Implementation Plan for the Large Scale Deployment of Renewable Energy Sources in Crete – Greece
REAC / NTUA / CRES, GREECE

Summary

The Regional Energy Agency of Crete, in collaboration with the National Technical University of Athens and the Centre of Renewable Energy Sources, has carried this study referring to the perspectives of RES in Crete. An Implementation Plan for exploitation of RES for the period 1998-2010 is defined. The plan is mainly focused on the exploitation of RES for electricity production. A general description of Crete's electrical system and a forecast of the island's electricity demand are presented. The rationale used in the formulation of the Implementation Plan and the proposed actions are detailed. All the technical and operational constraints are taken into account. The impacts of RES integration into the electrical system are considered. Furthermore, the necessary investment costs for the implementation of the plan and the related socio-economic and environmental benefits have been evaluated. Finally, the Implementation Plan as a whole is a quite attractive investment that improves the operation of the electrical system of Crete and provides it with an adequate safety margin covering the maximum average net hourly production.

End-user area

- New buildings
- Refurbishment of buildings
- Transport and mobility
- **Financial instruments**
- Industry
- **Legal initiatives (regulations, directives, etc)**
- **Planning issues**
- **Sustainable communities**
- User behaviour
- Education
- Other

Target Audience

- **Citizens**
- Households
- Property owners
- **Schools and universities**
- **Decision makers**
- **Local and regional authorities**
- Transport companies
- **Utilities**
- **ESCOs**
- **Architects and engineers**
- **Financial institutions**
- Other

Technical

- **Energy efficiency**
- **Heating**
- **Cooling**
- Appliances
- **Lighting**
- CHP
- District Heating
- **Solar energy**
- **Biomass**
- **Wind**
- Geothermal
- **Hydro power**
- Other

Context

Crete is the fourth largest island in the Mediterranean, with a population marked in recent years by a net increasing trend and economic growth rates double the national average. The existing autonomous electrical system faces sometimes problems caused by the high rates of increase in electricity demand (the highest nationwide due to seasonal variations mainly from tourism). There are a series of characteristics, which make Crete an ideal area for development of RES.

The total dependence of the region's autonomous energy system on fuel imports from mainland
The availability of a rich and largely under-exploited RES potential (the highest solar radiation in Europe)
The high investment interest related to RES (favorable legislative framework motivated the private sector)
The positive attitude of the public towards RES exploitation contrary to the significant objections for the construction of new thermal plants.

Objectives

The plan suggests actions aiming at electricity savings (solar hot-water systems, replacement of incandescent bulbs, passive and hybrid systems for cooling, time-zone pricing system, bioclimatic design etc.) along with promoting RES technologies for electricity production. The objectives of the Implementation Plan are: (I) to cover the additional electricity demand in a sustainable way, (II) to cover the maximum average net hourly production, (III) to provide the electrical system with an adequate safety margin, (IV) to require the minimum interventions to the existing grid and (V) to use the most mature and cost-effective RES technologies. The planning of the electricity system is based on the forecasting of annual electricity net production and on the forecasting of maximum and minimum net power production. Accurate forecasting is a crucial step therefore logistic models were used, taking into account the historical data up to 1997 for the entire electricity system of Crete.

Process

A simple procedure was followed to formulate the Implementation Plan and is constituted by the following steps: 1. The electricity demand and the maximum net average hourly production are estimated in the period 1998-2010 by using simple forecasting techniques. 2. The existing production units are examined to estimate their remaining life span and their capability of covering the future demand. 3. If the electricity production of the existing units is inadequate to fully cover the future electricity demand, then new units should be installed. Priority is given to RES technologies. 4. Among the various RES technologies available, biomass, small hydro units and Wind Farms are considered initially as the most promising RES units for the electrical system of Crete. Data about the initial capital expenditure, the operational cost and the capacity factors of each RES unit are found from either national or international experience. 5. At first, the goal is to cover the future electricity demand. Therefore, RES units are integrated with the existing and new thermal units so that total energy production capability of all units exceeds future demand. 6. In a second phase, the aim is to cover the maximum average net hourly production and to have an adequate safety margin. Therefore, the future maximum net hourly production together with the targeted safety margin defines the required installed capacity of the electrical system of Crete. This total installed capacity is divided among the various units. 7. The fifth and sixth steps are repeated several times in order to find the optimum solution, that is to estimate the required installed capacity, the energy production and the time that the installation will take place for each production unit.

The existing electrical generation system of Crete appears to be rather centralized. The selection of suitable locations of the RES plants is crucial both from the economic and the technical point of view. A GIS program supported a general methodology of resource assessments. In general, site selection is the output of the implementation of several considerations and restrictions over the region under examination: RES potential (wind speed, biomass potential, streams, etc.), topography of the region (altitudes, terrain slopes, etc.), sub regions dedicated to special activities (archaeological sites, airports, urban districts, etc.), difficulty of access and energy transportation, balanced distribution of the plants (leads to a stable electrical system, reduces electrical losses, leads to balanced local development), existing electrical grid, environmental impacts.

Financial resources and partners

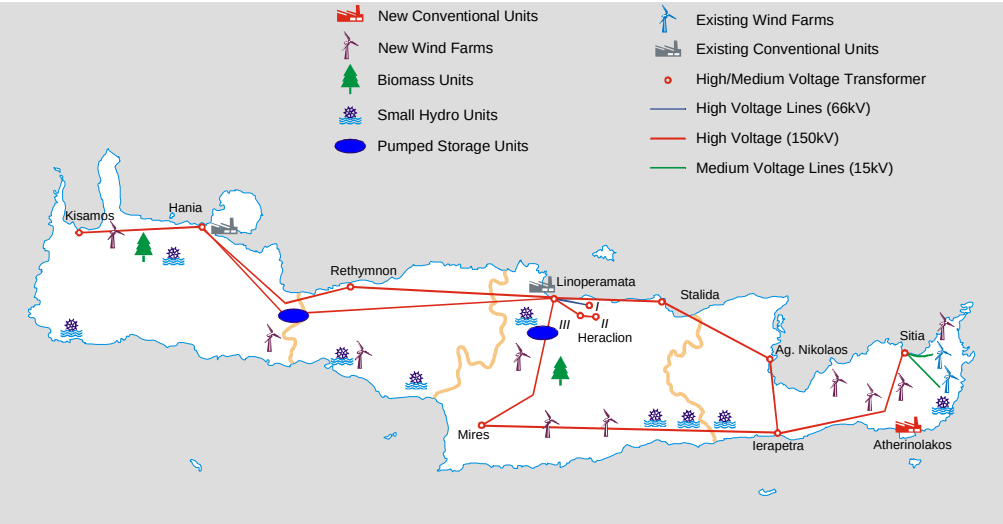
The duration of the project was 18 months. The total cost of the project was 470,000€. The Commission of the European Communities contributed 43% of the costs in the project up to 200,000€. The partners in this project and their roles is portrayed in the following table:

Involvement	Strong	Average
REAC	Implementation Plan	Exchange of information
	Information campaign	Analysis and the study part
NTUA	Analysis and the study part	Exchange of information
	Implementation Plan	Information campaign
CRES	Exchange of information	Implementation Plan
	Information campaign	
ICAEN	Exchange of information	

Results

The proposed sites for all the electricity production units selected according to the methodology are presented in Figure 1.

Figure 1 Existing and future electricity production units and the electrical grid of Crete.



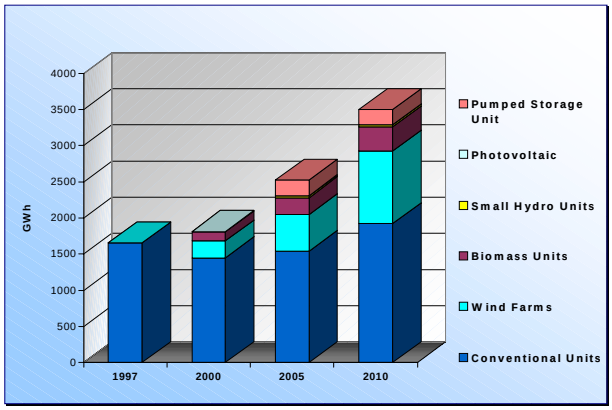
There are two general groups of actions differentiated by both the time that can be applied and by their significance. Short-term actions refer to the period 1998-2005 and medium-term actions to the period 2005-2010. Table 1 provides a detailed presentation with a yearly time schedule. The Implementation Plan provides the framework for the potential “optimum” development of RES in Crete taking into consideration the investors interest.

Table 1. Time schedule of RES installations in Crete

	Wind (MW)	Biomass (MW)	Hydro (MW)	PSU (MW)	PV (MW)	SHWS 1000m^2
1998	17.3	-	0.6	-	0.07	25
1999	55.45	-	0.6	-	0.1	50
2000	89.3	20	0.6	-	0.2	87.5
2001	115.2	20	1.01	-	0.3	125
2002	124.8	20	1.56	-	0.8	175
2003	134.8	40	2.15	-	1.4	225
2004	140.5	40	3.99	-	1.7	287.5
2005	200	40	6	125	2	362.5
2010	250	60	6	125	4	500

The contribution of various sources to the electricity supply for the years 2000, 2005 and 2010 are presented in Figure 2. The contribution of the conventional fuels (diesel and fuel oil) decreases from almost 100% in 1997 to 81% in 2000, to 61% in 2005 and to 55% in 2010. The total renewable electricity production will reach 19% of the total in 2000, 39% in 2005 and 45% in 2010. The annual electricity demand increases from 1078 GWh in 1990, to 1815 GWh in 2000, 2484 GWh in 2005 and 2700 GWh in 2010. Energy savings due to additional Solar Hot Water Systems utilization are considered (52.5 GWh in 2000, 218 GWh in 2005 and 300 GWh in 2010).

Figure 2 Contribution of various sources to electricity supply (year 2000, 2005 and 2010).



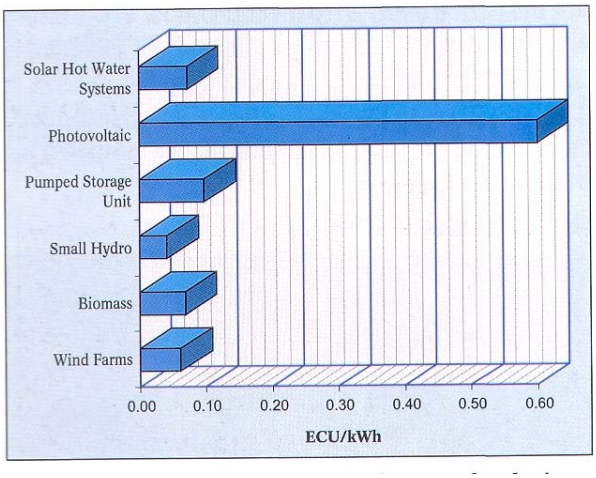
The RES installations expected and the data used for the economic analysis, are depicted in Table 2. The financial parameters required have been set, according to the Greek law and the requirements of the Operational Program for Energy of the Ministry of Development. Considering the parameters, a discount rate of 8% and a 15 years lifetime, the indexes Internal Rate of Return (IRR) and Net Present Value (NPV) of the Implementation Plan for the period 1998-2010 are: NPV=289 MEURO, IRR=17.6%.

Table 2. Data used for the RES economic analysis – period 1998-2010.

Actions (1998-2010)	Installed Capacity	Energy Produced or saved (GWh)	Investment cost (MEURO)	Maintenance and operation cost (MEURO /year)
Wind Farms	250 MW	625	280	5.7
Biomass	60 MW	355	95.5	13.3
Small Hydro	6 MW	26	8.42	0.092
PSU	125 MW	212	157	2.4
PV	4 MW	5.5	27.2	0.14
SHWS	500,000 m^2	300	171.6	1.7
TOTAL		**1,524 GWh**	**740 MEURO**	**23.3 MEURO/ year**

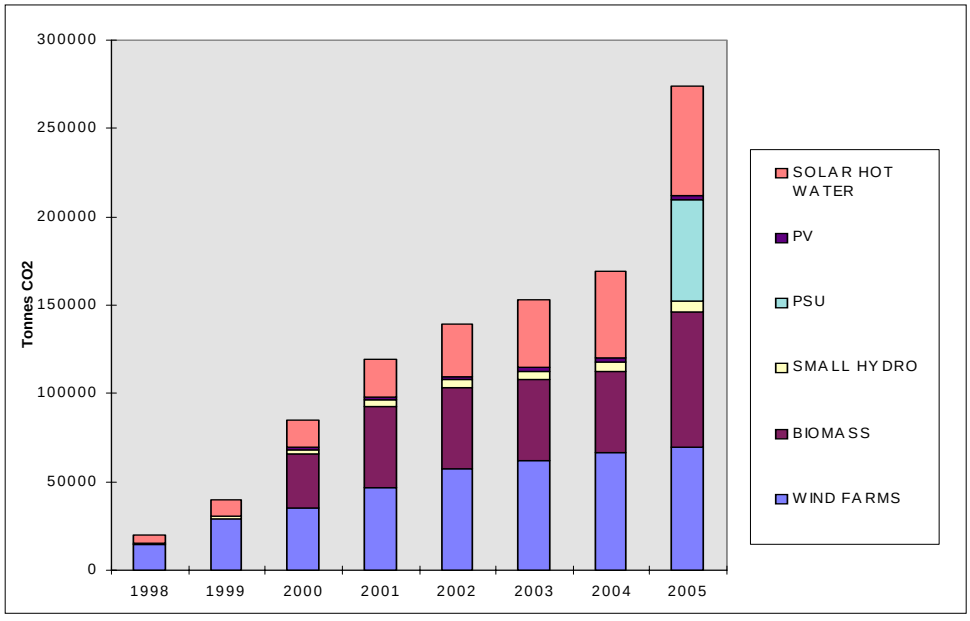
The electricity production cost for each RES technology has been calculated and is presented in Figure 3.

Figure 3 Energy production cost of RES technologies



Significant fuel substitution is expected due to the Implementation Plan and pollution is avoided. The avoided CO_2 emission is 976,000 tn per year in 2005 and 1,238,000 tn per year in 2010.

Figure 4 Tonnes CO_2 avoided



The effects of RES projects on the socio-economic development of the region, regional employment and the environment are calculated and presented in Figures 4 and 5. 315 new permanent jobs will be created due to the operation of the plan in the region. The total employment during the manufacturing, installation and operation phase is 8467 man-years.

Figure 5 Regional benefit created by 1 kEURO investment of various RE technologies.

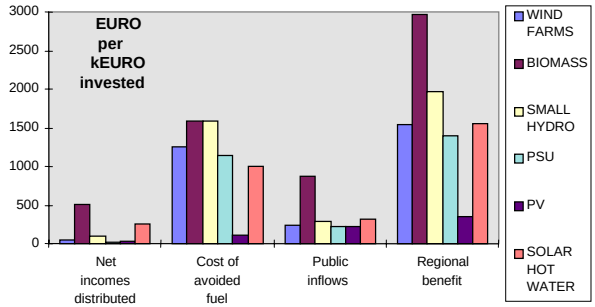
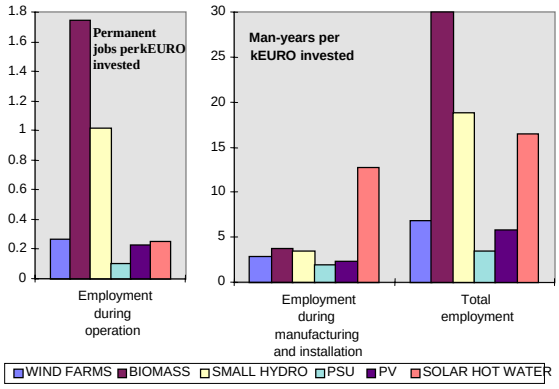


Figure 6 Employment effects in the region created by 1 kEURO investment of various RE technologies



The socio-economic and environmental effects considered to be of paramount importance for the island and in accordance with the European and National energy and environment priorities.

Lessons learned and repeatability

The proposed Implementation Plan is realistic, feasible, economically viable and environmentally sound. It takes into consideration all the technical, social and legislative issues. Thanks to the implementation plan the installed electrical capacity in Crete will be increased in an economic, ecological and socially accepted way. The analysis demonstrated that penetration of RES due to their regional character minimises the transmission losses and improves the operation of the electrical system of Crete. The economic analysis proved that the Implementation Plan as a whole is a quite attractive investment. The mean cost of RES electricity production is less than the mean cost of conventional units' electricity production. This project may partly cancel or delay future installations of conventional units. The Implementation Plan creates significant economic regional benefit, local employment and considerable amounts of CO_2 emissions reduction.

Realization of the Implementation Plan calls for a general consensus between all involved parties. In this direction a particular effort during the definition of the Implementation Plan was made for the extensive participation of all parties (PPC, local authorities, local population, scientists) as well as of all potential investors in RE technologies and energy saving projects. The island of Crete may and should constitute a preferential area for the extensive deployment of RES. It could become a pilot region in Mediterranean and one of the "100 Communities" to realise the goals and objectives of the EU Energy and Environment Directives. The success of such a pilot experience can provide the necessary guidelines for the massive penetration of RES in other regions and in larger energy systems. The methodology of the socio-economic evaluation of RES in Crete can also be used in other regions to support their energy policy.

Glossary:

REAC Regional Energy Agency of Crete

NTUA National Technical University of Athens

CRES Centre of Renewable Energy Sources

ICAEN Energy Institute of Catalonia

PSU Pumped Storage Unit

PV Photovoltaic

SHWS Solar Hot Water Systems

Contact for more information:

Organisation / Agency: Regional Energy Agency of Crete

Main contact: Dr Nicolas Zografakis, Director of the Regional Energy Agency of Crete

Address: Kountourioti Square, 71202 Iraklio, Crete, Greece

Tel: +302810224854

Fax: +302810343873

E-mail: enrg_bur@crete-region.gr

Web Site: www.crete-region.gr (Natural Resources, Energy)

Printed reports or other literature available:

Title: “Implementation Plan for the Large Scale Deployment of Renewable Energy Sources in Crete-Greece”

The development of this Publication was supported to a significant extent by the ALTENER Programme of the European Commission