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# RERINA
# D2.2.v4
# Typology of RET Uses in Insular Areas

## PUBLIC

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# 1. Introduction

Within the scope of RE-RINA project is to identify and study the various energy uses in European Insular Areas that can be accommodated by renewables, as well as to identify the alternative Renewable Energy Sources (RES) and corresponding Renewable Energy Technologies (RETs) that are appropriate for accommodating these uses. This attempt will lead to the development of a typology of RET Uses in European Insular Areas which will facilitate the selected group of interest to identify what are the alternative RETs appropriate to be implemented for satisfying the different energy needs within the insular area under consideration each time. It will also facilitate the identification of best-practice and the transfer of know how on RETs applications within different insular areas.

The objective of this task is to develop a typology that will identify and systematically categorise the different types of RETs' use that are appropriate for remote, ecologically sensitive island areas.

The development of such a typology is imperative for the identification of the alternative RETs appropriate to different insular areas, the prioritisation of these RETs in terms of their requirements and operational performance with regards to the islands/areas characteristics and therefore the development of a comprehensive and complete Local Plan for the development of Sustainable Energy Island Community.

The developed typology will have substantial contribution in increasing market penetration of small scale RETs and therefore effectively promoting reasonable costs of these technologies. Therefore the development and validation of a typology of RET use in remote, ecologically sensitive insular areas including the corresponding RET typology will have a substantial contribution to standards.

This report is organized into five sections. Section one presents the methodological approach developed and rational followed for the implementation of the typology. Section two presents the main examples of the RET schemes including the best available RETs, while section three provides the major well tested Energy Efficiency applications. In section four exist some successful technological paradigms from those applications. Section five contains a list of the typology of the most common uses, which was developed within RE-RINA based on the analysis of the partners.

Special attention was given to select and present information, which seems simplistic to the mature experts, but it is essential for the next steps of the current project.

# 1. Methodological Approach

In order to develop the Typology of RETs Use in European Insular Areas a methodological approach has been developed and implemented. This approach is based on the rationale that the developed typology should guide local planners to identify what type of RES can provide energy appropriate to accommodate their needs spatial conditions, and what are the alternative technologies (RETs) per RES type that could be considered in order to choose the most appropriate technology to implement. Therefore, the developed typology should also provide local planers with the necessary information that will support an initial decision on selecting the RETs to be implemented, i.e. the typology should provide information on the operational requirements of RETs and on their impacts (i.e. costs and benefits).

As illustrated in the figure 1, the first methodological step is to identify the main energy uses and the areas of application of these energy uses based on the potential socio-economic activities the demographic, cultural and environmental characteristics of an insular area. The second step involves the identification of the alternative RES that are appropriate to provide the required energy within the different types of use. Within the third step the categories of RETs that can be applied for the production of energy in each type of energy use, their decisive to be applied requirements and their expected costs and benefits will be identified. Finally, within the fourth step the best available technologies from each identified RETs category and for each category of energy use application will be identified.

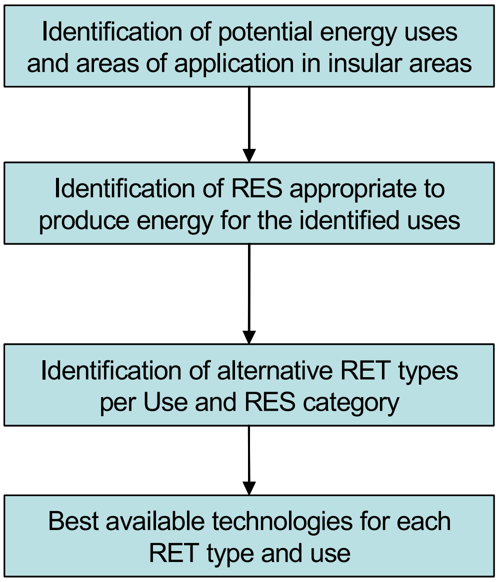


Figure 1.1. Methodological Steps for Developing the RETs Uses Typology for European Insular Areas

An important issue that has been considered in the development of this typology is that further to the identification of the different RET uses concerning the development of energy, there are several RETs that are related to the RUE and which are very important for the implementation of Sustainable Communities. Therefore, considering that within an insular area the major activities that rationalization of the use of energy can be considered is residential and tourism the typology is focusing on issues related to rationalization of the use of energy in buildings. The part of the typology that is related to RUE applications is considered as separate part as can be identified in the next section of this report.

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# 2. Examples of Renewable Energy Technology Schemes

## 2.1. Wind Energy

*Wind turbines convert the kinetic energy in wind to mechanical power that runs a generator to produce electricity. Wind turns the blades, which spins a shaft connected to a generator that makes electricity. Major components include the rotor, nacelle, tower, and foundation.*

*The rotor is at the centre of the spinning part of the turbine and turns the electric generator in the nacelle. Large turbines are roughly 80 m tall, where the winds are stronger and less turbulent.*
*Wind is cost competitive with other generation sources. The fuel is free, and environmental impacts are minimal.*

### *2.1.1. Wind Basics*

Many people, even in the Mediterranean islands, still think of wind power as the old farm windmills or the small wind spinners that help to power cabins or farm sites. However wind technology has made great progress in the past 20 years and today wind is the fastest growing source of electricity in the world. The technology has been developed to the point that wind is cost-competitive with the conventional generation sources. It has incomparable less environmental impacts compared to the conventional energy sources and the fuel is free.
Wind turbines installed in EU are as large as 5 MW each with capacity factors of up to 40%.

Today many wind developers have enough experience on successful wind projects, building large projects of tens of wind turbines. Municipal and cooperative utilities have built smaller projects of two or three turbines each.

In addition, wind turbines have been installed in several schools in order to offset some of the buildings' electricity use and to educate students and the community at large.

### *2.1.2. Farmer owned wind*

In Denmark, much of the wind development is owned by farmer-owned cooperatives. This is an intriguing idea as well, and many are interested in the idea that farmers can develop and own wind projects, "harvesting the wind" on their own land. Locally-owned wind projects are appealing because they keep more of the revenue from the projects in the community. There are now several groups of farmers with small projects and a couple of models for farmer-owned wind.

Farmer-owned wind projects, which have all of the same elements of any other wind project depend on a number of different factors. One of the most important is the wind potential at the site while the power purchase agreement defines the price and terms of purchasing the electricity by an utility company.

The design of the project includes the type of turbine, tower and installation. Interconnection and transmission access are another set of prime considerations. Most wind projects require some level of permitting.

Finally legal structure, ownership, and financing are also to be considered. Farmers developing wind projects work with lawyers, accountants, wind turbine manufacturers and other experts to put all of the elements of a project in place.

### *2.1.3. Assessing Wind Potential and Application Suitability*

In each country and regional areas have specific rules that the decision maker should take into account. In this chapter exist - some generic - a few basic things to think about when considering whether a community wind project is viable.

***1. Which is the wind potential in the area?*** To begin, generally assess the wind speed of the area by looking at the relevant wind potential maps. They contain the results from wind speed and direction data collected over more than 10 years of monitoring from a wide network of data points.

Ideal wind sites are characterized by 8 m/s average velocity or better, but wind projects can still be viable on 6 m/s.

***2. Do trees or buildings surround the site?*** If obstacles such as trees and buildings surround your proposed site, wind may not be your best option, but consider:

- If the wind blows primarily from the north and you have buildings to the south, it may not be as much of a problem.
- If the wind blows from the north and you have forest to your north, then wind may not hold much electrical generating promise.

***3. Is your site higher than its surroundings (for 1 to 2 miles) or are you located in a valley?***

- If you are located in a valley, wind is not a good option.
- If you are located on a prominent point or ridge, wind may be an option.

***4. Will you be able to install a wind tower in this zone?*** There is a limitation by law for facilities with specific power capacity. Always check local zoning ordinances for siting specifications.

***5. Are tall towers allowed in your neighbourhood or rural area?*** There are other tall towers in the area? Is it –in general-accepted? There is any barriers in the siting of the wind turbine?

***6. Are you located near an airport?*** The air aviation authorities have put regulations, which stipulate minimum distances from airport runways for structures of various heights that apply to wind towers, especially the tall ones.

***7. Data from Wind Monitoring.*** It is usually wise to monitor actual wind speeds for six months to a year using an anemometer before investing in a wind project. Anemometers are sometimes mounted on existing towers or on a newly erected tower. The following data is needed to fully evaluate the feasibility and costs of a wind project:

- Site elevation (higher is better)
- Monthly average wind speed (to determine the amount of likely power generation)
- Wind Rose data (wind speed and direction frequency data help evaluate the site and where best to put the turbine)
- Site exposure information
- Height above ground (at what height the measurements were taken)
- Data recovery (number of hours of valid data vs. total possible hours – ideally 90% of total)
- Data record (year and months with measurements)
- Site location with respect to your property (wind speeds generally increase to the north and west)

### *2.1.4. Wind Project Costs*

The amount of energy in the wind is a function of wind speed. The energy in wind increases with the cube of wind speed. This means that if you double the wind speed, the energy production increases eight times. In addition, wind speed varies with height above the ground, and generally speaking increases with height. How the wind speed varies with height depends on the terrain, season, time of day, and other meteorological factors.

The cost of wind energy relates directly to the average wind speed at the site and the size of the wind farm. For example, the turbine in area A produces just under 1.5 million kWh/yr with a 7 m/w average wind, while the same turbine in area B produces 2.24 million kWh/yr with a 16 mph wind (an increase of about 50%). Construction of commercial scale wind energy plants currently costs about 800-1,000 €/kW of nameplate capacity. From a production standpoint, large-scale wind is now cost-competitive with conventional electric generation and costs are projected to decline further.

There are economies of scale in wind development, and in general, as might be expected, smaller wind projects have higher costs. There are, however, numerous programs to help improve the economics of small projects, such as small-scale wind incentives for installations of 2 MW or less and programs offering special financial assistance for these small-scale wind installations.

A power purchase agreement with a utility is necessary in almost every case. Even projects built to supply electricity to one building or a campus facility are usually interconnected to the utility grid. Because of this, the utility should be contacted very early in the project planning process. Utilities are becoming more interested in purchasing wind energy because of the state requirements for green electricity.

### *2.1.5. Other Project Elements*

Other project elements include electric interconnection and transmission, project design, licensing, ownership, financing, and operations and maintenance. All of these will require technical expertise. Depending on the size and complexity of the project, one or more consultants/engineers will likely be needed. Each and every one of these parameters is critical to project success.

***Interconnection and Transmission*** Projects will be connected to the electricity grid and utilities understandably have requirements related to standardization and safety.

Transmission will be necessary if the project is designed to deliver power to a distant user. The EU transmission system is being upgraded. Even small projects may need to go through a review of transmission availability.

***Project Design and Licensing***

Project design includes consideration of which size and type of turbine is best suited to the proposed site.

Turbines from different manufacturers have slightly different designs and features. There are different types and sizes of towers and different types of foundations.

Road access to the turbine for operation and maintenance is another consideration.

Almost every project will require some level of licensing. Larger projects are licensed by the Member State Authority (usually the Regulatory Authority). Smaller projects will have to meet local siting requirements.

***Ownership and Financing.*** Financing is a critical element of any wind project since the bulk of the costs are up-front capital costs. The ownership structure and financing costs can be interrelated issues since the ownership may impact the financing available.
For instance Municipal, tax free financing will be lower cost, , than a bank loan available to a private owner.
Several EU financing supporting schemes exist. These are a critical element for the economic viability of all wind projects.

***Operations and Maintenance*** Someone will need to operate and maintain the wind project over time. Even though modern wind turbines are largely trouble free, arrangements for the occasional repairs and regular required maintenance would impact project costs.

### 2.1.6 Environmental concerns

In general compared to the conventional energy sources the environmental impacts associated to wind energy are reduced. During operation, no $CO_2$ emissions or other atmospheric pollutants are emitted and once dismantled no dangerous waste is left behind.
Wind turbines, however, can have an impact upon wildlife if they are sited in the wrong place and should be kept away from important bird nesting areas and bird migration routes. The significance of any impacts depends on the type of species and habitat involved, but also on the additive effects between the different adjacent wind-farm developments (as in the cases where they might be creating a “barrier”).
A proposed development should not cause adverse effects on the integrity of conservation objectives of statutory international and national sites. This should also apply in the cases of the other project elements for example works and investments of a

supportive nature, such as access roads and energy transfer infrastructures (cables, poles). The impacts of these supportive infrastructures should always be assessed along with the impacts of the energy investment (turbines) and all measures for the mitigation of impacts (rehabilitation of sites, closing of roads, underground channeling of cables, etc) should be undertaken.

Besides the impacts on biodiversity, conflicts with other land or marine uses would be identified and minimised though careful siting and operation of wind energy projects.

With appropriate siting of wind turbines also the problem noise could be reduced. Wind turbine developments should respect the local noise limits, preferably according to the world's best practices.

The visual and landscape effect of wind turbines is another issue causing great concern with regard to wind farm development. Whether wind turbines have a negative aesthetic effect is usually subjectively established, although in cases some objective criteria may be put in place. Opinions on aesthetic issues are very important to local communities and their quality of life but the way in which a wind project is thought of can change depending upon the circumstances under which it is developed and the degree to which local communities feel involved in the decision making process.

In any case, the development of wind farms should be guided by a process that allows the positive benefits of developing renewable energy (e.g. greenhouse gas emissions reduction) to be materialised without causing excess burdens upon fragile ecosystems.

The development of wind farms should be managed sensitively and framed within the regional and local spatial planning guidelines. This should include development of national, regional and local wind targets, assessing high value habitats and identifying no go areas for wind development.

Every proposal for wind energy projects, like all the other RES technologies projects, should be subjected to a well prepared environmental impact assessment (EIA) – always in the framework of a wider and integrated SEA procedure. The EIA should provide a comprehensive analysis of potential impacts of the proposal upon fauna and flora, including marine and bird species, the potential interactions with other sea or area users that may result from the proposed project and if the project will potentially result in unacceptable levels of intrusion. The assessment should be transparent, involving full consultation with all interested parties early in the process and should identify specific measures to be adopted in order to avoid or reduce any impacts where practicable.

## 2.2 Hydro

Hydroelectric power plants convert the potential energy in water pooled at a higher elevation into electricity by passing the water through a turbine and discharging it at a lower elevation. The water moving downhill turns the turbine to generate electricity. The elevation difference between the upper and lower reservoirs is called the “head”.

### 2.2.1 Hydropower basics

The economics of hydropower development requires that the supporting infrastructure (i.e. transmission lines, site access, dam development) is either present or readily available for development. Suitable sites have limited capacity and most of the significant hydroelectric resources have already been captured. There is not significant development potential for large hydropower projects, but several small sites with the necessary infrastructure support do exist. These sites could present potential small-scale electricity generation opportunities for rural and insular areas.

### *2.2.2. Operational modes*

Hydropower facilities operate via three primary operational modes. Many projects can function in more than one of these modes. The three types of hydropower operational modes include:

***1. Run-of-River Mode*** uses the natural flow of the river by channelling a portion of the river to a canal to spin the turbine. This may or may not require the use of a dam, but technically requires that the flow in and out of the reservoir are equal.

***2. Peaking Mode*** captures and releases water when the energy is needed.

***3. Storage Mode*** captures and stores water during high-flow periods to augment the water available during low-flow periods, thus allowing power production to be more constant. Pumped storage mode allows hydropower facilities to store power by pumping water from a lower reservoir to an upper reservoir during periods of low-energy demand. During periods of high energy demand the water can be re-released to the lower reservoir to spin the turbines and create electricity.

### *2.2.3. Current Technology Status*

Hydroelectric power generation is a well developed technology and therefore is generally very reliable except during periods of sustained drought or in the presence of ice. Both limit the availability of water to turn the turbines.

Hydroelectric plants boast an overall efficiency of about 80%, significantly higher than that of either coal or natural gas. The capital costs for constructing a hydropower facility are estimated to be in the range of 1,700 - 2,300 €/kW. Operating costs of hydroelectric plants are often low in comparison to those of fossil fuel plants because the flowing river water generally has no direct cost associated with its use. However, based on the Community Water Framework Directive (2000/60/EC) any water related use and service should take into account also the (often but not always non-monetary) cost for the environment and the resources.

### *2.2.4. Environmental and social concerns*

While new hydropower plants should only be considered, where they emerge as the best option in a comprehensive cost benefit

assessment, which must include energy efficiency options as well as the cost for the natural resource, once they are approved, their construction proposals must meet the guidelines of the World Commission on Dams.
Large hydroelectric projects especially those inundating large areas for storage reservoirs can have severe impacts on surrounding ecosystems, water resources and communities. Some of the social impacts can include changes in water availability, complete dislocation of communities and flooding of surrounding villages. Environmental impacts from the dam itself or the regulation of the water flow can include restriction of fish movement, local extinctions of freshwater species, changes to downstream habitats, possible coastal erosion.

Small hydropower plants (usually the definitions say smaller than 10 MW) generally do not involve storage reservoirs but can still have impacts on river ecosystems. In countries where the potential for large hydro schemes has been exploited, further small schemes can cause considerable damage on the remaining unregulated rivers.

However, small hydropower plants can play an important role in a sustainable energy mix. It is thus not possible to make generic statements about the sustainability of small hydropower plants. Each scheme needs to be judged on its own merits in relation to the site-specific situation, including river basin-wide impacts.

Based on the Water Framework Directive, member states are obliged to manage all water resources at the river basin level. In this respect all water uses, including hydropower potential and the development of any hydroelectric projects, should be examined within the framework of the respective river basin, its impact on water quality and ecological status and evaluated accordingly. Hydropower is a water-use that imposes significant morphological and hydrological alterations to surface water. As such a cost-recovery assessment should be developed before the agreement on any such project, including environmental and resource costs. An economic analysis of water services based on long-term forecasts of supply and demand for water in the river basin district will also be necessary.

To address the potential environmental and social concerns, it is imperative that project developers do an environmental analysis on their site that includes an analysis of the potential impact to flora, fauna, water quality and quantity in the whole river basin and opt for sites of minimum environmental impact. Efficient hydropower sites that minimise the area flooded per unit of energy produced should be preferred. Moreover, comprehensive environmental mitigation measures (environmental flow regimes, habitat restoration and protection, fish ladders) can significantly reduce the environmental impact of hydropower projects and need to be included in all planned and existing hydropower plants.

## 2.3. Biomass

### 2.3.1. Biomass basics

Biomass is any organic material not derived from fossil fuels that can be converted to a fuel useful for generating electricity. Biomass can also be waste products or crops planted specifically to produce energy ("dedicated crops").

Biomass generates electricity by combustion, which releases the stored solar energy contained in the plant matter. Unlike wind or solar, a benefit of biomass is that it is "dispatchable" – that is, it can be turned on and off on demand. Utilities in particular like this feature, because it ensures that the power is available when they need it the most.

### *2.3.2. Sources of biomass*

Also referred to as "feedstocks", biomass for a power plant can come from a wide variety of sources, including the following:

***Wood Residues:*** This refers to leftover wood from other uses, and not wood harvested specifically for biomass energy utilisation. The lumber, pulp, and wood milling industries already extensively use wood waste to produce power. Wood residues can also come from forest thinnings, urban tree trimmings, residual construction material, demolition material, wood pallets, and other waste.

***Agricultural Residues:*** This includes primarily mill residues (waste from a processing plant, like nut hulls and oat hulls) and field residues (left in field after harvest, like corn stover and wheat straw). The removal of field residues for energy must be balanced with the benefit to soil quality that residues provide.

***Energy Crops:*** These are crops that are "dedicated" for energy production. The most promising include woody crops like willows, hybrid poplars, and sycamore; and herbaceous crops like switchgrass and other prairie grasses. Often these types of energy crops offer environmental benefits over conventional crops, like less need for crop inputs, habitat for wildlife and reduced erosion and run-off.

***Animal Waste:*** Dry animal waste, primarily from poultry, can be burned directly for heat and power. Wet manure can be digested to produce biogas

***Sewage Sludge:*** Although the solids can be burned, a more common option for producing energy at a sewage treatment plant is anaerobic digestion, which produces energy while treating the waste.

***Liquid Biofuels:*** Liquid fuels like ethanol and biodiesel are primarily used in transportation applications, but could also be burned to produce electricity.

### 2.3.3. Converting biomass to electricity

Usually raw biomass as it is harvested is not suitable to be used for power generation. It must go through a process to prepare it for use in an energy plant. If the biomass is being used in a conventional power plant, the biomass is usually "homogenized". Homogenization converts materials of different sizes into a mixture of uniformly sized particles. Most commonly homogenization includes sorting and size reduction (by cutting, grinding, or pulverizing). Sorting helps eliminate contaminants and size reduction helps injection of material into combustor at a more constant rate and creates greater surface area for maximum burn efficiency.

Technology to convert solid biomass to electricity is based in large part on existing coal-fired technology, which is a well-developed technology. Biomass is generally cleaner burning than coal, as it

typically contains less pollutant-forming components such as sulphur (S), nitrogen (N) and heavy metals. It does present a few technical challenges in comparison to coal, however.
Often biomass is high in alkali metal, such as sodium, potassium and calcium. While the combustion of these materials is not generally considered an air pollutant, it can cause corrosion and deposits to form within the boiler, increasing the maintenance requirements of a biomass plant. The lower heat content of biomass also means that a larger volume of boiler is required to produce the same amount of energy as a coal-fired plant. The space for storage and handling are also greater than for coal plants.
Co-firing biomass with coal at existing coal plants (typically in percentages of less than 15% biomass) shows much promise in the near term for greatly expanding the use of biomass. Some modification of the existing plant is necessary to allow co-firing, estimated to be around 180-200 €/kW of biomass capacity.
An option that shows great promise for the future is gasification. Gasification generally involves pyrolysis, or heating the biomass to high temperatures in the absence of oxygen, which causes the volatile portion of the biomass (this can be 70-80%) to gasify.
Much of the remaining biomass can be gasified through a steam injection process. After cleaning, the gas can be used in very efficient and low-polluting combustion turbines, such as those that are currently used for natural gas, or perhaps in fuel cells.

### *2.3.4. Environmental Considerations*

Accounting for the environmental impacts of biomass is perhaps more complicated than for any other RES. Different impacts are likely to arise depending on which category of biomass feedstock is used and which technologies are used to convert the biomass to useful energy.

Electricity generation from biomass fuels currently uses the same basic technology used in power plants that burn solid fossil fuels. The combustion of biomass can produce the same air pollutants as fossil fuel combustion. These pollutants have been shown to be responsible for asthma and other health and environmental problems. However, the advantage that biomass has over fossil fuel emissions is that biomass is a carbon-neutral power source in that $CO_2$ absorbed by the raw material while growing, offsets that generated during combustion. Therefore, biomass has a reduced impact on global warming. Furthermore, new technologies, now being developed can improve power production efficiency from biomass and result in very low levels of emissions of other atmospheric pollutants (SOx, volatile organic compounds, CO, NOx and particulates)

Large-scale energy crop production is likely to have a similar range of potential negative environmental impacts as those found in existing conventional agriculture including fertilizer and pesticide use that pollute the water, and loss of a useful soil amenity (for example, manure that is burned). Nevertheless, there can also be positive environmental benefits of growing biomass, when the best agricultural practices are adopted – for example, some biomass sources can reduce erosion, improving water quality near streams and providing habitat for wildlife.

The development of biomass resources and the conservation of biodiversity and local environments can go hand in hand. it is imperative, when considering a renewable energy source as complex as biomass with multiple benefits and concerns, to consider the net environmental benefits of a biomass energy project – that is, including all environmental effects from the project, both negative and positive. Therefore, bioenergy project schemes need to be subject to rigorous and transparent environmental impact assessments.

The following criteria present a few of the aspects that need to be considered to evaluate sustainable biomass energy production:

***Impact on Water Quality*** Biomass crop growth should minimize pollution due to erosion, pesticides, nutrients or waste products.
***Impact on Soil Quality*** Soil quality should not be degraded.
***Effect on Wildlife*** There should be no detrimental impact on local wildlife in comparison to alternative land uses. There should be no conversion of natural forests or High Conservation Value habitats involved in raw material production or supply.
***Effect on Air Quality*** Biomass energy production should result in net reductions in air pollutants.
***Net Energy Balance*** Does it provide more energy than is consumed in making the energy (such as the energy used to produce fertilizer, drive tractors, dry the crop, etc.)?
***Biodiversity*** Does the biomass increase the diversity of our nation's genetic crop base?

### *2.3.5. Economic Viability of Biomass*

The economic viability of biomass continues to increase. However, biomass facilities using dedicated energy crops currently cost more than traditional fossil fuel plants. Perhaps if the full environmental impacts of these fossil plants were included, the balance would change. In any case, just as for wind, the economics will improve over time as more plants are built (economy of the production scale).

There are many situations when biomass is economically viable on its own right. When low value sources of biomass are available as a by-product of another process, or that have no other useful purpose, fuel costs can be dramatically reduced. This is why there are so many biomass plants at paper mills, where there is a lot of wood waste. Many studies also suggest that the most economic use of biomass is in co-firing at existing coal plants.

The economics also improve when waste heat from electric generation is used for other purposes. As was mentioned earlier, biomass has the advantage of being able to produce electricity on demand, which also adds value. With the proper nurturing, biomass can become an important part of our energy mix.

## 2.4. Liquid Biofuel

### 2.4.1 Liquid Biofuel basics

The last decade has seen a tremendous growth in the use of biofuels to replace petroleum-based transportation fuels.

Rural economies not only benefit from growing the raw material for biofuels, but can also benefit by being involved in the production of biofuels.

Besides the fact that it's a renewable source of fuel, ethanol is an environmentally benign fuel additive that can substitute for MTBE. MTBE is a fuel oxygenate that was found to pose a significant environmental threat to ground and surface water, enhanced by its ability to rapidly penetrate the ground.

In some areas corn is currently the primary feedstock for ethanol. Corn-based ethanol can be produced by either the wet milling or the dry milling method. Dry milling is the most common process used, and consists of grinding up the corn and adding water to make mash. The mash is then cooked to kill off the bacteria and expose the starches. Enzymes are added to convert the starch to sugar, which is then converted to ethanol by yeasts. The ethanol is then purified for use as a fuel.

### 2.4.2. Ethanol's future

Because of its high starch content, corn is a good candidate for the current fermentation methods used to create ethanol. However, corn is a fairly input-intensive crop (in terms of energy, fertilizer and chemicals) and the corn kernel is only a small percentage of the whole plant. In the long-term, other crops may be used to produce ethanol more efficiently and with less impact to the environment.

Methods to convert cellulose (the fibrous material in plants) into ethanol show the most promise for the future. Then perennial crops like switchgrass that don't need to be replanted every year and have less input requirements could be used for ethanol.
It is estimated that with steady improvements over the next decade in cellulosic conversion technology will improve the cost of producing ethanol.
Cellulosic ethanol would also reduce greenhouse gases, because less fossil fuel is needed to produce it. It is estimated that using a 10% blend of cellulosic ethanol results in the reduction of 4 to 5 times more greenhouse gases than using a 10% blend of corn ethanol. The first cellulosic ethanol plants might be paired with current corn ethanol plants, utilizing the cellulose-rich by-products of the corn/starch ethanol process.
A promising source for biethanol production is the waste from sugarbeet and food processing plants. These, rich in sugar , waste could provide appropriate substrates for good bioethanol concentration solutions.

### 2.4.4. Biodiesel basics

Biodiesel is a fuel commonly made from a chemical reaction between soybean oil, methanol, and lye. Although soybean oil is the most common feedstock, other non-petroleum oils and greases (such as waste grease from cooking food) can be used. Biodiesel can be used in its pure form or can be blended with petroleum diesel. Any percentage of biodiesel can be used, but 2% (B2) and 20% (B20) are the most common. Biodiesel's use as a transportation fuel in diesel engines, is becoming more wide spread, but it can also be readily used in standby, emergency and remote diesel electric generators.

Using a biodiesel mixture to fuel emergency generators, rather than pure petroleum diesel, can help reduce emissions that result from the operation of diesel electric generators.
Although diesel electricity generators are one of the most polluting sources, biodiesel electric generation is still a very dirty source , even when compared to other fossil fuel sources. Therefore, traditional diesel generators using biodiesel fuel are a source suitable for backup power or other special situations, but not suitable for generating  significant amount of our electricity .

### 2.4.5. Biodiesel and the environment

Although diesel – even biodiesel blends – is a very polluting fuel, biodiesel is less polluting than standard diesel. As the percentage of biodiesel goes up, there are reductions in emissions (including sulfur dioxide, carbon monoxide, volatile organic compounds and particulates).

The addition of biofuels to diesel and gasoline allows for more complete combustion, which therefore reduces the amount of carbon monoxide emissions and unburned hydrocarbon emissions, causing a reduction in some ground-level ozone causing pollutants.
However, the addition of oxygenated fuels causes combustion temperatures to rise, which results in increased formation of nitrogen oxides. Biodiesel blends of 100% or 20% also reduce visible smoke and odors.

Today is not very clear what role biodiesel would play to help or hinder meeting any future diesel emissions rules. Like ethanol, biodiesel also results in a net reduction in greenhouse gases.

***Emission Reductions from Replacing Diesel with Biodiesel*** *(20% and 100% blends)*

| ***Emission*** | ***B-20*** | ***B-100*** |
| --- | --- | --- |
| *CO* | *-13%* | *-43%* |
| *CxHy* | *-11%* | *-56%* |
| *Particulates* | *-18%* | *-55%* |
| *NOx* | *1%* | *6%* |
| *Air Toxics* | *-0.3%* | *-1.5%* |

Incorporating biodiesel into our fuel mix would not only support the use of RES and improve air quality, but it would also help provide additional income to farmers facing restructuring problems (i.e. the new Common Agricultural Policy).

## 2.5. Solar Energy

### 2.5.1. Solar Energy basics

There are still plenty of opportunities for solar in European islands even in the Northern Europe. Although the cost of generating solar electricity is currently expensive relative to traditional sources, solar energy can be economic in many situations, such as for heating hot water even if it is impractical to connect to the electric grid. When buildings are designed to maximize the light and heating potential from the sun, significant "passive solar" energy savings can be realized.

There are several types of applications that would be most cost effective for solar electric systems. These included:

***Government***

- Lighting, for public lake access, trails, and rest rooms
- Communications, such as emergency call boxes
- Vehicle battery charging for snow removal equipment, earth moving equipment, and emergency vehicles
- Monitoring, such as remote weather stations
- Warning signals
- Off-grid facilities such as state park residences, remote equipment storage buildings, and fire towers
- Military installations (open space illumination with individually powered autonomous units).

***Travel and Tourism***

- Residences, such as remote cabins and hunting facilities
- Battery chargers for recreational vehicles, trolling motors, and sailing vessels
- Lighting for boat launches/docks and parking areas

- Water pumping for pond aeration and potable water

***Agriculture***

- Fence chargers
- Stock tank aerators
- Water pumps

Several case studies emphasize similar applications integrating both solar electric opportunities as well as passive and active solar thermal water heating systems.

### 2.5.2. Photovoltaic Power

Photovoltaic systems (PV), produce electric DC power from sunlight because of the photovoltaic effect (a semi conductive process that generates electricity without moving parts or emissions). Inverters can be added to convert the DC power to grid-compatible AC power.
PV panels (a combination of many cells) produce maximum the most electricity under periods of high solar output, or insolation during sunny summer days. They are generally mounted on un-shaded south-facing exposures and have optimum energy production when the sun’s rays are perpendicular to the panel.
The most common type of photovoltaic cell is constructed of semiconductor-grade crystalline silicon wafers that have grid contact structures on the front and back to create an electric circuit. Photovoltaic cells can be linked together to form panels or arrays.
Electricity is generated when light photons excite the bottom wafer to donate an electron to the upper wafer, resulting in the flow of electricity when attached to an electric circuit.
PV systems do not create noise, air or water emissions, or have any moving parts and the panels themselves are generally designed to last for almost 30 years.

One of the key benefits of incorporating PV systems into our electricity generating system has to do with timing. The amount of energy that solar electric systems generate directly correlates with the sunlight intensity and length. This peak condition occurs most often during hot, sunny, summer days, when electricity demand is also at its peak. This peak demand is when electricity is most expensive to generate and most valuable to the utility.

Thus, although solar power is an intermittent power source, it provides power when it is most needed.

The cost of PV (15 cents/kWh or more) is not yet competitive with other sources of electric generation and the payback of a grid-interconnected system may take 30 years or more. PV can be cost-effective for off-grid applications, however.

### 2.5.3. Photovoltaic system facts

- Installation costs are about 5.000-7.000 €/kW
- In Cyprus, 1 kWp of PV grid connected system can produce approximately 1.500 kWh per year (as an average for 20 years of operation) if installed facing South with a fixed inclination of about 30 degrees.
- Factors such as inverter and wiring efficiency, the orientation and tilt of the panels, and shading can increase or decrease this amount.
- The orientation and tilting of the panels can optimize for winter or summer, and morning or afternoon generation. A panel with a fixed orientation will receive the most potential for sunlight by orienting the panel due south and setting the tilt angle at the latitude of the site’s location
- Single-axis and dual-axis tracking capabilities (automatically following the sun across the sky during the day and season)

increase the capacity of fixed technologies during general summer demand periods.

- Panels can be mounted on the roof, on the ground, or on poles.

Off-grid applications can be cost-effective instead of building a new utility line, as can small signs, outdoor lighting, cabins, etc.
On-grid applications, even with subsidies, need a non-financial basis for continuing with the project – for example a concern for the environment or a desire for energy independence.

### 2.5.4. Solar hot water systems

Direct use of solar energy can also be employed in active and passive water heating systems, which typically have shorter payback periods than PV systems. Depending on the cost of energy, the lifetime cost of a solar water heating system can be about 4-5 years, which is lower than heating water with gas or electric.
Active solar thermal applications use collectors and mechanical pumps to make the most of the sun's natural ability to heat water. Water is pumped into solar collectors stationed on south facing roofs, allowed to warm, and then stored in a pre-heat storage tank. This system requires, often, a conventional water heater backup to ensure hot water on demand and during winter months.
Research is being conducted on solar thermal systems that generate electricity, and a few test plants exist, but unlike solar water heating and PV, solar thermal electricity generation is still a long way from being a commercial technology.

### 2.5.5. Passive Solar Design

Good building design with the sun in mind can save energy. Passive solar design integrates a combination of building features to reduce the need for heating, cooling and daytime lighting.
The design often does not have to be complex, but does involve knowledge of solar geometry, window technology and local climate.
Typical passive solar features include careful orientation of the building, careful positioning and selection of windows including additional window glazing, added thermal mass for heat storage, use of natural ventilation and larger roof overhangs.
Choosing an architect and builder knowledgeable of passive solar techniques is key to realizing savings from passive solar design. Although a passive solar design may initially cost more, savings are born out over the lifetime of the building, and the increased cost can often be paid back in several years through energy savings.

### 2.5.6. Environmental concerns

Solar power is an extremely clean way to generate electricity. There are no air emissions associated with the operation of solar modules or direct application technologies.

The large amount of land required for utility-scale solar power plants, poses an important problem, especially where wildlife protection is a concern. But this problem is not unique to solar power plants. Generating electricity from coal actually requires as much or more land per unit of energy delivered if the land used in strip mining is taken into account. Solar-thermal plants (like most conventional power plants) also require cooling water, which may be costly or scarce in desert areas.

Furthermore, residential-scale passive construction, photovoltaic, solar water heating, and other direct applications can reduce land use impacts from typical utility generation, transmission and distribution.

## 2.6. Geothermal energy

### 2.6.1. Geothermal energy basics

Geothermal energy - heat from the earth - is an important energy source having environmental and economic advantages over fossil and nuclear energy sources. Electricity generated from geothermal steam supplies power without polluting atmosphere or water, or creating radioactive waste. Nowadays clean heat from geothermal water dries vegetables, heats greenhouses, and warms clusters of homes and buildings in district heating systems. Geothermal heat pumps provide highly efficient heating, cooling, and hot water for homes and schools.

Only a small fraction of the available geothermal resources are being used today. Improvements in technology and widening recognition of geothermal energy's true value will lead to a greatly increased amount of this renewable resource being developed in essentially all countries of the world.

Geothermal energy is heat from deep in the earth. Temperature in the earth increases with depth, reaching a level of 4.200°C at the core. Since heat always moves from hotter regions to colder regions, the earth's heat flows from its interior toward the surface. Some 42 million $MW_{th}$ reach the surface continually, and are radiated away into space as the earth continues cooling from a molten state that existed more than 4 billion years ago. This enormous outward heat flux drives such geologic processes as plate tectonics, volcanism, mountain building, and earthquakes, making our earth a dynamic, ever-changing place to live.

In areas of magmatic intrusion and volcanism, deep ground water may be heated and set into upward circulation through fractures and pores in the rock. If these thermal waters reach the surface, hot springs, boiling mud pots, geysers, and fumaroles occur. It is these hydrothermal resources - ground water heated by molten or recently solidified rocks at depth - that are used today for generation of electricity and direct applications of heat.

From earliest times, hot waters from geothermal springs have been used for bathing and cooking. Today, applications of low- and moderate-temperature (40 to 150 °C) geothermal waters have expanded enormously to include the heating of large tracts of homes and buildings (district heating), heating of greenhouses for growing vegetables and flowers, fish farming (aquaculture), drying of foods and lumber, and many other uses. In Iceland, most of the homes and other buildings are connected to geothermal district-heating systems, and in the Paris basin in France, many homes are heated by bringing thermal water to the surface. Geothermal greenhouses exist also in Italy and in Greece.

### 2.6.2. Geothermal Heat Pumps - Saving Energy

No technology for home heating and air conditioning is more efficient than the geothermal heat pump (GHP). GHPs reduce electricity use 30% to 60% compared with traditional electrical heating and cooling systems. The net savings in energy consumption mean fewer adverse environmental impacts from coal mining and power plant emissions. Domestic hot water can be produced essentially free by the GHP during the air-conditioning season and for small cost in winter. Maintenance costs for GHP systems have proven to be very low. Best of all, the customer enjoys lower utility bills.

GHP systems can be used for a variety of applications, including the heating and cooling of homes, schools and other buildings, as well as commercial and industrial heating and refrigeration. Used for years in Europe, geothermal heat pumps are now making a big impact on energy efficiency in the U.S. and Canada.

The heat pump itself operates on the same principal as the home refrigerator, which is actually a one-way heat pump. The GHP, however, can move heat in either direction. In the winter, heat is removed from the earth and delivered into the home or building (heating mode). In the summer, heat is removed from the home or building and delivered for storage into the earth (air-conditioning mode). Because electricity, which powers the GHP, is used only to move heat, not to produce it, the GHP will deliver 3 to 4 times more energy than it consumes.

The GHP unit sits inside the home or building, at the site normally used for a gas furnace. In a typical installation, a loop of plastic pipe is placed in a vertical hole bored several hundred feet deep, and the hole is then backfilled. An environmentally safe antifreeze solution is circulated through the loop and through the heat pump for removing heat from or transferring heat to the ground. There is no consumptive use of ground water, nor is there any contact between the solution in the plastic pipe and the earth or ground water.

Several alternative ground-loop installations have also been successfully used. Loops of plastic pipe can be placed in a horizontal trench, either stretched out or in the form of coils (the so-called "slinky" configuration). Placement at the bottom of a nearby pond is also possible if the pond does not freeze in winter.

### 2.6.3. A low cost alternative

The real cost of energy is not reflected in the utility bills or at the gasoline pump. There are additional, external costs that we all pay indirectly. External costs include those resulting from atmospheric pollution due to burning of fossil fuels -- adverse health effects from dirty air, crop damage from ground level ozone, and corrosion damage to buildings, bridges, and other installations from acid precipitation. There is also increasing evidence that global warming is underway as a result of the well documented buildup of $CO_2$ in the atmosphere, presumably due partly to burning of fossil fuels. If so, the costs of rising sea levels and disrupted weather patterns could be enormous in our own time, and even higher for future generations. Other external costs include military expenditures to keep petroleum supplies secure, environmental damage to life in the oceans and on land from oil spills, and the treatment and storage of radioactive waste, as well as the costs of keeping that waste secure. Our taxes also support significant direct economic subsidies to the fossil and nuclear sectors. If all of these costs of procuring and using energy were accurately accounted for and included directly in our bills, we would be truly dismayed by the total.

Since the major portion of energy-use costs, the external costs, is hidden, the market sends the wrong signals to users of energy, discouraging use of clean energy sources while jeopardizing our environment. Accurate pricing, including the external costs, would lead to altered energy-use patterns and fuel sources — to much more emphasis on renewable energy and conservation options.

Geothermal energy is proven, and can help by both increasing our domestic energy supply and by contributing to energy efficiency. Accelerated development of renewable resources and energy conservation are the lowest-cost options in some cases, even with the hidden costs of the conventional energies. If the hidden costs were made visible in energy pricing, geothermal energy would be seen for what it really is -- a true bargain.

### 2.6.4. Improving Geothermal Technology

Only the very highest grade geothermal resources can be developed economically. The primary barrier to rapid development is costly or inadequate technology. Three high priority areas for research are drilling, exploration, and power plants.

**(i) Drilling**

Because of the high temperature and corrosive nature of geothermal fluids, and the hard rocks found in geothermal environments, geothermal drilling is difficult and expensive. Drilling costs account for one-third to one-half of the cost for a geothermal project.

**(ii) Exploration**

The major problem in exploration is how to detect permeable, producing zones deep in the subsurface so that wells can be drilled to intersect them. Present geological, geochemical, geophysical, and remote sensing exploration techniques are not specific enough, and lead to too many dry wells.

**(iii) Power Plants**

The efficiency in converting geothermal steam into electricity in the power plant and the cost of power-plant components and construction directly affect the cost of power generation. Corrosion of components and deposition of scale are problems in some plants. Improved power plants would lead to cheaper geothermal development.

Highly successful applied research programs are being carried out in EU and USA. As a result, the cost of generating power from geothermal resources has decreased by 25% over the past two decades. However, further improvements are necessary if we are going to realize the immense promise of clean, reliable geothermal energy.

### 2.6.5. Power generation

Geothermal resources have been known since the dawn of mankind, when natural hot springs were first used for cooking and bathing. Today, the use of geothermal energy is increasing rapidly. Resources having temperatures higher than about 150°C are usually used for generation of electricity. Lower-temperature resources are used to heat homes and greenhouses, dry food and lumber, raise fish, and provide water for cooking and bathing.

Systems for the use of hydrothermal energy have proven to be extremely reliable and flexible. Nearly 40 years of production have been achieved at The Geysers field in California and at Wairakei, New Zealand, while the Larderello field in Italy has produced geothermal electricity since 1904. Many geothermal electric-power plants are available for generation 95% of the time or more. Geothermal plants are modular, and can be installed in power increments to fit needs. Construction time can be as little as 6 months for plants in the range 0,5-10.0 MW and as little as 2 years for clusters of plants totalling more than 250 MW.

### 2.6.6. Environmental concerns

Geothermal energy, like any other renewable energy source, has reduced environmental impacts compared to those of the conventional energy sources. $CO_2$ emissions from geothermal plants are about 5 % of that emitted by coal- or oil-fired power plants per kilowatt-hour of energy generated. Geothermal plants also emit no nitrogen oxides and low amounts of $SO_2$. Furthermore, although the disposal of water and wastewater may cause significant pollution, used geothermal fluids are generally collected and re-injected and may be reused once the water has been reheated by the earth. The location of geothermal energy installations may sometimes cause concerns - like remote wind farms - especially when they are located at remote sites that may have significant wilderness, scenic or recreation value but a well-prepared environmental impact assessment (EIA) can significantly add to the quality of the overall project.

# 3. Energy efficiency applications

## 3.1. Improving energy efficiency

### 3.1.1. Basics on improving energy efficiency

Building a brand-new, shiny, renewable energy power source in the islands is very attractive. Doesn't everyone want to have the latest, greatest and cleanest power plant to supply their power and stimulate the local economy? New RETs, such as the wind turbines being erected all over the islands, do get a lot of attention. However, there is a much less glamorous way to "produce" energy that is often cheaper and smarter than building a new plant. This is energy efficiency – consuming less energy by using it more efficiently. Because energy efficiency reduces energy bills, it's also Euro- smart.

The capacity of engineers to think of ways to do things faster, cheaper and better is astounding. We are most familiar with this in terms of computers – it seems that in the time it takes to get from the factory to our house, a new computer is obsolete. But while our society has an obsession with GHz, we pay relatively little attention to kWs – the energy consumed by the products we buy.

And yet just as computers continue to get faster and faster, so there are improvements in technologies and processes that can use less energy to provide the same level of service.

These include compact florescent light bulbs, super-efficient appliances, variable speed motors, and ultra-efficient heating and cooling systems.

A compact florescent light bulb can produce the same amount of light as a standard incandescent bulb, but uses a quarter the power and can last 10 times as long. LED (light emitting diode) bulbs that are starting to enter the market are even more efficient and long lasting.

There is enormous potential to further increase our energy efficiency.

### 3.1.2. Implementing energy efficiency

The approach to implementing energy efficiency will vary slightly depending on whether it is in the residential, commercial or industrial sector. Implementing an energy efficiency project for a homeowner may be as simple as adding insulation and installing some efficient light bulbs, but may be more complex if it involves ventilation and other "house system" elements. For larger projects, a systematic approach to energy efficiency involves 5 basic steps:

***1. Identify Energy Efficiency Opportunities: the Energy Audit***

Uncovering the hidden opportunities of energy efficiency is the first step, and energy audits are an excellent way to do this. A skilled energy auditor will complete a thorough examination of a facility to identify all the opportunities for energy efficiency improvements. The more complex the facility, the more expertise required by the auditor.

If you're trying to decide whether or not to do an energy audit in a building, you might consider performing a benchmark evaluation to see how a building ranks in comparison to similar structures.

***2. Decide which Opportunities to Implement:*** Often economic considerations dictate which opportunities are implemented. The most common criterion used is simple payback – how long does it take to pay back the cost of the improvement with the energy savings that result from the improvement? For example, if you buy a compact florescent light bulb for €6 to replace a less-efficient bulb, and the new light bulb saves €3/year in energy bills, the simple payback is 2 years.

The acceptable length of payback will vary depending on who is paying for it – businesses typically don't consider anything longer than a 2-year payback, while institutions or individuals may have a longer time frame, perhaps 7 to 10 years, or even longer. It is important to remember that after the payback period, the project will continue to reap energy savings for the life of the project; the "profits" of investing in the project.

Because the simple payback method does not take into account environmental costs (the so-called externalities), an environmentally committed individual or institution may even implement efficiency projects that cannot be justified by economic payback alone.

***3. Financing:*** In the long run, carefully chosen energy efficiency projects will not only pay for themselves, but reduce overall spending on energy. However, for large facilities it is sometimes difficult to come up with the initial capital funds to finance these projects. There are several ways to overcome this problem:

• Set up a revolving loan fund for energy efficiency projects.

• Consider having an outside company do the efficiency project. There are some companies that will do the assessment, implement and finance the project, in exchange for a share of the energy savings, which may make sense in certain situations.

• Grant and loan programs for energy efficiency projects. Utilities often offer rebate programs for high-efficiency products, and may have other programs – your local utility should know what programs you qualify for.

Other financing programs exist; for example, the local authorities have special financing available to them for energy efficiency projects, the EU and the national authorities offer programs for improving the energy performance of buildings.

***4. Implementing the Energy Efficiency Projects:*** Once you've made a plan for what projects you want to do, you have to decide if you want to do them yourself, use staff within your organization, or contract for services. If you contract the projects out, choosing a qualified contractor to install the energy efficiency projects is key to realizing the energy savings.

***5. Maintenance:*** In some cases, maintenance of an energy efficiency project will not be an issue, but in some cases it is worthwhile to consider how the project will be maintained. This is especially important in dealing with processes and systems.
For example, many types of energy efficiency gains in complex Heating, Ventilation and Air Conditioning systems (HVAC) tend to diminish over time unless they are maintained.

### 3.1.3. Barriers to energy efficiency

So if energy efficiency is so marvellous and cost-effective, why aren't we doing more of it? Here is a summary of some of the main reasons.

***Information Gap:*** Consumers and even contractors often aren't aware of energy efficiency options or the economic and environmental benefits they offer. Consumers also may not believe the potential saving estimates claimed by contractors and auditors.

***Lack of Investment Budget:*** Residential, businesses and government customers may lack the up-front capital required to make investments in energy efficiency projects.

***High "Transaction Costs"*** Making an informed purchase or considering energy efficiency measures often involves more time, money and hassle than the consumer is willing to invest.

***Split Incentives*** If the person who pays the monthly energy bill is different than the person who pays for the equipment, there is a split incentive. This is most evident in landlord/tenant relationships. The landlord does not have an incentive to purchase the more expensive, higher efficient equipment because the landlord does not reap any of the benefits of lower operating costs. The tenant is often unaware of equipment upgrades and does not actually own the equipment; therefore the tenant does not invest in more efficient equipment even though they would capture significant savings. This same dilemma can also occur in large institutions where the person paying the energy bill is different than the person responsible for capital improvements.

***Short Term Costs are Often Emphasized over Long Term Costs*** For example, builders try to keep construction costs as low as possible, without considering the long-term energy costs of inefficient construction methods.

### *3.1.4. Overcoming barriers: Policies and programs to encourage energy efficiency*

Recognizing that some policy direction is necessary to overcome barriers and more fully capture the potential of energy efficiency, policy makers have created programs to stimulate energy efficiency.

### *3.2. Combined Heat & Power/District Energy*

***Combined Heat and Power (CHP),*** also known as cogeneration, is based on the simple idea of recovering and utilizing the waste heat created from the generation of electricity. Typically 60 % or more of the energy used to produce electricity in central-station power plants is wasted. CHP is utilized by industries or institutions that have a use for the waste heat produced from electrical generation, such as for industrial processes or space heating. District energy systems also achieve efficiencies by centrally producing the heat and/or cooling for multiple customers in a concentrated area, like a city center. When district energy systems include CHP, they can achieve the highest efficiencies. While CHP and district energy systems can utilize renewable energy fuels, they often use fossil fuels.

Due to the increased fuel efficiency, even use of standard fossil fuels can have environmental benefits.

#### 3.2.1. CHP and district heating energy basics

CHP can reduce air emissions from combustion since less fuel is burned when electricity and thermal energy are generated together. CHP also reduces the discharge of hot waters from cooling towers into community lakes and rivers because the water is reused. CHP and district energy are an opportunity for communities and local businesses to expand production of local energy and most efficiently use renewable or fossil fuel resources.

CHP is actually a range of technologies that simultaneously produce electricity and useful thermal or mechanical energy from a single energy source. Typically, a CHP system first uses a gas turbine or reciprocating engine generator set to generate electricity. The thermal energy generated by the turbine or engine is recovered and recycled as usable steam or hot water. Since CHP systems are based on capturing and recycling this otherwise wasted thermal energy, a CHP system must be located at or near the facility or buildings that will be utilizing both the electricity and heat generated by the CHP system.

Due to the increased fuel efficiency, even use of standard fossil fuels can have environmental benefits.

A district energy system traditionally refers to centrally producing heat and/or cooling for multiple customers in a concentrated area, such as a city center, a university campus, or a hospital complex. Normally, a district energy system is a prime candidate for adding CHP.

When CHP is incorporated into an industrial, commercial, institutional, or district energy application, system efficiencies as high as 80% can be realized, compared to typical coal power-plant efficiencies of about 30%. These increased efficiencies can provide energy cost savings and lower emissions, while providing higher reliability of electric service.

### 3.2.2. CHP technology options

Combustion turbines (simple cycle and combined cycle), reciprocating engines, and steam turbines are the primary technologies used to generate electricity from CHP systems.

Fuel cells and microturbines are also suited for CHP, but can be expensive options.

If a facility is already producing steam from a boiler, it may be a candidate for a type of steam turbine called a back pressure turbine.

Many industrial facilities generate steam at high pressures and during the industrial process will drop the pressure through pressure reducing valves. In these applications, a back pressure steam turbine is a relatively inexpensive way of utilizing the pressure drop to generate electricity onsite. Installed costs can be as low as € 500 per kW of capacity for the addition of a turbine to an existing boiler system.

Heat-recovery systems are also essential components of CHP systems, so that the waste heat can be recycled for use in industrial processes or in space conditioning the facilities. Absorption chillers can convert hot water or steam into chilled water for air conditioning. A desiccant dehumidifier can be utilized to remove moisture from the air which in turn can reduce air conditioning loads and provide better indoor air quality. In a CHP system, the recovered heat can be utilized to regenerate the desiccant material in the dehumidifier.

### 3.2.3. How do you determine if a CHP system might be appropriate?

***Consistency and Size of Thermal and Electric Loads:*** Constant, level loads are best for a CHP system, since the CHP system can run as close to continuously as possible, increasing the economic payback. If the facility is closed for a portion of the year, or has widely varying thermal or electric loads, a CHP system is less likely to make economic sense. It is usually most cost effective to size a CHP system at less than peak demand so that the system is able to operate as much as possible at full capacity.

***Planned New Construction or Upgrades:*** It is best to plan CHP projects for new construction sites or sites in need of upgrades. These technologies are easier to incorporate with newer facilities that are likely to be more reliable and require less maintenance. If the avoided costs for upgrades or replacements can be put back into the CHP project, the project becomes more cost effective.

***Cost of Purchased Power:*** If the cost of power is high, it will make on-site generation more cost competitive.

***Value of Sold Electricity:*** If excess power can be sold at a sufficient price, it becomes more economical. Incentives can also help.

***Available and Affordable Fuel Supply:*** If there is an opportunity to use lower-cost, easily accessible fuels with CHP as compared to current fuels used for thermal production, CHP presents an option to avoid higher costs.

**(i) CHP in the industrial sector**

There are several industrial facilities in EU that have already incorporated CHP systems into their onsite operations. The paper industry in particular has significant experience operating CHP facilities and utilizing their biomass residuals (waste wood) to power their operations.

***(ii) CHP in the commercial and institutional sectors***

Institutional buildings are a large source of this potential. Schools and Universities have large heating loads that can be served by CHP systems. CHP paybacks tend to be in the 4 to 7 year range, which is more acceptable to the long term planning horizon of an institutional owner than a private for-profit company.

Buildings that need highly reliable or back-up power, such as hospitals, computer data centers and telephone switching centers, are an especially attractive possibility. A CHP system can serve as an effective backup power system that will pay for itself, rather than simply be an expense.

### (iii) CHP and district heating

District heating does not necessarily have to produce both heat and power, but often this is the case. It is also not limited to just downtowns, but can also include “campus heating” of educational and other multiple-building facilities.

Waste heat from local processing facilities also presents and opportunity for community-wide heating and cooling systems. This would both promote private-public cooperation and decrease the energy usage of the entire community.

Installing district energy systems is not without obstacles. These systems require significant capital investment to create the necessary infrastructure support. This means that district energy systems need community support, but district energy presents a real solution for improved energy efficiency and presents a tangible way for communities to reduce their fuel consumption.

## 3.3. Fuel Cell

***How Fuel Cells Work***

*A fuel cell is an electrochemical energy conversion device like a battery. Fuel cells produce electricity via a chemical reaction, harnessing the chemical attraction between hydrogen and oxygen. The oxygen is taken from the air, and hydrogen fuel can come from water via electrolysis or from fossil fuels like gasoline or methanol. A catalyst pries hydrogen atoms apart into a positive ion and an electron. The positive ions pass through a membrane to bond with the oxygen; the electron travels around the membrane and through a circuit, generating an electrical current. On the other side of the membrane, the oxygen, hydrogen ions and electrons recombine to form water.*

*There are a number of different fuel cell technologies under development to serve different needs. Different types of conductive materials or electrolytes are used. Proton exchange membrane (PEM) fuel cells are most common in vehicles and in small devices. Other types are alkali, molten carbonate, phosphoric acid, and solid oxide fuel cells.*

### 3.3.1. Fuel Cell basics

Fuel cells are on the cutting edge of future technologies and have the potential to reshape our energy future. They use an electrochemical process to turn hydrogen and oxygen into pollution-free electricity and heat.

Fuel cells have the theoretical potential to make the European islands energy independent, transforming their economy from one based on imported fossil fuels to a “hydrogen economy” fuelled by hydrogen generated with local RES. Fuel cells offer an opportunity for communities interested in pursuing renewable energy demonstration projects as the technology is still under development and all aspects of the technology and the supporting infrastructure are in need of pilot trials.

Although the first fuel cell prototype was made in England in 1838, the modern version of fuel cell technology was developed as part of the space programme. Fuel cells can replace internal combustion engines in vehicles, batteries in all sorts of portable devices like cell phones and watches, and can generate electricity and heat for buildings and homes. Fuel cells are modular and can be small enough to fit in a watch or big enough to power large buildings.

The most immediate future applications for fuel cells will be in vehicles and replacing batteries in phones and other mobile electronics. All of the major auto manufacturers have fuel cell vehicles under development and Honda and Toyota began leasing fuel cell cars on a small scale in 2003. Fuel cells are also being used in pilot trials at schools and in city buses in European cities. Stationary applications in buildings for heating and electricity will likely follow close behind.

The high cost of fuel cells, however, still remains a barrier for widespread commercial use, but expectations are that they will be cost competitive with other technologies by the end of this decade.

Fuel cells can operate at conversion efficiencies as high as 80% for fuel cells running on hydrogen. Fuel cells running on methanol or gasoline are only 40% efficient, but all fuel cells have the added advantage of producing thermal hot water that can be integrated into a combined heat and power system. This makes them an efficient energy source that can evolve to serve multiple needs.

Fuel cells also provide the added benefit of providing a “clean” source of energy. Because the energy is generated by a chemical reaction, the electron stream generated from fuel cells is cleaner than that normally generated using conventional power plants. For many industries the quality of their power is not of extreme importance, but for some niche applications, such as computer chips, power quality is crucial.

### *3.3.2. Hydrogen Fuel*

Fuel cells have the potential to be pollution-free and to make the European islands energy independent. Whether or not they live up to that promise depends on how the hydrogen fuel is generated. Hydrogen is all around us.

Water is made of hydrogen and oxygen and hydrogen is in all living things, but it is rarely in the elemental form needed for fuel. It takes energy of some kind to generate pure hydrogen. Hydrogen can be produced via three primary mechanisms.

***Electrolysis*** generates hydrogen by splitting the water molecule into its two components, hydrogen and oxygen, by passing an electrical current through the water and then capturing the hydrogen. The question is how to generate the electricity to do it. Will it be coal, nuclear power, or electricity from RES?

The cleanest and most environmentally friendly way of generating hydrogen is to use RES, like wind, biomass, or solar, to generate the electricity to perform the electrolysis. This choice has the additional benefit of bringing economic development opportunities to the insular areas.

Using wind and solar power to generate hydrogen makes these intermittent resources more valuable. They can be used when available to produce hydrogen, solving the dilemma of their intermittent nature.

***Bio-chemical Conversion of Biomass*** The plant material all around us contains hydrogen. Demonstration projects are showing that hydrogen fuels can be made from plant waste materials using enzymes, fermentation, catalysts, and algae. Many communities have wastes from sugar beet plants, food processing plants, ethanol and biodiesel facilities, and even sewage treatment plants that may in the future be used to generate hydrogen fuels.

***Reforming of Fossil and Bio Fuels*** requires pre-treatment of the fuel, which could be crude oil, methanol, ethanol, natural gas, or even gasoline or diesel fuel, in a “fuel reformer” that extracts the hydrogen for use in a fuel cell. The drawback to this method is that except for ethanol and methanol, it still requires the use of imported fossil fuels and still produces air pollution and greenhouse gases. On the other hand, reforming fossil fuels is a more efficient mechanism of using these fuels because it involves a chemical reaction rather than thermal production and results in more km/L.

Using wind, biomass, and solar power to make hydrogen fuel will increase the flexibility and reliability of these intermittent RES, creating a larger market for the power.

## 4. Technological paradigms

There are several technological paradigms. In this chapter are selected the most common and the most successful ones. An idea of the existing possibilities for the selection of the system is presented in the Table 4.1.

Table 4.1
Suggested initiatives for the exploitation of RES in Mediterranean islands

| Type of the island | Initiatives | Penetration limit |
|---|---|---|
| Grid-connected | Grid-connected wind farms and large solar systems | none |
| Diesel-oil electricity production and high population | Large solar systems and wind farms | 30% of the peak energy |
| Sparely populated islands with/without diesel-oil electricity production | PV-wind-diesel systems with energy storage | 30% of the peak energy |
| Small islands with large numbers of tourists | Central wind-PV systems with energy storage | no |
| Islands with local electricity grid | Grid-connected wind and grid-connected/ roof-mounted PVs | 30% of the peak energy |
| Small islands with insulated buildings and high cost grid-connections | RES electrification of free-standing buildings | no |
| Expensive water and minor energy demands | Desalination =using wind or PV | NA |

### 4.1. Desalination

For islands and remote areas it is already worth calculating if a complete autonomous renewable energy and water supply system saves costs compared to conventional technology, especially for smaller plants (SWRO 300–1.500 m3/d).

An autonomous renewable energy supply system can basically be divided in two parts. The first part consists of the autonomous energy supply system where the main power supply is generated by a wind turbine and stable electricity supply is guaranteed despite fluctuating winds. The fluctuating power of the Wind Energy Converter (WEC) is smoothened and offered to a consumer. The second part contains desalination plant with (1) the ability to adapt to the fluctuating power offered with the autonomous renewable energy supply system and (2) a very low specific energy consumption.

Due to the requirement of low specific energy consumption the RO—process was chosen. An energy recovery was developed to meet the special requirement of variable production to adapt to the available power. Therefore the desalination process needs to be controlled completely automatic, including not only the standard operation also basic cleaning processes.

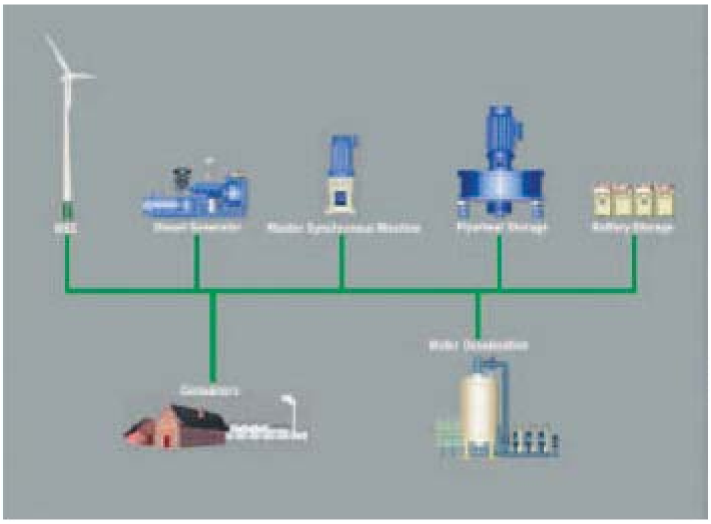

Fig.4.1. Presentation of the ENERCON wind desalination system

The so-called 'ENERCON Stand alone System' is currently in its application phase on the Norwegian Island of Utsira.
The system which was installed in 2004 is the first of its kind functioning in real conditions worldwide. The system combines several different components to form a highly efficient sophisticated system. The main energy supplier is an ENERCON wind turbine, which, due to its adjustment concept (variable speed, variable blade control), is easily combined with other components.
The wind turbine in the stand-alone system uses the existing grid infrastructure and offers, depending on the amount of wind, a savings of up to 90% of the diesel fuel consumed by guaranteeing power supply when the diesel generator is off. A diesel generator shutdown is, however, only possible using further standalone components which assure grid frequency and voltage control and also to ensure that the critical situation of switching users on and off remains stable. ENERCON's Master- Synchronous Unit controls the voltage, while the flywheel storage is used to control the frequency. This also allows the grid to be maintained without the diesel generator. The generator can be shutoff as soon as the turbine supplies enough energy within the minutes range and provides the users with power. If wind fluctuations occur and not enough energy is available, the diesel generator has to be started. To avoid this, short-term and long-term storages can be deployed when necessary.
With gusty winds the fluctuations are short but frequent in the seconds range. In order to balance this out, a flywheel storage system is used. Batteries can be used as longterm storage, for example, when more power is available than the desalination plant or the connected users require. Inversely, when there is a lack of energy, the batteries are discharged to cover the shortage. This type of energy storage can be used as a medium or long-term storage in the minutes or hours range depending on the batteries'

capacity design. Since this type of storage is seldom needed, sufficiently durable batteries can be used. Another solution for time periods within the hours and days range is an electrolyser, for example. This utilises excess energy to produce hydrogen, which then can be stored. For longer periods of calm winds, this can drive a hydrogen generator or supply a fuel cell (in the test on Utsira together with Norwegian Company Hydro). Compressed air storage or pumped storage power stations are other possible long-term storage options to complete ENERCON's stand-alone system.
Together all these components form a closed autonomous power system, which, depending on the design, can provide power to a certain capacity for a desalination plant without causing any pollution.
A special Energy Management System controls these components so that they can work together and work together efficiently, depending on the offer and demand. It either automatically switches off or on, or adjusts.

### 4.2. Hydrogen for autonomous insular systems

In order to take advantage of the natural beauties of the numerous European islands as an economic potential, the proposed sustainable form of tourism needs safety of energy supply. The required energy could be provided by RES such as the sun and/or wind, whereas the drinking water will be provided by desalinization plants.
The use of hydrogen as a bearer and storage of energy is a completely new technology, which is expected to be a future substitute for fossil fuels. The hydrogen energy system based on the harnessing of solar and wind energy as primary sources, represents a realistic possibility for meeting the insular energy

supply needs. Besides providing electric energy, the proposed system (Figure 4.2) will supply fuel for the tourist resort and the drinking water supply.

The proposed system would function as follows:

- conversion of solar energy into thermal energy by solar heat collector for the needs of tourist resorts
- supply of resorts with electric energy produced by photovoltaic cells and wind turbine generators
- conversion of the surplus electric energy into hydrogen through electrolysis
- storage of hydrogen and oxygen in high pressure vessels
- the greater part of the produced hydrogen would be used directly as a substitute for fossil fuel
- a small quantity would be converted into electric energy using fuel cells (in case of insufficient of electric energy in solar and wind power plant).

Obviously, hydrogen stores energy.

The alkaline based FC (AFC) stack units are available at a lower cost per kW of FC stack, and they are forecast to remain the cheapest FC technology due to the lack of expensive platinum catalyst (PEM), or high temperature ceramic materials—as used in solid oxide fuel cells (SOFC). A FC unit will be fuelled directly by hydrogen gas that will be produced by reforming a portion of the biogas output from the plant.

A FC unit will be operated in base load mode and coupled to a battery pack for hybrid operation. A hybrid configuration will derive maximum utilisation of an approximately ‘base load’ rated FC and a peak load supplying lead acid battery pack.

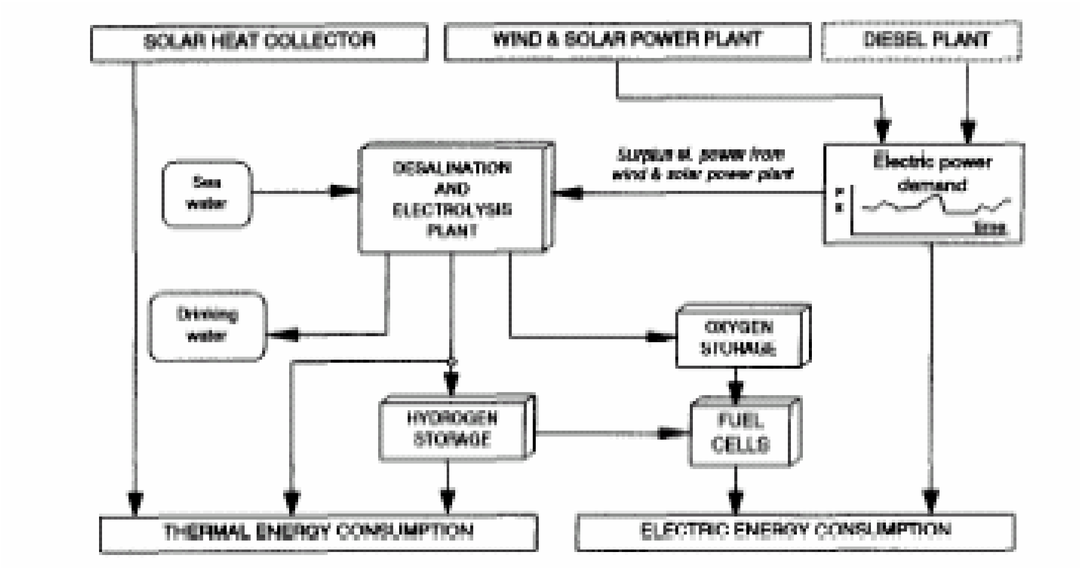


Fig. 4.2. Model of hydrogen energy system for autonomous tourist centers at Adriatic islands

Additionally it will provide a power blackout ride through capability (as frequently occurs in island situations). Such a hybrid configuration will permit high utilisation of the FC technology at the lowest possible capital cost (recognising the significant capital cost barriers present in the current FC market, and price differential between the expensive FC element and cheap battery fraction).

## 4.3. Hybrid systems

Hybrid systems, for example coupling of wind engines with a diesel and battery system, is a viable solution for supplying power to remote regions. They achieve high fuel savings and maintain the highest supply reliability. The wind turbines load the batteries and allow for periodic shut down of the diesel engines, thus decreasing operating and maintenance costs. The load is satisfied by the wind turbines directly, while load or wind speed fluctuations are balanced by the batteries.

Under favourable wind conditions, the generated kWh cost is usually 20–40% less expensive than the cost of a simple diesel powered station. Photovoltaics (PV) can be integrated into the power supply grid, coupled with wind turbines or with a diesel–battery system, for increased reliability.

The load is satisfied by the electrical output from the PV or the wind turbines directly, while load or solar/wind speed fluctuations are balanced by the batteries. In isolated areas, where the cost of diesel fuel is very high and difficult to transport, PV use is economically attractive. Large scale solar heating applications that store the collected solar heat during summer for space heating in winter, result to cost reductions of about 25% compared to the cost of common small solar domestic hot water systems, with a ratio of investment cost to delivered heat of about 1 €/kWh per year.

### 4.4. Pumped hydro storage systems

In conventional electrical energy production systems the generating plants have to cover fluctuations in demand, with peak periods possibly representing a high percentage of actual consumption, while still trying to maintain minimum costs. These demand peaks are generally supplied by what are known as 'cyclical plants', which are smaller in size and output than the conventional plants used to cover the base demand. The cyclical plants tend to be powered by coal, fossil oil or gas but also operate using cyclical pumped storage systems. The pumped hydro storage systems use excess electricity production, in periods of low demand, to pump water to a deposit situated at a certain height, recovering it at a later time through a turbine when it is required to cover peak load periods.

The technological advances made since the first pumped hydro storage systems were built between 1910 and 1927 have meant a spectacular increase in total installed world capacity. Nowadays pumped hydro storage systems are considered by engineers and planners to be an attractive alternative for the expansion of power systems, as a considerable amount of energy can be stored with this technique, the generating equipment is highly reliable and the power output can be extensively regulated maintaining a practically constant efficiency within the generated power range.

Another reason that has awoken interest in the large scale use of hydro storage systems since the 1970s has been the increase in the use of RES to generate electricity. In this sense, various projects have been proposed aimed at adding the use of wind energy to already existing hydroelectric power stations, as well as projects for small sized hybrid systems, fundamentally in Europe and Asia.

When one of the power subsystems involved in electricity generation produces energy with a high random component (stochastically), as is the case of a wind farm where the energy output depends on the wind speed, there exists uncertainty as to the availability of sufficient energy at any one instant to cover demand. One form of reducing this uncertainty, and thus ensuring customer satisfaction by not placing limits on demand, is through the installation of an energy storage system that enables adaptation of the irregular nature of the supply from wind turbines to the irregular nature of the demand. Though there are proposals to increase the use of RES in island electricity grids through the storage of hydrogen the only feasible means of storing large quantities of electrical energy at the present time is using pumped storage systems. However, as various experts have pointed out, hydro storage systems may present a number of problems such as, for example, the environmental damage caused by reservoirs and the difficulty of finding topographically suitable sights with sufficient water capacity to make the installation of such systems profitable.

Fig. 4.3 shows an outline of the most general configuration of the proposed system. It consists of a wind farm (WF) with nw identical wind energy conversion systems (WT); a hydroelectric plant (HP) of nt identical hydraulic turbines and their corresponding electrical generators (HT); a water pumping station (PS) with np identical motor pump sets (MP); a water storage system (WS), consisting of a lower (LR) and upper (UR) reservoir; a control system (CS);12 a conventional electrical power system (CPS); and the load system (LS).

The LS is dependant on the load structure (domestic, industrial, commercial) and the climatic characteristics of the region whose energy requirements the system aims to cover, but which here are considered uncontrollable by the CS.

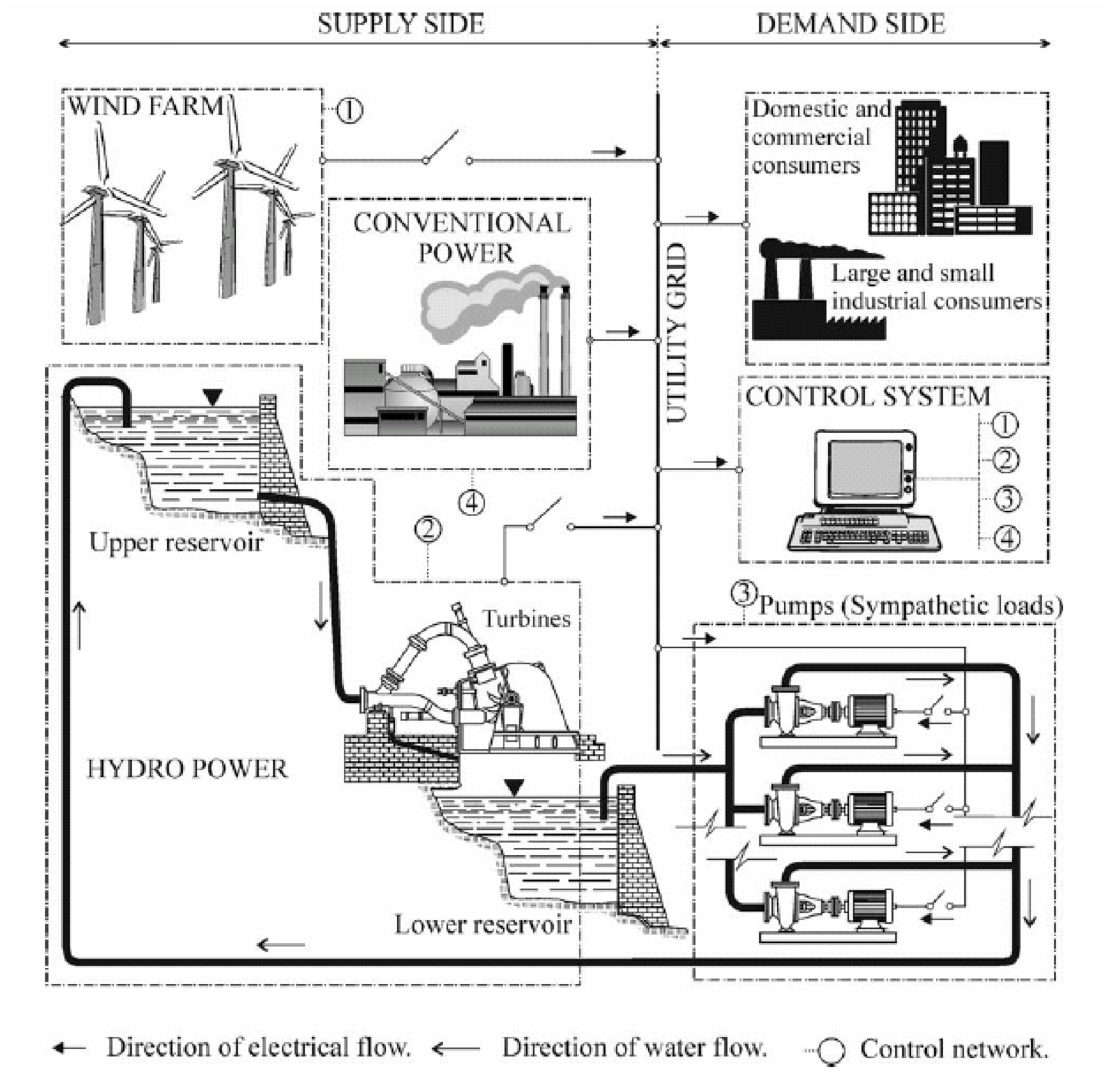


Fig. 4.3. Schematic representation of the proposed system.

As can be seen in Fig. 5.3, the various power and load subsystems in the proposed model are connected to the same electrical grid. The advantage of this system configuration is that the WF can be located in an area of high wind potential which does not have to coincide with the installation area for the PS. However, its peculiarity lies in the fact that if the aim is to maintain the stability of the system without compromising its reliability, then it requires the CS to be able to control part of the demand in addition to the energy supply.

### 4.5. Solar drying

The basic reason for drying crops is to preserve them so that excess production in time of glut is not allowed to rot. In the Third World, more than 30% of crop production may be lost because of spoilage and solar crop drying is a simple way to reduce this.
In the figure 5.4 is presented a mixed-mode solar dryer.

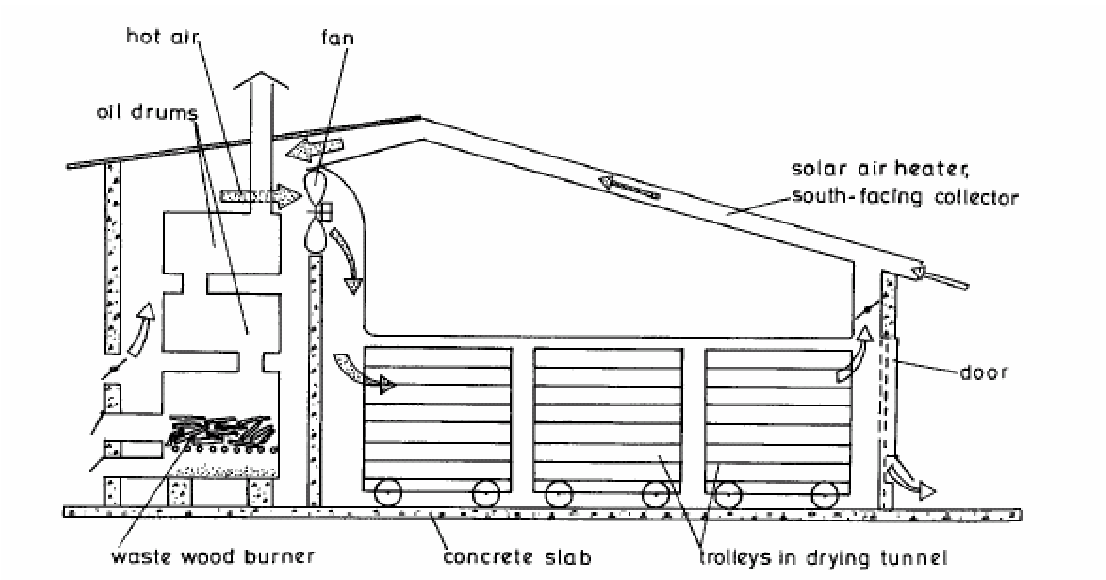


Fig. 4.4. A 100 m2 mixed-mode solar dryer .

### 4.5. Solar cooling

The interest in air conditioning (AC) especially in the domestic and the services sectors, is constantly growing not only due to the continuously increasing trend of improved comfort, but also due to the high ambient temperatures during the recent years. In parallel, passive techniques, used traditionally in the past to keep comfortable indoor conditions, seem to have been neglected in many new buildings and even in the cases that have been taken in account for the construction of the building, usually are insufficient to provide the required indoor conditions without supplementary cooling or heating.

In the summertime the electricity demand raises due to the wide use of heating ventilation air conditioning (HVAC) systems, which increase the peak of electric load, causing major troubles in the electric supply system. At the same time the greenhouse gases emissions are increased, by the energy production or by the leakage of the cooling fluids, intensifying the vicious circle of the climate change.

In the solar assisted air conditioning cooling (SAC) systems solar heat is required to drive the cooling process. During the last decade the SAC technologies have proved their efficiency and reliability. SAC systems use harmless water-based cooling fluids, and much less primary energy than the conventional systems. SAC systems can be used, either as stand-alone systems or with conventional AC, to improve the indoor air quality. Additionally they cooperate with already existing conventional indoor installations.

The use of solar energy to drive cooling cycles for space conditioning of most buildings is especially promising in Southern Europe, since the cooling requirements of a building are roughly in phase with the solar radiation.

SAC systems installed so far may be classified into:

- **Closed systems:** thermally driven chillers, which provide chilled water, that is either used in air handling units to supply conditioned air (cooled, dehumidified) or is distributed via a chilled water network to the designated rooms to operate decentralized room installations, e.g. fan coils. Technically mature machines for this purpose are absorption chillers (most common) and adsorption chillers (a few hundred machines worldwide, but of rising interest in SAC);

- **Open systems**, allowing complete air conditioning by supplying cooled and dehumidified air according to the comfort conditions. The "refrigerant" is spray water, which it is in direct contact with the atmosphere. Most common systems are desiccant cooling systems using a rotating dehumidification wheel with solid sorbent.

## 5. Typology of RETs Use

In the following tables 5.1 and 5.2 are represented the RETs and RUE Uses typologies for European Insular areas. The provided information derived from literature review on islands energy needs and RES and RUE Technologies applications in insular areas; besides the current expertise of the RERINA partners was exploited

It is obvious that the typologies provided below are not be exhaustive however they include all major potential uses of energy in an insular area that can be produced through the implementation of RETs. Special attention has been provided in order the typology to include all potential energy uses that can be accommodated from renewables that may be considered in the four case-studies of the RE-RINA project, i.e. the four insular areas that Sustainable Energy Plans will be developed and implemented.

It is estimated that these applications can cover more than 75% of the total typical energy needs in the insular areas.

**Table 5.1 Typology of RETs Uses in European Insular Areas**

| Application Areas | Applications Sub-areas | Renewable Energy Source | technological maturity (max:3, min:1) | economical maturity (max:3, min:1) |
|---|---|---|---|---|
| **1. HEATING/COOLING** | | | | |
| **Outdoor swimming pools** | Tousist hotels/resorts<br><br>Athletic centers | Solar Thermal | 3 | 2 |
| **Hot water** | Houses and commercial spaces | Solar Thermal | 3 | 3 |
| | | Geothermal Low Enthalpy Energy | 2 | 3 |
| **Space Heating** | Houses and commercial spaces | Solar Thermal | 3 | 2 |
| | | Geothermal Low Enthalpy Energy | 2 | 3 |
| | | Biomass Energy | 3 | |
| | Greenhouses | Geothermal Low Enthalpy Energy | 2 | 3 |
| | | Biomass Energy | 2 | 3 |
| | Aquaculture farms | Geothermal Low Enthalpy Energy | 2 | 3 |
| | | Biomass | 2 | 3 |
| | Farms | Biomass Energy | 2 | 3 |

| | | | | |
|---|---|---|---|---|
| | District Heating | Geothermal Low Enthalpy Energy | 2 | 2 |
| | | Geothermal High-Medium Enthalpy Energy | 2 | 2 |
| | | Biomass Energy | 2 | 3 |
| **Cooling appliance or refrigerators** | House, Commercial and hotel buildings | Solar Thermal | 2 | 1 |
| | Large application of cooling/refrigerating i.e. warehouses & supermarkets | Solar Thermal | 2 | 1 |
| | | Photovoltaic Energy | 3 | 2 |
| **Biofuels Industry** | Production of Methanol and Ethanol | Geothermal High – Medium Enthalpy Energy | 3 | 3 |
| | Production of Ethanol | Biomass Energy | 2 | 2 |
| **Agricultural Industry** | Drying of seeds, wool, hay, etc. | Geothermal High – Medium Enthalpy Energy | 2 | 2 |
| | | Biomass Energy | 2 | 3 |
| | Drying of serials | Geothermal Low Enthalpy Energy | 2 | 2 |
| | | Biomass Energy | 2 | 3 |
| | Conservation of meat and vegetables | Geothermal High – Medium Enthalpy Energy | 2 | 2 |
| | | Biomass Energy | 2 | 3 |
| **Wastewater treatment plants** | | Wind Energy | 3 | 3 |
| | | Biomass | 2 | 2 |

**2. ELECTRICITY**

| | | | | |
|---|---|---|---|---|
| | | Geothermal High Enthalpy Energy | 2 | 2 |
| | | Biomass Energy | 2 | 2 |
| | | Wind power | 3 | 3 |
| | | Photovoltaic Energy | 2 | 2 |
| | | Small and Micro Hydroelectric Energy | 2 | 2 |
| **Remote electrification systems non-connected to the network** | Electrification of housing, commercial, agricultural and industrial facilities | Wind energy | 3 | 3 |
| | | Photovoltaic Energy | 2 | 2 |
| | | Small and Micro Hydroelectric Energy | 2 | 2 |
| **Autonomous electrification systems** | Street lighting, Electricity for signaling (telematics) applications, telecommunication systems, telemeasurement systems and alarm systems | Photovoltaic Energy | 2 | 2 |

**3. TRANSPORT**

| | | | | |
|---|---|---|---|---|
| **Transportation Vehicles** | | Biofuels | 3 | 3 |
| | | Hydrogen Energy | 2 | 2 |
| | | Electricity produced from renewables | 2 | 2 |

**Table 5.2 Typology of RUE Applications Uses in European Insular Areas**

| Application Areas | RUE Technology Types | technology / technique maturity | economical maturity |
|---|---|---|---|
| **1. HEATING** | | | |
| **Residential, Hotels, Public and Commercial Buildings** | Insulated Windows and Doors | **3** | **3** |
| | Bioclimatic Concepts in Building Design | **3** | **3** |
| | Zone Heating System | **3** | **2** |
| | Water Heating Systems | **3** | **2** |
| | Insulated Hot Water Installation | **3** | **2** |
| | Energy Efficient House Appliances | **3** | **3** |
| | Automatic air-conditioning control systems | **3** | **2** |
| **2. COOLING** | | | |
| **Residential, Hotels, Public and Commercial Buildings** | Windows with special glazing | **3** | **2** |
| | Bioclimatic Concepts in Building Design | **3** | **2** |
| | Zone Cooling System | **3** | **2** |
| | Automatic air-conditioning control systems | **3** | **2** |
| **3. HOT WATER** | | | |
| **Residential, Hotels, Public and Commercial Buildings** | Efficient patterns of use of hot water coming from solar thermal technologies based on the climate characteristics | **3** | **3** |
| | Fixtures like low-flow | **3** | **2** |

| | | | |
|---|---|---|---|
| | showerheads that reduce hot water use | | |
| | Appliances using directly hot water | **2** | **3** |
| | Water Heating Systems | **3** | **2** |
| | Insulated Hot Water Installation | **3** | **2** |

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