Implementation Plan for the Large Scale Deployment of RenewableEnergy Sources in Crete-Greece

The perspectives of RES in Crete are analysed and an Implementation Plan for their exploitation for the period 1998-2010 is defined. The plan is focused on the exploitation of RES for electricity production. The rationale used in the formulation of the Implementation Plan and the proposed actions are detailed. The impacts of RES integration into the electrical system are considered. Finally, a special emphasis is given to the definition of the necessary investment costs for the realisation of the plan and the related socio-economic and environmental benefits.

Introduction

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 a chronic problem caused by the high rates of increase in electricity demand and the reluctance of the population to accept the installation of new thermal power stations. Innovative solutions are needed, which should provide both a sustainable development and a high standard of living. The use of RES can become the basis of a new alternative energy policy for the island RES harvesting and the use of appropriate commercially available technologies can have multiple direct and indirect impacts on the local development, the employment, the environment and the transfer of know-how for local production.

The objective of this work was to analyse the perspectives of RES in Crete. The defined Implementation Plan for the period 1998-2010 is focused on the exploitation of RES for electricity production since the major problem of Crete's energy system is the inability of the existing electrical system to meet the increasing demand.

In formulating the Implementation Plan, a detailed analysis of the energy system of Crete, carried out within past studies[2], is considered. A general description of Crete's electrical system and a forecast of the island's electricity demand was carried out[1].

An implementation plan for res in crete

Objectives and constraints

The Implementation Plan was formulated on the basis of the available RES potential, the technical constraints for the RES penetration and the existing legislative framework. Thus, the Implementation Plan provides the framework for the potential "optimum" development of RES in Crete taking into consideration the investors interest.

Formulating a scenario for the maximum possible penetration of RES into the electrical system of Crete, the assumption that RES will be used to cover 100% of the new - after 1998 - electricity demand was considered. The objectives of the Implementation Plan are:

a to cover the additional electricity demand in a sustainable way,

b to cover the maximum average net hourly production,

c to provide the electrical system with an adequate safety margin,

d to require the minimum interventions to the existing grid, and

e to use the most mature and cost-effective RES technologies

Technical and financial constraints, as well as operational and management problems, which could have an effect on the Implementation Plan are also considered:

Technical constraints:

- Wind farms, photovoltaic and solar thermal systems can not reliably cover maximum loads due to their intermittent operation.
- Although large Pumped-Storage systems can store wind and solar energy, such systems should not be expected to operate before 2005 due to technical difficulties.
- Although RES technologies proposed in this report are mature enough, technical risks still exist.

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Operational and management constraints

- Harvesting of agricultural by-products for bio-electricity production could face several difficulties as it has not been tested before in Greece.
- Compatibility of RES plants with the existing electricity grid could postpone their exploitation.

Financial constraints

- The significant existing grant policy as far as RES exploitation is concerned (40% on the total investment cost), is unlikely to continue indefinitely due to limited budgets.

Presentation of the plan

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 (see table I). The plan promotes electricity production by exploiting several RES technologies (Wind farms, Biomass, Small Hydroelectric Units, Photovoltaic installations, Pumped Storage Units) at a maximum possible penetration rate in order to cover the increase of electricity demand. Moreover, it suggests additional actions aiming at electricity savings (solar hot-water systems, replacement of incandescent bulbs, passive and hybrid systems for cooling, time-zone pricing system etc.).

Contribution to the energy supply

The contribution of various sources to the electricity supply for the years 2000, 2005 and 2010 are presented in Figure 1. 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 in 2005 and 2700 GWh in 2010. Energy savings due to additional Solar Hot Water Systems utilisation are considered (52.5 GWh in 2000, 218 GWh in 2005 and 300 GWh in 2010).

Location of Sites

The exact location of the RES plants is crucial both from the economic and the technical point of view. The selection of suitable locations was made via a general methodology of resource assessments supported by a GIS program. 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.).
- The topography of the region (altitudes, terrain slopes, etc.).
- Subregions 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

Figure 2 presents the proposed sites for all the plants.

	Wind (MW)	Biomass (MW)	Hydro (MW)	PSU (MW)	PV (MW)	SHWS 1000m²
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

Table I. Time schedule of RES installations in Crete

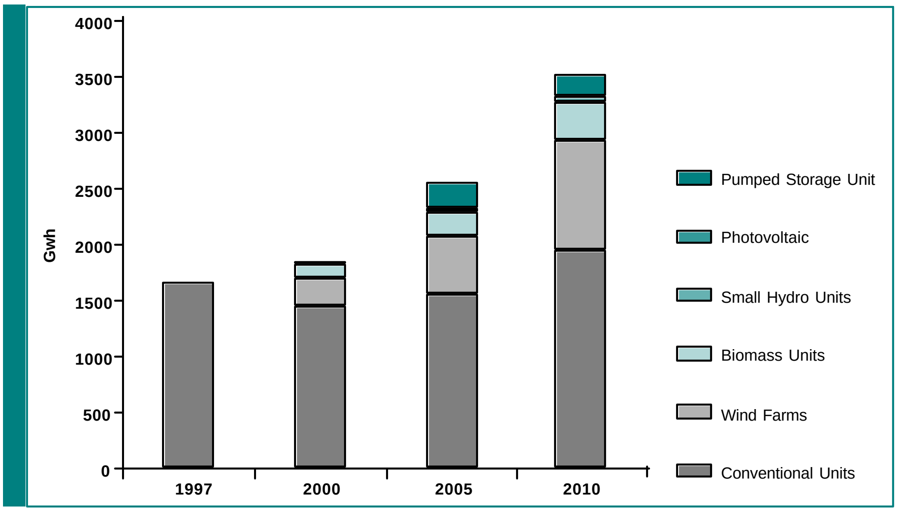

Figure 1. Contribution of various sources to electricity supply (year 2000, 2005 and 2010).

Economic evaluation of the implementation plan

The economic evaluation of the proposed RES investments has been carried out and the implementation plan as a whole during the period 1998-2010 has been evaluated. The basic output of this analysis is the Net Present Value (NPV) and the Internal Rate of Return (IRR) of the total investment. The RES installations expected during the period 1998-2010 and data used, are presented in Table 2.

The financial parameters required for the economic analysis have been set, according to the law 2601/98 and the requirements of the Operational Program for Energy (OPE) of the Ministry of Development, as follows:

- Grants: 40% of the total investment (in case of SHWS the grants are assumed the 15% of the total investment),
- Own capital: 60% of the total investment,
- Exchange rate: 350 drachmas/EURO,
- Price of the electricity sold to PPC: 0.0714 EURO/kWh

Considering the above 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

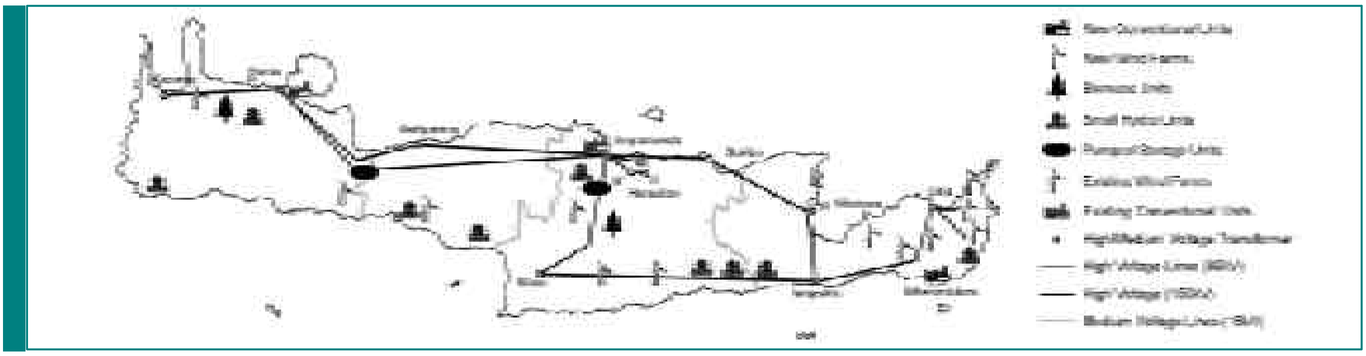

Figure 2. Existing and future electricity production units and the electrical grid of Crete.

Implementation Plan of RES in Crete for the period 1998-2010 are:

NPV=289 MEURO

IRR=17.6%

SOCIO-ECONOMIC AND ENVIRONMENTAL EVALUATION

Methodology

RES investments create new jobs and local income and have benign environmental effects. In this chapter the socio-economic and environmental aspects of the Implementation plan are presented. The methodology adopted for the assessment of the relative impacts is mainly based on the existing assessment tools and methodologies[3, 4].

In addition, actual data about RES projects that have been launched in Crete have been collected, analyzed and used to adapt the above-mentioned theoretical input to the specific aspects of the Implementation Plan. The tool was applied to the different sectors of the Implementation Plan and to the Plan as a whole, assessing the socio-economic and environmental impacts of RES development in Crete.

The methodology that supports the Assessment Tool estimates the effects of RES projects on the economic development of the region, regional employment and the environment. The present analysis examines the impacts that only affect the region of Crete.

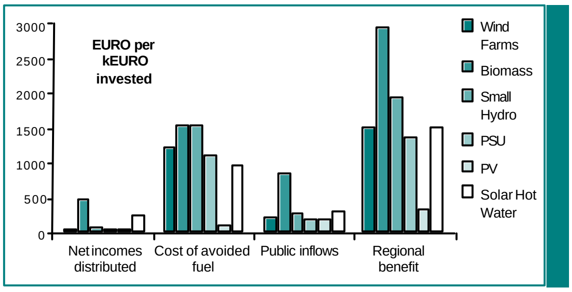

Figure 3. Regional benefit created by 1 kEURO investment of various RE technologies.

Comparison of RE technologies

Considering the various RE technologies to be used, indicators that quantify the socio-economic and environmental impacts have been calculated. The indices are then used for the evaluation of the Implementation Plan, considering in parallel the technical aspects that the large-scale development of RES entails.

In Figure 3 the Regional Benefit created by the various technologies is compared. The indexes are reduced per unit cost of investment. Figure 4 shows the employment effects due to RES investments. For most of the RES employment effects during manufacturing phase are limited. An exemption exists in the case of SHWS, as local industry employs local people. During

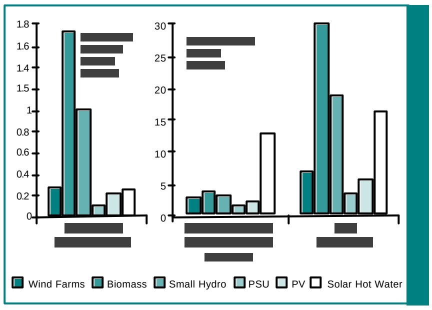

Figure 4. Employment effects in the region created by 1 kEURO investment of various RE technologies

operation, the creation of regional permanent jobs is important for combating unemployment.

Evaluation of the Implementation Plan

In the diagrams 1 and 2 the detailed application of the aforementioned methodology is presented for the short-term actions (period 1998-2010).

In Diagram 1 the employment effects of the Implementation Plan during manufacturing, installation and operation are presented.

In Diagram 2 the assessment of the Socio-Economic evaluation of the Implementation Plan is presented.

With regard to the socio-economic evaluation of the implementation plan we can note:

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

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

- The implementation plan during 1998-2010 requires an investment of 740 MEURO and a total subsidy of 253 MEURO. On the other hand it creates 511 MEURO Regional Added Value and returns a Regional Benefit of 1226 MEURO (Total net income distributed in the region is 107 MEURO, the cost of avoided fuel is 872 MEURO and the public inflows are 247 MEURO). The Regional Internal rate of return is 18% and the pay back period of the subsidy to the public receipts is 11.6 years.
- 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.
- 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 2005 and 1,238,000 tn per year 2010.

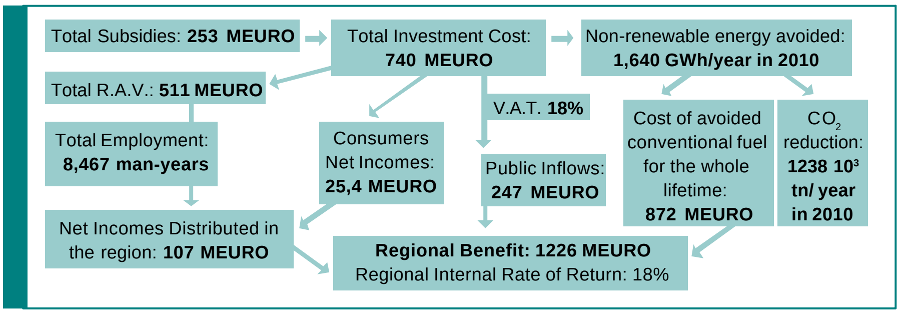

Diagram 2 Socio-Economic evaluation of the Implementation Plan - Period 1998-2005

Conclusions

The proposed Implementation Plan is realistic, feasible and economically viable. It takes into consideration all the technical, social and legislative issues. It is in accordance with the priorities of the EC White Paper for RES and the targets of CO_2 emissions reduction. Thanks to the implementation plan the installed electrical capacity in Crete will be increased in an economic, ecological and socially accepted way. The implementation plan:

- may partly cancel or delay future installations of conventional units. The construction of new thermal plants in Crete to fully cover future demand raises significant objections due to public opinion reactions and environmental impacts,
- covers the maximum average net hourly production, provides the electrical system with an adequate safety margin, and uses the most mature and cost-effective RES technologies,
- improves the operation of the electrical system of Crete, minimizing the transmission losses due to their local character.

With the realisation of the Implementation Plan the contribution of RES will reach 39.4% of the total annual electricity demand of the island by 2005 and 45.4% by 2010. In addition hot water solar heater utilisation will contribute to reduce the electricity demand by 218 GWh (approximately 10%) by 2005 and 300 GWh by 2010.

With regard to the socio-economic evaluation of the implementation plan we can note:

- 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,
- the implementation plan creates significant economic regional benefit, local employment and considerable amounts of CO_2 emissions reduction.
- The island of Crete may and should constitute a preferential area for the extensive deployment of RES. It could become a pilot region in the Mediterranean and one of the first "100 Communities" to realise the goals and objectives of the EC White Paper. The results and the experience gained should be disseminated to other Regions. The methodology of the socio-economic evaluation of RES in Crete, can also be used in other regions to support their energy policy.

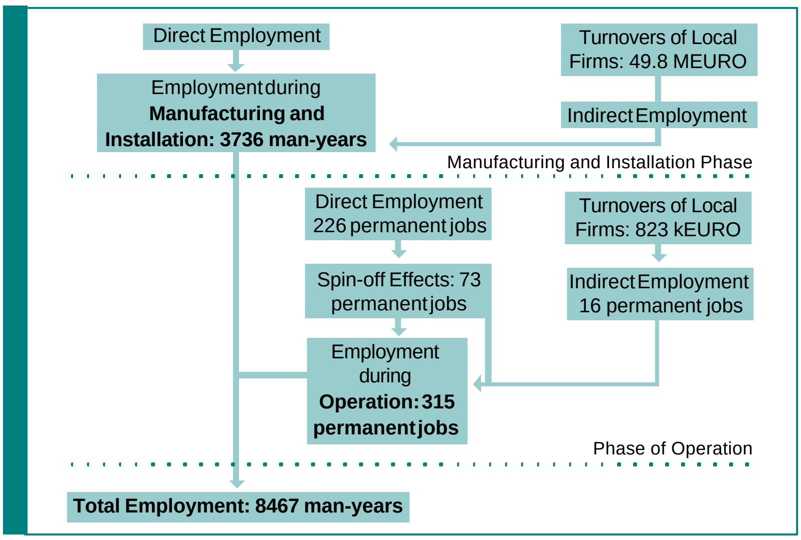

Diagram 1. Calculation of employment effects of the Implementation Plan - Period 1998-2005

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