and structure of energy demand and production

The evolution of the energy production and demand since 1966 (up to 2006) are presented in **Figure 2.1**, whereas the sectoral demand is presented in **Figure 2.2.**

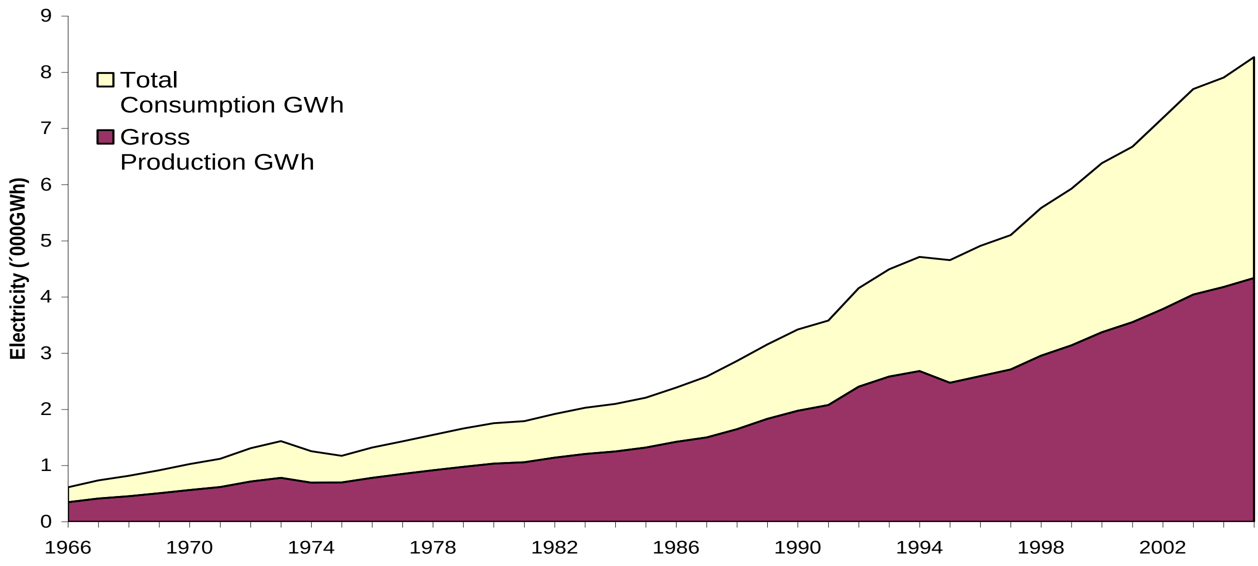

Figure 2.1. Total electricity production and consumption (1966-2005)

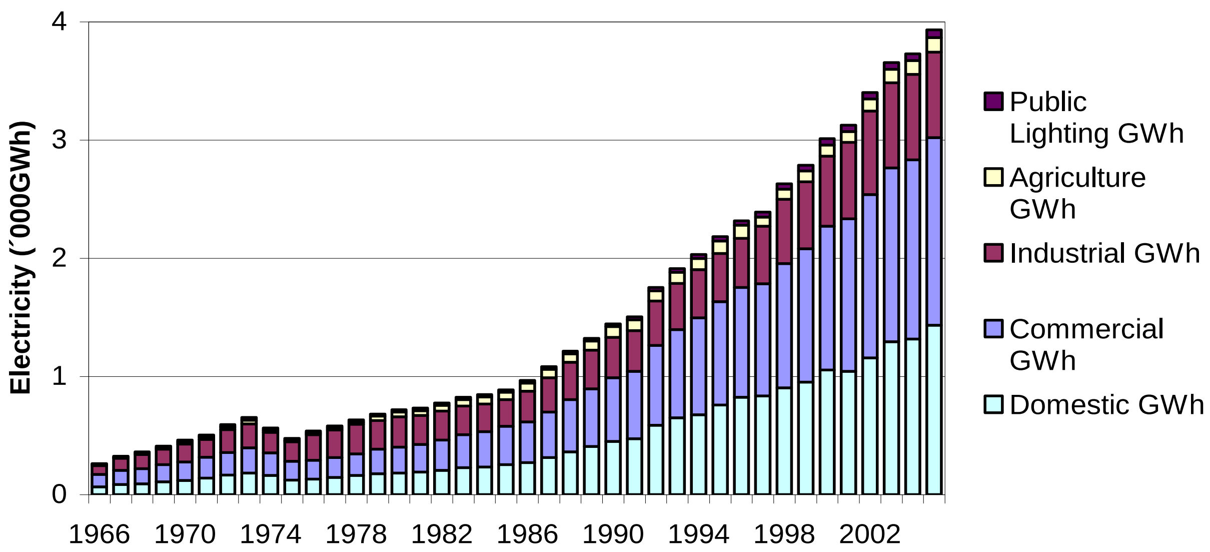

Figure 2.2. Total electricity consumption by category (1966-2005)

Structure of the energy production

1. Vasilikos Power Station

Vasilikos Power Station, with an installed capacity of 298 MW (2 x 130 MW Steam Units and 38 MW Gas Turbine Unit) generated in 2004, 1,718,062 MWh, which corresponds to 41.14% of the total electricity generated from the Authority's Power Stations. During the same period the Station exported, 1,619,717 MWh, which corresponds to 41.00% of the total electricity exported from the Authority's Power Stations.

The thermal coefficient of efficiency of the Steam Units for units generated reached 39.45% whereas the corresponding thermal coefficient of efficiency for the Gas Turbines reached 27.84%.

Moreover, the thermal coefficient of efficiency of the Steam Units, for units exported, reached 37.19% whereas the corresponding thermal coefficient of efficiency for the Gas Turbine reached 24.37%.

2. Dhekelia power station

Dhekelia Power Station, with an installed capacity of 360 MW (6 x 60 MW Steam Units), generated in 2004, 1,967,851 MWh which corresponds to 47.12% of the total electricity generated from the Authority's Power Stations. During the same period, Dhekelia Power Station exported, 1,870,535 MWh which corresponds to 47.35% of the total electricity exported from the Authority's Power Stations.

The thermal coefficient of efficiency of the Power Station for units generated reached 31.26% whereas the respective coefficient of efficiency for units exported reached 29.71%.

3. Moni power station

Moni Power Station, with an installed capacity of 330 MW (6 x 30 MW Steam Units and 4 x 37.5 MW Gas Turbine Units), generated in 2004, 490,236 MWh which corresponds to 11.74% of the total electricity generated from the EAC's Power Stations. During the same period the Station exported 460,227 MWh, which corresponds to 11.65% of the total electricity exported from the Authority's Power Stations.

The thermal coefficient of efficiency of the Steam Units for units generated reached 24.89% whereas the corresponding thermal coefficient of efficiency for the Gas Turbines reached 25.46%. Moreover, the thermal coefficient of efficiency of the Steam Units for units exported reached 23.33% whereas the corresponding thermal coefficient of efficiency for the Gas Turbines reached 24.67%.

Growth rates currently evolving and current demand and production (2015-2025)

The primary energy production per source in thousands kWh is illustrated in **Table 2.1**.

Table 2.1. Electricity production and consumption by category, 1966-2005

(000's ΩΧΒ) (000's kWh)

Έτος Year	**Ακαθάριστη Παραγωγή Gross Production**	**Συνολική Κατανάλωση Total Consumption**	Οικιακή Domestic	Εμπορική Commercial	Βιομηχανική Industrial	Γεωργική Agriculture	Οδικός Φωτισμός Public Lighting
1966	**348.896**	**262.934**	65.569	104.315	74.982	9.048	9.020
1967	**412.507**	**325.179**	84.960	118.875	102.460	7.468	11.416
1968	**453.649**	**362.581**	92.449	128.297	118.135	11.024	12.676
1969	**507.618**	**409.454**	106.991	146.236	130.647	11.067	14.513
1970	**563.603**	**460.518**	119.759	157.323	150.601	16.301	16.534
1971	**618.196**	**503.337**	140.259	174.586	152.852	18.127	17.513
1972	**715.899**	**591.333**	164.108	192.086	193.199	22.873	19.067
1973	**781.651**	**651.637**	182.901	213.347	201.558	33.123	20.708
1974	**693.215**	**563.152**	163.224	190.997	172.295	18.259	18.377
1975	**698.437**	**475.022**	121.771	159.128	166.503	11.101	16.519
1976	**782.687**	**537.267**	130.502	161.004	215.525	13.466	16.770
1977	**848.602**	**582.581**	145.610	168.378	233.124	18.131	17.338
1978	**914.546**	**632.154**	162.946	182.821	248.388	19.781	18.218
1979	**977.284**	**681.797**	175.263	209.316	241.094	37.503	18.621
1980	**1.034.365**	**718.804**	183.254	218.702	257.299	39.762	19.787
1981	**1.059.822**	**730.906**	191.664	233.855	242.738	42.060	20.589
1982	**1.140.271**	**774.697**	205.865	254.285	246.864	47.900	19.783
1983	**1.206.208**	**822.579**	228.448	278.103	243.936	52.920	19.172
1984	**1.249.897**	**845.836**	234.073	299.703	232.211	59.002	20.847
1985	**1.318.567**	**886.733**	253.552	323.570	225.449	62.332	21.830
1986	**1.422.574**	**966.039**	269.601	346.045	258.808	69.282	22.303
1987	**1.501.135**	**1.083.022**	312.353	385.367	291.003	70.678	23.621
1988	**1.646.821**	**1.214.457**	362.408	439.940	317.031	70.863	24.215
1989	**1.831.057**	**1.322.573**	407.343	486.857	328.425	76.260	23.688
1990	**1.974.480**	**1.445.452**	449.958	538.989	341.285	91.485	23.735
1991	**2.077.004**	**1.503.151**	472.143	570.563	343.415	91.112	25.918
1992	**2.404.214**	**1.752.911**	586.553	676.453	374.313	87.649	27.943
1993	**2.581.075**	**1.911.241**	650.505	744.466	391.848	93.181	31.241
1994	**2.680.991**	**2.031.809**	675.069	821.296	405.509	96.301	33.634
1995	**2.473.046**	**2.180.930**	758.963	872.421	407.555	106.581	35.410
1996	**2.591.986**	**2.315.298**	824.484	927.968	415.379	110.094	37.373
1997	**2.710.522**	**2.391.005**	834.487	948.789	487.922	75.837	43.970
1998	**2.954.010**	**2.629.024**	904.348	1.050.017	544.145	85.075	45.439
1999	**3.139.155**	**2.785.414**	951.682	1.129.163	567.042	88.709	48.818
2000	**3.370.267**	**3.011.231**	1.054.942	1.215.003	593.756	94.890	52.640
2001	**3.551.471**	**3.124.753**	1.041.826	1.290.228	647.568	92.574	52.557
2002	**3.784.895**	**3.401.137**	1.156.677	1.382.461	707.117	100.884	53.998
2003	**4.043.704**	**3.656.024**	1.294.103	1.469.264	721.190	113.050	58.417
2004	**4.176.149**	**3.729.297**	1.316.033	1.515.748	722.371	117.278	57.867
2005	**4.338.187**	**3.930.707**	1.432.830	1.585.922	725.392	120.648	65.915

The demand for electricity in Cyprus continues to rise. The Cyprus Energy Regulatory Authority (CERA) and the Transmission System Operator (TSO), which are both regulators, have provided data for historic demand and made estimates of future demand up to 2015. Their projections are based on an analysis of maximum demand on an hourly basis and at different times of the year. A strong correlation between actual electricity demand and gross domestic product (GDP) was identified for the period 1995 to 2005, despite the fact that GDP was not taken into account in the CERA/TSO analysis. This was then projected based on Ministry of Finance GDP projections to 2009, and beyond to 2015 assuming the same rate of increase in GDP.

The projected annual electricity demand over the particular period correlated very closely with CERA/TSO projections (**Figure 2.3**). For the period 2015 to 2025 it is expected to have the same rate of increase regarding the energy demand.

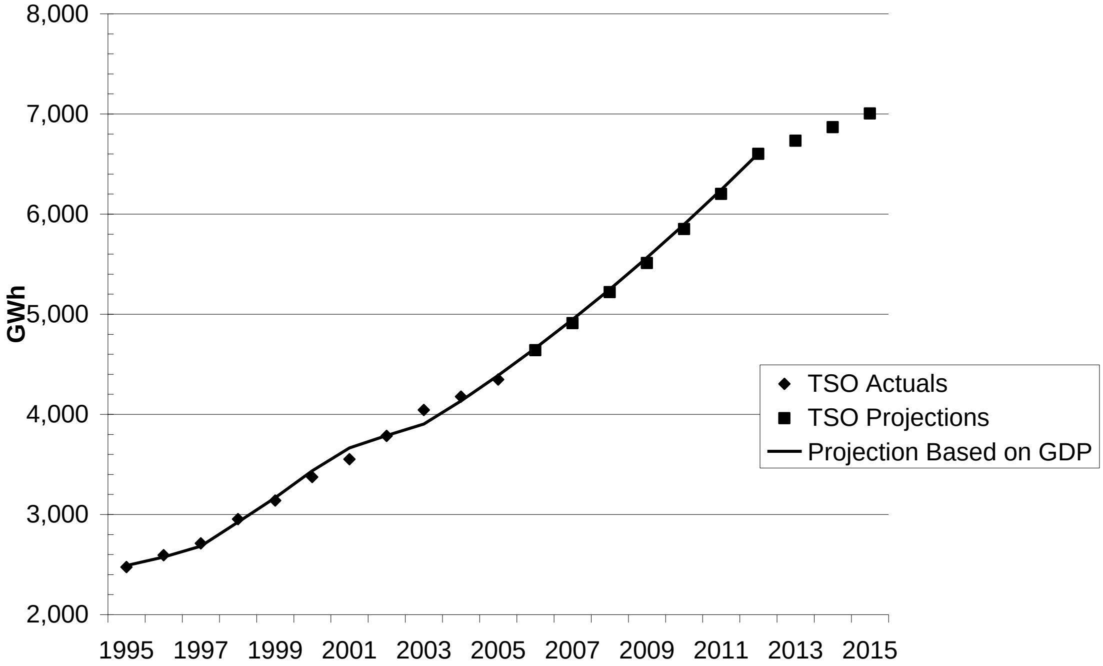

Figure 2.3. Forecast based on TSO and GDP projections of energy demand based up to 2015

This correlation is based on the equation:

$$D = 1.1191 \times G - 2{,}151.8$$

Where

D = Gross Annual Electricity Demand (GWh)

G = Gross Domestic Product (GDP) in Cyprus Pounds (CYP) at 1995 prices

The predicted gross electricity demand for each year of the period up to 2015 is summarised in **Table 2.2** below. Gross demand is expected to increase from 4,910 MWh in 2007 to 7,004 MWh in 2015, an average increase of 5.2% per annum.

Table 2.2. Projected Gross Electricity Demand

	Energy Demand (GWh)	After Impact of 6% RES (GWh)	After Impact of 5% RUE (GWh)	After Impact of 5% RUE & 6% RES (GWh)
2007	4,910.00	4,910.00	4,910.00	4,910.00
2008	5,220.00	4,910.00	4,910.00	4,910.00
2009	5,510.00	4906.8	4,959.00	4,645.80
2010	5,850.00	5179.4	5,234.50	4,903.90
2011	6,200.00	5499	5,557.50	5,206.50
2012	6,600.00	5828	5,890.00	5,518.00
2013	6,732.00	6204	6,270.00	5,874.00
2014	6,866.60	6328.08	6,395.40	5,991.48
2015	7,004.00	6454.604	6,523.27	6,111.27

The gross demand will be reduced because as a consequence of the energy saving programmes (RUE) and renewable energy sources (RES).

Notional targets for the contribution of energy efficiency measures are set for all Member States in the Energy End-Use Efficiency and Energy Services Directive (Directive 2006/32/EC of 27th April 2006). Cyprus has set the indicative targets of 5% contribution of RUE to electricity demand up to 2010. It is assumed that for the period until 2015 the same increase will be achieved.

The potential contributions of Renewable Energy Sources (RES) have already been defined by the Cyprus Energy Service. These figures are consistent with the report that Cyprus has submitted to the EC on the implementation of the Directive on the Promotion of Electricity from Renewable Energy Sources (2001/77/EC) up to 2010, indicates a target of 6% for the contribution of RES to electricity demand in 2010. It is assumed that for the period until 2015 the same increase will be achieved.

2.2.3. Impacts and risks of the observed and forecast evolutions

Energy dependence and energy bill, reduction in export capacities

Cyprus does not import or export energy.

Greenhouse gas effect

National Binding objectives relative to Kyoto Protocol

The European Union, representing the 15 pre-May 2004 Member States, is an Annex I signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and an Annex B signatory to its Kyoto Protocol. The Kyoto Protocol (KP) sets quantified targets for reducing greenhouse gas emissions for those signatories that are included in its Annex B. Cyprus ratified the UNFCCC as a *non-Annex I* party on 15th October 1997, and on the same basis, subsequently ratified the Kyoto Protocol on 16th July 1999.

It follows that Cyprus has no emissions limitation commitments under the KP. Indeed, out of 25 EU Member States, only Cyprus and Malta have no commitments. All the other 23 Member States are individually Annex I Parties to the Convention (Annex B to the Kyoto Protocol), and so have quantified emission limitation commitments. Thus, for the time being, Cyprus and Malta have exceptional status within the EU.

Although Cyprus does not have any individual reduction limitation commitments, the country fully supports the European Commission in leading all 25 Member States towards ambitious reductions in greenhouse gas emissions, together with the EU's leading role in the international action on climate change. Also, as a Member State of the European Union, Cyprus is now bound by the obligations set out in European Union legislation.

The starting point and the duration of the second commitment period have not been discussed yet, while it is obvious that there will be a new burden-sharing agreement of the EU Member-States for this period. Therefore, the formulation of policies and measures for the reduction of greenhouse gases emissions (with a time horizon that covers also the period 2010-2020) is essential for Cyprus.

Evolution of CO_2 emissions from the energy sector

The results from the calculations made for the GHG emissions by sector are presented in **Table 2.3,** and the sectoral contribution to the total GHG emissions for 1990 to 2004 in **Figure 2.4.**

Table 2.3. Total GHG emissions (in Mt CO_2 eq) by sector for the years 1990-2004

	1990	**1991**	**1992**	**1993**	**1994**	**1995**
Energy	4452.86	4452.86	5153.95	5502.00	5556.78	5541.75
Industrial Processes	570.52	570.52	566.55	547.85	530.82	514.95
Solvent and Other Product Use	2.29	2.29	2.41	2.45	2.49	2.51
Agriculture	570.62	570.62	621.62	645.22	639.48	663.50
Land-Use Change and Forestry	-18.90	-18.90	-57.52	-52.26	-68.56	-72.33
Waste	433.23	433.23	461.37	465.15	475.44	481.11
Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**6010.62**	**6010.62**	**6748.38**	**7110.41**	**7136.45**	**7131.49**

	1996	1997	1998	1999	2000	2001
Energy	5865.31	6012.27	6364.20	6498.85	6762.53	6664.58
Industrial Processes	513.48	458.04	604.61	1347.41	1392.49	1375.20
Solvent and Other Product Use	2.54	2.56	2.59	2.59	2.59	2.59
Agriculture	684.58	666.00	671.72	666.86	671.85	695.59
Land-Use Change and Forestry	-83.08	-99.95	-116.22	-116.22	-116.22	-116.22
Waste	473.97	480.48	489.30	546.52	558.58	580.80
Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**7456.80**	**7519.40**	**8016.21**	**8946.01**	**9271.82**	**9202.54**

	2002	2003	2004
Energy	7073.37	7338.07	7612.77
Industrial Processes	1386.32	1383.52	1480.16
Solvent and Other Product Use	2.59	2.59	2.59
Agriculture	718.44	721.78	671.72
Land-Use Change and Forestry	-116.22	-116.22	-116.22
Waste	590.84	615.76	630.02
Other (please specify)	0.00	0.00	0.00
TOTAL	**9655.35**	**9945.51**	**10281.05**

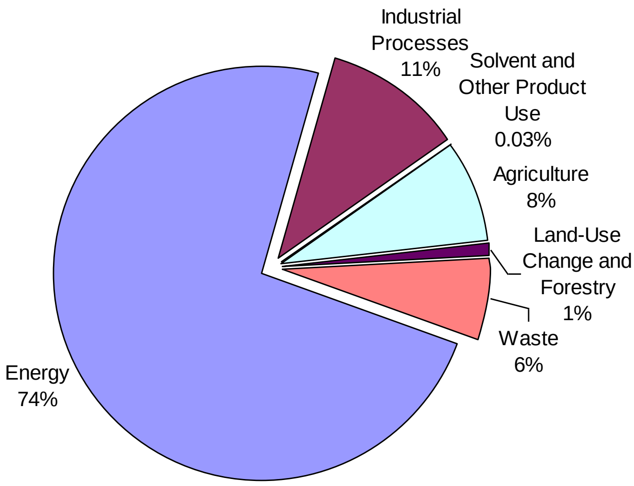

Figure 2.4. Contribution of activity sectors to total GHG emissions during 1990 and 2004

Emissions caused by the sector of Energy for 2004 accounted for 74% of total GHG emissions, corresponding to an increase of 71% in comparison to 1990 levels, and 3.4% in comparison to 2003. The sector with the greatest increase of emissions since 1990 is industry, showing an increase of 159% in comparison to 1990 and 7% in comparison to 2003. A large decrease however, has been achieved by the land use changes and forestry. Moreover, agricultural emissions even though have increased by 17.7% between 1990 and 2004, have reduced by 7% between 2003 and 2004. **Table 2.4** shows the contribution of the sectors to the total emissions produced annually.

Table 2.4. Contribution of sectors to the total emissions produced annually for 1990-2004

	Energy	Industrial Processes	Solvent and Other Product Use	Agriculture	Land-Use Change and Forestry	Waste
1990	74.1%	9.5%	0.04%	9.5%	-0.3%	7.2%
1991	74.1%	9.5%	0.04%	9.5%	-0.3%	7.2%
1992	76.4%	8.4%	0.04%	9.2%	-0.9%	6.8%
1993	77.4%	7.7%	0.03%	9.1%	-0.7%	6.5%
1994	77.9%	7.4%	0.03%	9.0%	-1.0%	6.7%
1995	77.7%	7.2%	0.04%	9.3%	-1.0%	6.7%
1996	78.7%	6.9%	0.03%	9.2%	-1.1%	6.4%
1997	80.0%	6.1%	0.03%	8.9%	-1.3%	6.4%
1998	79.4%	7.5%	0.03%	8.4%	-1.4%	6.1%
1999	70.6%	14.6%	0.03%	7.2%	-1.3%	5.9%
2000	73.5%	15.1%	0.03%	7.3%	-1.3%	6.1%
2001	72.4%	14.9%	0.03%	7.6%	-1.3%	6.3%
2002	73.3%	14.4%	0.03%	7.4%	-1.2%	6.1%
2003	73.8%	13.9%	0.03%	7.3%	-1.2%	6.2%
2004	74.0%	14.4%	0.03%	6.5%	-1.1%	6.1%

Evolution of CO_2 emissions from the energy sector

The assumptions used for the calculations and projections performed for the scenarios of "Business as Usual" are Demographic characteristics, Weather conditions and Macroeconomic rates. For the projection of emissions from the energy sector, the ENPEP (Energy and Power Evaluation Program) model was used. ENPEP was developed by the Argonne National Laboratory (ANL, USA) and comprises several distinctive models, which have as target the full analysis/simulation of the energy/electricity system, with parallel quantification of its environmental and social consequences. The emissions calculated on the basis of sector and gas. **Table 2.5** summarises the results of the sectors energy, agriculture, industry, tertiary, wastes, contributing the most to the GHG emissions.

Table 2.5. Emissions of GHG per sector in kt CO_2 equivalents, based on the BaU scenario, projected for 2010, 2015 and 2020

Sector	1990	2010	2015	2020
Energy	4452.9	10689.8	12539.7	15175.4
Industry	570.6	646.5	686.1	665.7
Solvents	2.3	3.0	3.0	3.0
Agriculture	570.6	739.0	741.1	741.1
Wastes	433.2	632.1	657.3	638.4
TOTAL	6029.6	12710.4	14627.2	17223.6
Comparison to 1990		110.8%	142.6%	185.7%

Other impacts on the environment

Emission projections provide a tool which enables the authorities to decide the most appropriate national policies and measures to be adopted and implemented to achieve emission targets. Emission projections depend on a wide range of assumptions including future economic growth, structural changes in the economy, implementation rate of cleaner technology as well as global factors including world economic trends and fuel prices which are outside the scope of national influence. Furthermore, the implementation of the relevant EU environmental legislation plays an important role in the design of each State´s policy. For the reduction of emissions to the required level, it is necessary to implement policies to reduce emissions progressively, i.e. by building on existing measures and by implementing additional measures. In the following tables the projected emissions for the four NEC pollutants are given.

Table 2.6 Projected Emissions Report for SO2, NOx and VOC

	Reference Year (2000)	Latest Historic Year (1990)	2010 Projection		
			BaU	With Measures	With Additional Measures
SO2					
1 Energy industries (Combustion in power plants & Energy Production)	33.51	22.21	36.00	24.00	-
2 Manufacturing Industries and Construction (Combustion in industry)	4.04	4.80	5.00	4.50	-
3 Road Transport	7.50	4.49	9.00	0.50	-
4 Other Transport	NE	NE	-	-	-
5 Other sectors	3.67	1.86	4.00	3.00	-
6 Fugitive emissions (from fuels)	NE	NE	-	-	-
NOx					
1 Energy industries (Combustion in power plants & Energy Production)	5.98	3.52	8.00	5.50	-
2 Manufacturing Industries and Construction (Combustion in industry)	0.44	0.40	0.50	0.50	-
3 Road Transport	9.92	6.50	11.00	7.00	-
4 Other Transport	NE	NE	-	-	-
5 Other sectors	1.30	0.58	1.50	1.50	-
6 Fugitive emissions (from fuels)	NE	NE	-	-	-
VOC					
1 Energy industries (Combustion in power plants & Energy Production)	2.49	1.49	3.00	3.00	-
2 Manufacturing Industries and Construction (Combustion in industry)	2.84	2.05	3.00	2.00	-
3 Road Transport	9.42	9.26	10.00	4.00	-
4 Other Transport	NE	NE	-	-	-
5 Other sectors	0.24	0.10	0.30	0.30	-
6 Fugitive emissions (from fuels)	0.74	0.71	1.20	0.40	-

2.2.4. Financing and investment needs

According to the existing policies a grants scheme for the promotion of the Renewable Energy Sources was established for the period 2002 – 2010. The scheme provides financial incentives in the form of government grants for the promotion of investments in the field of energy saving and energy production from renewable energy sources. Due to the recently official announcement for the commencement of the new grants scheme for the promotion of RES and Energy Conservation, a lot of foreign investors have expressed interest in RES investments. On the other hand Cypriots wish to get financial incentives provided by the government in order to invest for energy production for their own uses. The utilisation of RES seems to develop rapidly as consequence of the formulation of the Grant Scheme.

Currently, in Cyprus due to favourable climate conditions the solar energy is extensively used especially for the production of sanitary hot water. The present image of Solar Water Heating Systems is excellent in Cyprus among individual users:

- In individual house – people are satisfied with their SWHS's and would buy a new one if they had to replace their old one.
- In flats – people would like to "switch to solar".
- In hotels and apartments – SWHS is a "must" for any new hotel builder.

However, the solar industry managers seem to be more sceptical and the problems faced by the Cyprus industry, at present, are:

- Non-expanding domestic market, so it appears as necessity to promote export sales;
- To disengage from the highly saturated market of individual SWHS's in favour of collective housing systems, tourism and health facilities, and industrial hot water processes.
- New solar application should be investigated i.e. space heating and cooling.

3. PART II: Rational energy use (REU) – Renewable energies (RE): policies, tools, progress, resulting effects, case studies

3.1. RUE and RE Policies

The Action Plan is the result of the Cyprus Government commitment towards the promotion of RES and Energy Saving. It provides the creation of a special financing mechanism to promote energy conservation and to increase the share of renewable energy sources. The Action Plan sets targets for the increase of the utilization/contribution of the country´s main renewable energy sources, to the total electricity consumption and overall to the total energy balance. It includes a financing mechanism for programmes to encourage renewable energy sources and it proposes measures to eliminate administrative obstacles. The Action Plan covers the period 2002-2010.

3.1.1. Expected results

Increase the share of energy from renewable sources in the provision of total energy produced from 4% in 1995, to 9% in 2010. Increase of electricity generated from renewable energy sources, from the present zero level, to 6% by 2010.

The above stated targets are indicative and are subject to re-evaluation every two years. Additional programs for the promotion of renewable energy sources and energy conservation may be introduced in future, so as to achieve the targets set by the Action Plan.

3.1.2. Design and priorities of policy measures

The energy policy must have a long term planning period. The energy system is linked to all activities and represents one of the most important key factors for the economic development of Cyprus. The satisfaction of energy needs in a safe and reliable way forms a prerequisite for a sound evolution of productive and consumer profiles. The economic competitiveness depends to a large extent on the proper relation between the cost and quality of energy inputs. Furthermore, the quality of life depends significantly on the capital-intensive and have a long life-cycle, during which their total profit is determined. The energy sector itself constitutes a basic element of the development process and an important source of income and employment.

Concluding, the characteristics of the energy sector itself, together with its links to the energy sector itself, together with its links to the various economic activities, determine the long-term character of the energy policy adopted. Any change in the "energy doctrine" requires the formulation of a permanent policy framework and decision process, the impacts of which will gradually occur within a 10-20 years time.

Thus, an Action Plan for the promotion of RES in Cyprus presupposes that, in the long-term, the penetration of RES will not continue to represent a marginal issue, but on the contrary it will form a constitutional element of the Cyprus energy policy. Under this condition, the most important issues related to the energy policy of the country, together with issues related directly or/and indirectly with he efficient formulation and performance of a new energy doctrine that incorporates RES to the maximum possible extent are investigated.

The action plan presented below comprises 4 basic guidelines: (a) bring the state and society into action, (b) increase the reliability of RES, (c) motivate investors and investments and (d) reduce barriers for specific RES. Some of the proposed measures are presented in the following table.

Table 3.1. Proposed measures for the Cyprus RES and RUE policy

Potential barriers	Policy measures
Low public awareness	Organisation of information campaigns. Introduction of relevant courses to the educational programmes of all levels
Insufficient supply of information to investors and end-users (private agents, agricultural co-operations and local authorities) concerning the available RES potential and the possible technological resources.	Creation of a central database on the RES potential and the experience gained from investments realised. Activation of the public sector in order to set the example. Development of the "energy consultants" group.
Reluctance of local authorities and organisations to realise RES investments, due to high investment risk and/or lack of financial resources.	Promotion of new financial scheme by means of information of finance institutions. Incentives for the development of industry involved in renewable technologies. Incentives for the development of pilot projects to be used as successful examples
Lack of a concise time schedule for RES development	Formulation of a national action plan for RES
Reluctance of end-users for realising RES investments in the final demand level	Extension of the support measures to the domestic sector Promotion of investments for combined use (e.g. RES/desalination)
Difficult penetration of renewable technologies with high investment cost	Differentiation of subsidies from the investment cost to the price of the energy produced
Mistrust of public agents concerning the reliability of renewable technologies	Gradual shifting of subsidies from the investment cost to the price of the energy produced
Bureaucracy obstacles and delays in the license procedure	Simplification of the approval procedure Submission of the supporting documents only to the Ministry of Commerce, Industry and Tourism ("one-stop-shop")
Low reliability of RES	Use of certified products R&D promotion
Technical constraints in electricity generation	Optimal management of the electricity network by EAC
Distortion of relevant prices	Tax and price policy, tradable permits
Proposed list of supportive measures by technology: Wind farms	
Disregard of potential environmental impacts	Proper sitting of wind farms on the basis of noise and visual impact
Eventual "saturation" phenomena in some areas, because of wind farms' over-concentration	Determination of the "carrying capacity" per area
Insufficient supply of information to the investors concerning the RES potential in the various sites	Formulation of a guide for investors containing wind velocities, topographical, land-use and technical data for the various sites Creation of a network for wind speed measurement in various regions/

	model simulation
Uniform buy-back price, regardless of the type of load covered	Differentiation of buy-back prices
Operational problems of wind turbines due to different wind conditions in Cyprus	Specification of equipment quality standards
High dependence on imported equipment	Incentives for the development of domestic manufacturing
Reservations of EAC concerning the effects of the installed wind systems to the network behaviour	Software development in order to forecast wind velocities and consequently the energy and power contribution from wind farms
Proposed list of supportive measures by technology: Biomass	
Indifference of farmers to dispose the agricultural residues	Prohibition of the on-site burning of agricultural by-products
Uncertainty about the availability of biomass to supply the conversion plants	Long-term contracts with farmers for raw material provision
Reservations of farmers to shift towards new cultivations Potential negative environmental impacts due to the irrational use of fertilisers and pesticides in energy plantations	Support of farmers by specialised agronomists Incentives
Atmospheric pollution during combustion	Establishment of upper limits for atmospheric pollutants generated from biomass conversions
Lack of biofuels' competitiveness compared to conventional fuels	Lower taxation of biofuels. Establishment of a mandatory biofuel percentage in gasoline and diesel
Proposed list of supportive measures by technology: solar collectors	
Low level of penetration in the hotel sector	Mandatory installation of solar collectors for water heating provided by the building code in the new hotels Incentives for the hotel sector
Reluctance to install solar collectors for water heating in existing buildings because of low profitability	Tax compensation Mandatory use of solar collectors in public buildings (new and existing) Provision of grants
Potential visual impact in case of solar collectors' installation in traditional buildings	License from relevant authorities according to specified rules (more flexible legislation concerning the aesthetic impact)
Low competitiveness of PVs	Subsidies to photovoltaic use, especially in remote systems

3.2. Instruments and measures to be taken in favour of RUE and RE – Law for the promotion of RES

To enforce the provisions of Directive 2001/77/EC of the European Parliament, Cyprus ha introduced relevant legislation for the implementation and monitoring of the announced energy policy.

An new law [33(I) 2003], provides for the creation of a Special Fund whose proceeds will come from a levy of £0.0013 per KWh (approximately 0.0074 euro cent) on all electricity consumption, donations and government grants. The Fund finances programmes for the promotion of renewable energy sources and energy conservation which are approved by the Council of Ministers. It is managed by a Committee headed by the Permanent Secretary of the Ministry of Commerce, Industry and Tourism.

The Law was approved in 2003. Its implementation is monitored by the Energy Service of the Ministry of Commerce, Industry and Tourism.

The Energy Service operates its own Applied Energy Centre (AEC), which in close collaboration with the Cyprus Institute of Energy (CIE), serves as the focal point for all efforts in the field of energy conservation and renewable energy sources.

The Cyprus Institute of Energy was established in 2000 by the Minster of Commerce Industry and Tourism and its primary objectives are to promote Renewable Energy Sources utilisation and energy saving/conservation. It shares the facilities with the AEC and it has the flexibility to cooperate with the private sector. Both the AEC and the CIE play a significant role during the implementation phase of the national grant scheme for the promotion of RES.

3.2.1. Financing Arrangements

The Law provides for the financing mechanism for programs for renewable energy sources and energy conservation. The Electricity Authority of Cyprus will be purchasing all electricity generated from renewable energy sources at the price of 3.7 Cyprus cents per KWh. Provision of grants and subsidies of about £42 million CY Pounds by 2010 for the implementation of programmes for renewable energy sources and energy conservation.

3.2.2. Reducing Administrative obstacles

Cyprus government, with the cooperation of all competent authorities and bodies has established the legal framework and prepared the necessary infrastructure for the liberalization of the electricity market. As a result 35% of the electricity market has been opened to competition, as from the date of accession (1/5/2004), thus terminating the monopoly status that the previous law was providing to the Electricity Authority of Cyprus.

Following a decision by the Council of Ministers, the Cyprus government has created the Cyprus Energy Regulatory Authority(CERA) as an independent authority, with the aim of securing competition and for the protection of all consumers, responsible for the regulation of the electricity and gas market with exclusive rights to issue licenses for all activities relating to electricity and gas, to approve tariffs, to dissolve disputes, to protect consumers and to secure a reliable electricity system.

3.2.3. Facilitating Grid Connection

Following a decision by the Council of Ministers, the Cyprus government has created the Transmission System Operator (TSO) as an independent authority, to facilitate and guaranty access to the country's transmission and distribution system, with exclusive duties to operate, synchronize and control the transmission system with objective, non discriminatory criteria, to secure the proper maintenance and development of the electricity network and to arrange for the trading of electricity on a dally basis.

3.3. Grant Schemes

Grants and/or subsidies are provided for investments by companies, households and public sector bodies in energy conservation and in renewable energy systems such as wind, solar thermal, photovoltaic, small hydro, biomass and desalination.

Table 3.2. Grant Schemes

Energy Conservation	
▪ Energy conservation in existing enterprises 30%. Maximum amount of grant £50,000 ▪ Thermal Insulation of Existing households 30%, Maximum amount of grant £1,000 ▪ Co-generation - 30% Maximum amount of grant £100,000. Day Rate: 1.71cent Night Rate: 1.50 cent [Day=07:00-23:00 Night=23:00-07:00]	
Renewable Energy Sources	
Wind Energy Systems for electricity generation	▪ Large commercial Systems greater that 30KW - For the first five years 5,40c per KWh, subsidy 5,40-3,70=1,70c per KWh. - For the next 10 years the subsidy will very from 2,80c up to 5,40c per KWh, depending on equivalent hours of operation of the wind park, (average of the first five years). ▪ Small systems of up to 30 KW capacity 40% Maximum amount of grant £10,000. 3.70c/KWh No operating support is offered
Solar Thermal Systems	▪ Installation or/and replacement of central water heating systems. 30% of eligible costs. Maximum amount of grant £10,000. ▪ Installation or/and replacement of space heating and cooling. 40% of eligible costs. Maximum amount of grant £50,000 ▪ Domestic solar systems new and / or replacement 20%. Of investment, maximum amount £100 for forced circulation systems and £200 for water heating systems. ▪ Installation and / or replacement of swimming pool water heating systems. 30% of eligible investments, maximum amount of grant £10,000
Biomass	Biomass, landfill and sewage waste utilization For Small and Medium Size (SMS) enterprises the grant will be 30% in the form of regional aid plus "deminimis" aid. In any case the total amount from both forms of aid will not exceed 40% of eligible costs. 3.7 cent per KWh. The maximum amount of grant is £400,000. No operating support is offered.
Photovoltaic Systems	▪ Small photovoltaic systems of 5 KW capacity, connected to the grid. - For households and other entities and enterprises not engaged in economic activities the grant is set to 55% of eligible costs. The maximum amount of grant £9,500 - For enterprises the grant is 40% of eligible costs. The maximum amount of grant is £7,000. Subsidy 12 c/KWh – 3.70 =8.30 C/KWh ▪ Small hybrid/stand alone PV systems (not connected to the grid), of up to 5KWp capacity. - For households and other entities and enterprises not engaged in economic activities the grant is set to 55% of eligible costs. The maximum amount of grant £9,500 - For enterprises the grant is 40% of eligible costs. The maximum amount

	of grant is £7,000.
Desalination using RES	For Small and Medium Size (SMS) enterprises the grant will be 30% in the form of regional id plus "deminimis" aid. In any case the total amount from both forms of aid should not exceed 40% of eligible costs. The maximum amount of grant is £100,000
Hydroelectric systems	For Small and Medium Size (SMS) enterprise the grant will be 30% in the form of regional aid plus "deminimis" aid. In any case the total amount from both forms of aid should not exceed 40% of eligible costs. The maximum amount of grant is set to £ 30,000. Price for generated KWh is 3.70 cent. No running support is offered.

3.4. Energy Efficiency Evolution – decoupling

Oil and electricity are the major energy sources in the residential/ tertiary sector.

The potential of reducing energy demand in the building sector is assessed. In the frame of the current assessment two building uses are dealt with, (a) the residential because it is the largest sector and so any small reduction at the unit level –the residence- entails a large overall reduction at the building stock level and, (b) the tourist accommodation due to the important place it has in the economy of the island and the very large energy demand in electricity.

The report outlines the assessment of the potential of energy reduction. Three potential scenarios of demand reduction are formulated, associated with the level of energy demand reduction intensity.

The *first* one is the so called business as usual scenario which, in this report is called "baseline scenario". It estimates the reduction if no measure is applied. It is noted that a small reduction is anticipated due to the fact (a) energy equipment such as heating systems burner/boiler, light-bulbs etc. available on the market today have a better efficiency and so they can potentially save energy. Furthermore, due to the age of the building stock there will be a need for building refurbishment such as replacement of glazing etc. Similarly, double glazing will replace single glazing since the latter is gradually taken away from the market.

Taken into account this reasoning the following measures are considered for this scenario:

<u>Residential</u>

- burner/boiler system on the central heating plants and the replacement of individual oil heaters
- single glazing with double (reduction of infiltration is also taken into account)
- rood insulation

- replacement of solar collectors

<u>Tourist accommodation</u>

- burner/boiler system on the central heating plants and the replacement of individual oil heaters
- single glazing with double (reduction of infiltration is also taken into account)
- rood insulation
- efficient lighting
- replacement of solar collectors

The *second* is an intermediate scenario, which also includes legislative measures for energy efficiency. These measures are:

- TIR (Thermal Insulation Regulation). It has been proposed but not yet enforced. Its enforcement is foreseen for the end of year 2005 or early 2006.
- The new directive on energy efficiency of the commission
- The current legislation on efficiency of boilers/burners

The *third* scenario will result in a high reduction and includes both the above scenarios and specific initiatives such as financial support for the final users or for the market actors.

3.5. Renewable Energy Evolution

The following energy contribution to the country's energy balance is expected by year 2010, provided that all £42 million are offered in the form of grants and/or subsidies. Increase of the share of energy from renewable sources from 4% in 1995 to 9% of total energy consumed in 2010. Increase of electricity generated from renewable energies, from the presently zero level, to 6% by 2010.

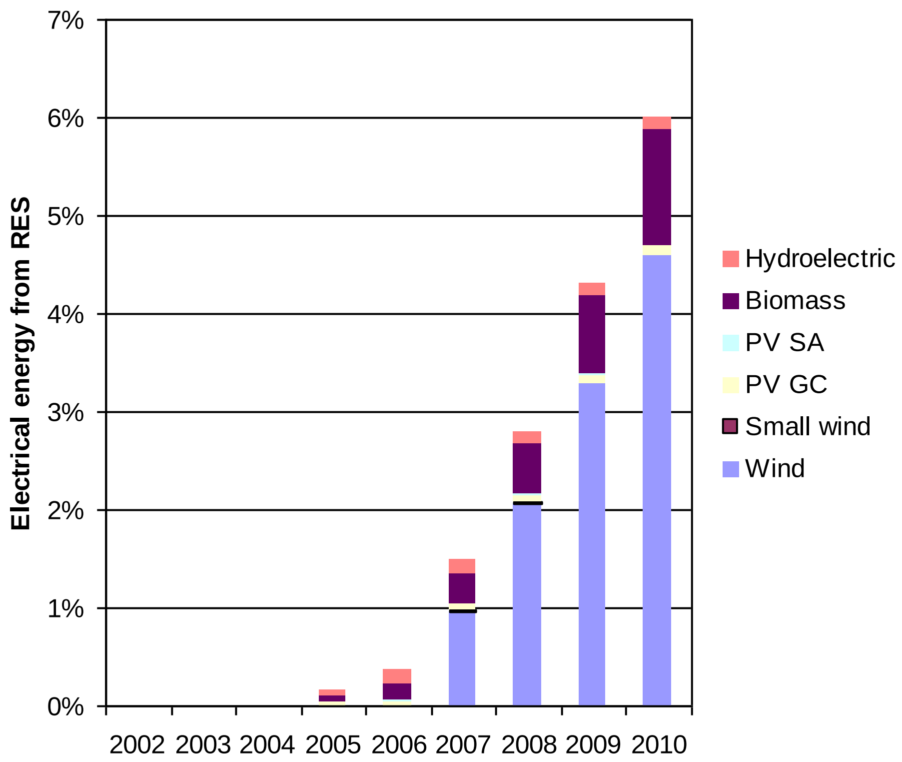

Figure 3.1. **Electrical energy generated from RES as percent of total electrical energy consumption**

Table 3.3. **Expected evolution of RES in Cyprus**

Year	Wind	Small wind	PV GC	PV SA	Biomass	Hydroelectric	TOTAL
2002	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
2003	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
2004	0.0000%	0.0000%	0.0010%	0.0000%	0.0000%	0.0000%	0.0010%
2005	0.0000%	0.0010%	0.0310%	0.0060%	0.0720%	0.0610%	0.1710%
2006	0.0000%	0.0020%	0.0470%	0.0090%	0.1720%	0.1430%	0.3730%
2007	0.9670%	0.0040%	0.0620%	0.0120%	0.3090%	0.1360%	1.4900%
2008	2.0690%	0.0050%	0.0750%	0.0140%	0.5040%	0.1290%	2.7960%
2009	3.2830%	0.0070%	0.0860%	0.0160%	0.7820%	0.1230%	4.2970%
2010	4.5880%	0.0080%	0.0880%	0.0170%	1.1790%	0.1170%	5.9970%

3.5.1. Monitoring the process and time frame

The Programme is being implemented since February 2003 and shall expire the last day of 2006. The progress is monitored by the Energy Service of the Ministry of Commerce, Industry and Tourism. The programme is a substantially improved version of a previous programme implemented in the period 1999 – 2002, covering a much wider range of sectors of economic activity and providing much more generous incentives. It is expected that a revised version of the programme will be introduced when the existing programme expires.

3.6. RES potential

The main renewable sources for production of electricity in the republic of Cyprus are presented by their exploitable potential: (1) wind, (2) Biomass, (3) Small Hydro and (4) Solar.

3.6.1. Wind Potential (On shore)

In Cyprus there are some areas with mean wind velocity of 5-6 m/s and few areas with 6,5-7m/sec. The estimated maximum exploitable potential is 150-250MW considering the following restriction.

- Sub-regions dedicated to special activities are excluded.
- Sub-regions of less than 5m/s are of no interest, at least for the current state of technology.
- Sub-regions of very high altitudes or slope.

The WIND IN Cyprus is affected by the following factors:

- From anticyclones moved from west to east, from the Siberian anticyclone during the winter and from the low pressure crated in the area of India and expanded until the area of Cyprus during the summer.
- See breezes generated in coastal areas as a result of the different heat capacities of see and land, which give rise to different rates of heating and cooling.
- Mountain valley winds created when cool mountain air warms up in the morning and begins to rise while cool air from the valley moves to replace it. During the night the flow reverses.

3.6.2. Wind Potential (Off shore)

The prospect of installing wind turbines in the Southern coast of Cyprus (near shore applications) is currently been investigated.

Initial studies showed that due to the high depth of the sea at relatively short distance from the shore, more that 30m depth at a distance of 300m from the shore, the cost of the installation of the wind turbines is expected to be very high, to the extend that the elevated wind resort which exists at those areas will not be enough to compensate with the increase in revenue so that these kinds of projects are economically fusible.

3.6.3. Solar Potential

The Meteorological service of Cyprus has classified the Island in 14 zones from a climatic point of view. However, from the considerations, affecting the use of solar energy, the classification may be broadened to 3 zones – coastal, central plains and mountains.

The collection of sunshine duration data at a number of meteorological stations started in 1959. Statistical analysis shows that all parts of Cyprus enjoy a sunny climate. The mean daily sunshine, i.e. the time interval from sunrise to sunset, for Cyprus varies from 9.8 hours in December to 14.5 hours in June.

The mean Global Solar Radiation in MJ/m^2 per day and in KWh/m^2 per day is shown in **Table 3.4**.

Table 3.4. Mean hourly global solar radiation at Athalassa (horizontal surface) for 1999 - 2002

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Total (MJ/m^2)	9.7	13.3	17.3	20.8	25.1	27.5	27.1	24.2	20.5	15.6	10.9	8.1
Total (kWh/m^2)	2.7	3.7	4.8	5.8	7	7.7	7.5	6.7	5.7	4.3	3	2.3

3.6.4. Biomass Potential

The theoretical potential is always estimated from data for the cultivated areas for each crop and the residue yield. Then the available potential can be evaluated with the assumption that only a portion of the theoretical potential is available for energy exploitation since there are other uses for most agricultural residues. Current biomass exploitation refers to a significant amount of agricultural residues in connection to the traditional wood stoves and the prospects of the development of energy crops, even though, further analysis and on site investigation may identify possible difficulties on harvesting of agricultural byproducts for bioelectricity production.

Biomass resources in Cyprus include a wide range of biomass residues,, agricultural and forest, municipal solid waste, sewage water sludge and a considerable potential of energy crops, which include traditional herbaceous corps, or short rotation woody crops. A large energy potential exists from energy crops that can be grown on deforested or otherwise degraded lands.

- Exploitation of agricultural residues. (ligrocellulocic, other vegetables, animal wastes)
- Energy crops (woods maintenance, forestry exploitation)

- Exploitation of landfill gas from the following waste disposal plants.

Table 3.5. Exploitation of landfill gas from the following waste disposal plants

	Lefkosia	Lemesos	Larnaka	TOTAL
	100,000 tn wastes/y	150,000 tn wastes/y	45,000 tn wastes/y	295,000 tn wastes/y
Capacity	1.1MWe (1.5MWth)	1.75MWe (2.5MWth)	0.45MWe (0.7MWth)	3.3 MWe (4.7MWth)
	7.5GWh/y	15.6GWh/y	2.7 GWh/y	25.8 GWh/y

3.6.5. Hydro Potential

In Cyprus the potential for small hydro plants is very limited, especially with the water shortages over the last years. The suitable sites are estimated as being adequate for a maximum of about 1MW installed capacity.

3.7. Existing or expected effects and benefits of RE and RUE

3.7.1. Rationale for the formulation of scenarios

The establishment of the scenarios was formulated on the basis of the analysis of energy demand, the available RES potential, the analysed technical, non-technical and legislative issues. Moreover, the investor's interest, the maturity and cost-effectiveness of the technologies and the public attitude have been considered.

The first scenario named "Baseline Scenario" is an attempt to estimate the RES penetration in the energy system of Cyprus as expected until 2010 without any special policies implemented. This means that very low implementation of RES and RUE is expected. This scenario is to be used as a point of reference in the evaluation procedure.

The second scenario named "implementation of existing policies scenario", as its name indicates, estimates the expected RES penetration if the existing policies are fully implemented. The approved funds have also been taken into consideration.

The third scenario named "Advanced policies scenario", investigates the possibility of increase the RES penetration by the implementation of new advanced policies, in order to achieve the established targets. It should be noted that this scenario has been formulated on the basis: "which should be the RES and RUE integration in the energy system and which additional advanced policies should be established in order to achieve the established targets?"

3.7.2. RES for electricity and heat

Wind Farms

Wind energy is to be exploited during the next years in Cyprus, since it is the most techno-economically viable source for electricity production. Although the wind potential can not be characterised as abundant, there is as interest for implementation of wind plants in the best sites.

The electricity contribution of these units is depended on the mean wind velocity of the site. Given the wind potential, the capacity factor of the wind farms varies between 26% in the most suitable sites and 18% in the worst. In **Table 3.5** the expected efficiency (capacity factor) of the wind farms is presented.

Table 3.6. Capacity factor of wind farms

Wind farms	Capacity factors	Mean wind velocity	Annual electricity production (GWh/MW installed)
First 50MW	26%	6.5	2.28
Next 100MW	23%	6	2.01
Last 100MW	18%	5.5	1.58

In the "baseline scenario" the wind farms will not exceed 50MW in 2010 and 150MW in 2020. In the "implementation of existing policies scenario" about 80 MW are expected in 2010 and 200MW in 2020. Finally in the "advanced policies scenario" the target is for 110MW in 2010 and 250MW in 2020.

Photovoltaic Cells

The use of photovoltaic solar energy in Cyprus is still in its infancy. Photovoltaics have been used by the Cyprus Telecommunication Authority (CYTA) for the telephone kiosks and transmitters. The Cyprus Radio-Telephone Authority has also used photovoltaics for transmitters. The present installed capacity of photovoltaics (remote systems) is estimated at 0.2MW.

Given that the solar potential in Cyprus the photovoltaic solar energy plants are expected to have a capacity factor 17%. In all scenarios the installed capacity of photovoltaics is limited due to the high requires installation cost.

In the "baseline scenario" the photovoltaics will not exceed 1MW in 2010 and 2.5MW in 2020. In the "implementation of existing policies scenario" about 2MW are expected in 2010 and 5MW in 2020. Finally in the "advanced policies scenario" the target is for 3MW in 2010 and 8MW in 2020.

Biomass-municipal solid waste

The most promising perspective is the exploitation of municipal solid waste for co-generation of electricity and heat.

In the "baseline scenario" the MSW plants will not exceed 3.3MW in 2010 and 4.3MW in 2020. In the "implementation of existing policies scenario" about 3.3MW are expected in 2010 and 5MW in 2020. Finally in the "advanced policies scenario" the target is for 5.5MW in 2010 and 8.5MW in 2020.

Small hydro

In Cyprus the potential for small hydro plants in strictly defined. The suitable sites are adequate for about 1MW installed capacity. Although the electricity production is strongly site dependent, an estimation of an average capacity factor 68%.

In the "baseline scenario" the small hydro plants will reach 1MW 2020. In the "implementation of existing policies scenario" the same capacity is expected in 2010 while in the "advanced policies scenario" in 2008.

Solar hot water systems

Although the degree of SHWS penetration in the domestic sector is very high (about 90% of individual houses and 80% of apartments), there are prospects for utilisation of solar thermal application in the hotel industry, the commercial-public and industrial sectors. Additionally, the utilisation of solar thermal energy for other applications (i.e. space heating and space cooling) can give further prospects after 2010.

In the "baseline scenario" the rate of new installations is about 5000m^2 per year. In the "implementation of existing policies scenario" the expected rate is about 7500m^2 per year and in the "advanced policies scenario" the target is for is about 10000m^2 per year.

3.7.3. RES in transport

Concerning RES penetration in transport, the proposed solution is to produce and mix biofuels with diesel. In the "baseline scenario" the kick-off of the production of biofuels is expected not earlier than 2010, when this process will be more mature and cost-effective.

In the "implementation of existing policies scenario" about 3200 tn biofuels will be produced in 2007, while they are needed 509000 tn in 2010 ("advanced policies scenario") in order to achieve the target of RES supply in transport sector (5.75% in 2010).

3.7.4. Details of the scenarios

Table 3.7. **Baseline Scenario: Development of RES, RES supply in electricity and RES supply in electricity**

	2002	2005	2010	2015	2020
Development of RES					
Wind (MW)	0	10	50	100	150
PV (MW)	0	0,2	1	1,6	2,5
Biomass-MSW (MWe)-(MWh)	0	0.45-0.7	3.3-4.7	4.3-6	4.3-6
Small-hydro (MW)	0	0,2	0,5	0,75	1
SHWS (1000 m^2)	655	670	695	720	745
Biofuels (1000 tn)	0	0	5	30	80
RES supply in electricity					
Wind (GWh)	0	23	114	215	315
PV (GWh)	0	0,3	1,5	2,4	3,8
Biomass (GWh)	0	3,0	21,7	28,3	28,3
Small-hydro (GWh)	0	1,2	3	4,5	6
RES electricity production (GWh)	0	27	140	250	353
Electricity generated before RUE (GWh)	3785	4340	4950	5440	5850
Electricity generated after RUE (GWh)	3785	4297	4777	5114	5353
RES supply in electricity demand	0%	1%	3%	5%	7%
RES supply in heat and transport					
Biomass heat (ktoe)	0	0.4	2.655	3.39	3.39
SHWS (ktoe)	32.6	33.3	34.54	35.78	37.03
RES heat (ktoe)	32.6	33.7	37.2	39.17	40.42
Heat demand (ktoe)	867	875	897.2	1015	1124
Heat demand with RUE measures (ktoe)	867	867	865.8	953,9	1029
RES supply in heat demand	3.8%	3.9%	4.3%	4.1%	3.9%
Transport Demand (ktoe)	620	650	717	740	760
RES in transport (ktoe)	0	0	0.405	2.43	6.48
RES supply in earth transportation	0.0%	0.0%	0.1%	0.3%	0.9%

Table 3.8. **Existing Policies Scenario implementation: Development of RES, RES supply in electricity and RES supply in electricity**

	2002	2005	2010	2015	2020
Development of RES					
Wind (MW)	0	20	80	150	200
PV (MW)	0	0,2	2	3,5	5
Biomass-MSW (MWe)-(MWh)	0	0.45-0.7	3.3-4.7	4.3-6	5-7
Small-hydro (MW)	0	0,4	1	1	1
SHWS (1000 m^2)	655	675	712,5	750	787,5

Biofuels (1000 tn)	0	18.3	60	110	160
RES supply in electricity					
Wind (GWh)	0	46	174	315	394
PV (GWh)	0	0.3	3.0	5.3	7.6
Biomass (GWh)	0	3.0	21.7	28.3	32.9
Small-hydro (GWh)	0	2,4	6	6	6
RES electricity production (GWh)	0	51	205	355	441
Electricity generated before RUE (GWh)	3785	4340	4950	5440	5850
Electricity generated after RUE (GWh)	3785	4297	4777	5114	5353
RES supply in electricity demand	0%	1%	4%	7%	8%
RES supply in heat and transport					
Biomass heat (ktoe)	0	0.4	2.655	3.39	3.954
SHWS (ktoe)	32.6	33.5	35.41	37.27	39.14
RES heat (ktoe)	32.6	33.9	38.07	40.66	43.09
Heat demand (ktoe)	867	875	897,2	1015	1124
Heat demand with RUE measures (ktoe)	867	867	865,8	953,9	1029
RES supply in heat demand	3.8%	3.9%	4.4%	4.3%	4.2%
Transport Demand (ktoe)	620	650	717	740	760
RES in transport (ktoe)	0	1.48	4.86	8.91	12.96
RES supply in earth transportation	0.0%	0.2%	0.7%	1.2%	1.7%

Table 3.9. **Advanced Policies Scenario: Development of RES, RES supply in electricity and RES supply in electricity**

	2002	2005	2010	2015	2020
Development of RES					
Wind (MW)	0	20	110	200	250
PV (MW)	0	0,5	3	5,5	8
Biomass-MSW (MWe)-(MWh)	0	0,45-0,7	5,5-7,7	7,5-10,5	8,5-12,1
Small-hydro (MW)	0	0,5	1	1	1
SHWS (1000 m^2)	655	680	730	780	830
Biofuels (1000 tn)	0	100	509	555	600
RES supply in electricity					
Wind (GWh)	0	46	235	394	473
PV (GWh)	0	0,76	4,5	8,3	12,1
Biomass (GWh)	0	3,0	36,1	49,3	55,8
Small-hydro (GWh)	0	3	6	6	6
RES electricity production (GWh)	0	52	281	458	547
Electricity generated before RUE (GWh)	3785	4340	4950	5440	5850
Electricity generated after RUE (GWh)	3785	4297	4703	5005	5236
RES supply in electricity demand	0%	1%	6%	9%	10%
RES supply in heat and transport					
Biomass heat (ktoe)	0	0.4	4.35	5.932	6.836

SHWS (ktoe)	32.6	33.8	36.28	38.77	41.25
RES heat (ktoe)	32.6	34.2	40.63	44.7	48.09
Heat demand (ktoe)	867	875	897,2	1015	1124
Heat demand with RUE measures (ktoe)	867	867	852.4	933.6	1006
RES supply in heat demand	3.8%	3.9%	4.8%	4.8%	4.8%
Transport Demand (ktoe)	620	650	717	740	760
RES in transport (ktoe)	0	8.1	41.23	44.96	48.6
RES supply in earth transportation	0.0%	1.2%	5.8%	6.1%	6.4%

3.7.5. Indicators characterising the scenarios

In the following a comparative presentation of the three scenarios was formulated in terms of:

- deviations from targets
- financial and economic (comparison of the required financial resources like investment cost, subsidies – support cost)
- environmental impact (avoided emissions of CO_2, SO_2, NO_x and PM_{10})
- social impacts (employment created)

Deviation from targets

In the following comparative chart the RES supply in primary target for 6% RES contribution to primary energy 2010 seems to be very difficult to be achieved. In the current policies scenario the rate of RES supply is about 2.5% in 2010. Even in the advanced policies scenario the rate of RES remains less than the target.

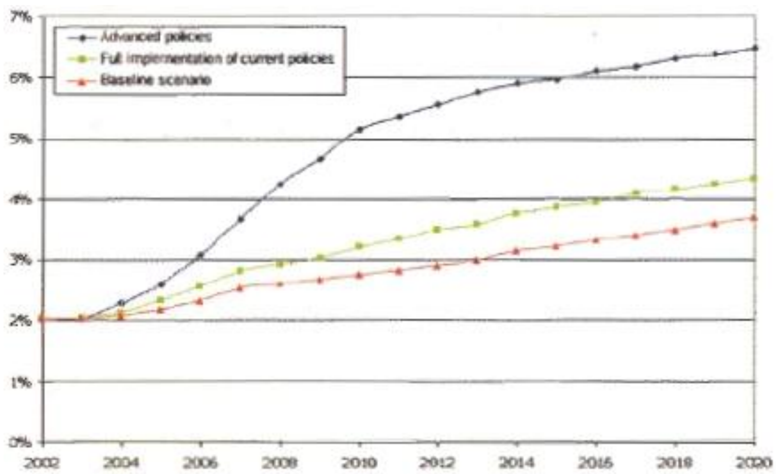

Figure 3.2 RES supply in the primary energy consumption

The official target of 6% RES contribution to electricity supply in 2010 can be achieved by the advanced policies scenario. **Figure 3.3** shows that the contribution of RES to electricity supply in 2010 could vary between 2.9% (baseline scenario) and 6% (advanced policies scenario). By the full implementation of current policies the RES contribution will reach 4.3% in 2010.

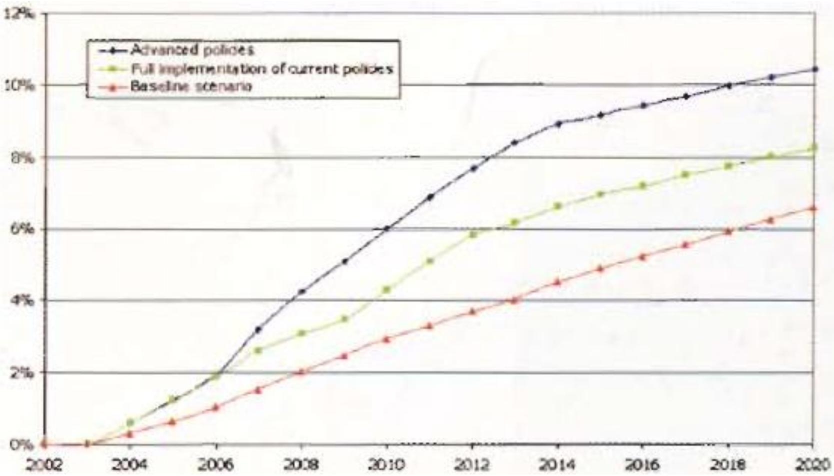

Figure 3.3 RES supply in the electricity consumption

In the heating sector, the RES contribution is already near 4% thanks to the high penetration of solar hot water systems in the domestic sector. For the new apartments a solar hot water system is considered as standard equipment, as well as the replacement of the existing systems with similar after the end of their lifetime. Some small ups and downs in the rate of RES supply in heat are justified by the introduction of medium scale CHP municipal solid waste plants.

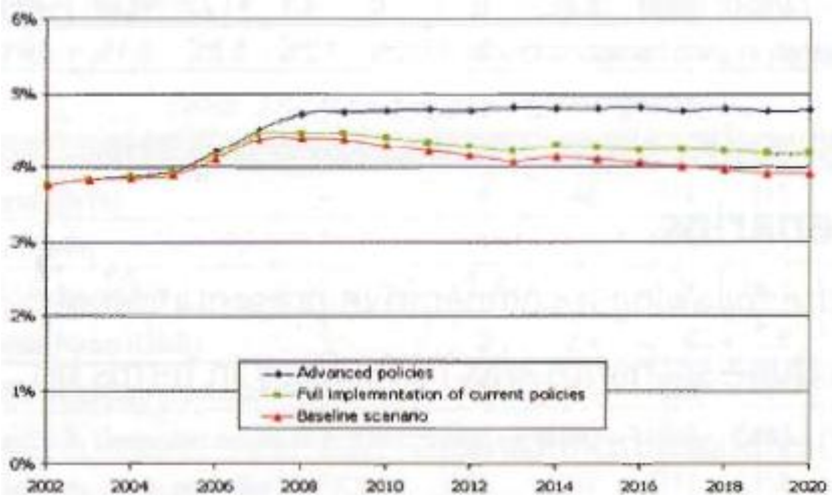

Figure 3.4 RES supply in heat

Finally, the most difficult target of introduction of RES in the transport sector (5.75% in 2010) seems to be unattainable, since by the current policies the expected rate is less than 1%.

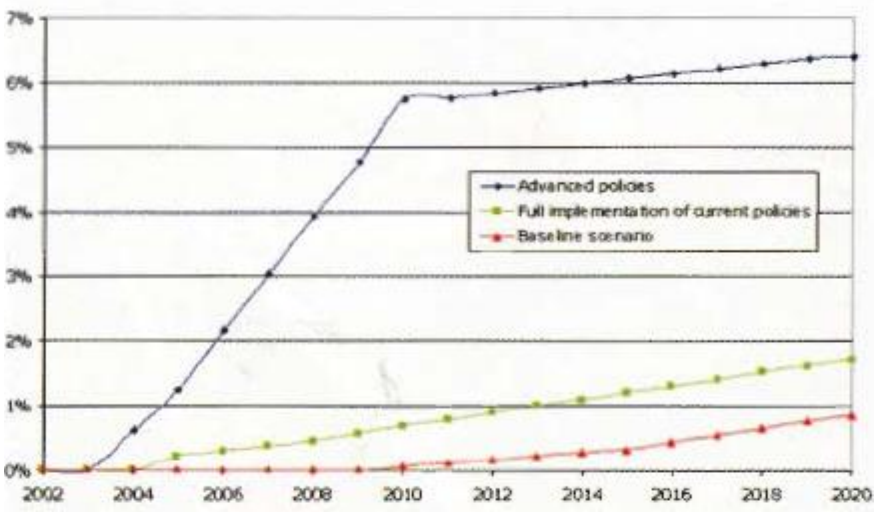

Figure 3.5 **RES supply in transportation**

Financial and economic analysis

The required investment costs for the implementation of the scenarios are presented in **Figure 3.5**. By terms of present value the investment cost is presented in **Table 3.9**.

Table 3.10. **Present Value of the investment cost (1000€)**

	2003-2010	2003-2020
Advanced policies	229916	344864
Full implementation of current policies	1022899	197702
Baseline scenario	58383	129416

According to the existing legislation (subsidies approved and support in the electricity market price), the required for the support of RES is present in **Figure 3.6**, while in **Table 3.10** the present value of the required resources is shown.

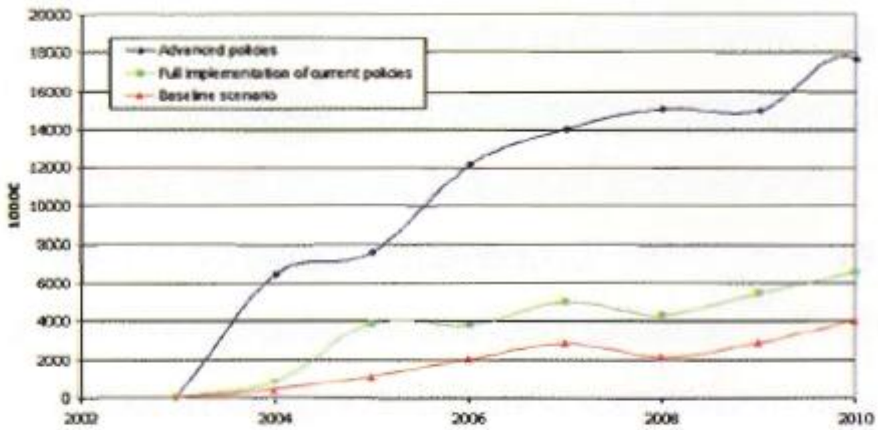

Figure 3.6 **Annual Required subsidy and support cost for the alternatives scenarios (1000€) 2003 – 2010**

Table 3.11. **Present Value of the required subsidy and support costs (1000€)**

	2003-2010	2003-2020
Advanced policies	63924	125247
Full implementation of current policies	21433	70994
Baseline scenario	10835	44904

Environmental impacts

The avoided CO_2 emissions due to the alternative scenarios are presented in **Figure 3.7**.

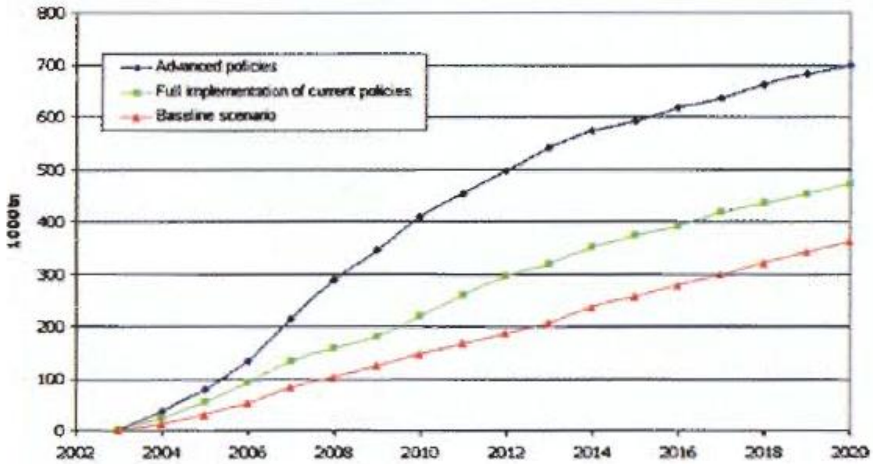

Figure 3.7 Yearly avoided CO_2 emissions (2003-2020)

Social impacts

The created employment is presented in **Tables 3.12 and 3.13** in man-years.

Table 3.12. Created employment due to the alternatives scenarios (2003-2010)

2003-2010 (man-years)	During construction	During O&M	Total employment
Advanced policies	272	917	1189
Full implementation of current policies	193	634	826
Baseline scenario	124	396	520

Table 3.13. Created employment due to the alternatives scenarios (2003-2010)

2003-2010 (man-years)	During construction	During O&M	Total employment
Advanced policies	602	5322	5924
Full implementation of current policies	455	3793	4248
Baseline scenario	331	2575	2906

4. PART III: Examples of good practice, case studies

4.1. The photovoltaic system at electricity authority of Cyprus' new head offices

4.1.1. Introduction

In the last years the electric grid tied systems have became the most extended application in the photovoltaic (PV) activity sector. This has lead to the development of a specific engineering that optimizes the layout and increases the performance of the systems, minimizing the environmental impact, the possible effects over the electric grid and looking forward in the architectural integration in buildings and landscapes. The PV plants require a simple installation and a minimal maintenance. Besides, the modular characteristic of this kind of systems enables future enlargements and allows obtaining a high performance in partial running.

Photovoltaic power plants represent a real contribution to the diversification in the production of electricity. They are non-contaminant producers that use local resources of energy as alternative to external fuel dependency.

4.1.2. Systems description

A grid-connected photovoltaic system comprises three clearly differentiated elements: the photovoltaic generator, the DC/AC power conditioning unit, and the monitoring and metering devices. The photovoltaic modules generate a current proportional to the incident solar radiation. The photovoltaic generator comprises several interconnected modules. The number of modules in series is the necessary to obtain the optimal operating voltage for the inverter. They conform one array. The number of arrays in parallel will be limited by the power of the inverter.

The DC/AC power conditioning unit transforms the direct current supplied by the generator into alternating current given to the grid. This unit also monitors the "maximum power point" of the generator. Protection mechanisms are also included, ensuring the safety of the personal and equipment of the installation and the quality of the power supplied to the conventional electric grid.

4.1.3. Site information

The photovoltaic generator for the New Head Offices for the Electricity Authority of Cyprus has been divided into different PV systems. Every system works independently and has been design to optimize the available surface and the production of electricity. The PV installation proposed for the New Head Offices for the Electricity Authority of Cyprus comprises the following PV systems:

- 19 PV Systems of 20 modules l-106 in series connected each one to a Sunny Boy 2000 DC/AC inverter.
- 24 PV Systems of 19 modules I-106 in series connected each one to a Sunny Boy 2000 DC/AC inverter.

Therefore, the total number of I-106 unframed modules is 836 for a total peak power of the photovoltaic systems offered of 88.616 Wp. Only one type of module and inverter will be used in the whole installation, thus logistic and maintenance operations will be reduced and the installation simplifies.

4.1.4. System characteristics

- P.V. Panels – Isofoton SA Spain
- Inverters – SMA Sunny Boy
- System Peak Power – 88.616 WP
- No. of PV Panels – 836
- No. of Invertes – 43
- Rating of inverters – 2000W
- PV Module – I-106 12V, 106Wp
- Guaranteed Energy Production 110,655 kWh per year

<u>Modules: Isofoton I0106/12</u>

The PV cells are laminated with EVA (Ethylene Vinyl Acetate) and encapsulated with a tempered glass front cover and a plastic polymer (TEDLAR) on the rear face.

PV Systems

19 – PV systems of 20 modules in series connected to a Sunny Boy 2000 Inverter. 24 Nos. PV systems of 19 modules in series, connected to a Sunny Boy 2000 Inverter. Every system works independently and has been designed to optimise the available surface and the production of electricity.

4.1.5. Individual system characteristics

1. The PV System replaced the sun-shades we had on the building. So they serve two purposes:

    - production of electricity
    - sun – shading

   With this arrangement, we saved the cost of the sun shades, around £70,000 (Euro 100,000) and made the use of the PV system financially more bearable.

2. In order to increase the performance of the system without sacrificing the aesthetic of the building, it was decided to tilt the PV panels' arrangement by 15 degrees to the horizontal.

3. In order to minimise the effects of the shading of the top panels to the lower panels, it was decided to install the long side of the panel parallel with the building. This way, every module of each series has the same irradiation at each time and the performance of the whole series is similar. The hot-spot effect is reduced.

4.1.6. Energy production

To estimate the energy produced from the PV system, a deep shadow analysis was performed. The system was divided into four groups as shown in the **Tables 4.1** and **4.2**.

Table 4.1. Estimated Energy production in PV systems

No		Yearly energy produced per PV System (kWh/year)	Total energy produced (kWh/year)
1	**PV Systems with no shadows over the whole year**		
	• 10 PV Systems with 20 modules in series	2,947	29,471
	• 12 PV Systems with 19 modules in series	2,794	33,525
2	**PV Systems with partial shadows from May 5th till August 10th**		
	• 3 PV Systems with 20 modules in series	2,722	8.167
	• 4 PV Systems with 19 modules in series	2,581	10,323
3	**PV Systems with partial shadows from April 8th till September 6th**		
	• 3 PV Systems with 20 modules in series	2,333	7,000
	• 4 PV Systems with 19 modules in series	2,212	8,847
4	**PV Systems with partial shadows from March 16th till September 29th**		
	• 3 PV Systems with 20 modules in series	1,961	5,884
	• 4 PV Systems with 19 modules in series	1,860	7,438
TOTAL ESTIMATED YEARLY ENERGY PRODUCED			**110,655 kWh/year**
TOTAL PEAK POWER OF THE PV SYSTEMS			**88,616 Wp**

Table 4.2. Estimated energy production of the plant

	Total daily average energy production (kWh/day)	Total energy production per month (kWh/month)	Monthly performance ratio (%)
JANUARY	192	5,959	81.1
FEBRUARY	247	6,928	81.3
MARCH	310	9,617	80.0
APRIL	332	9,963	72.7
MAY	349	10,829	65.5
JUNE	354	10,623	60.0
JULY	353	10,954	58.9
AUGUST	365	11,305	63.5
SEPTEMBER	369	11,066	71.3
OCTOBER	338	10,479	78.8
NOVEMBER	223	6,680	79.7
DECEMBER	202	6,250	81.7
AVERAGE DAILY	303		72.9
ANNUAL TOTAL (kWh)		**110,655**	**70.4**

4.1.7. Financial information

The total cost of the system is about 500,000 Euros. Even if this value represents a serious investment effort in the first stage, the economically viability of using this renewable systems is acceptable especially if the system will be used for domestic building blocks applications and or for medium and large size industrialise buildings.

4.1.8. Photos

Figure 4.1. EAC building

4.2. Mari Wind Farm Project

4.2.1. Description

The purpose of the Mari Wind Farm Project is to install and operate a wind farm, which will be producing renewable electricity from wind. The produced electricity will be fed into the National Grid of the Electricity Authority of Cyprus and sold on the basis of a Power Purchase Agreement to be concluded with the Transmission System Operator and the Electricity Authority of Cyprus. The project activity will generate greenhouse gas (GHG) emission reductions by avoiding CO_2 emissions from electricity generation by thermal power plants that supply the national Grid.

The site of the Mari Wind Farm Project is located at the Southern coast in the Larnaca District of the Republic of Cyprus. The project earmarks the installation of 8 turbines with a capacity of 1.5 MW each, resulting in a total capacity of 12 MW. Grid connection shall be at the nearby substation "Mari" at a distance of some 2 km at the medium voltage level (22 kV to be operated at 11 kV for the time being until planned changes of the system are carried out). Wind measurement has been carried out for one year from November 2003 onwards showing an average wind speed of 4.9 m/s at a height of 50 m which is a rather low wind speed in terms of good wind farm site quality. According to the energy yield expertise from Windtest Kaiser-Wilhelm-Koog, Germany, the annual electricity production is expected to be some 21 GWh. The project will represent the first wind farm ever realized in the Republic of Cyprus and will assist the country in establishing and promoting the use of grid connected renewable energy technologies. Hence it will contribute to a reduction of GHG emissions in conjunction with the current oil-fired power plants. With regard to sustainable development the project contributes in several ways:

- reduction of CO_2 and other air pollutants through development of renewable technology
- contribution towards achieving the targets and objectives of the country's policy regarding the promotion and the use of renewable energies in order to increase the contribution of electricity consumption from renewable energy sources from 0% to 6% by 2010
- infrastructure development in the environs of the project also with regard to attract visitors for environmental and teaching purposes
- creation of local employment during construction and for the later maintenance and operation, thus creating and strengthening local knowledge and experience in the field of these new this new technology.

Owner of the wind farm will be the project company Mariwind Farm Ltd.. Wincono Cyprus Ltd. will be responsible for technical and commercial management.

4.2.2. Site Location and Description

The project is located in the environs of the village Mari, Larnaca District, Republic of Cyprus between the towns of Larnaca and Limassol as indicated in the following map.

Figure 4.2. Map of the Republic of Cyprus; location of the Mari Wind Farm Project

The site is located directly between the Vasilikos Power Station (to the West) and the Vasilikos Cement Works (to the East) on top of a ridge with an altitude of 80 m at the coast line (South) ascending to 112 m towards inland (North). At wind turbine no. 3, which is located at the UTM WGS84 coordinates of 527654 E and 3843425 N, the wind farms main substation (coupling point building) shall be installed for the connection to the national grid via an overhead line.

4.2.3. Technology of the project

Type and category

The project is specified as “Grid connected renewable electricity generation” (from wind energy) and belongs to category I.D.. The installed capacity will be 12 MW, thus being below 15 MW and eligible as small-scale project.

Technology

The project envisages the installation of the turbine type VENSYS 77, which is a gearless wind turbine equipped with a three-blade rotor, pitch control with a rated output of 1,500 kW. This converter generates electric current that is fed directly into the public grid. Optimum aerodynamic rotor efficiency, at every wind speed, is achieved by using variable speed technology. The 77 m rotor diameter and 85 m hub height result in an overall height of 123.5 m.

Figure 4.3. Site layout of the Mari Wind Farm Project

The wind farm will be connected via a medium voltage overhead line, on 22 kV level –but for the time being operated at 11 kV- to the Mari substation (11/66 kV) at a distance of some 2km where the electricity will be fed into the National Grid. The turbines - of which the technology development is from Vensys Energiesysteme GmbH&Co.KG are to be manufactured by VENSYS-CKD, Czech Republic. Most likely, other components such as transformers and switchgears will be imported from Germany. Infrastructure work such as preparation of roads, building of foundations and cabling will be carried out by local companies.

Wind availability and electricity production

Wind measurement has been carried out by German Windtest Kaiser-Wilhelm-Koog, Germany, as of November 2003 for a one year period. Subsequently a yield expertise has been elaborated by the same institute. Whilst the measured wind speeds were not very high (4.9 m/s at a height of 50 m), the extrapolation to hub height and the analysis of the anticipated production shows reasonable results due to the anticipated high efficiency of the chosen wind turbine type. The annual electricity production is estimated at 21,219.9 MWh.

4.2.4. Reduction of GHG emissions

The implementation of Mari Wind Farm Project will generate an estimated reduction of 118,948 tCO2 over the first crediting period of 7 years. This reduction results from the displacement of the generation of electrical energy from the fossil fuel fired plants that would otherwise have fed electricity into the National Grid. The proposed project faces several barriers, especially technological barriers, barriers due to prevailing practice and investment barriers.

Table 4.3. Estimated emission reductions

Years	**Annual estimation of emission reductions [tCO_2e]**
2007 (May – December)	11,329
2008	16,993
2009	16,993
2010	16,993
2011	16,993
2012	16,993
2013	16,993
2014 (January – April)	5,664
Total estimated reductions	**118,948**
Total number of crediting years	**7**
Annual average over the crediting period of estimated reductions	**16,993**

4.3. Alexigros Wind Farm Project

4.3.1. Description

The purpose of the Alexigros Wind Farm Project is to install and operate a wind farm, which will be producing renewable electricity from wind. The produced electricity will be fed into the National Grid of the Electricity Authority of Cyprus and sold on the basis of a Power Purchase Agreement to be concluded with the Transmission System Operator and the Electricity Authority of Cyprus. The project activity will generate greenhouse gas (GHG) emission reductions by avoiding CO_2 emissions from electricity generation by fossil fuel power plants that supply the National Grid. Commissioning is planned for 01/05/2008.

The site of the Alexigros Wind Farm Project is located at the Southern coast in the Larnaca District of the Republic of Cyprus. The project development comprises the installation of 21 turbines with a capacity of 1.5 MW each, resulting in a total capacity of 31.5 MW. The technical terms for the grid connection at the high voltage system are currently being investigated by the Transmission System Operator. Wind measurement is being carried out since March 2006 for a period of minimum half a year up to one year. According to a preliminary energy yield expertise based on wind data from the nearby station at Larnaca Airport, the annual electricity production is expected to be 69 GWh per year.

The project will represent one of the first wind farms ever realized in the Republic of Cyprus and the first large scale wind farm. It will assist the country in establishing and promoting the use of grid connected renewable energy technologies. Hence it will contribute to a reduction of GHG emissions in conjunction with the predominant oil-fired power plants. With regard to sustainable development the project contributes in several ways:

- Reduction of CO_2 and other air pollutants through development of renewable technology
- Contribution towards achieving the targets and objectives of the country's policy regarding the promotion and the use of renewable energies in order to increase the contribution of electricity consumption from renewable energy sources from 0% to 6% by 2010
- Infrastructure development in the environs of the project also with regard to attract visitors for environmental and teaching purposes
- Creation of local employment during construction and for the later maintenance and operation, thus creating and strengthening local knowledge and experience in this new technology.

Owner of the wind farm will be a project-company which has yet to be set up. Wincono Cyprus Ltd. will be responsible for technical and commercial management.

4.3.2. Site Location and Description

The project is located between the villages of Klavdhia, Tersephanou and Alethriko in the Larnaca District, Republic of Cyprus. The town of Larnaca is at a distance of some 8 km in north-easterly direction as indicated in the following map.

Figure 4.4. Map of the Republic of Cyprus; location of the Alexigros Wind Farm Project

The wind farm's terrain is mildly hilly and forms a kind of a ribbed plateau in the area. The highest point of the area is the "Mouti tou Alexikou" (next to wind turbine no. 14) with an altitude of 209.1 m and the UTM WGS84 coordinates of 547645 E and 3859628 N. As also indicated in the map, the highway south of the village Klavdhia passes along the northwestern ridge of the wind farm area under consideration.

Figure 4.5. Site layout of the Alexigros Wind Farm Project

4.3.3. Technology of the project

The project envisages the installation of the turbine type VENSYS 77, which is a gearless wind turbine equipped with a three-blade rotor, pitch control with a rated output of 1,500 kW. This converter generates electric current that is fed directly into the public grid. Optimum aerodynamic rotor efficiency, at every wind speed, is achieved by using variable speed technology. The 77 m rotor diameter and 85 m hub height result in an overall height of 123.5 m.

Most likely, the wind farm will be connected to the transmission system (high tension at 66 or 132 kV) from where the electricity will be fed into the National Grid. The exact location for the grid connection and the technical terms are under elaboration by the Transmission System Operator.

The turbines - of which the technology development is from Vensys Energiesysteme GmbH&Co.KG ¬are to be manufactured by VENSYS-CKD, Czech Republic. Most likely, other components such as transformers and switchgears will be imported from Germany. Infrastructure work such as preparation of roads, building of foundations and cabling will be carried out by local companies.

Wind availability and electricity production

Wind measurement is being carried out by German Windtest Kaiser-Wilhelm-Koog, Germany, since March 2006 for a period of 6 to 12 months. Subsequently a yield expertise will be elaborated by the same institute. For the purpose of the assessment of the wind conditions and the energy prediction for the wind farm site, a preliminary yield expertise had been carried out by Wincono Cyprus Ltd. in cooperation with the Meteorological Service of Cyprus in April 2005. Wind data of the Meteorological Service from Larnaca Airport, which is at a distance of some 10km to the East, have been analyzed. The wind speed extrapolated to the hub height of the wind turbine and other factors such as the topography of the area and the siting of the turbines were used for the prediction of the energy yield.

The summarized result of the study is as follows:

Table 4.4. Wind data and energy production assuming a turbine of the type VENSYS 77 (including 20% reduction because of wake effects and safety reduction)

Type	Value
wind speed at 10m (measured at Larnaca Airport)	4.15 m/s
wind speed at 85m (calculated)	6.7 m/s
energy production wind farm (21 x VENSYS 77)	69,380 MWh/a

Whilst the measured wind speeds at Larnaca Airport were not very high (4.15 m/s at a height of 10m), the extrapolation to hub height and the analysis of the anticipated production shows reasonable results due to the anticipated high efficiency of the chosen wind turbine type.

The expected energy production of 69,380 MWh/a includes a 20% safety reduction, as on-site wind measurements have not been carried out yet.

4.3.4. Reduction of GHG emissions

The implementation of Alexigros Wind Farm Project will generate an estimated reduction of 388,910 tCO_2 over the first crediting period of 7 years. This reduction results from the displacement of the generation of electrical energy from the fossil fuel fired plants that would otherwise have fed electricity into the national grid. The proposed project faces several barriers, especially technological barriers, barriers due to prevailing practice and investment barriers.

Table 4.5. Estimated amount of emission reductions over the chosen crediting period

Years	Annual estimation of emission reductions [tCO_2e]
2008 (May – December)	37,039
2009	55,559
2010	55,559
2011	55,559
2012	55,559
2013	55,559
2014	55,559
2015 (January – April)	18,520
Total estimated reductions [tCO_2e]	**388,910**
Total number of crediting years	**7**
Annual average over the crediting period of estimated reductions [tCO_2e]	**55,559**

4.4. Solar Hot water systems success story

Cyprus is one of the leading countries in the use and construction of solar heating systems, 93% of households are equipped with solar water heaters and 53% of hotels have installed large solar water heating systems. The EU study "Sun in action" ranks Cyprus first with 0.86m^2 of installed solar collector per capita.

Increased efficiency and cost effectiveness of solar hot water systems contributed to their wide penetration in urban, rural and isolated communities in Cyprus. Local industry is characterised by high quality of standards in the construction and know how in this field. In Cyprus manufacturers provide their products directly to the end users. The average market price of a typical water heater system of 150 litre hot water capacity, with 3m^2 of solar collectors is about 1000 euro plus 15% VAT. This price includes the installation cost and the hot and cold water storage tank.

5. PART IV: Proposals for more sustainable energy development

5.1. Summary of under exploited RE and RUE

One of the most important key issues related to the energy sector is the need for diversification of the energy supply sources. At the moment, Cyprus is almost entirely dependent on oil imports for its energy mix (94%), with a small but growing contribution from renewable energy sources. Electricity generation, is based exclusively on oil, and is exhibiting a significant increase in recent years, due to the increasing electricity demand.

Any type of Renewable Energy Source can be considered under exploited in Cyprus apart from solar-thermal. Thus, any development that can take place based on the policies and measures described in previous sections, could be described as more sustainable energy development.

The Action Plan for the promotion of RES as set in Cyprus determines that the contribution of RES to the total energy consumption of Cyprus should rise from 4.5% in 1995 to 9% in 2010.

5.2. Proposal for a sustainable energy development

5.2.1. Objectives

For help the strengthening of country's sustainable development policies diversification of the energy supply sources is the primary concern. This corresponds to construction of a receiving / regasification terminal for Liquefied Natural Gas (LNG), which would make possible the importation of natural gas. This project is planned to begin in 2007 and be completed by 2009.

The overall environmental situation in Cyprus is characterized by deficiencies in environmental infrastructure, particularly in the area of urban waste water treatment, solid and hazardous waste management. Moreover, a continuous degradation of the natural environment particularly in the coastal areas was observed, due mainly to tourist development, whereas in the area of the energy intensity of the economy and the green house gases emissions, the relevant indicators for Cyprus are at relatively higher levels as compared to the EU average. This is to be explained by the following factors:

- The technology used in the generation of electricity (use of heavy fuel oil);
- The operation of energy intensive industries such as cement production;
- The absence of public transport systems such as railways, simultaneously with the fact that the bus system is not well developed.

Energy consumption is steadily increasing, whereas the transport sector accounts for a significant percentage of the total energy consumption.

5.2.2. Main Tools

The main policy priorities pursued by Cyprus in the area of the environment are the following:

- The creation / expansion of the environmental infrastructure for a sustainable management of resources and waste;
- The protection, preservation and management of coastal areas;
- The promotion of energy saving and renewable energy sources;
- The reduction of greenhouse gases emissions;
- The internalization of external environmental costs.

Measures underway / planned

Renewable Energy: A programme, became operational as from February 2004, with a view to promote energy saving and renewable energy sources utilization; hence contributing positively to environmental sustainability. The targets of the programme are to increase the contribution of renewable energy sources from currently 4% to 9% by 2010 and for electricity production from zero to 6% by 2010. The programme provides financial incentives in the form of grants for the encouragement of investments and/or tariff subsidisation in the fields of energy conservation and the promotion of Renewable Energy Sources (RES) utilisation. It is financed through a special Fund; its revenue accruing from a levy of 0,13 cent (CYP) / Kwh on the consumption of electricity.

Transport sector: The following measures were adopted in November 2004 for the encouragement of the sustainable use of energy:

- A significant reduction of the excise duty for small and middle class volume engine vehicles;

- A 15% discount for the purpose of the excise duty for cars with CO_2 emissions of 150gr/km or less and, at the same time, a 10% penalty on cars with CO_2 emissions of 275gr/km or more;
- Excise duty and registration fees on electric cars were abolished, whereas dual propulsion cars (hybrids) are now subject to half the registration and circulation fee;
- An incentive for scrapping of vehicles older than 15 years, was introduced;
- The discount in the form of a lower circulation licence that benefited older cars was abolished;
- Finally, a provision was introduced for a small fee, paid for each saloon and light commercial vehicle before being cleared by the Customs (one cent per cc of engine – e.g. for a 1600cc car EURO 27 is paid). The total amount so collected is earmarked for the development and enhancement of public transport, and is considered as an innovative measure to Cyprus budgetary practice.

Elaboration of a five year programme for the promotion of energy saving, which will be implemented as from 2006. The programme will be mainly financed from the special fund for energy conservation and the promotion of renewable resources. It includes a number of measures:

- The undertaking of an intensive campaign on energy saving;
- The provision of a subsidy on the excise duty of hybrid cars;
- Promotion of the use of biofuels through the imposition of a zero excise duty on biofuels;
- Expansion of the use of the school bus;
- Energy saving through relevant investment expenditure in public buildings;
- By the construction of new buildings of the broader public sector, the relevant provisions on energy saving should be complied with;
- Public procurement – The energy performance will be introduced as a criterion in the purchases of electrical equipment and motor vehicles by the Government.

Reduction of Greenhouse Gases Emissions

A Strategic Plan for a reduction on greenhouse gases emissions has been prepared, in order for the country to contribute to the global efforts to address climate change. Actions to promote the use of RES, such as installation of wind farms, of high efficiency air conditioning systems and electric appliances, energy-efficient lighting bulbs and automations, solar collectors, photovoltaic systems, promotion of co-generation and energy conservation and the campaign on public awareness on climate change, commenced since 2004. These actions are mainly financed from the special fund on renewable resources.

5.2.3. Economic and financial costs

See previous sections

5.2.4. Benefits

See previous sections

5.2.5. Indicators

See previous sections

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