# 458: Renewable Energy Sources in Small Communities

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**Abstract**

Greece has a typical Mediterranean climate with long periods of sunshine throughout the year. Nevertheless, in several regions, a number of climate subtypes exist because of topographical influences on air masses coming from the Mediterranean. Together with the geographical position and the sea, this allows for the extensive development of renewable energy sources (RES). National legislation has passed Law 3468/2006 that shows for 2010 a target of 20.1% set for electricity production from these sources. This paper is concerned with the use of RES in island communities (Aegean Sea). Projects, which mainly concentrate on wind and some solar energy, are examined in terms of their approach holistic or otherwise. A brief analysis of the implemented renewable energy source is conducted together with an examination of its level of integration in the areas/municipalities under investigation. Where necessary, specific renewable energy options are proposed. Projects are examined in terms of their application under local/national planning requirements, effort towards creating emission-free areas, promotion of sustainable communities and integration of renewable energy sources within the existing landscape.

Keywords: energy, wind, solar, communities, Greece

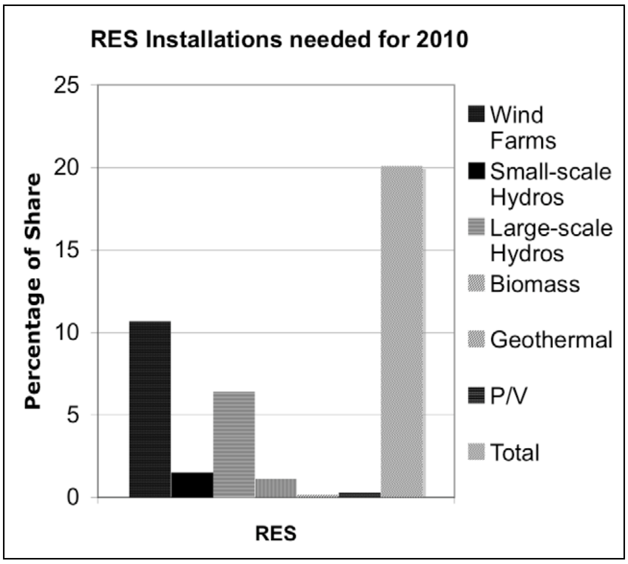


*Fig 1. Renewable Energy Sources Installations Chart*

## 1. Introduction and Background

In Greece national legislation has passed Law 3468/2006 that shows for 2010 a target of 20.1% set for electricity production from renewable energy sources (RES) (Fig.1) [1,2]. EU Directive 2001/77/EC, on the promotion of electricity produced from RES, indicates the same [2]. The law's implementation is a joint responsibility of the Ministry of Development; the Ministry for the Environment, Physical Planning and Public Works; the Regulatory Authority of Energy. The Ministry of Development supports renewable energy projects through the Operational Programme "Competitiveness", which comes under the 3rd Community Support Framework (2000-2006) with a proposal implementation deadline the end of 2008. In the 4th Programming Period (2007-2013), most available funding is directed towards regional areas. Actions such as "financial incentives for innovative energy investments in Greek islands" and subsidies ranging from 30% to 50% for energy investments are in place in order to encourage development, implementation, improvement, competitiveness in areas of interest that include renewable energy sources. Eligibility for funding includes corporations and individual persons. Already a total of 174 energy investments are being implemented (budget 704.68 million euros) (Fig.2).

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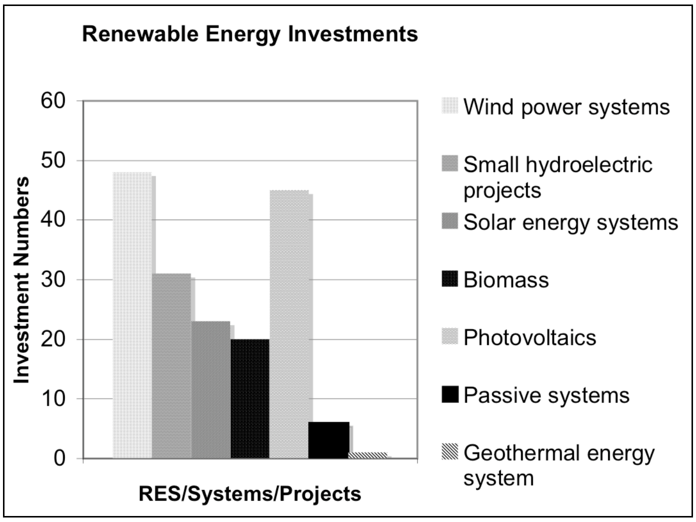


*Fig 2. Renewable Energy Investments Chart*

Greece's renewable energy production is therefore on the rise, driven by pressure from the European Union and the realisation of economic and commercial opportunities involved [3]. The Development Ministry, through the same programme, is also promoting projects that include the creation of new jobs, regional economic/workforce development and the use of natural resources. The Greek State, private sector, European Regional Development and European Social Funds provide the finance. The total cost of the Programme is 6,392.3 million euros. The private sector, European Community and Greek State contribute specific depicted amounts that make up the total financial assistance available (Fig.3) [4]. For the regions of Central & Western Macedonia, Central Greece, Attica and Southern Aegean "development actions are to be implemented with a total budget of around 1,498 million euros in the context of their local regional operational programmes" [2,5].

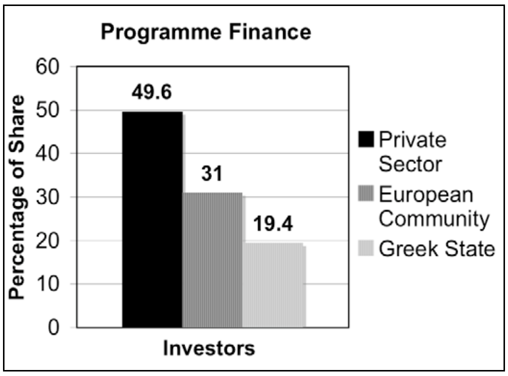


*Fig 3. Programme Finance Chart*

Projects are also planned relating to the Aegean Islands' interconnectivity and connection to the mainland's national power grid, which in the past was not technologically feasible. In addition the big distances between certain island groups (i.e. north to south Aegean) makes the realisation of such projects extremely difficult. Nevertheless a small number of interconnectivity projects have been completed, one example being Euboea's connection with Attica, others will be implemented in the future. Fortunately the distance between some Cycladic group islands is small which makes possible their interconnectivity and for others (belonging to the same group) connection to the national power grid a possibility. This will reduce reliance on existing local power stations and avoidance of their extension (due to ever increasing energy demands), less local environmental pollution and reliance on imported oil for station operation. Interconnectivity coupled with the use of RES and wind power in particular not only can produce enough energy for local and group island consumption but the generated energy can be exported to the major energy consumption centre (the mainland/Athens).

## 2. Communities and RES

The benefits of using renewable energies include the non-emittance of greenhouse gases, promotion of environmental sustainability, positive economic effects for the locals, self-sufficiency and independence. The creation of sustainable communities/groups should be encouraged as well as direct involvement/control and financial/environmental incentives provided, perhaps in the form of shares in all the technologies implemented. Every project is unique due to the different location, geology, settlements, climate/microclimate, in addition to other considerations.

In order to promote/integrate renewable energy uses in small and/or usually remote rural communities it is necessary to study in depth the areas' traditional, socio-economic and environmental conditions. Further studies are necessary which take on board the architectural heritage, present/future development projects, financial benefits and implications. Furthermore research should be conducted which relates directly to the eventual choice of certain strategies/projects over others and their direct effect on the communities concerned.

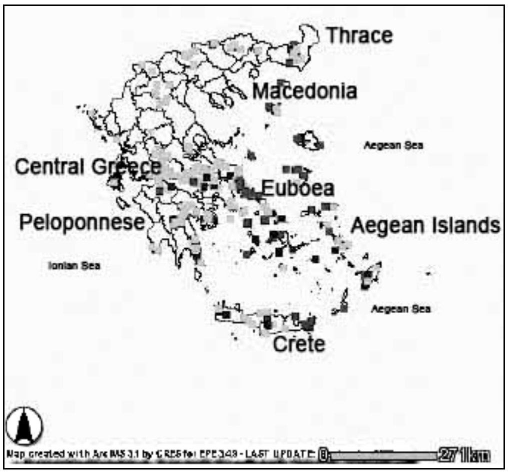


*Fig 4. Map of Greece/Wind Farms in various stages of operation [1,6]*

Currently in Greece the application/exploitation of RES technologies is usually implemented by companies, with huge economic interests, most of which do not involve local communities in truly substantial ways. Various governments have habitually ignored both the needs and representatives of these localities. Many communities, after having been left for years to fend for themselves, now resent being partially muscled out of what they have (land, a way of life which is agricultural/tourism related, etc.) by big corporations and/or private companies with governmental support. Naturally large engineering companies, investment groups and corporations, among others, prefer big developments because there is greater opportunity for a substantial return on their investment particularly since such projects are initially very costly. Nevertheless damaging local communities and areas of natural beauty, as well as unbalancing the local eco system is also undesirable.

An appropriate assessment of local energy requirements and RES, the choice of applicable renewable energy technologies and levels of exploitation should involve both the communities concerned and the outside investors. A great number of wind farm projects though have already been developed in various islands and mainland Greece. The majority has been built on the big islands of Crete and Euboea as well as mainland Thrace, Macedonia, Central Greece and the Peloponnese (Fig.4).

During the construction of wind farms on the Aegean Sea's islands of Euboea (population 208,408) and Crete (population 540,054) jobs were created which benefited the locals (Fig.5) [7]. In these areas regular power cuts plagued local communities and businesses but now have become a thing of the past. Additionally energy companies pay the municipalities concerned 2%-3% of the gross annual income from their electricity producing wind farms [3]. Large Greek private energy producers like Terna Energy S.A. have currently in operation eight wind farms of 116MW - four in Euboea, two in Crete, and two in the north-eastern part of mainland Greece [3]. The wind farms in operation have contributed to "the reduction in greenhouse gas emissions (by about 320,000 tons of CO2 annually), substantial savings in domestic conventional fuel consumption (savings of about 400,000 tons of lignite annually), coverage of important energy needs (annual energy needs of 60,000 households)" [3,8].

For example in Euboea, a big and mountainous island, which lies along the eastern coast of Central Greece (total area 3,896 square kilometres, 208,408 inhabitants) there is in the Tsilikoka location a 10.2MW wind farm/park consisting of 17 Vestas wind turbines and a substation for the connection with the National High Voltage Transmission System. The land required was about 100ha, 1% of which was direct park area intervention (wind turbines). The cost of construction was approximately 11 million euros. Its energy production replaces 25,000 tons of CO2 annually [3,8].

*Fig 5. Photo of Wind Farm [3] (Euboea Island)*

Despite the environmental benefits people are apprehensive regarding the planning permissions/licenses connected with the construction of wind farms and/or solar fields, particularly on the Aegean Sea's islands, where it is now permitted to install a total of 8,706 wind turbines (2MW, 90m high, 60m diameter). Islanders are concerned that the architectural and natural environmental beauty of their areas (one to two storey high houses, rare plants and animals) will be overshadowed by 90m high wind turbines and endless stretches of solar fields. Some locals believe that the wind farms' necessary road works and land requirements (however limited) will destroy parts of the natural terrain and abuse protected areas. Locals are worried about the permission of extensive and oversized solar fields, gigantic and noisy wind parks erected on their usually small islands, up to a kilometre away from their communities and businesses. Yet all energy requirements for the air-conditioning/heating of restaurants/hotels/etc as well as for hot water production and domestic uses can be covered through the utilization of RES technologies with little actual financial costs in the long run.

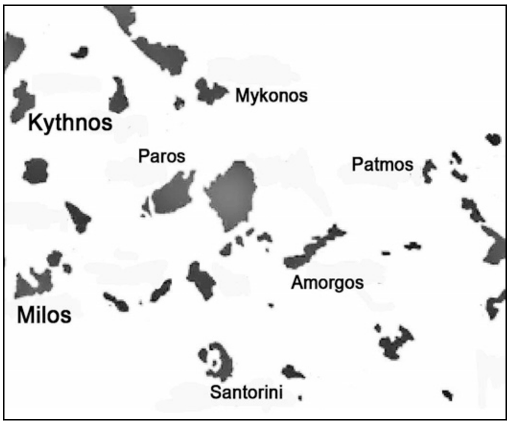


*Fig 6. Southern Aegean Periphery Map (Plan of Cycladic Island Group)*

The Periphery of Southern Aegean includes the Cycladic Islands, which are located on the south-eastern part of the country (Fig.4&6). The periphery covers an area of 5,286 square kilometres (4% of Greece's total area) and has a total population of 257,481 inhabitants [7]. The area is composed of 79 islands 48 of which are inhabited and are at a certain distance from each other (i.e. the Dodecanese / population 163,476; Cyclades / population 94,005), the mainland and Athens [7]. Most of the islands are mountainous with water and energy shortages especially in the summer months. Lack of a good transportation system does not allow the unification and equal economic development of these scattered islands (Fig.7&8).

*Fig 7. View of Cycladic Island*

Renewable energy sources potential is especially high on the Cycladic group. Even though these islands have a mean wind speed above 9m/s, full use of wind power technologies can be limited due to the variable yearly electricity demand, local electrical network limitations, variability in wind energy availability and financial constraints.

*Fig 8. View of Dodecanese Island*

During the summer season there is an increase of almost 40% of the total annual consumption of energy. In these circumstances RES technologies can work in combination and/or as standalone systems covering the energy requirements of a particular location with the additional possibility of exporting energy while promoting sustainability.


*Fig 9. Plan of Kythnos*

The island of Kythnos belongs to the Aegean Sea's Cycladic group of islands (Fig.6&9). It is 52 nautical miles from the Port of Piraeus and has an area of approximately 99 square kilometres with a population of 1,632 inhabitants [7]. As with all tourist destinations during the summer months the island's residents increase dramatically. The local population is occupied mainly with tourism, agriculture and fishing. Kythnos has high wind and solar potential. In 1982 the installation of five wind turbines of 20kW each took place making it the first wind park in Europe. A year later the first photovoltaic/hybrid system of a total 100kW capacity was installed. It operated with a combination of diesel, wind power and solar energy. The system provided electrical power in a remote area not connected to the grid and used more than one source of energy making it more reliable than a one-source system.

The island has not yet managed to fully develop and exploit its RES potential. In 2000 the old wind turbines were replaced by a single 500 kW, which for a few hours during the winter months covers all the island's electricity requirements. The old hybrid/photovoltaic system is no longer operational due to lack of finances for part replacements but in 2001 the first autonomous microgrid system was installed that produces electricity for the Gaidouromadra valley community, which is located on the east-southern side of the island in a remote, seaside but barren area.

The Gaidouromadra microgrid system provides electricity to twelve houses and the peak power in each is limited by 6A fuse. The "grid and safety specifications for the house connections respect the technical solutions of the local electricity utility" so that and if required the system can be connected to the existing power grid [9]. The system is composed of 10kWp in multiple small

PV arrays, a battery bank of a nominal 53kWh capacity, and a diesel genset. The PV modules are integrated as awnings into the various dwellings. Required battery inverters/banks, diesel genset/tank and computer monitoring equipment are housed in a 20m2 building, which is located in the centre of the locality.

The microgrid, which provides electricity, is powered by three (Sunny-island) battery inverters connected in parallel. A second system with about "2kWp mounted on the roof of the building is connected to a (Sunny-island) battery inverter and a 32kWh battery bank" [9]. This provides the power for the system's monitoring and communication needs. Finally it is considered that integrating an AC wind turbine of 2-3kW will strengthen the system's power production, minimise diesel fuel use while diversifying resources [9].


*Fig 10. Plan of Milos*

Milos is another Cycladic island of 4,390 inhabitants with an area of 151 square kilometres and a high RES potential (annual solar radiation of 1,660kWh/m2 and average wind velocity of 7.1m/sec) (Fig.6&10) [7,10]. During the summer months the island's population increases dramatically. The locals are occupied mainly with tourism, mining and agriculture. There is use of geothermal energy technologies (i.e. boreholes) for the supply/storage of thermal energy as the island has good geothermal capability. It has been estimated that "three new geothermal boreholes of a total capacity of 1,800MWh/year will cover the energy requirements of Milos for hot water procurement and the climatization of 25 small hotels in Adamas", which is a port town located on the southern side of the island [10].

There is already utilisation of wind power but it is estimated that the addition of "a fourth 850kW wind turbine to the existing system will cover the electricity needs for the desalination unit of a 2,000m3/day capacity" [10]. The fourth wind turbine together with the three existing ones will reach a 2,400kW capacity and collectively can continue to feed the local network with "8,650 MWh/year electricity for the island's general purposes and the desalination unit". Solar thermal energy can be further utilized with a "20% expansion of the 1,100 units in order to cover all the sanitary water requirements of the houses in the island" [10]. Photovoltaic panels can be added to buildings (restaurants, houses, bars, etc.), which can generate electricity even under cloudy conditions.

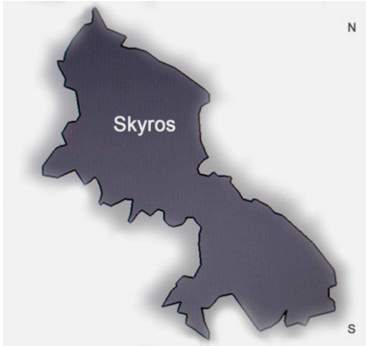


*Fig 11. Plan of Skyros*

Skyros is a small Aegean Sea island, which is located on the eastern side of Euboea (Fig.4&11) and belongs to the Sporades group of islands. It has 2,901 inhabitants and an area of approximately 209 square kilometers [7]. The southern part of Skyros, also known as the Vouno, is a Natura 2000 site because of its rare endemic plants. Over a year ago an engineering company and a Greek Orthodox Monastery (the owners of the land on which the prospective wind farm might be built) proposed to install up to 85 wind turbines on Vouno. According to this company the turbines were expected to produce for the islanders an annual income of over 2.5 million euros. Nevertheless, implementing such a big project on a protected site did not go down well with the locals who were also apprehensive about the effect such a scheme would have on tourism. The project is currently postponed until certain issues are legally resolved.

Irrespective of cases like Skyros, in 2005 the installed capacity of wind systems in Greece exceeded 573MW with an additional 177MW in 2006 [3]. Wind farms are constructed in areas with the appropriate climatic/microclimatic conditions, usually on mountainous pastures, not very near local communities and/or areas of outstanding natural beauty (Fig.12). In the summer sheep/goat herds are sometimes known to stand under the shade of the turbines seeking protection from the hot summer sun [3]. There is usually no disruption to agricultural activities. Nevertheless the roads needed to construct for a wind farm's installation (depending on size) are considered by some as unsightly.

*Fig 12. Wind Farm View [3]*

## 3. Conclusion

Communities need to be integrated into RES plans/developments in order to be cooperative, envisage and reap some of the environmental/financial benefits from such investments. More importantly they need to be given incentives financial and/or otherwise. There has to be a balance between projects, development size, location and area required for the extensive implementation of RES technologies. Locally available resources such as wind, solar thermal, geothermal, hydro, biomass and photovoltaics should be utilized together with as much as possible local finances and/or manpower. The goal, if possible, should be self-sufficiency and independence from outside sources in order to cover all energy demands.

As many islands/remote areas suffer from water shortage and have variable energy demands, wind turbines producing electricity can cover the needs of seawater desalination units. Some desalination water can also be used for irrigation purposes thus increasing/reinforcing agricultural activities, while areas outside a locality's water network can make use of it too. Installations of an appropriate number of solar collectors/fields, of optimal inclination according to the seasonal thermal requirements, can be used for the creation of solar air-conditioning systems/hot water production for hotels/restaurants/homes.

Photovoltaic/Hybrid systems can provide electricity to isolated communities/remote areas, which are not connected to a power grid. These systems can use two or more different sources of energy such as wind and solar. This means that there is a high level of reliability, operating economy, use of RES and non-reliance on a single system. As wind and sun energy sources among others are abundant on the Greek Islands and the country in general, combining power generating systems that complement each other while matching the energy demand with the individual system, can be an efficient solution for remote localities.

Dehumidification desiccant systems can be in place, which use solid dehydrates and hot water (produced from solar fields) in order to dehumidify internal spaces. Photovoltaic panels can be positioned on buildings in order to generate energy even under cloudy conditions. The electricity produced can be used and/or forwarded to the electricity mains for an annual financial return. Energy production, consumption and export will therefore be environmentally friendly, improve local conditions as well as make financial sense while promoting sustainability.

## 4. Acknowledgements

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