IOS – AEGEAN ENERGY AGENCY

Executive summary of the work done on Energy planning (Work package 3)

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Table of Contents

1. Introduction

The Ios Aegean Energy Agency, in cooperation with the Regulatory Energy Authority (RAE), the Center of Renewable Energy Sources (CRES), the Ministry of Development and other national and/or local institutions, has undertaken an initiative to elaborate a consistent strategy for the development of RES and energy savings in Aegean islands. This initiative coincides with the publication of the Common Ministerial Degree for RES planning in the Greek territory (2464/3.12.2008) which introduce for the first time criteria for the spatial distribution of RES installations and especially wind energy. Under these circumstances, this study (Energy Planning) could be considered as the first stage or the blueprint of a more general and detailed strategy which is an ongoing process. Besides the spatial planning, other factors as the energy demand, the potential of RES, the technical challenges and barriers, the financial mechanisms and the sociopolitical parameters, should be the structural elements of the synthesis and the set of the conclusions. The final aim is to provide local authorities, regional institutions, investors and environmental groups, with a meaningful tool for the right decisions at the right time. Finally, this study was concentrated firstly at the group of islands participating in the "Aegean Islands Network for Sustainable Development" – DAFNI for which the necessary data has been available. In a second stage, the study will be extended to some other islands (not belonging to the network) which are considered – given their size and their resources – as key players in the near future: Samos, Ikaria and Kalymnos are in the top of the list.

Greek islands present many advantages for promoting such a sustainable energy planning, because they usually possess a significant RES potential, which remains practically unexploited, whereas energy demand depends highly on imported conventional fuels. In addition, Greek islands very often present significant tourism related activities causing high seasonal variations in energy demand and producing severe impacts on the natural environment. These impacts along with the adverse environmental effects of conventional fuels may negatively affect the sustainable development of the tourism sector.

The present energy status of the island under consideration was determined. Due to the lack of available data, a bottom-up approach was applied for estimating the needs of all energy consuming activities. By taking into account the currently used technologies, their energy efficiency coefficients and the type of fuels consumed, the final energy consumption was calculated and translated in terms of primary energy requirements by moving backward to the level of energy supply.

The energy balances of the islands are presented in charts, as annexes of the report.

Today, the maturity of RES technologies offers the opportunity for the islands to succeed energy independence, by the integrated large-scale exploitation of their abundant RES potential with respect to the natural environment and in harmony with local activities. It is therefore of primary importance to investigate this possibility and to establish local plans identifying the optimal path towards maximum RES integration in islands with the aim to achieve 100% RES supply. To this purpose, it is necessary to scrutinize all technical and non-technical issues that have to be effectively resolved.

2. Methodology – Data – Sources

2.1. Description of Methodology

For reaching an effective energy planning tool at the local level of the island, it was necessary to effectively match the available RES potential to a given profile of energy demand. This requirement emanates from the decentralized nature of RES and the capacity of several RES exploitation technologies to meet only specific categories of energy demand. Therefore, a consecutive analytical procedure was developed including the following steps:

First, the present energy status of the island under consideration is determined. To this purpose, a bottom-up approach is applied for estimating the needs of all energy consuming activities. By taking into account the currently used technologies, their energy efficiency coefficients and the type of fuels consumed, the final energy consumption is calculated and translated in terms of primary energy requirements by moving backward to the level of energy supply.

Additionally, since a large number of islands are included in the DAFNI network, a classification of the islands per various indicators, as size, population, climate conditions, status of grid's interconnection, tourism development, RES potential and others is helpful for the presentation of indicative case studies.

The next step was to investigate the possible contribution of RES in the so calculated energy needs, either at the final demand or at the supply level. The main information required at this stage refers to the exploitable potential of RES and savings.

For making optimal use of the exploitable local resources and maximize RES penetration, the various barriers should be recorded. Initially, a number of technical issues were investigated, encompassing changes to existing infrastructures and incorporation of hybrid systems, as well as the grid infrastructure, energy management, energy storage and/or power conditioning technologies.

In order to estimate the degree that the specified technical solutions can be practically exploited in the island, non-technical issues were considered. These issues refer principally to economical, environmental, social and legislative parameters that may positively or negatively influence RES integration. Finally one of the most significant issues for the penetration of RES and energy saving techniques is the social acceptance, which was analyzed thoroughly, while case studies of islands where inhabitants are opposed to RES projects were presented

2.2. Description of data & sources

The data needed for input of the energy planning tool and for reaching results in the planning of the energy strategy where numerous, so where the sources. A large database was established for the handling and the exploitation of these data, which are mainly grouped in the following categories: geographical, climate, demographical, tourism, agriculture, transportation, fuel consumption (domestic, transport, electricity production), water consumption and infrastructure, electricity networks, interconnections, demand & supply of electricity, conventional electricity production units, energy storage, RES (potential, installed RES units, applications and permissions for RES installations, rates of growth – prospects).

4. Issues (barriers, strengths, weaknesses & opportunities)

4.1. Technical issues

For the Greek islands, given the determined RES potential and the significant number of RE technologies available, the selection of the appropriate mix and layout of the available options, should aim at effectively meeting the planning objectives, namely:

to cover energy demand in a sustainable way,

to secure the system's stability and reliability,

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

In order to achieve maximum degree of RES penetration and surpass the shortcomings of RE applications which deal with one RE technology, various RE technologies should be used in combined schemes aiming at maximizing efficiency, while changes in existing energy infrastructures may be necessary for accommodating RES in an optimized way. Moreover, if in the long term renewables are intended to play a prominent role in total energy supply, a radical renewal of energy infrastructures has to take place. The main technical issues to be considered in establishing the path towards an energy planning can be classified in two broad categories as follows:

4.1.1. Site-specific characteristics

The selection among different RE technologies and among their possible combinations should consider a small number of site-specific characteristics, such as kind of energy infrastructure, energy consumption per area unit, grid interconnection and sufficiency and power consumption patterns.

4.1.2. Resources and technology specific characteristics

Besides site-specific characteristics, an energy planning based on RES should take into account the capacities and constraints of the existing technologies in combination with the main features of renewable resources, which are: intermittency, energy storage, hybrid systems, energy management and load management..

4.1.3. Limitations in Non-interconnected Islands

Great interest has been expressed in wind energy development investments in the non-interconnected islands, due to the high wind energy potential, and electricity sales price.

In the past few years RAE established a methodology for determining the maximum allowed installed capacity and the issuing permissions for the electricity production from RES in the non-interconnected islands. According to the new rules, the limit of new capacity that can be installed and the extent to which production can be constrained will be determined for each island separately and will be revised every two years. The capacity and energy penetration limits will be calculated so as to ensure a minimal capacity factor of the order of 27.5%. It is worth mentioning that this procedure was put in place for the first and only time in spring 2003.

4.1.4. Interconnection of the Greek islands with the Mainland

Several studies on the interconnection of Greek islands with the mainland has been published or presented in the last years. A list of theses studies is given hereafter:

1. Study on the interconnection of Crete with the mainland
2. Studies on the Cycladic complex interconnection with the mainland
3. Strategic study on the interconnection of Greek islands

Cycladic islands

The interconnection of the Cycladic islands to the mainland system has been partly realized and it is currently under study to be expanded to include most major islands of the region. It presents a special interest because of the large length of the cable lines involved and the considerable electric power demand of particular islands and the group in total. The main part of these interconnections have been approved and are expected to be realized until 2015, except of the connection of Milos, which will be realized only in case of geothermal exploitation for power supply.

The benefits from the interconnections of the Cycladic Islands with the mainland are summarized:

- Increase the reliability of supply in the islands
- Reduce the operating hours of the oil-fired power stations decreasing local pollution
- Enable the gradual decommissioning of the autonomous diesel stations
- Increase the exploitation of the wind potential

Interconnection of North Aegean islands

The priorities in this islands complex are:

- 1st phase: Chios-Lesbos
- 2nd phase: Ikaria-Samos
- 3rd phase: Lemnos

Interconnection of Crete

The interconnection of Crete is not planning yet and then it is not expected to be realized until 2030.

Interconnection of Dodecanese complex

The interconnection of Dodecanese complex is examined in two levels:

- Among them
- And with the mainland through Crete (pre-feasibility study)

The interconnection of Dodecanese with the mainland via Crete is examined in the framework of this strategic study, but it is not yet planning.

Evaluation – Prospects

The interconnection of islands is a political will during the last years due to several reasons:

- Exploitation of the islands wind & solar potential
- High cost of local power stations
- Improvements in the technology of cables and underwater connections
- High rates of increase of the energy demand

- Difficulty in the sitting of new local conventional power stations
- Improvement of the quality of life and need for current of better quality
- Benefits for the consumers due to the market deregulation

Figure 1. Overview of the examined interconnections of all the Aegean islands

The financial evaluation of the above presented interconnections has been realized taking into consideration several issues.

The main technical conclusion of all the examined case studies is that the installation of underwater cable is technically feasible.

For the economical feasibility of the interconnections, most of the case studies examined are profitable and the others offer marginal profitability. It has been proved from the studies of the islands' interconnection that the benefits from the development of wind farms overcome the costs of underwater connections.

4.2. Economical issues

Economic issues refer to all the parameters influencing the competitiveness of RES with respect to conventional fuels or energy forms. Costs and prices of the market as well as the overall market conditions are the main driving forces, which define the competition between different energy alternatives. A list of the major economic issues that have to be examined in the development of plans for RES integration is given below:

4.2.1. Production Cost

The cost of producing heat and power depends on the type of the technology used, with conventional technologies being generally less expensive than renewable ones, as well as on time and location.

4.2.2. Prices and the liberalization process

In a perfectly competitive environment, prices are assumed to reflect the production costs, while being directed by the overall balance between demand and supply. Therefore, RES electricity producers who are not able to reduce production costs, are vulnerable to free competition. In fact, the progress of the liberalization process is quite dissimilar in each EU country, while energy prices do also greatly differ according to the adopted policies regarding:

Total charges on production costs

Environmental taxes

Subsidies

4.2.3. Funding Mechanisms

A key-factor for RES development is the availability of the necessary funds. Funding is combined with the transferring of the risk associated with RES investments. This is the case with Third Party Financing (TPF) which is widely applied for implementing innovative and/or high capital intensive technologies.

4.3. Environmental issues

The deterioration of the environmental quality and the growing environmental awareness of the last two decades has generally assisted in the development of RES, which are practically exempt from major environmental burdens. The most important environmental issues connected with RES exploitation are global warming and atmospheric pollution. The development of RES can positively affect environmental quality, which are affected by conventional systems, principally at the local level. Nevertheless, RES are often accused to cause also environmental repercussions, such as noise and visual intrusion, which do not have a detrimental effect on human health or on natural ecosystems, but sometimes cause a negative attitude of public against RES. Environmental effects of RES which should be taken into account in the design and implementation of local plans.

4.3.4. Protected habitats in the islands of DAFNI network – NATURA 2000

Greek islands possess a high degree of biodiversity at all levels-genetic, species, habitat and landscape. Many of the habitats have been identified as important to nature and are statutorily protected (NATURA 2000 network).

Accordingly to the recent ministerial decision, 49828/2008 (ΦΕΚ 2464 Β' / 03.12.08), RES installations are generally prohibited in these areas. The minimum allowed distance of potential RES installations from them is determined at case and depends mainly on the RES technology and the potential installed power.

4.4. Institutional issues – Legislation

The overall legislation regarding the operation of the energy sector may directly or indirectly affect the deployment of RES technologies. Relevant legislative measures can be classified in two broad categories:

4.4.1. Measures enhancing the development of RES

The greatest effect have regulations concerning the encouragement of RES projects and minimization of financial risks through incentives, such as subsidies, tax exemptions, pay-back tariffs and long-term contracts. Furthermore, the establishment targets and programs at the national or regional level related with the development of RES may also considerably motivate market forces.

4.4.2. Measures removing barriers hindering the development of RES

Pollution charges or taxes on fossil fuels constitute the opposite side of incentives for RES and have both the same objective.

Implementation of RES projects in Greece is usually retarded or hindered due to malfunctions created by administrative procedures and legal gaps. Among the most crucial barriers is the very complicated and time consuming process of issuing installation and operation licenses, a simplification of which is necessary.

4.4.3. Framework for the land-planning development of RES

A ministerial decision for the physical planning and allocation of RES published in December 2008, defining land-planning priorities, rules and constraints for the development of RES.

This decision defines general rules for the land planning of wind farms, hydro-power plants and rest RES. It divides the national territory into four main categories:

- Mainland (including Evia),
- Attika region,
- Inhabited Aegean and Ionian islands (including Crete)
- Uninhabited islands.

According to this ministerial decision, two types of regions of special interest for wind power plant developments in mainland Greece are identified: Regions of Aeolian Priority (RAP), which assemble the highest priority, and Regions of Aeolian Suitability (RAS), which are defined as suitable for potential wind power plant developments under favorable conditions (mainly areas with high wind energy potential).

Additionally, the required distances of wind farms, and biomass power plants from other land uses, activities and infrastructures are defined. Finally, there is an attempt for the quantification of the visual effect of wind farms.

It should be noted that the islands, which are always areas with abundant wind potential are not considered as Regions of Aeolian Priority neither Regions of Aeolian Suitability. Additionally, the individual features of this geographical area are recognized and additional restrictions are defined. Moreover, special criteria of allocation of RES for inhabited islands are set.

4.5. Social acceptance

The large-scale deployment of RES is expected to produce benign effects on employment, regional development and public finance. However, in many cases, societies raise obstacles to RES development.

4.5.3 What's going on in Greece

In general

Beyond the technical-economical obstacles, the policy and the legislation, the penetration of RES and energy saving techniques in a society is determined to a great degree by their social acceptance.

In Greece, in general terms, there is a lack of social acceptance of RES, mainly when it comes at large investments for electricity generation, as wind parks, hydroelectric plants and geothermal electricity output units. It is fact that in Greece there is deficit of informing and sometimes mistrust towards RES.

With regard to the local authorities, they are often possessed by scepticism toward RES and often raise objections.

Local societies are not ready for RES utilization, mainly because of their ignorance and lack of informing, while, in general, energy saving techniques are faced rather positively, however with some scepticism.

Social acceptance of RES and energy savings in the islands

The general attitude of residents and local authorities of islands towards RES and energy savings, with regard to small scale applications, is rather positive, without however some reactions, objections, disagreements and skepticism. The attitude of local societies changes in general terms proportionally to the MWs of the potential RES installations. As far as wind turbines are concerned, one of their main reasons of opposition of residents is the aesthetics, which is subjective, and makes them afraid of loosing their tourism rates. The other causes for objection of societies are owed in their ignorance and lack of briefing and familiarization with RES.

Nevertheless, some local societies and local authorities of islands tend to be more positive towards RES applications. Such societies are those that have been informed adequately, or have been familiarized with wind turbines, or are not based mainly on the tourism for their growth, therefore are less afraid of any repercussions in this sector.

Another important reason for which local societies of islands, but also of mainland, react in the RES investments, and more specifically in wind farms' installation is their suspiciousness against private investors. Greeks are regionalists, that's why they cannot tolerate private growth and development. However, a method for changing this negative attitude, is to include the residents of a region or municipality that hosts RES investments as shareholders.

From the above, results the necessity of a national strategic approach on public briefing and awareness via the media and the press. Moreover, briefing of local authorities is required in order that these will advance not only in the briefing of citizens, but also in pilot projects and RES installations.

Informing of public, dissemination activities and action to the sensitization of local societies are required. This can be strengthened from the interest of private institutions and stakeholders of local market, from the action of not governmental organisations and policy makers and from the informing of local authorities.

Large scale RES installations in islands

With regard to potential large scale RES installations, such as wind parks or geothermic plants the attitude of societies is almost always opposite. Specifically, in the case of small islands the reactions against large scale RES applications are very intense. Inevitably, those create negative attitude and suspiciousness in the local societies, because these societies are immature to accept such large RES penetration, while in certain cases, these projects are excessive and exceed the scale of such small and sensitive islands. The controversial question of size of potential RES applications (wind farms) can be approached with various scientific and effective ways, as is the landscape architecture, combined with study of various likely scenarios of investment.

5. Potential of RES and savings

5.1. Wind potential

5.1.1. Resource - Wind Speed

Greek islands have very good wind energy potential. Various institutions have performed measurements of wind speed and have shown that most of the islands have wind speed potential between 7 and 11 m/s. Maps of the wind energy potential and an estimation of the technically and economically available wind potential of the Aegean islands are presented in the Report.

5.1.2. Existing applications for wind energy development in Greek islands

In the Report, the current situation of the wind farms' applications in Greece is presented. Off course, there is a large distance between the application and the operation of a wind farm, especially due to the bureaucracy and the strict license procedure in Greece.

Applications for large scale wind farms in islands

There are several applications for large scale wind farms in islands. Some large investors and companies plans to install large wind farms in islands undertaking the underwater interconnections with the mainland.

Such applications, that have particularly favorable wind potential, have caused intense reactions from local communities.

Applications for wind farms in uninhabited rock islands

There are three applications for wind farms in uninhabited rock islands close to Attica region.

Applications for off shore wind farms

There are only some few applications for off shore wind farms.

5.2. Solar potential

5.2.1. Solar resource

Greece is a country with great sunlight that is suitable for the exploitation of solar energy. Abundant solar irradiation is provided in the Aegean islands, especially in those of the South Aegean Sea, and with a noticeable duration all over the year.

Maps of the yearly sum of global irradiation in Greece, are presented in the Report.

This solar potential can be exploited by installation of solar-thermal systems, mainly for the production of domestic hot water, a sector which has been already quite developed in Greece, since many years, but also by installation photovoltaic systems for electricity production, that is still in the earlier stage in Greece.

5.3. Geothermal energy

The geological conditions in Greece encouraged in general the creation of very important geothermal potential. At the maps included in the Report, are presented the geothermal fields of the Aegean islands, where geothermal potential in Aegean islands is considerable.

The temperature of the geothermal fluid or steam, varies from region to region. Fields of low enthalpy are more common (Lesvos, Chios, Kos, Milos, Santorini, Limnos, Samothraki, Kos, Kythnos, Ikaria). In the cases where geothermal fluid has high temperature, the geothermal energy can be used mainly for electricity generation. Such cases are the high enthalpy fields of Nisyros and Milos.

Despite the undoubted existing wealth of geothermal potential, applications of geothermal energy for electricity generation have not been installed in the Aegean islands, due to social opposition. However, at the moment, appears that the reactions begin to be bent slowly and new proposals are under issue.

5.4. Biomass

5.4.1 Energy from Waste

Energy from waste refers to any waste treatment that creates energy in the form of electricity or heat from a waste source.

Producing energy from waste through producing of combustible fuel commodity, which is the most common, and mature technology for the exploitation of energy from waste, requires the existence of an operating wastes sanitary burial space. It is important that the wastes sanitary burial space operates for many years so as to maintain a significant potential of landfill combustible fuel. Thus, the potential for producing energy from waste depends on the existence of such places and their potential, which is expressed by the amounts of the mean annual rejected waste and their total operating period.
Unfortunately very few of the islands have such landfills, so that the potential for electricity production is limited.

5.4.2. Woodfuel for heating

The most common use of biomass in Greece as a fuel for space heating (sometimes also for water heating) is the combustion of wood into fireplaces and woodstoves. Specifically in islands, woodfuel production is limited. There are only few islands that the houses have fireplaces, and these are mainly the islands of North Aegean, which have some wood fuel production and colder winter.

New energy efficient woodstoves have appeared in market. Such systems reach high efficiency factors, are cost effective and can be easily integrated. Thus, if promoted adequately, they could have a high penetration in these islands, so that the oil consumption for heating will be reduced.

5.5. Potential of savings

In Greece, guidelines and ministerial decisions towards the adoption of the European directive 2002/91/CE related to energy efficiency in buildings are under issue. At the moment, Greece has just set the regulations for the EPBD (Energy Performance of Buildings Directive).

Applications of RE technologies and energy saving techniques can be promoted in buildings, especially in public and hotel buildings.

5.5.1. Potential of savings at municipal, public and school buildings

There is no doubt that applications at municipal, public and school buildings could have great demonstrative character and influence social acceptance towards energy saving.

5.5.2. Potential of savings at hotels

Tourism sector provides a great potential of energy savings. Hotels can be converted into energy efficient buildings, increasing the profit margin in the tourism sector.

5.5.3. Potential of savings at households

A main target group of Agency's actions promoting energy efficient buildings is the domestic sector.

Information campaigns will be conducted, aiming at the penetration of energy efficient techniques and technologies to households.

6. Water Shortage - Desalination using RES

Water shortage is one of the most significant problems of the Greek islands, which is magnified during the summer season because of the massive number of tourists that visit them. Many of the islands are almost completely dependent on water transportation from the mainland, especially in summer season. Towards the search of a solution for this problem, the Agency will study the **integration of desalination technologies using RES**.

To this direction, the islands that depend from water transportation in order to cover their needs, as well as islands that have already installed conventional desalination units, have been identified. Moreover, data for transported quantities of fresh water in each island, distances covered by water transfer ships, average costs of transported water and water pricing policies have been evaluated towards the prioritization of the following actions. Moreover, is presented the average annual cover of water supply and irrigation needs of the islands of DAFNI network, as part of a preliminary draft for management of water resources of Aegean islands.

7. Classification – Producing indicators

For the prioritization of the actions that will consist the strategy for an efficient energy planning and will determine the next steps of the Agency, a classification procedure of the islands was needed. To this direction, several indicators were produced, as regards:

- The islands' features (population, area, population density, tourism development, status of the grid's interconnection, electricity production cost)
- The building (domestic, public & tourism) sector (heating needs, manufacturing activity, buildings' age, hotel beds, beds/hotel)
- PV development (solar potential, subsidy rates, applications for PVs)
- Geothermal fields
- Water Shortage – Desalination (transported quantities of fresh water, distance covered by water transfer ships)

8. Future planning

The future planning is determined on the basis of the results obtained in all previous steps and specifies the time and means needed to achieve the maximum integration of RES in the islands with respect to the local environmental and social character. Priorities are identified.

8.1. Actions

The interconnection of the autonomous islands and the exploitation of the wind potential, is consisted in the following actions:

- **interconnection of islands with the mainland**
- **development of hybrid systems (wind-hydro)**
- **large scale wind integration**
- **moderate wind development**
- **small wind turbines**

The development of **photovoltaic systems** is examined in the following categories:

- **on-grid**
- **building integrated systems**

The exploitation of the **geothermal energy**, is examined in the following actions:

- **electricity production**
- **heating (buildings)**
- **heating (greenhouses)**

The exploitation of the **biomass potential**, is examined in the following actions:

- **energy from waste**
- **agriculture & energy crop cultivation**
- **woodfuel exploitation**

The further development of **solar hot water systems** is examined in the following sectors:

- **households**
- **hotels**

The development of **solar heating and cooling systems** is examined only **in hotels**.

The **energy efficiency in buildings** is examined separately in:

- **households**
- **hotels**
- **public buildings (municipal buildings, schools)**

The **desalination with RES** is a separately action.

Finally, the **transport sector** is examined at a local level using **biofuels & hydrogen** only for **public vehicles and public transportation buses**.

8.2. Terms

First of all, actions require a short medium or long term planning. The implementation of an action in **short, medium or long term** depends on several factors:

- the nature of the action and the required time for the planning and the implementation
- the maturity of the technology
- the legislation
- the investors interest

8.3. Priorities

The identification of an action as a **high medium or low** priority action depends on several factors as well:

- regional or national benefits
- cost effectiveness
- maturity of the technology
- potential
- need for remove of barriers
- public acceptance

8.4.Results

8.4.1. Exploitation of the wind potential

			wind energy		
island	**interconnection prospects**	**hybrid (wind-hydro) RES systems**	**large scale wind integration**	**moderate wind development**	**small wind turbines**
Aigina	√	–	–	–	* / M
Alonnisos	√	–	** / M	** / S	* / M
Amorgos	** / L	** / M	** / L	* / S	* / M
Andros	√	–	** / S	** / S	* / M
Irakleia	** / M	* / M	–	–	** / M
Ios	** / M	*** / S	* / M	* / S	** / M
Kea	√	–	** / S	* / S	* / M
Kimolos	** / L	** / M	–	–	* / M
Koufonisi	** / M	–	–	–	** / M
Kythnos	** / M	*** / S	** / M	** / S	* / M
Kos	* / L	** / M	** / L	** / S	* / M
Lipsi	* / L	** / M	* / L	–	* / M
Lesvos	* / L	*** / S	*** / M	√	** / M
Limnos	* / L	* / M	*** / M	** / S	** / M
Milos	** / L	* / M	* / M	√	* / M
Myconos	** / M	* / S	* / M	** / S	** / M
Naxos	** / M	*** / M	** / M	** / S	** / M
Nisiros	* / L	** / M	–	–	* / M
Paros	** / M	** / M	** / M	** / S	** / M
Patmos	* / L	* / S	–	* / S	* / M
Rhodes	* / L	*** / M	** / L	** / S	** / M
Samothraki	√	–	** / L	* / S	* / M
Santorini	* / L	* / M	–	–	* / M
Sikinos	** / M	** / S	* / M	* / S	* / M
Sifnos	** / M	** / M	* / M	* / S	* / M
Skopelos	√	–	* / M	* / S	* / M
Skyros	*** / M	** / S	*** / S	–	* / M
Syros	** / M	* / M	–	* / S	** / M
Shoinoussa	** / M	** / M	–	–	* / M
Tilos	* / L	** / M	–	–	* / M
Folegandros	** / M	** / M	* / M	* / S	* / M
Chios	* / L	** / M	*** / M	** / S	** / M

Table 8.1

8.4.2. Geothermal energy and Biomass

	geothermal energy					
		heating		**biomass**		
island	**electricity production**	**buildings**	**greenhouses**	**energy from waste**	**agriculture & energy crop cultivation**	**woodfuel exploitation**
Aigina	–	–	–	–	* / M	–
Alonnisos	–	–	–	–	* / M	** / S
Amorgos	–	–	–	–	–	–
Andros	–	–	–	–	* / L	–
Irakleia	–	–	–	–	–	–
Ios	–	–	–	–	–	–
Kea	–	–	–	–	* / L	–
Kimolos	–	** / M	* / M	–	–	–
Koufonisi	–		–	–	–	–
Kythnos	–	* / M	* / M	–	–	–
Kos	–	** / M	** / S	** / L	* / M	–
Lipsi	–	–	–	–	–	–
Lesvos	–	*** / S	** / S	** / M	*** / M	** / S
Limnos	–	* / M	* / M	** / S	*** / M	* / M
Milos	*** / S	*** / S	*** / M	–	–	–
Myconos	–	–	–	–	* / L	–
Naxos	–	–	–	* / L	* / M	–
Nisiros	*** / S	*** / S	* / M	–	** / M	–
Paros	–	–	–	–	* / L	–
Patmos	–	–	–	–	–	–
Rhodes	–	–	–	*** / S	* / L	* / S
Samothraki	–	* / M	* / L	–	* / L	* / S
Santorini	–	** / M	** / M	** / L	* / M	–
Sikinos	–	–	–	–	–	–
Sifnos	–	–	–	–	–	–
Skopelos	–	–	–	–	** / M	*** / S
Skyros	–	–	–	–	* / L	* / M
Syros	–	–	–	** / L	* / L	–
Shoinoussa	–	–	–	–	–	–
Tilos	–	–	–	–	–	–
Folegandros	–	–	–	–	–	–
Chios	–	* / M	* / S	** / M	* / M	** / S

Table 8.2

For the electricity production, only the islands that have geothermal fields of high enthalpy are included.

For the heating in buildings, in the second column only the islands that have geothermal fields of low enthalpy are included.

For the heating in greenhouses only the islands that have geothermal fields of low enthalpy and grenhouses are included.

8.4.3. Solar applications

	PVs		solar hot water		
island	**on-grid**	**building integrated systems**	**households**	**hotels**	**solar heating & cooling**
Aigina	* / M	** / M	** / S	*** / S	* / M
Alonnisos	* / M	* / M	* / S	*** / S	** / M
Amorgos	** / S	** / M	* / S	* / S	–
Andros	* / M	* / M	** / S	* / S	–
Irakleia	** / M	** / M	* / S	* / S	–
Ios	** / S	** / M	* / S	*** / S	* / M
Kea	* / M	* / M	* / S	* / S	* / M
Kimolos	* / S	** / M	* / S	* / S	–
Koufonisi	** / M	** / M	* / S	** / S	–
Kythnos	*** / S	** / M	* / S	* / S	** / M
Kos	*** / S	*** / S	*** / S	*** / S	*** / S
Lipsi	** / M	** / S	* / S	* / S	–
Lesvos	*** / S	*** / S	*** / S	* / S	** / M
Limnos	*** / S	** / S	** / S	* / S	** / M
Milos	** / S	** / M	* / S	** / S	* / L
Myconos	** / S	** / M	* / S	*** / S	** / M
Naxos	** / S	** / M	** / S	** / S	* / M
Nisiros	* / S	** / M	* / S	* / S	–
Paros	** / S	** / M	* / S	*** / S	* / M
Patmos	** / S	** / M	* / S	*** / S	* / L
Rhodes	*** / S	*** / S	*** / S	*** / S	*** / S
Samothraki	* / S	** / M	* / S	** / S	–
Santorini	* / S	** / M	* / S	*** / S	* / M
Sikinos	** / M	** / M	* / S	* / S	–
Sifnos	** / S	** / M	* / S	** / S	–
Skopelos	* / M	* / M	* / S	*** / S	** / M
Skyros	** / S	** / M	* / S	* / S	–
Syros	* / S	** / S	** / S	* / S	* / M
Shoinoussa	** / S	** / M	* / S	** / S	–
Tilos	** / M	** / M	* / S	** / S	–
Folegandros	** / M	** / M	* / S	*** / S	–
Chios	*** / S	*** / S	*** / S	* / S	** / M

Table 8.3

8.4.4. Energy efficiency in buildings

	energy efficiency in buildings			
			public buildings	
island	households	hotels	municipal buildings	schools
Aigina	*** / S	** / S	** / S	** / S
Alonnisos	** / S	** / S	* / M	** / S
Amorgos	* / M	* / M	* / M	* / S
Andros	** / S	* / M	* / M	* / S
Irakleia	* / M	* / M	–	* / L
Ios	* / M	** / S	* / M	* / S
Kea	** / S	* / M	* / M	* / S
Kimolos	** / S	* / M	–	* / M
Koufonisi	** / S	* / M	–	* / L
Kythnos	* / M	* / S	* / M	* / S
Kos	* / S	*** / S	** / S	** / S
Lipsi	** / S	* / M	–	* / M
Lesvos	*** / S	* / S	*** / S	*** / S
Limnos	*** / S	* / S	** / S	*** / S
Milos	* / S	* / S	* / M	* / S
Myconos	* / M	** / S	* / M	* / S
Naxos	* / M	** / S	* / S	** / S
Nisiros	* / M	* / M	–	* / M
Paros	* / M	** / S	* / S	** / S
Patmos	** / S	* / S	* / M	* / S
Rhodes	* / M	*** / S	*** / S	** / S
Samothraki	*** / S	* / S	* / M	** / S
Santorini	* / S	** / S	* / S	** / S
Sikinos	* / M	* / M	–	* / L
Sifnos	** / S	* / S	* / M	* / S
Skopelos	** / S	** / S	* / M	** / S
Skyros	* / S	* / M	* / M	** / S
Syros	* / M	* / S	*** / S	** / S
Shoinoussa	* / S	* / M	–	* / L
Tilos	* / S	* / S	–	* / M
Folegandros	* / S	* / S	–	* / M
Chios	*** / S	* / S	*** / S	*** / S

Table 8.4

8.4.5. Desalination and transport sector

island	desalination & RES	transport sector (biofuels & hydrogen at public vehicles & trasportation)
Aigina	* / L	* / L
Alonnisos	–	–
Amorgos	** / S	* / L
Andros	–	* / L
Irakleia	* / S	–
Ios	* / M	* / L
Kea	* / L	–
Kimolos	*** / S	–
Koufonisi	*** / S	–
Kythnos	* / M	–
Kos	–	** / L
Lipsi	*** / S	–
Lesvos	–	** / L
Limnos	–	* / L
Milos	√	* / L
Myconos	* / M	* / L
Naxos	–	* / L
Nisiros	** / S	–
Paros	* / M	* / L
Patmos	*** / S	* / L
Rhodes	–	** / L
Samothraki	–	–
Santorini	** / S	* / L
Sikinos	** / S	–
Sifnos	* / M	* / L
Skopelos	–	* / L
Skyros	–	–
Syros	* / S	* / L
Shoinoussa	** / S	–
Tilos	–	–
Folegandros	*** / S	–
Chios	* / M	** / L

Table 8.5

ANNEX

Presentation of the case studies islands

This annex is a summary of the analytical presentation of 4 of the 32 case studies islands that are presented in the final report.
These islands are: Ios, Kos, Santorini and Lesvos, and are presented at the map below:

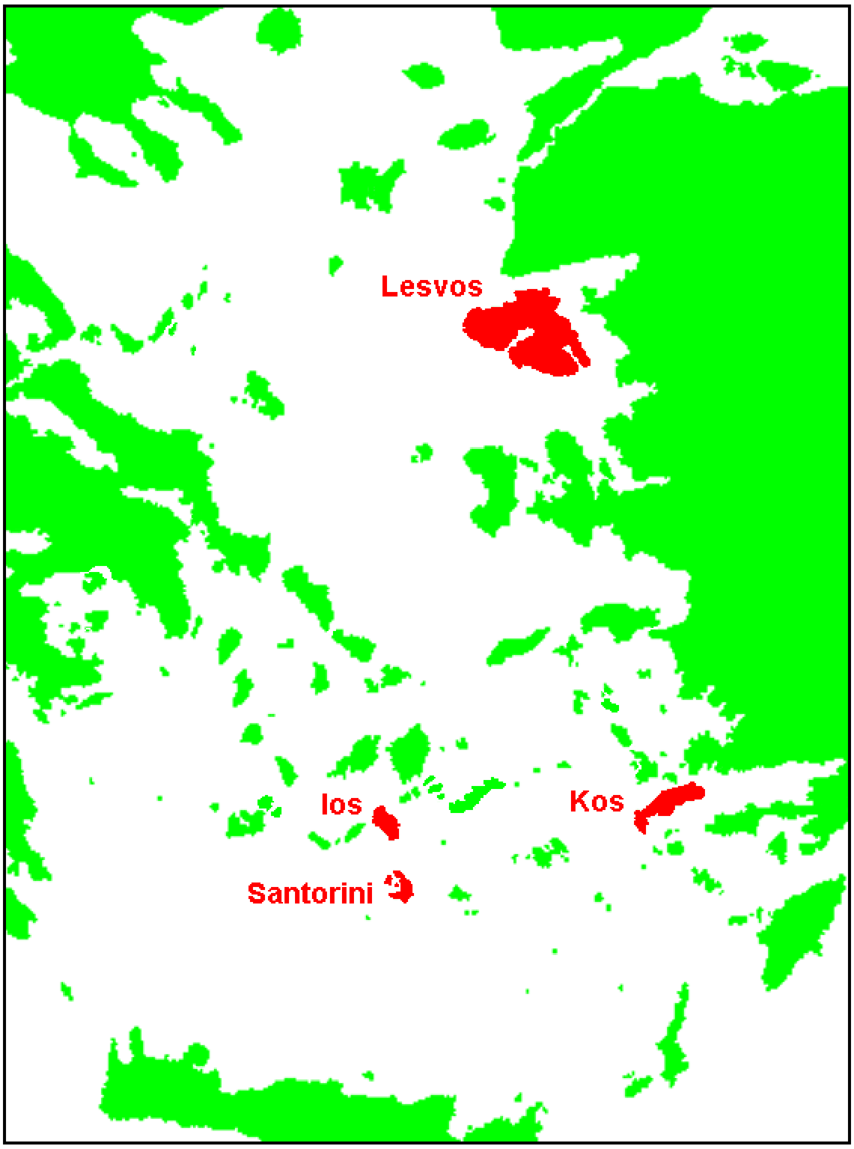
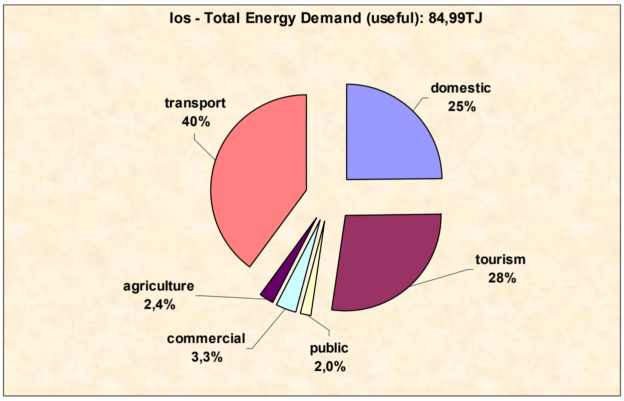


Figure 2. 4 of the 32 case studies islands that are presented in the final report

Ios

Area: 109.024 km^2	**Island Chain:** Cyclades	**Population:** 1.838 (2001)	**Density:** 17 /km²

Energy balance



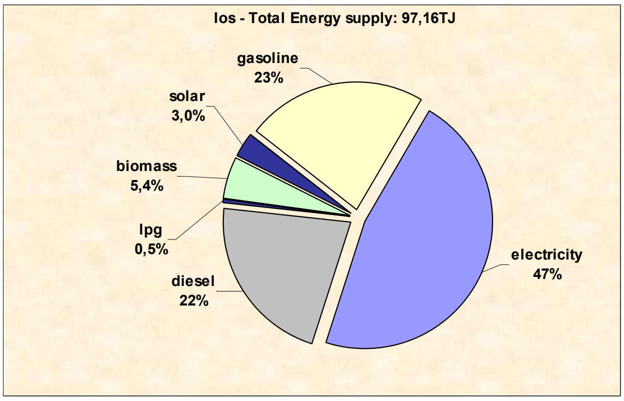


Figure 1. Total energy demand (useful) – supply in Ios island (2007)

The electrical system

Status of grid's interconnection:	**Annual rate of increase of electricity demand:**	**Annual electrical energy demand (2006):**	**Peak of electricity demand (2006):**
Connected with other islands. (Ios is part of Paro-Naxia autonomous system, which includes Paros, Antiparos, Folegandros, Ios, Irakleia, Koufonisi, Naxos, Sikinos and Sxoinousa. The local power station of this system is located in Paros.)	12%	12.6 GWh	3,9 MW

RES potential - Current development of RES

Figure 2. Current development of RES (applications and installations)

There are three wind turbines in operation:

- 0.6MW – Purgos – with operation license
- 0.56MW (2*0.28MW)– Pelekania - with operation license

There are two applications for photovoltaics:

- 99.36kW – Almiros – under the evaluation procedure
- 149.04kW – Pelekania - under the evaluation procedure (same owner with the wind turbine)

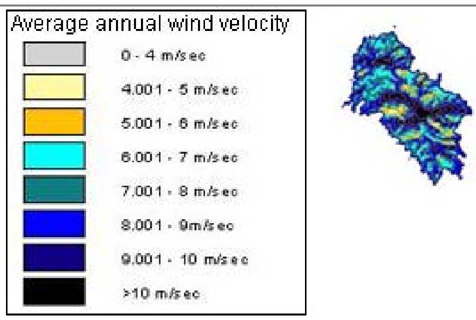


Figure 3. Wind potential

Water demand - supply

Annual water demand and supply (Ministry of Development, 2008):

Desalination (%)	Transported amounts (%)	Reservoirs (%)	Subareal water (%)	Supply (%)	Demand (m^3)
38,48		1,27	60,25	100	278.987

Energy plan

Short term:	**Medium term:**	**Long term:**
hybrid (wind-hydro) RES systems, solar hot water (hotels), PVs (on grid), energy efficiency in buildings(hotels)	Interconnection, small wind turbines, PVs (building integrated systems)	

Kos

Area: 290.313 km²	**Island Chain:** Dodecanese	**Population:** 30.947 (2001)	**Density:** 107 /km²

Energy balance

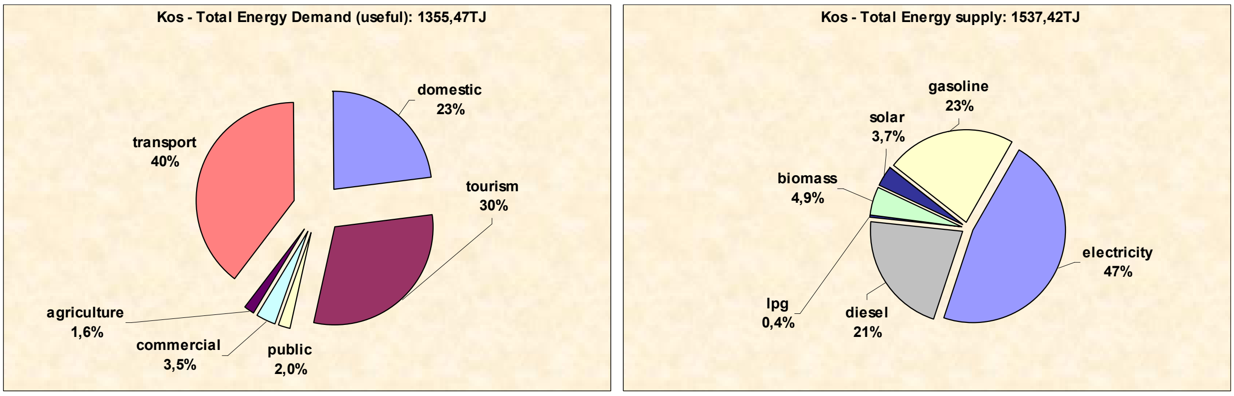


Figure 1. Total energy demand (useful) – supply in Kos island (2007)

The electrical system

Status of grid's interconnection: Connected with other islands (Kos is part of the autonomous system of Kos-Kalymnos which includes Kos, Kalymnos, Leipsoi, Nisiros, Pserimos, Telendos and Telos. Local power stations are located in Kos and Kalymnos). In Kos there are 12 thermal power plants (diesel and HFO) with total capacity 78MW.	**Annual rate of increase of electricity demand:** 7%	**Annual electrical energy demand (2006):** 156.3 GWh	**Peak of electricity demand (2006):** 41,1 MW

RES potential - Current development of RES

Figure 2. Current development of RES (applications and installations)

There are around 30 applications for PVs and several for wind farms.
As regards the wind farms:

- One wind farm is in operation.
- 3,6MW – Kouvas (municipality of Dikaiou)– Installation license
- 15.3MW – Kardamaina (municipality of Kos) – Negative response from ministry of development
- 7.2MW – Varavola (municipality of Kos) – Negative response from ministry of development
- 2.4MW – Agia Marina (municipality of Kos) – under the evaluation procedure
- 1.8MW – Ag.Marina (municipality of Kos) – with production license

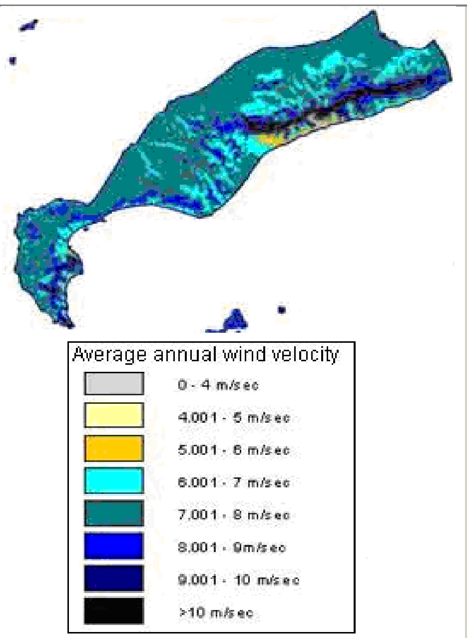


Figure 3. Wind potential

Water demand - supply

Annual water demand and supply (Ministry of Development, 2008):

Desalination (%)	Transported amounts (%)	Reservoirs (%)	Subareal water (%)	Supply (%)	Demand (m^3)
			98,55	98,55	5.428.825

Energy plan

Short term: PVs (on-grid &building integrated systems), solar hot water (households & hotels), solar heating & cooling, energy efficiency in buildings (hotels, municipal, schools), moderate wind development, geothermal energy (heating-greenhouses)	**Medium term:** hybrid (wind-hydro) RES systems, geothermal energy (heating-buildings)	**Long term:** large scale wind integration, energy from waste, transport sector (biofuels, hydrogen)

Santorini

Area: 73 km²	**Island Chain:** Cyclades	**Population:** 13.402 (2001)	**Density:** 184 /km²

Energy balance

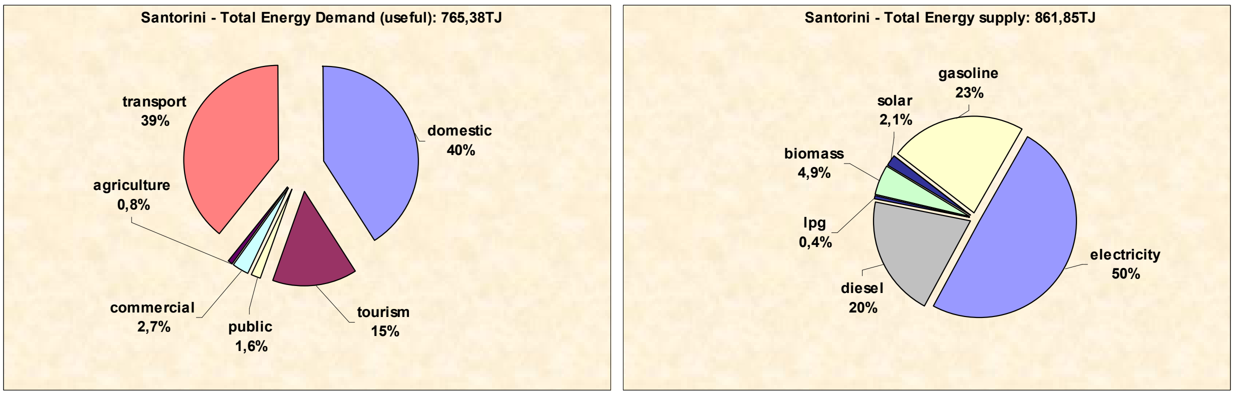


Figure 1. Total energy demand (useful) – supply in Santorini island (2007)

The electrical system

Status of grid's interconnection:	**Annual rate of increase of electricity demand:**	**Annual electrical energy demand (2006):**	**Peak of electricity demand (2006):**
Autonomous. (Santorini is an autonomous power supply system with local power station. Thirasia is supplied through an underwater cable) In the local power station of Santorini, there are 10 thermal power units (diesel and HFO), with cumulative capacity 33.1MW.	9%	106.8 GWh	34 MW

RES potential - Current development of RES

Figure 2. Current development of RES (applications and installations)

There are three applications for 220kW photovoltaics installations (Delendra-Soultanina, Mauropoulou-Messarias and Firostefani). Additionally, there are three wind farms (1.7MW in Mouzakia, 1.98MW in Xilogarades-Thirasia and 4.5MW in Kimisi-Kerasia-Kera) under the evaluation procedure. And one wind farm of 1.32MW capacity with production license in Agia Faneromeni-Louroi.

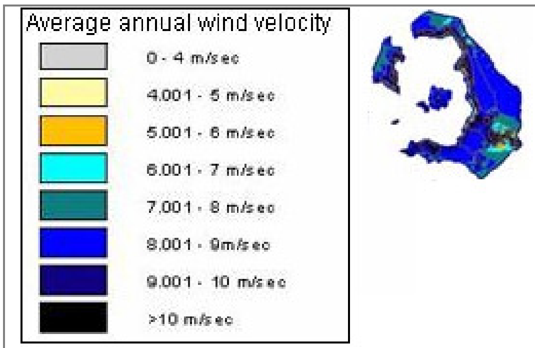


Figure 3. Wind potential

Water demand - supply

Annual water demand and supply (Ministry of Development, 2008):

Desalination (%)	Transported amounts (%)	Reservoirs (%)	Subareal water (%)	Supply (%)	Demand (m^3)
4,28	0,36	25,87	54,32	84,83	1.984.189

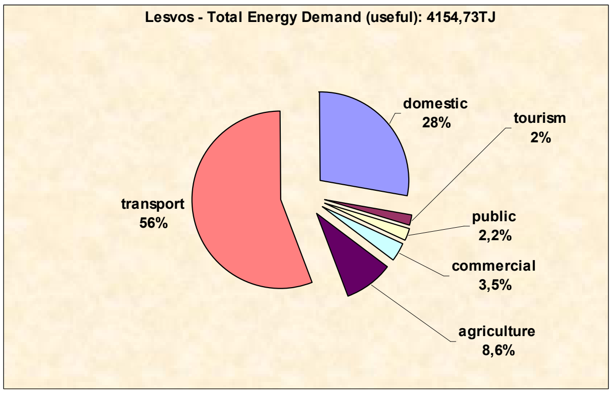
Energy plan

Short term:	**Medium term:**	**Long term:**
solar hot water (hotels), desalination & RES, energy efficiency in buildings (hotels & schools)	geothermal energy (heating - buildings & greenhouses), PVs (building integrated systems)	energy from waste

Lesvos

Area: 1.632.819 km²	**Island Chain:** North Aegean	**Population:** 90.643 (2001)	**Density:** 56 /km²

Energy balance



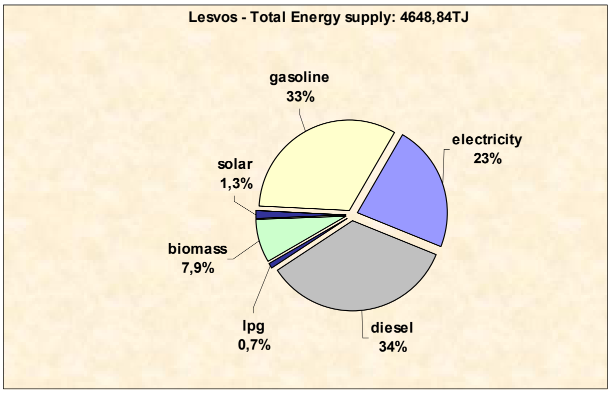


Figure 1. Total energy demand (useful) – supply in Lesvos island (2007)

The electrical system

Status of grid's interconnection: Autonomous (Lesvos is an autonomous non-interconnected island with local power station.) In the local power station of Lesvos, there are 11 thermal power units (diesel and HFO), with cumulative capacity 77MW.	**Annual rate of increase of electricity demand:** 9%	**Annual electrical energy demand (2006):** 258.7 GWh	**Peak of electricity demand (2006):** 64.6 MW

RES potential - Current development of RES

Figure 2. Current development of RES (applications and installations)

150 applications for photovoltaics and 26 for wind farms.

Among them there are several applications in the north and east Lesvos, which consist a part of the the huge plan of 1600MW from Rokas – Iberdrola in Lesvos, Chios, Lemnos.

Currently, 11,8MW wind farms are in operation (Eletaen 2007).

Wind farm capacity (MW)	Number of wind turbines	Type of wind turbine
2,03	9	VESTAS
0,60	2	HMZ WINDMASTER
0,23	1	MICON
4,20	7	ENERCON
4,80	8	ENERCON

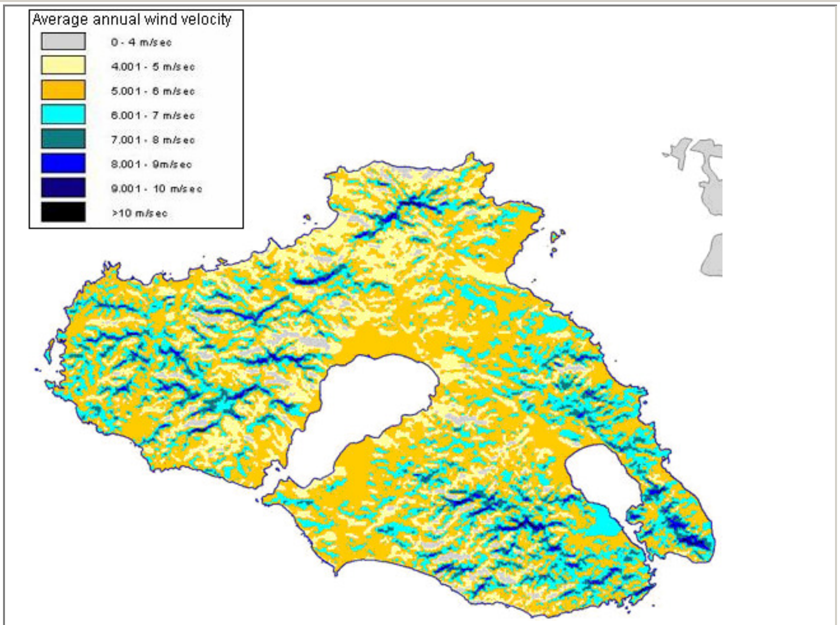


Figure 3. Wind potential

There is also an application with production licence for a 8MW geothermal application of electricity production in the municipality of Petra in Stipsi.

Water demand - supply

Annual water demand and supply (Ministry of Development, 2008):

Desalination (%)	Transported amounts (%)	Reservoirs (%)	Subareal water (%)	Supply (%)	Demand (m^3)
			99,04	99,04	9.135.851

Energy plan

Short term:
PVs (on-grid &building integrated systems), energy efficiency in buildings (households, municipal buildings, schools), hybrid (wind-hydro) RES systems, geothermal energy (heating–buildings & greenhouses), biomass - woodfuel exploitation, solar hot water (households)

Medium term:
large scale wind integration, small wind turbines, biomass - agriculture & energy crop cultivation, energy from waste, solar heating & cooling

Long term:
transport sector (biofuels & hydrogen at public vehicles & trasportation)