

## DOCUMENT NOTE

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## 1 INTRODUCTION

This Report (Deliverable D3.2) presents an assessment of major existing barriers to maximum penetration of renewable energy in island electrical systems, and recommendations for overcoming these technical, economical, political, social and environmental barriers. The report aims at defining a set of useful guidelines for regulatory authorities, policy makers, RES developers, utilities, and any other stakeholder with responsibilities or influence on the electric market.

This Report (Deliverable D3.2) includes information regarding barriers stopping the development of renewable energies and the deployment of energy storage technologies, in different European islands and remote regions. The barriers have been identified, and a set of recommendations to overcome them have been analyzed, trying to determine the implementation cost of each of them, and the benefits that will derive, in terms of increase RES penetration. This information will be useful for optimizing cost-effective strategies to foster the use RES-storage system integration in these regions.

The report addresses solutions to overcome technical, economic and political/regulatory barriers. Issues that include proposals for improving grid stability of weak electrical grids faced with high RES penetration; actions to improve the financial feasibility of energy storage projects; and needed changes in local administrative regulations which could simplify the approval of RES-energy storage integration projects.

The approach for the elaboration of this report has consider the issues which are limiting the deployment of RES and energy storage systems, analysis of possible actions that could contribute to improve the situation, and the definition of cost effective strategies. The report has been divided in four phases:

- Thorough analysis of the existing situation, and identification of existing technical, economic and political (regulatory) barriers
- Analysis of possible solutions to overcome each of the barriers identified
- Estimation of the cost associated to the implementation of each of the proposed solutions
- Estimation of the impact of each implemented solution, towards the goal of maximizing RES penetration in weak grids of island and remote regions

Given the difficulties to establish the impact of each of the proposed solutions, a methodology with reasonable criteria has been used to estimate the cost and the benefits of implementing each of them. The objective is to define cost competitive strategies for maximum RES penetration in islands. The methodology will be applied to two case studies, La Graciosa island in Spain and Milos in Greece, to produce the optimum cost efficient strategy for overcoming existing barriers and promoting RES in these two islands.

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## **2 IDENTIFICATION OF BARRIERS TO HIGHER RES PENETRATION**

There are important technological, economical, political and social barriers that would have to be overcome in order to achieve the goal of maximizing the use of available renewable energy resources in islands. Through the STORIES project a thorough identification work of these existing barriers has been made.

The need for enacting policies to support renewable energy is often attributed to a variety of barriers that prevent investments from occurring. The objective is to offer a methodology that can support the definition of cost competitive policies necessary to foster RES development in islands and remote regions, and that the renewable energy potential of these regions can be realized at a reasonable cost.

For the preparation of this report, efforts have been made to identify all those possible barriers which could be stopping the development of RES in islands and remote regions. The barriers have been divided into a set of five categories:

- Grid capacity and management
- Economic
- Regulatory / legislative frameworks
- Social, including public awareness and externalities
- Market issues

### **2.1 GRID CAPACITY AND MANAGEMENT BARRIERS**

The small and weak electrical grids are a main obstacle to maximum RES penetration in island regions. The need to have back-up conventional power on stand by for when the wind stops blowing or the sun does not shine, is an important cost that has to be supported by local utilities. Besides high percentage penetration of intermittent RES generated electricity induces stability problems in the islands electrical systems.

#### **a) Fluctuation of RES**

There are technical limitations and difficulties to manage power fluctuations in small electrical grids. The intermittence and variability of the RES such as solar and wind limits their maximum penetration in weak electrical grids. Rapid reductions in the power output from

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these sources, caused by the wind dropping off or a cloud passing overhead must be managed with appropriate control or short term storage systems to maintain constant power output.

**b) Non-programmable RES**

The alleatory nature of wind, solar and other RES sources makes it necessary to have conventional power systems in stand-by for when the wind does not blow or the sun do not shine.

**c) Small and weak grids**

Weak electrical grids limits the amount of RES electricity generation

**d) Lack of co-operation of RES with the existing conventional generation local units in grid integration**

The thermal units already installed on the islands are characterized by significant technical minimum. Besides, their response especially when the system load is low can be rather slow. This may lead to preventive limits to RES penetration (Dynamic limit).

**e) Insufficient grid capacity (transport and transmission lines)**

Quite often significant RES potential exists in areas with very weak networks. Thus, there is limitation in the capacity of energy to be transferred

**f) Limitations of sea and road transport infrastructure and hoisting capacities limit the size of large wind turbine**

Difficulty to transport certain RES technology components to, and in islands. Larger wind turbines cannot be as easy transferred to the islands as on the mainland. There may be problem for large cranes to come to install such units increasing the technology prejudice

**g) Insufficient funds allocated to long-term R&D by public authorities**

the current public funds allocated to long-term R&D are not enough to encourage investments in the sector and to ensure continuity in the improvement of RES Technologies implementation (for example, energy-related research has been reduced from 66% of total EU research funds in the early 1980s to 12% under FP6).

## 2.2 ECONOMICAL BARRIERS

Developing new renewable resources will require large initial investments to build infrastructure. These investments increase the cost of providing renewable electricity. Besides, renewables developers and customers may have difficulty obtaining financing at rates as low as may be available for conventional energy facilities. Financing costs can greatly affect the price

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and competitiveness of wind energy, since most of the cost is in capital and little is in operation.

**a) High initial capital cost**

Renewable energy investments generally require higher amounts of financing for the same capacity. Initial capital costs for renewable energy technologies are often higher on a cost-per-unit basis (i.e., \$/kW).

**b) High financing costs**

Financing is unreasonably costly for renewable energy technologies. High financing costs are especially significant to the competitive position of renewables, since renewables generally require higher initial investments than fossil fuel plants, even though they have lower operating costs. Renewables developers and customers may have difficulty obtaining financing at rates as low as may be available for conventional energy facilities. Financial institutions are generally unfamiliar with the new technologies and likely to perceive them as risky, so that they may lend money at higher rates.

**c) Lack of access to credit**

Consumers or project developers may lack access to credit to purchase or invest in renewable energy because of lack of collateral, poor creditworthiness, or distorted capital markets.

**d) Financing risks and uncertainties**

The initial high investment cost associated to renewable energy systems, makes it necessary to dispose of a stable price framework to guarantee that the investment can be recovered in a reasonable time period

**e) High transactions costs**

Small projects have high transaction costs at many stages of the development cycle. Renewable energy projects and companies are generally smaller than conventional energy projects. These small companies are less able to communicate directly with large numbers of customers. They will have less clout negotiating favourable terms with larger market players.

**f) Lack of economies of scale**

The reasons for high cost have to do with technological maturity. The biggest factor, however, is the lack of economies of scale. Unfortunately, as long as relatively few units are produced, prices will remain high. This leads to low demand and therefore low production volumes. Mass-commercialisation is needed for RES systems to be competitive with conventional technologies. This ‘chicken-and-egg’ relationship between production and consumption is one of the most fundamental challenges of commercialising a technology that competes with a mass produced incumbent

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**g) Difficulty of fuel price risk assessment**

Risks associated with fluctuations in future fossil-fuel prices may not be quantitatively considered in decisions about new power generation capacity because these risks are inherently difficult to assess. Renewable energy technologies avoid fuel costs (with the exception of biomass) and so avoid fuel price risk. Thus, risks of severe fluctuations are often ignored. However, this benefit, or “risk-reduction premium,” is often missing from economic comparisons and analytical tools because it is difficult to quantify.

**h) Imperfect capital markets**

No level playing field for renewable energy technologies. Undisclosed subsidies and some investment restrictions produce inefficient investment decisions. Public subsidies for conventional forms of energy, both implicit and explicit, are channelled in varying amounts to all forms of energy, which can distort investment cost decisions. Large subsidies for fossil fuels can significantly lower final energy prices, putting renewable energy at a competitive disadvantage if it does not enjoy equally large subsidies. Subsidies and lack of internalisation of externalities are principle problems to the development of all renewable energy technologies.

**i) Unequal tax burdens between renewables and other energy sources**

Conventional generating technologies have a lower tax burden. Fuel expenditures can be deducted from taxable income, but few renewables benefit from this deduction, since they do not use market-supplied fuels. Income and property taxes are higher for renewables, which require large capital investments but have low fuel and operating expenses.

**j) Failure of the market to value the public benefits of renewables**

Externalities are not internalised in energy/fuel prices. Without internalising environmental and other costs, renewable generation is more expensive than conventional technologies. Many of the benefits of renewables are "public goods" which not always motivate everyone who benefits to pay for them. The environmental impacts of fossil fuels often result in real costs to society, although environmental impacts and associated dollar costs are often included in economic comparisons between renewable and conventional energy, investors rarely include such environmental costs in the bottom line used to make decisions. Renewables will be unable to compete on a level playing field with conventional generation until new policies are adopted to internalize the public costs of these fossil fuel sources. As well as the economic benefit, there are social and environmental benefits associated with renewable energy such as reduced noise, clean air, no risk of spillage of fuel, attraction of eco-tourists, and reduction of greenhouse gas emissions.

**k) Cost of electricity transport and distribution are not considered**

RES are suitable technologies for distributed generation and may not receive full credit for the value of their power. Utility generation planning departments generally consider only the cost of generating electricity with a distributed technology, not the potential savings in transmission

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and distribution costs. RES fed into distribution networks near final consumers rather than at centralized generation facilities may not require transmission and distribution, but utilities may only pay wholesale rates for the power, as if the generation was located far from final consumers and required transmission and distribution. RES can help avoid investments to upgrade transmission or distribution lines. Renewable technologies are sometimes cost-effective when this integrated value is considered.

**l) Insufficient incentives for governments and private companies to support renewable energy development**

There is the need for price-setting policies by establishing favourable pricing regimes for renewable energy relative to other sources of power generation. A government may provide the subsidy from its own funds or may compel utility companies to purchase the electricity thus produced, passing the costs on to its consumers.

**m) High O&M cost**

The maintenance and service of a huge number of large wind turbines will be a challenge, especially for offshore applications. New service and maintenance concepts have to be developed.

### 2.3 REGULATORY / LEGISLATIVE FRAMEWORK BARRIERS

Full value of distributed generating technologies is not always well assessed. Small renewable energy systems for distributed generation can help avoid, not only investment in new conventional generation power and fossil fuel consumption, but also investments to upgrade transmission or distribution lines. Renewable technologies are sometimes cost-effective when this integrated value is considered, and it is important that this vision be shared by regulatory authorities, which are able to contribute to define a framework that gives priority to RES development.

**a) Transmission access**

Grid connection and access is not fairly provided. Utilities may not allow favourable transmission access to renewable energy producers, or may charge high prices for transmission access.

**b) Utility interconnection requirements**

Individual home or commercial systems connected to utility grids can face burdensome, inconsistent, or unclear utility interconnection requirements.

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**c) Restrictions on siting and construction of RES plants due to lack of spatial planning**

Wind turbines have faced specific environmental concerns related to siting along migratory bird paths and coastal areas. Also urban development or territorial protection of different kinds affect the availability of land where to develop and installed different RES systems

**d) Lack of legal framework for independent power producers**

In the absence of a legal framework, independent power producers may not be able to invest in renewable energy facilities and sell power to the utility or to third parties under so-called “power purchase agreements.”

**e) Unfavourable power pricing rules**

Renewable energy sources feeding into an electric power grid may not receive full credit for the value of their power.

**f) Delays in authorisation procedures**

Long lead time to obtain necessary permits. Exact time to obtain a license is legislative set but always much more time is needed. Especially spatial planning related to permits can take many years. Permits for new renewable energy plants are difficult to obtain due to not optimized administrative processes. They often include unnecessary requirements and lack transparency of information

**g) Lack of planning for promotion of clean renewable energies**

Although ambitious objectives are set by national and regional authorities with respect to RES promotion, not always a credible realistic planning to achieve the objectives exists.

**h) Lack of standards**

Large number of national or regional standards, recommendations, instructions or requirements for interconnection of intermittent RES to network. Government organizations are not too much involved in definition of interconnection rules which are often the source of controversies between RES developers and network operators.

**i) Lack of specialised administrative data**

Not organised land registries, unsolved property and use of land, management of protected areas

**j) Lack of cooperation between different authorities and standard procedures**

A high number of authorities at local, regional and national level are involved in the authorization processes. For both permitting and financial support, and RES developers should submit the same or very similar information multiple times to different authorities. Besides complex, long, expensive and non-transparent procedure for obtain RES licences and permits, there are many organizations and intermediate structures of consultation without having a

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coordination and common direction between them. Too many licences, approvals, decisions for small systems <50 kW.

**k) Lack of transparency as for authorization and certification procedures**

The current situation demonstrate confuse and imprecise procedures for the customer, also due to the existing “non-organic” legislation for authorization and certification. To this aim, some EU countries are trying to simplify their legislation by the creation of “unique” tests. Nevertheless, it persists too many relevant documents.

**2.4 SOCIAL, INCLUDING PUBLIC AWARENESS AND EXTERNALITIES BARRIERS**

General public usually have insufficient information to make informed choices on energy use. Most utilities provide little or no information about their emissions or the fuels they use. Because renewable technologies are relatively new, most customers know little about them. Even local electricity companies may be unfamiliar with renewables. Most utilities have not studied how renewable resources could fit into their systems or what local resources are available.

**a) Lack of commercial skills and information**

Markets function best when everyone has low-cost access to good information and the requisite skills.

**b) Perceived technology performance uncertainty and risk**

Proven, cost-effective technologies may still be perceived as risky if there is little experience with them in a new application or region.

**c) Environmental externalities**

Although environmental impacts and associated dollar costs are often included in economic comparisons between renewable and conventional energy, investors rarely include such environmental costs in the bottom line used to make decisions.

**d) Insufficient renewable energy technical skills**

In specific markets, skilled personnel who can install, operate, and maintain renewable energy technologies may not exist in large numbers. Project developers may lack sufficient technical, financial, and business development skills. Consumers, managers, engineers, architects, lenders, or planners may lack information about renewable energy technology characteristics,

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economic and financial costs and benefits, geographical resources, operating experience, maintenance requirements, sources of finance, and installation services

**e) Lack of information on RES among decision makers, professionals and citizens**

Information about RES to the population is essential for the acceptance of RES technologies and sites. Even local electricity companies may be unfamiliar with renewables. Most utilities have not studied how renewable resources could fit into their systems or what local resources are available. Urban planning departments or building inspectors may be unfamiliar with renewable energy technologies and may not have established procedures for dealing with siting and permitting

**f) Small number of licenses granted**

The number of licences granted for RES microgeneration is limited, and often is taken by large RES production sites

**g) Lack of public acceptance and resistance from local groups**

Certain RES technologies may be perceived as detrimental for local groups' interests, particularly in environmentally sensitive areas. This could be the case of fishermen and environmentalist associations who oppose to small hydro-power applications, accusing them of damaging fish stocks and the overall local environment.

**h) General political climate**

High policy ambitions about RES promotion, but limited realisation of practical measures.

**i) Safety issues (H2)**

For many decades, hydrogen has been produced and used for commercial and industrial purposes, with an exemplary safety record. Normally, in these commercial and industrial environments, only well-trained personnel come into contact with hydrogen. Should hydrogen become more widely used as an energy carrier, contact with laypersons demands different fail-safe routines and technologies. As with today's energy carriers, no absolute measure of safety can be provided; only relative safety levels can be offered. At this stage, only a small number of hydrogen and fuel cell systems and components are in operation today. Consequently, very limited data is available on the operational and safety aspects of these new technologies and demos are required to understand hydrogen's behaviour and to support the development of technologies for the detection and safe management of unscheduled hydrogen releases or incidents involving hydrogen systems

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## 2.5 MARKET ISSUES BARRIERS

These barriers could be considered “market distortions” that unfairly discriminate against renewable energy. Market failures will limit the development of renewables unless special policy measures are enacted to encourage that development.

**a) Energy markets are not prepared for renewable energy**

Commercialization barriers faced by new technologies competing with mature technologies

**b) Poor market acceptance, technology prejudice**

Proven, cost-effective technologies may still be perceived as risky if there is little experience with them in a new application or region. The lack of visible installations and familiarity with renewable energy technologies can lead to perceptions of greater technical risk than for conventional energy sources.

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### **3 RECOMMENDATIONS FOR OVERCOMING BARRIERS TO HIGHER RES PENETRATION**

Technical solutions do exist which could contribute to increase the use of renewable energy sources in island. To each of the barriers previously identified in part 4, ideas are given on possible actions that might contribute to eliminate each barrier. The identified barriers have been separated in the following five groups:

- Grid capacity and management
- Economic
- Regulatory / legislative frameworks
- Social, including public awareness and externalities
- Market issues

#### **3.1 GRID CAPACITY AND MANAGEMENT BARRIERS**

Technical barriers are the most objective and difficult barriers to be overcome. The elimination of some existing barriers will only be possible through more intensive R&D efforts to look for solutions related to energy storage and reinforcement of grid stability expose to high penetration of intermittent RES sources.

##### **a) Fluctuation of RES**

- Energy storage systems: Energy storage systems can help so that the capacity of the interconnection line is sufficient to meet the transfer capacity. There will be some loss of energy but may be more profitable or easier (due to environmental issues) than reinforcing the grid. Better planning of power systems with integrated energy storage, bottlenecks could be spotted in early phase with proper planning.
- Implementation of different energy storage systems based on reversible pumped-hydro storage when possible, and batteries and hydrogen technologies. An automated system containing a solar or wind system, diesel spinning reserve, and a storage mechanism such as a battery could be used to increase the penetration of renewables.

##### **b) Non-programmable RES**

- Weather forecasting numerical models: Reliable wind and solar prediction is possible through the development of climate models for 48 hrs forecast. This would be an important tool for electrical generation programming that would make a maximum use of available RES
- Programmable loads to use excess energy from RES. Installation of RES that can provide some kind of "Ancillary" service: The use of RES, especially wind that cannot

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offer reduction of their output at many steps when required but only on/off decision creates more reduction when necessary to the wind power injection compared to the desired ones. Water desalination or H2 production for transport fuel could be two possible applications of variable loads capable of consuming excess electrical power from RES at valley hours of the demand curve.

- Demand management: Possibility of displacing loads to level the demand curve. Peak shaving could contribute to adjust demand to supply from the RES generators

c) **Small and weak grids**

- Dynamic stability studies of the electrical grid to realistically assess the RES penetration limits, and cost effective solutions to reinforce the grids: The rigorous study of the grids is important to determine the weakest points which have to be reinforced in order to strengthen the capacity of electrical grids to absorb the RES electric power. This will allow to make optimum investment decisions in the electrical infrastructures for maximum RES penetration
- Reinforcement and extension of the electricity grid: Investment on transport lines and other generation and distribution infrastructure, could contribute to improve RES penetration.
- Management tools with on-line dynamic security assessment tools: Using such software tools can provide aid to the operators of an island power system to quickly evaluate the danger of frequency deviations that could lead to a collapse of the power system. In such a way, they can place limits to RES penetration even more efficiently for various potential disturbances. The power of such tools is reinforced if they are combined with uncertainty management methods. Possibilities to remote control production of wind farms and other RES production systems, to adjust their output to the needs and grid capacity, could be important instrument to support the curtailment policy that could allow for increase of the installed RES power

d) **Lack of co-operation of RES with the existing conventional generation local units in grid integration**

- New control concepts must be defined. Requirements on active power control, frequency control, voltage control: A critical indicator is the level of penetration in the electricity system, without harming the system as a whole. Improved focus on grid compatibility is the answer to this challenge. Development of new balance rules and reactive power capabilities coordinated under new philosophy for reactive balances and voltage control. Use of FACTS coupled with energy storage device enables two quadrant steples control of VARs which means full range producing or consuming VARs.

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e) **Insufficient grid capacity (transport and transmission lines)**

- Efficient management of the electricity network : The efficient management of the network with rules for injecting energy to the grid will help in the initial installation of RES capacity till reinforcement takes place
- Use of Geographical Information Systems (GIS): Such a solution can help in identifying the most suitable locations for installing RES taking into account not only the RES potential but also the proximity to "stronger" networks. The IRR of a RES investment may be higher even if not on the best RES regime due to limited connection works

f) **Limitations of sea and road transport infrastructure and hoisting capacities limit the size of large wind turbine**

- Determination of the limits of the size of wind turbines : Level of height and size of wind turbines should be determined instead of just banning wind turbines installations
- Smaller pieces of wind turbines : Smaller pieces of each wind turbine can be more efficiently transported to the site
- Smaller wind turbines : Although not so much efficient a larger wind turbines, these can be transported to the installation site quicker and with more limited impact on the environment

g) **Insufficient funds allocated to long-term R&D by public authorities**

- R&D activities aiming at overcoming restrictions in unit size of RES generation equipment: Wind capture is proportional to wind speed and rotor area. The present technology is limited in size. Research activities that could contribute to solutions to limitation in strength properties of the materials which are reaching their limits. New solutions for overcoming the high weight of gearless multiple generators and the price/availability of materials for permanent magnet generators limits the use of this technology.
- R&D activities aiming at increasing the reliability of wind turbines and contributing to overcoming technology risk: The reliability of main components (blades, gearboxes, generators) has to be improved. Technology research to improve reliability of wind turbines through their projected lifetime. Gear box and drive train transmissions in particular need better understanding and improved simulation and design tools.

## 3.2 ECONOMIC BARRIERS

Solutions to economic barriers should aim at supporting the developers of RES by reducing the risk of their projects, and practical policies that focus more on subsidies to RES generation, and the elimination of existing ones for fossil fuels and nuclear power.

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a) **High initial capital costs**

- RES business development and microcredit : Supports private entrepreneurs to provide renewable energy products and services to end-users and offer consumer credit for purchases
- Capital cost reduction policies : Reduces investment costs through subsidies, rebates, tax relief, loans, and grants
- Promote long-term power purchase agreements between consumers and RE generators : Possibilities that providers of energy services can guarantee from consumers an stable price framework that could allow to recover their investments

b) **High financing costs**

- Favourable Low-interest loans programs offering financing for the purchase of renewable energy equipment. : Considering the social benefits of RES end users of these clean technologies should receive government support to reduce the financial cost of their investment

c) **Lack of access to credit**

- Attract Venture capital and private equity investments in clean energy companies :
- Microcredit programs lending for household-scale renewable energy systems: Small amount credits for the installation of home RES system (solar thermal, photovoltaic and low power wind turbines).

d) **Financing risks and uncertainties**

- Guaranteed price during the economic life of the project: Would required necessary governmental financial support for utilities to cover the difference between the cost they will be required to pay RES energy production, and the price they charge consumers.

e) **High transactions costs**

- Promote the creation of associations for project developers : Create the conditions for project developers to get together to achieve a higher market force, and share costs among various projects

f) **Lack of economies of scale**

- Public programs to incentivise RES projects: Government can contribute through different public actions to stimulate the growth of the RES market.

g) **Difficulty of fuel price risk assessment**

- Instruments to realistically asses the risk on conventional fossil fuel sources : The estimation of the risk premium and application of this increment to the energy price that final consumers should pay

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**h) Imperfect capital markets**

- Life cycle-analysis: Lower fuel and operating costs may make renewable energy cost-competitive on a life-cycle basis. It is widely accepted that a true comparison must be made on the basis of total “lifecycle” costs. Lifecycle costs account for initial capital costs, future fuel costs, future operation and maintenance costs, decommissioning costs, and equipment lifetime.
- Phasing out subsidies for conventional technologies : The final price consumers are paying for the use of fossil fuels (or nuclear) energy is the result of applying several subsidies which makes them seem cost competitive with respect to RES
- Comparative line extension analyses : Analyzes the relative costs of renewable energy with conventional fuels and power delivery
- Competitive retail power markets : Provides competition at the retail level for power sales, including “green power” sales
- Subsidies for RES : Should include direct support to consumers, direct payments to investors in large and capital intensive projects, and other formulas that can reduce production cost, reduce project risk and guarantee a reasonable IRR for RES projects
- Investment tax credits for renewable energy : A strong that can have the same effect as an investment cost reduction
- Accelerated Depreciation: Accelerated depreciation allows renewable energy investors to receive the tax benefits sooner than under standard depreciation rules. The effect of accelerated depreciation is similar to that of investment tax credits.
- Tax exemptions: Import tax on RES system components should be eliminated to achieve a cost reduction.
- Imposition of high fossil fuel consumption / carbon taxes, and channel the revenue earned towards renewable energy development: Initiatives such as the European Trading Scheme, which allows for a cost to be allocated to every CO2 emission certificate, for assigning cost to fossil fuels. Nevertheless less market oriented formulas can be also consider such as directly applying a tax on fossil fuels to account for their emissions and other related negative impacts.

**i) Failure of the market to value the public benefits of renewables**

- Price-setting and quantity-forcing policies : Mandates prices to be paid for renewable energy, or requires a fixed amount or share of generation to be renewable
- Internalisation of externalities: Energy production, be it fossil fuels, nuclear or RES, should include external cost associated to the different impact of the energy systems on the environment and society. Strong methodology should be developed to correctly asses these costs and they should be added up together with the rest of the accounting cost. This external cost should also be used as the basis for subsidise to the electrical system. Emission fees or caps on total pollution, with tradable emission permits, are examples of ways to internalize the costs of pollution, creating a more level arena for renewables.

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- Application of support schemes that compensate renewable electricity for its positive environmental impacts and its contribution to the security of supply: The most economically sound approach to improve markets for renewable energy technologies lies in the “internalizing” of externalities. This could be climate change costs, health impacts from dust and NOx emissions, costs of acid rain (corrosion of buildings, acidification of lakes...), visual impacts etc.
- Emissions cap: One example of good practice is the EU emissions trading scheme, which is a cap and trade system, dealing with CO2 emissions from energy intensive installations. The system basically raises energy prices by the costs of the CO2 quotas, thereby benefiting the competitiveness of renewable energy technologies compared to fossil fuel technologies.

**j) Cost of electricity transport and distribution are not considered**

- Compensation for reduction in transport infrastructure: Consider the cost reductions of new transport infrastructure savings due to distributed generation based on RES, and application of these savings to support schemes for increase RES.

**k) Insufficient incentives for governments and private companies to support renewable energy development**

- Electricity feed-in tariff laws, set a fixed price for utility purchases of renewable energy: With feed-in tariffs (either fixed price or premium over the “power price”) the government fixes a price for every unit of electricity produced from any technology which it classifies as renewable. Tariff mechanisms have been widely applied in Europe, and have enjoyed particular success in Germany, Denmark and Spain. Their employment has led to significant increases in renewable electricity generating capacity, particularly of wind energy. Generators receive a fixed price for a fixed period, thus reducing volume and price risk to investors
- Issuing Green Certificates of guarantees of RES origin of electricity sold: Standardized certificates provide evidence of renewable energy production, and are coupled with institutions and rules for trading that separate renewable attributes from the associated physical energy.
- More public financial measures : At EU as well as at national and local level, they would overcome high investments required in the short run, allow adequate R&D in the long-term, as well as stimulate professionals’ training.

**l) High O&M cost**

- R&D activities aiming to decrease the cost of spare parts : Efforts to develop more simple systems to install, operate and maintain, as well as more cost effective production processes
- Training of personnel for efficient operation of RES systems : Labour productivity could be increased by investing more resources on improving technical skills of O&M personnel

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### 3.3 REGULATORY / LEGISLATIVE FRAMEWORK BARRIERS

Solutions to regulatory barriers have to consider that in many islands utilities control a monopoly on electricity production and distribution, and that in the absent of a legal framework that guarantees protection of independent power production and that gives priority to RES generation, new projects fro RES production are at a disadvantage. It is also important that regulators simplify all bureaucratic procedures that reduce the transaction cost that relatively small RES projects have to support.

RES will be unable to compete on a level playing field with conventional generation until new policies are adopted to internalize the public costs of these fossil fuel sources. Emission fees or caps on total pollution, with tradable emission permits, are examples of ways to internalize the costs of pollution, creating a more level arena for renewables.

#### a) Transmission access

- Privatization and/or commercialization of utilities : Changes government-owned and operated utilities into private or commercial entities
- Unbundling of generation, transmission and distribution: Eliminates monopolies so that separate entities provide generation, transmission, and distribution
- Power grid access policies: Gives renewable energy equal or favourable treatment for access to power grids and transmission systems
- Interconnection regulations: Creates consistent and transparent rules, norms, and standards for interconnection
- Self-generation by end-users: Allows end-users to generate their own electricity and either sell surplus power back to the grid or partly offset purchased power

#### b) Utility interconnection requirements

- Simplification technical standards and administrative procedures for grid connection of home installed RES systems: Small wind turbines and photovoltaic systems installed in home roofs should not face complicated bureaucratic work and expensive connection permits that could result in cost the families should support for connecting RES systems at home.

#### c) Restrictions on siting and construction of RES plants due to lack of spatial planning

- Development of more rigorous impact assessment studies which should also consider social end environmental positive impacts from RES : Elaboration of a special spatial layout, which identifies maximum percentage of RES in a specific area, accepting a reasonable negative impacts with respect to the benefits obtained from RES development

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- Pre-planning mechanisms in which municipalities are requested to assign locations for different RES types: All communities should aim to supply part of their energy needs from RES, and therefore should look for suitable land that should be available for RES project developers.

**d) Lack of legal framework for independent power producers**

- Creation of adequate legal frame : Ambitious RES goals should be backed not only by funding or financial instruments to support and promote RES, but also legal aspects in the relation of independent power producers and energy consumers should also be considered, in order to reduce risk and facilitate business development.

**e) Unfavourable power pricing rules**

- Real-time pricing : Values renewable energy production at the actual cost of avoided fossil fuel generation at any given time of the day
- Capacity credit : Provides credit for the value of standing renewable energy capacity, not just energy production
- Competitive wholesale power markets : Allows competition in supplying wholesale generation to the utility network and eliminates wholesale pricing restrictions
- Price-setting and quantity-forcing policies : Mandates prices to be paid for renewable energy, or requires a fixed amount or share of generation to be renewable
- Net metering : Values renewable energy production at the point of end-use and allow utility networks to provide “energy storage” for small users
- Loss reduction value: Capability of new RES power plant to reduce grid losses in the system.
- Grid investment value: Capability of new RES power plant to decrease the need of grid investment in the power system. The value could be negative if new power plant increases the need for the grid investment.
- Legislation required to make RES connection less onerous : Onerous planning regulations were also an important point – in Europe, for instance, the process for wind can take up to 3 months, compared to Canada, where it only takes a few days

**f) Delays in authorisation procedures**

- Streamlining the local regional administrative procedures that precede the installation of a new plant : Re-engineering of existing administrative processes in order to make the authorization procedure more simple and faster
- Simplification and harmonisation of administrative procedures at the EU level: At EU level, while taking into account national specific conditions and objectives. This would help accelerating the authorization/certification issuing. It would also be important to make sure that older legislation is evaluated so that it does not constitute a barrier for further proposed targets.
- Introduction of status of privileged for RES producers: New, more effective procedure. Specialized committees and agencies for coordination of procedure. Informatization

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and centralization of data collection system. Elimination of unnecessary approvals, permits, licences and documents.

- Lighter procedures for small projects and household installations : Small home installations should be treated with a very special status eliminating all unjustified technical and administrative requirements

**g) Lack of planning for promotion of clean renewable energies**

- Renewable energy targets on RES by setting minimum renewable energy shares of electricity generation: Quantity-forcing policies mandate a certain percentage or absolute quantity of generation to be supplied from renewable energy, requires that a minimum percentage of generation sold or capacity installed be provided by renewable energy. Obligated utilities are required to ensure that the target is met, either through their own generation, power purchases from other producers
- Regional energy planning with emphasis on the promotion of RES : Putting in place an adequate institutional framework backing the implementation of regional RES promotion policies to contribute to achieve realistic set quantified objectives for RES penetration

**h) Lack of standards**

- Compression and analysis of the best examples. Setting up committees for aligning the relevant issues: Harmonization of rules on regional national level. Better understanding of the difference between national rules will contribute to harmonisation of interconnection rules in EU and will help manufactures of RES to compile with new connection requirements.
- Consideration of the status of labelling: This is somewhat controversial. Actually, in many countries the “CE” mark is often not sufficient to authorize the operation of the equipment. The certification process, using the “CE” label on equipment, does not always imply an acceleration of the whole authorization process for that equipment.

**i) Lack of specialised administrative data**

- Reorganization or better organization of land registries: A more transparent land property information system. Establishment of state agency or committee for problem solving and coordination regarding complex land issues. Better laws and their execution.

**j) Lack of cooperation between different authorities and standard procedures**

- Standardize procedures/ Exchange information : Standardize procedures, such as administrative requirements and application forms among different authorities/ Exchange information between authorities involved
- One-stop authorization agencies : One-stop authorization agencies for processing authorization applications and providing assistance to applicants should be established

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- Institutional coordination : Clear guidelines for authorization procedures with clear attribution of responsibilities and obligatory response periods

**k) Lack of transparency as for authorization and certification procedures**

- Process reengineering of existing authorization procedures for RES projects: Eliminating all unnecessary requirements and guaranteeing transparency of the process. More information should be available as for how initiate the procedure, and different stages of the administrative process

### 3.4 SOCIAL, INCLUDING PUBLIC AWARENESS AND EXTERNALITIES BARRIERS

Most of the social induced barriers have to due with the lack of effective awareness activities to explain the economic, social and environmental opportunities of RES. This is true not only for the general public, but also to policy makers and regulators which in most cases lack the minimum understanding of theses technologies to make sound policies.

**a) Lack of commercial skills and information**

- Public investments and market facilitation activities : Provides public funds for direct investments or for guarantees, information, training, etc. to facilitate investments

**b) Perceived technology performance uncertainty and risk**

- Demonstration projects: To demonstrate the technical performance and the economic feasibility of different RES technological solutions.

**c) Environmental externalities**

- Renewable energy setasides : Allocates, or sets aside, a percentage of mandated environmental emissions reductions to be met by renewable energy
- Emissions cap and trade policies : Allows renewables to receive monetary credit for local pollutant emissions reductions
- Greenhouse gas mitigation policies : Allows renewables to receive monetary credit for greenhouse-gas emissions reductions

**d) Insufficient renewable energy technical skills**

- Training and education on all educational levels: Installation, operation, and maintenance courses that will contribute to improve workers technical skills and increase their productivity.

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e) **Lack of information on RES among decision makers, professionals and citizens**

- Public debates and workshops and educational information : Inform the population about RES solutions and benefits is crucial for social acceptance, is also important that RES knowledge starts in schools
- Awareness raising campaigns : They would have to be addressed to different kinds of stakeholders, such as decision makers, professionals and the general public, in order to show RES-e benefits (in terms of fuel costs saving, job creation as well as of CO2 emission cuts).

f) **Small number of licenses granted**

- Redefinition of grant parameters : If the number of licenses granted was related to maximum grid capacity for RES, and a part of these licenses was in advance directed for domestic producers, the number of microgeneration producers would be increased

g) **Lack of public acceptance and resistance from local groups**

- Demonstration projects: Increase public awareness and acceptance through the realization of demonstration project in co-operation with local communities.
- Awareness activities: The development of dissemination campaigns on the importance of clean energy technology and the establishment of training seminars for the public and the users of RES based power system will result in overcoming this barrier.

h) **General political climate**

- Record of action and implementation: Most regional governments are setting very ambitious plans regarding increase penetration of RES. However, without having the track record of action and implementation, the maximum score cannot be reached. Additionally, plans could be halted at local level before reaching national governments

i) **Safety issues (H2)**

- Establish pilot/demonstration projects: H2-RES integration demonstration projects are very important at the current technology development stage. They allow analysing the technical performance of existing system components, and contribute to their improvement. They also permit to demonstrate the economic feasibility, and give the opportunity for the creation of a niche market where technology developers can begin to commercialize their products.
- Assure safe and reliable hydrogen applications: Development of safety standards that can minimize accident risks. Very important for a new technology which is perceived by many as intrinsically unsafe
- Close current gaps in development of harmonized regulations, codes and standards for hydrogen : For a market to mature, it is important that system component manufacturers can agree on a series of minimum interconnection standards that can simplify the purchase of equipment to project developers

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- Build consumer confidence in hydrogen end use: Awareness activities aim at addressing the weaknesses of the image H2 technologies have on the general population, by given information on ongoing experiences with H2 installation in demonstration projects around the world.

### 3.5 MARKET ISSUES BARRIERS

Solutions to overcome market barriers should make emphasis in the need to support commercialization of RES systems faced by all obstacles that new technologies have when competing with mature technologies

a) **Energy markets are not prepared for renewable energy**

- Stimulate demand for RES : Policy and adequate funding and general framework should be defined for the promotion of RES

b) **Poor market acceptance, technology prejudice**

- Dissemination of information required : Awareness activities that can contribute to stimulate market demand

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#### **4 COST AND BENEFITS OF IMPLEMENTING SOLUTIONS TO OVERCOME EXISTING BARRIERS**

Once all possible existing barriers to RES penetration have been identified, the proposed methodology that will be followed to establish the optimum cost efficient strategy will, on a case by case analysis:

- Select from the list of all possible barriers the ones that have been identified and that apply to each concrete location
- Choose from the list of possible solutions to overcome barriers, the ones that appear to be feasible to implement in the concrete location
- Estimate the cost of implementing each of the proposed actions for eliminating existing barriers to RES energy storage systems.
- Estimate the percentage of increase RES penetration achieved through the proposed solution
- Defined a Cost effective ratio, which gives the relation of RES increase penetration to cost of the solution
- In a second analysis, choose those solutions which are more cost effective in terms of percentage of RES penetration that could be achieve (maximum “Cost effective ratio”)
- Calculate the total cost of simultaneously implementing the selected solutions.

The methodology will be applied to two case studies: La Graciosa in Spain, and Milos in Greece.

#### **4.1 LA GRACIOSA**

##### **a) OVERVIEW**

La Graciosa is a small volcanic island located to the north of the island of Lanzarote and given its physical dimension, it's reduce population, and the wind and solar radiation conditions, the island gives an excellent site for testing solution for 100 % renewable energy supply. It has plenty of solar and wind resources, and currently it is supplied of water and electricity from neighbouring Lanzarote. There are a couple of small mountains in the



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island which could give the opportunity for a wind-pump-hydro system for energy storage, which could contribute to grid stability for a maximum RES penetration.

Currently it has a population of 658 residents, and it is interconnected to Lanzarote by a submarine cable with a capacity of 1.3 MW.



## **b) IDENTIFIED BARRIERS AND COST ASSESSMENT OF SOLUTIONS TO OVERCOME THEM**

From the list of all possible existing barriers for RES penetration in islands and remote regions, those that apply to La Graciosa islands have been chosen, and the cost of the solutions to overcome them, and their positive impact in terms of increase RES penetration has been estimated. A new parameter has been included: “the Cost effective index”, which helps to select those solutions which are more cost effective. The identified barriers in La Graciosa (chosen from the list of all possible barriers) are the following:

<b>BARRIER</b>	<b>PROPOSED SOLUTION</b>	<b>COST</b>	<b>% INCREASE RES</b>	<b>Cost-effective index</b>
<b>GRID CAPACITY AND MANAGEMENT</b>				
Fluctuation of RES	Energy storage systems	2.500.000 €	40,00%	16,00
	Weather forecasting numerical models	1.000.000 €	10,00%	10,00
Non-programmable RES	Programmable loads to use excess energy from RES. Installation of RES that can provide some kind of "Ancillary" service	500.000 €	10,00%	20,00
	Demand management	2.000.000 €	10,00%	5,00

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	Dynamic stability studies of the electrical grid to realistically assess the RES penetration limits, and cost effective solutions to reinforced the grids	200.000 €	10,00%	50,00
	Reinforcement and extension of the electricity grid	2.000.000 €	10,00%	5,00
Small and weak grids	Management tools with on-line dynamic security assessment tools	300.000 €	5,00%	16,67
Lack of co-operation of RES with the existing conventional generation local units in grid integration	New control concepts must be defined. Requirements on active power control, frequency control, voltage control	300.000 €	5,00%	16,67
	Efficient management of the electricity network	300.000 €	5,00%	16,67
Insufficient grid capacity (transport and transmission lines)	Use of Geographical Information Systems (GIS)	300.000 €	5,00%	16,67
<b>ECONOMIC</b>				
	RES business development and microcredit	5.000.000 €	30,00%	6,00
	Capital cost reduction policies	5.000.000 €	30,00%	6,00
High initial capital costs	Promote long-term power purchase agreements between consumers and RE generators	500.000 €	10,00%	20,00
	Favourable Low-interest loans programs offering financing for the purchase of renewable energy equipment.	500.000 €	20,00%	40,00
	Attract Venture capital and private equity investments in clean energy companies	200.000 €	5,00%	25,00
Lack of access to credit	Microcredit programs lending for household-scale renewable energy systems.	400.000 €	10,00%	25,00
Financing risks and uncertainties	Guaranteed price during the economic life of the project	1.000.000 €	5,00%	5,00
	Subsidies for RES	500.000 €	5,00%	10,00
Cost of electricity transport and distribution are not considered	Compensation for reduction in transport infrastructure	200.000 €	5,00%	25,00
Insufficient incentives for governments and private companies to support renewable energy development	Electricity feed-in tariff laws, set a fixed price for utility purchases of renewable energy.	2.000.000 €	30,00%	15,00
High O&M cost	Training of personnel for efficient operation of RES systems	500.000 €	5,00%	10,00
<b>REGULATORY / LEGISLATIVE FRAMEWORKS</b>				

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	Power grid access policies	100.000 €	5,00%	50,00
	Interconnection regulations	100.000 €	5,00%	50,00
Transmission access	Self-generation by end-users	300.000 €	5,00%	16,67
Utility interconnection requirements	Simplification technical standards and administrative procedures for grid connection of home installed RES systems	200.000 €	5,00%	25,00
Restrictions on siting and construction of RES plants due to lack of spatial planning	Development of more rigorous impact assessment studies which should also consider social and environmental positive impacts from RES	100.000 €	5,00%	50,00
	Pre-planning mechanisms in which municipalities are requested to assign locations for different RES types	200.000 €	5,00%	25,00
Lack of planning for promotion of clean renewable energies	Regional energy planning with emphasis on the promotion of RES	500.000 €	20,00%	40,00
<b>SOCIAL, INCLUDING PUBLIC AWARENESS AND</b>				
Insufficient renewable energy technical skills	Training and education on all educational levels	100.000 €	5,00%	50,00
Lack of information on RES among decision makers, professionals and citizens	Public debates and workshops and educational information	100.000 €	5,00%	50,00
	Awareness raising campaigns	50.000 €	5,00%	100,00
Lack of public acceptance and resistance from local groups	Demonstration projects	250.000 €	5,00%	20,00
	Awareness activities	50.000 €	5,00%	100,00
<b>MARKET ISSUES</b>				
Poor market acceptance, technology prejudice	Dissemination of information required	50.000 €	5,00%	100,00

### c) OPTIMUM STRATEGY TO INCREASE RES PENETRATION

Based on the Cost effective index, the following solutions for overcoming RES penetration barriers in La Graciosa has been chosen:

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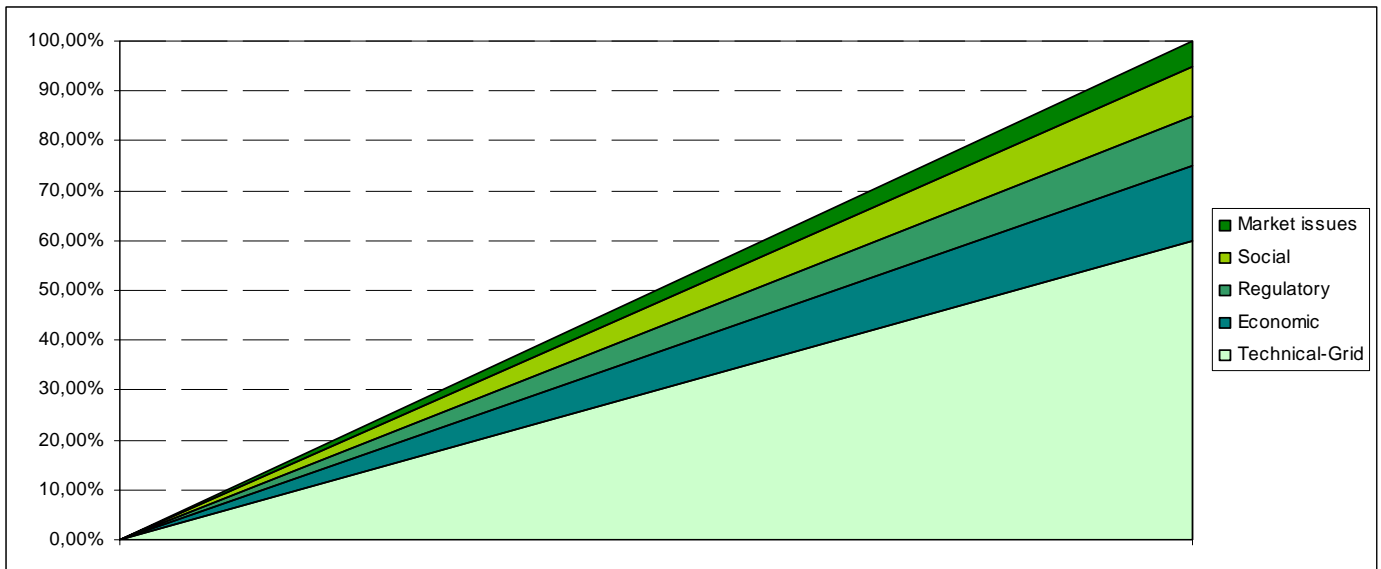
BARRIER	PROPOSED SOLUTION	COST	% INCREASE RES	Cost-effective index
<b>GRID CAPACITY AND MANAGEMENT</b>				
Fluctuation of RES	Energy storage systems	2.500.000 €	40,00%	16,00
	Programmable loads to use excess energy from RES. Installation of RES that can provide some kind of "Ancillary" service	500.000 €	10,00%	20,00
Small and weak grids	Dynamic stability studies of the electrical grid to realistically assess the RES penetration limits, and cost effective solutions to reinforced the grids	200.000 €	10,00%	50,00
<b>ECONOMIC</b>				
Lack of access to credit	Attract Venture capital and private equity investments in clean energy companies	200.000 €	5,00%	25,00
	Microcredit programs lending for household-scale renewable energy systems.	500.000 €	10,00%	20,00
<b>REGULATORY / LEGISLATIVE FRAMEWORKS</b>				
Transmission access	Power grid access policies	100.000 €	5,00%	50,00
Restrictions on siting and construction of RES plants due to lack of spatial planning	Development of more rigorous impact assessment studies which should also consider social and environmental positive impacts from RES	100.000 €	5,00%	50,00
<b>SOCIAL, INCLUDING PUBLIC AWARENESS AND</b>				
Insufficient renewable energy technical skills	Training and education on all educational levels	100.000 €	5,00%	50,00
Lack of information on RES among decision makers, professionals and citizens	Public debates and workshops and educational information	100.000 €	5,00%	50,00
<b>MARKET ISSUES</b>				
Poor market acceptance, technology prejudice	Dissemination of information required	50.000 €	5,00%	100,00
			100,00%	

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The optimization strategy, once the solutions are asses under the 5 different categories of barriers is

## OPTIMIZATION STRATEGY FOR MAXIMUM RES PENETRATION IN LA GRACIOSA

EXISTING BARRIER TO RES PENETRATION	CONTRIBUTION TO RES PENETRATION	IMPLEMENTATION COST	RES PENETRATION	ACUMULATED COST
Grid capacity and management	60,00%	3.200.000 €	60,00%	3.200.000 €
Economic, including non-existing or ineffective tariff schemes for RES-energy storage power systems	15,00%	700.000 €	75,00%	3.900.000 €
Regulatory / legislative frameworks	10,00%	200.000 €	85,00%	4.100.000 €
Social, including public awareness and externalities	10,00%	200.000 €	95,00%	4.300.000 €
Market issues	5,00%	50.000 €	100,00%	4.350.000 €
<b>OBJECTIVE RES PENETRATION</b>			<b>100,00%</b>	<b>4.350.000 €</b>



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## 4.2 MILOS

### a) OVERVIEW

Milos is a Greek island sited on the southwest part of the Aegean Sea and specifically in the group of islands called Cyclades. Its distance from Athens is 86 nautical miles, i.e. 160 km approximately. This island is 151 square kilometres in area and its coastal line is 125 km. It is considered generally as flat but semi-arid island. The highest mountains reach the high of 751m and 636m, while the rest have an altitude of less than 400m. It is a volcanic island with significant geothermal and mineral resources that have played significant role in its development throughout the ages in the Greek civilization.



There are almost 5000 people permanently living on the island, but the population rises about 5 times during the summer period due to tourism. However, significant percentage of the population is employed on the extractive industry of the island and therefore Milos is not only based economically on tourism development. Most of the people live in its northern part, which has greater plains where the capital and the harbour of the island is.



The generation of electricity in Milos is mainly based on oil products, and there is no interconnection to the mainland electric grid. A wind park comprising three wind turbines with a total capacity of 2.05 MW operates on the island as well. It should be noted that the peak demand of the island during summertime is ca. 11 MW, while the peak demand during winter decreases to approximately 4 MW. Milos has no significant drinking water resources, and until recently water was delivered by tank ship from Attica. But, a year ago, a wind energy driven desalination plant, based on Reverse Osmosis (RO) technology was commissioned, providing potable water to the island. The capacity of the desalination plant is currently 2000 m<sup>3</sup> of water per day.

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**b) IDENTIFIED BARRIERS AND COST ASSESSMENT OF SOLUTIONS TO OVERCOME THEM**

From the list of all possible existing barriers for RES penetration in islands and remote regions, those that apply to Milos islands have been chosen, and the cost of the solutions to overcome them, and their positive impact in terms of increase RES penetration has been estimated. A new parameter has been included: “the Cost effective index”, which helps to select those solutions which are more cost effective. The identified barriers in Milos (chosen from the list of all possible barriers) are the following:

BARRIER	PROPOSED SOLUTION	COST (€)	% INCREASE RES	Cost-effective index
<b>GRID CAPACITY AND MANAGEMENT</b>				
Non-programmable RES	Weather forecasting numerical models	300.000 €	2,00%	6,67
	Programmable loads to use excess energy from RES. Installation of RES that can provide some kind of "Ancillary" service	550.000 €	1,30%	2,36
Small and weak grids	Dynamic stability studies of the electrical grid to realistically asses the RES penetration limits, and cost effective solutions to reinforced the grids	200.000 €	2,00%	10,00
<b>ECONOMIC</b>				
High initial capital costs	RES business development and microcredit	5.000.000 €	30,00%	6,00
	Capital cost reduction policies	5.000.000 €	30,00%	6,00
	Promote long-term power purchase agreements between consumers and RE generators	500.000 €	10,00%	20,00
High financing costs	Favourable Low-interest loans programs offering financing for the purchase of renewable energy equipment.	500.000 €	20,00%	40,00
Lack of access to credit	Attract Venture capital and private equity investments in clean energy companies	200.000 €	5,00%	25,00
	Microcredit programs lending for household-scale renewable energy systems.	400.000 €	10,00%	25,00
Financing risks and uncertainties	Guaranteed price during the economic life of the project	1.000.000 €	5,00%	5,00
Cost of electricity transport and distribution are not considered	Subsidies for RES	500.000 €	5,00%	10,00
	Compensation for reduction in transport infrastructure	200.000 €	5,00%	25,00

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Insufficient incentives for governments and private companies to support renewable energy development	Electricity feed-in tariff laws, set a fixed price for utility purchases of renewable energy.	2.000.000 €	30,00%	15,00
High O&M cost	Training of personnel for efficient operation of RES systems	500.000 €	5,00%	10,00
<b>REGULATORY / LEGISLATIVE FRAMEWORKS</b>				
Transmission access	Power grid access policies	100.000 €	5,00%	50,00
	Interconnection regulations	100.000 €	5,00%	50,00
	Self-generation by end-users	300.000 €	5,00%	16,67
Utility interconnection requirements	Simplification technical standards and administrative procedures for grid connection of home installed RES systems	200.000 €	5,00%	25,00
Restrictions on siting and construction of RES plants due to lack of spatial planning	Development of more rigorous impact assessment studies which should also consider social and environmental positive impacts from RES	100.000 €	5,00%	50,00
	Pre-planning mechanisms in which municipalities are requested to assign locations for different RES types	200.000 €	5,00%	25,00
Lack of planning for promotion of clean renewable energies	Regional energy planning with emphasis on the promotion of RES	500.000 €	20,00%	40,00
<b>SOCIAL, INCLUDING PUBLIC AWARENESS AND EXTERNALITIES</b>				
Insufficient renewable energy technical skills	Training and education on all educational levels	100.000 €	5,00%	50,00
Lack of information on RES among decision makers, professionals and citizens	Public debates and workshops and educational information	100.000 €	5,00%	50,00
	Awareness raising campaigns	50.000 €	5,00%	100,00
Lack of public acceptance and resistance from local groups	Demonstration projects	250.000 €	5,00%	20,00
	Awareness activities	50.000 €	5,00%	100,00
<b>MARKET ISSUES</b>				
Poor market acceptance, technology prejudice	Dissemination of information required	50.000 €	5,00%	100,00

### c) OPTIMUM STRATEGY TO INCREASE RES PENETRATION

Based on the Cost effective index, the following solutions for overcoming RES penetration barriers in Milos has been chosen:

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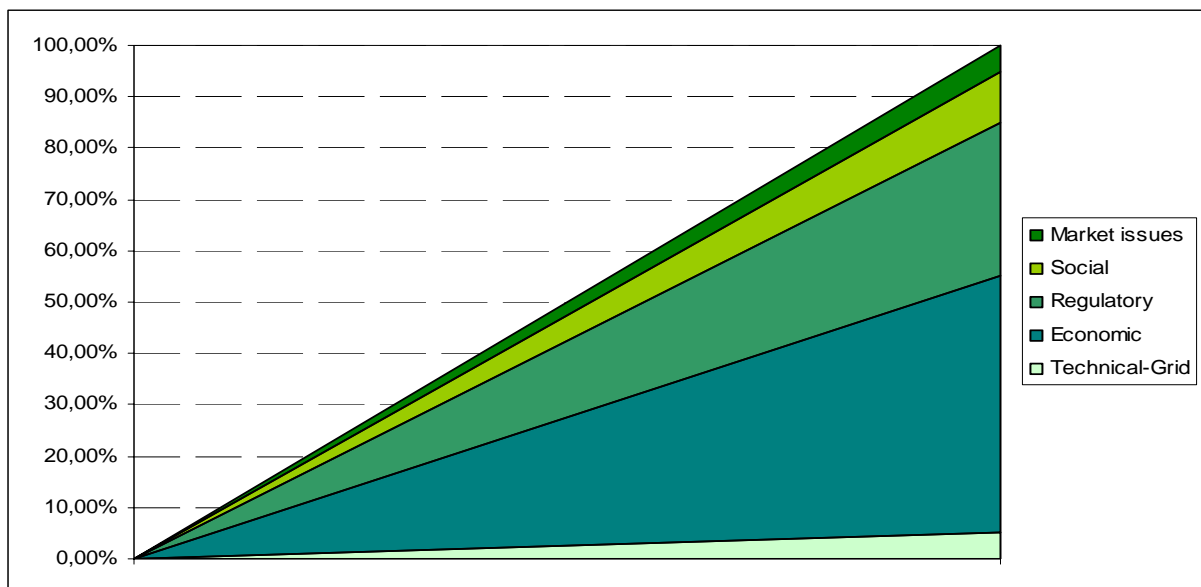
BARRIER	PROPOSED SOLUTION	COST (€)	% INCREASE RES	Cost-effective index
<b>GRID CAPACITY AND</b>				
Non-programmable RES	Weather forecasting numerical models	300.000 €	2,00%	6,67
	Programmable loads to use excess energy from RES. Installation of RES that can provide some kind of "Ancillary" service	550.000 €	1,00%	1,82
Small and weak grids	Dynamic stability studies of the electrical grid to realistically assess the RES penetration limits, and cost effective solutions to reinforced the grids	200.000 €	2,00%	10,00
<b>ECONOMIC</b>				
Lack of access to credit	Attract Venture capital and private equity investments in clean energy companies	200.000 €	5,00%	25,00
	Microcredit programs lending for household-scale renewable energy systems.	400.000 €	10,00%	25,00
Cost of electricity transport and distribution are not considered	Compensation for reduction in transport infrastructure	200.000 €	5,00%	25,00
Insufficient incentives for governments and private companies to support renewable energy development	Electricity feed-in tariff laws, set a fixed price for utility purchases of renewable energy.	2.000.000 €	30,00%	15,00
<b>REGULATORY / LEGISLATIVE</b>				
Transmission access	Power grid access policies	100.000 €	5,00%	50,00
	Interconnection regulations	100.000 €	5,00%	50,00
	Self-generation by end-users	300.000 €	5,00%	16,67
Utility interconnection requirements	Simplification technical standards and administrative procedures for grid connection of home installed RES systems	200.000 €	5,00%	25,00
Restrictions on siting and construction of RES plants due to lack of spatial planning	Development of more rigorous impact assessment studies which should also consider social and environmental positive impacts from RES	100.000 €	5,00%	50,00
	Pre-planning mechanisms in which municipalities are requested to assign locations for different RES types	200.000 €	5,00%	25,00
<b>SOCIAL, INCLUDING PUBLIC AWARENESS AND EXTERNALITIES</b>				
Insufficient renewable energy technical skills	Training and education on all educational levels	100.000 €	5,00%	50,00

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Lack of public acceptance and resistance from local groups	Awareness activities	50.000 €	5,00%	100,00
<b>MARKET ISSUES</b>				
Poor market acceptance, technology prejudice	Dissemination of information required	50.000 €	5,00%	100,00

The optimization strategy, once the solutions are asses under the 5 different categories of barriers is

OPTIMIZATION STRATEGY FOR MAXIMUM RES PENETRATION IN MILOS				
EXISTING BARRIER TO RES PENETRATION	CONTRIBUTION TO RES PENETRATION	IMPLEMENTATION COST	RES PENETRATION	ACUMULATED COST
Grid capacity and management	5,00%	1.050.000 €	5,00%	1.050.000 €
Economic, including non-existing or ineffective tariff schemes for RES-energy storage power systems	50,00%	2.800.000 €	55,00%	3.850.000 €
Regulatory / legislative frameworks	30,00%	1.000.000 €	85,00%	4.850.000 €
Social, including public awareness and externalities	10,00%	150.000 €	95,00%	5.000.000 €
Market issues	5,00%	50.000 €	100,00%	5.050.000 €
<b>OBJECTIVE RES PENETRATION</b>			<b>100,00%</b>	<b>5.050.000 €</b>



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### 4.3 EXAMPLES OF SOLUTIONS FROM BIBLIOGRAPHY

In this sub-section examples from applications of the solutions described in section **Error! Reference source not found.** are described. Focus is given on addressing grid capacity and management barriers.

#### Fluctuation of RES and Non-Programmable RES

##### i) Use of storage devices

Here an application from the island power system of Crete is described [i]. It was examined what is the magnitude of a storage device that can decrease the confidence interval required for forecasting error, load and RES from  $a\%$  down to  $b\%$ . For this purpose, it was calculated whether the capacity of the committed units for  $b\%$  confidence interval,  $Max\_act\_cap\_b(t)$ , can meet the required capacity for confidence interval equal to  $a\%$ , denoted as  $Uload\_a(t)$ . At each step of the performed simulation, the storage capacity to meet this requirement,  $Bat\_store\_cap(t)$ , is provided by (1). If this quantity is positive, this corresponds to the minimum capacity the additional unit to be committed to meet  $a\%$  confidence interval requirement should have.

$$Bat\_store\_cap(t) = Uload\_a(t) - Max\_act\_cap\_b(t) \quad (1)$$

Applying (1) for one year, 2000, at hourly steps with actual data from Crete, it was identified how often various levels of storage capacity would have been sufficient to lead to avoidance of committing additional costly unit. The percentages used are  $a=97\%$  and  $b=90\%$ . Table 1 summarizes the capacity that corresponds to various levels of frequency, the economic benefit for the operator of the island expressed in both absolute values and normalized ones according to the storage capacity.

**Table 1 Summary of the results of hedging confidence interval of forecasting tools via a storage device.**

Installed capacity (MW)	20	11	9.5	5
Frequency that storage device would suffice (%)	100	95	90	80
Annual benefit (k€)	2258	1882.98	1693.33	1315.533
Normalized value (€/kW of storage device installed)	112.92	171.16	177.22	263.07

The wind power curtailment for various storage capacity values and months is provided in Table 2. It is clear that low capacity of storage device can provide significant cost reduction for the utility and around 6.3% reduction in wind power curtailment, since less units are required

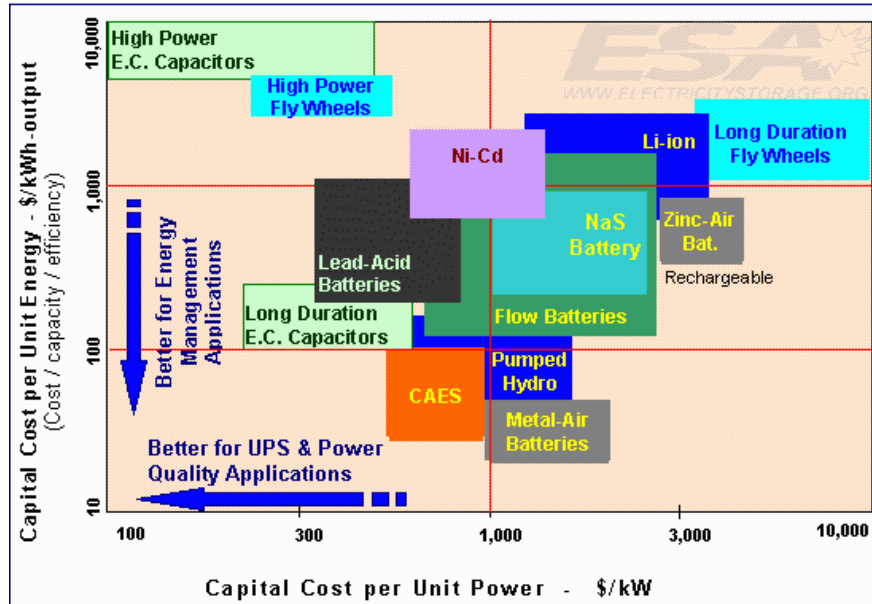
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to operate during low load periods. Significant amount of storage device capacity, i.e. 20MW, would be required to reduce by 46% the annual wind power curtailment.

**Table 2 Monthly wind power curtailment for various storage capacity values (MWh)**

Month	Installed storage capacity (MW)				
	0	20	11	9.5	5
January	998.3	291.8	901	901	901
February	2268.3	1257.6	2121.6	2121.6	2121.6
March	1834.6	1134.9	1750.6	1750.6	1750.6
April	1903.9	1263.1	1848.4	1848.4	1903.9
May	1078.9	449.3	982.6	982.6	982.6
June	266.7	44.3	211.1	211.1	211.1
July	0	0	0	0	0
August	0	0	0	0	0
September	42.9	1.6	42.9	42.9	42.9
October	926	395.1	801.9	801.9	801.9
November	1468.6	897.3	1399.9	1399.9	1401.6
December	1831.7	1030.8	1688.7	1688.7	1688.7
<b>TOTAL</b>	<b>12619.9</b>	<b>6765.8</b>	<b>11748.8</b>	<b>11748.8</b>	<b>11812.9</b>

The cost of the solution is the cost of the energy storage device. An idea on the cost is shown in Fig. 1.



**Fig. 1 Cost for applying energy storage devices [ii]**

It should be stressed that there is no remuneration for the other uses that the energy storage device may have which increase the benefits.

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Another example [iii] for the potential impact of wind power forecasting shows that the fluctuation of wind power plant due to wind forecasting error of 1m/s and 2m/s is respectively 12.5% and 25%. Combined with an appropriate sized storage device this fluctuation can be decreased to 0.06% and 0.12% respectively.

ii) Weather forecasting tools

The following examples from Crete and Kythnos indicate the impact that the improved wind power forecasting may have on the cost and the operation of an island power system. The above example for Crete for mitigating forecasting (load and wind power) errors and confidence intervals from 97% to 90% has as income up to 2.2M€. Moreover, the wind power curtailment is reduced by 46%, as column with header 20MW on Table 2 shows.

In order to evaluate wind power forecasting errors impact into economics on Crete, the MORE CARE economic scheduling algorithms, Unit Commitment (UC) and Economic Dispatch (ED) [iv], have been used off-line with actual data- load, wind power, units availability and fuel prices -from the power system of Crete, for the 5 last months of 2001 and the first 6 months of 2003.

In all cases the spinning reserve maintained for this purpose is given by the following equation:  
 $spinning\_reserve = Load\_reserve + Wind\_reserves$

where *load\_reserve* stands for the uncertainty in the load estimation, a constant percentage of the actual load in our case and wind reserves for the wind power production forecast errors.

For wind power forecast and *Wind\_reserves* three cases are studied.

- a. The operator of system does not have any confidence for the wind forecast and maintains *Wind\_reserves* at least equal to the total expected wind power production. It should be noted that this practice is rather common especially in island power systems.
- b. The operator of system has at his disposal one satisfactory wind power forecast tool which presents largest error 50% of the value of the forecast. In this case the operator maintains *Wind\_reserves* at least equal with half the Wind production.
- c. The operator of system has at his disposal a very satisfactory wind forecast model and maintains spinning reserve equal to 20% of wind power production.

In all cases the actual wind power production time-series is considered as the forecast for which the operator should maintain sufficient spinning reserve. For each one of the a-c cases a different UC schedule is provided and thus for the same load for dispatch to the thermal units, the ED changes from case to case.

The corresponding cost for all scenarios is presented in Table 3.

**Table 3 Summarizing the results for these 2 years.**

	20-50	50-100	20-100
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	kEuro	%	kEuro	%	kEuro	%
2001	544.53	1.14	1362.34	3	1906	4
2003	775.48	1.09	3260	4.33	4033	5.37

From the above analysis it can be concluded that the reduction in the overestimation of wind forecast from 100% down to 100% has significant savings, up to 3.2 Million Euro for 6 months or 4.33% of the operating cost with significant reduction of GHG emissions. Further improvement of the wind forecasting error from 50% down to 20% can also provide significant savings reaching up to 775 k€, or 1.1% of the operating cost with GHG emissions reduction.

This is due to the fact that less thermal units need to run to overcome the uncertainties imposed by the wind power forecasting and the quantification of this uncertainty is estimated by the analysis performed.

Similar approach with Crete is followed for Kythnos. Table 4 describes the scenarios simulated for this purpose. It is clear that the operating cost is significantly decreased as the wind power forecasting error is reduced. Table 5 summarizes the annual benefits due to this application.

**Table 4 Scenarios considered for forecasting errors**

	Load Forecast Error	Wind Forecast Error	PV Forecast Error	Operating cost (€)
Scenario I	6%	20%	50%	506602.02
Scenario II	6%	50%	50%	517774.54
Scenario III	6%	100%	50%	519778

**Table 5 Comparison of annual savings due to increased wind forecasting accuracy.**

Scenario I - Scenario II	Scenario I - Scenario III	Scenario II- Scenario III
5172.52€ 1.01%	13176.01€ 2.6%	8003.49€ 1.54%

Cost of the solution : The cost of the forecasting tool or the cost for upgrading an existing tool.  
 Increase of wind power penetration : Can decrease wind power curtailment up to 46%, i.e. about 2.8% in wind power penetration for Crete

In both cases improved wind power forecasting can help the operators to avoid having excess operating capacity that during low load period can lead to wind power curtailment.

iii) Programable loads to use excess energy from RES

3 examples are provided here. The first one comes from Milos, the second for Kythnos and the last one from Cyprus.

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For March 2006 and Milos power system, if an additional wind power turbine of 850kW is installed in co-operation with a desalination power plant producing 29,000m<sup>3</sup>, then the wind power curtailment is reduced by 52.5 MWh compared to no Desalination plant for this month only. The wind penetration is increased by 0.7%, due to increase in the load by 8%, but the wind power production injected to the grid is increased by about 13%.

The cost of this solution is the increase in the operating cost of the island and the pay-back for the desalination plant corresponding to this month.

For Milos island, for this month, there is increase in the O&M costs up to 29.000€ and the cost for operating and installing the desalination plant, estimated at 13.500€, amounting 41500€. For the whole year the initial estimations are that 44% of the wind power curtailed, if one additional wind turbine is installed, can be avoided if there is co-operation of a desalination plant with the foreseen production of the additional wind turbine. The installation and o&M cost for the desaliantion cost would be 550,000€, increasing wind power penetration by about 1.3%.

For Kythnos, dispersed desalination units operate in order to mitigate the wind power curtailment on the island that is estimated to be 12.7%. Producing about 18,000m<sup>3</sup> of water per year with small desalination units of 42 kW, the wind power curtailment is reduced to 7.1% compared to 12.7%. The wind power production increase is 6%.

The cost for such a solution comes from the minor increase 0.33% in the thermal units production, the centralized controller for the distributed units, i.e. a simple PLC, and the installation pay-back and O&M of the desalination units that is about 40,000€.

A similar analysis with Cyprus is performed for March, assuming that all the authorized wind parks would have been installed for 2007. During March the expected wind power curtailment would have been 8% of the produced energy. Having 5 desalination (RO) units of 1MW with 4.5kWh/m<sup>3</sup> operating the whole month and additional 9 when there is expectation of wind power curtailment, the corresponding results are presented in Table 6.

**Table 6 Results from Analysis in Cyprus**

Water produced (km <sup>3</sup> )	Energy Consumed (MWh)	Wind power curtailment	Wind power penetration	RES share on RO plant
1022.6	4602	5.8%	15.72%	24.9%

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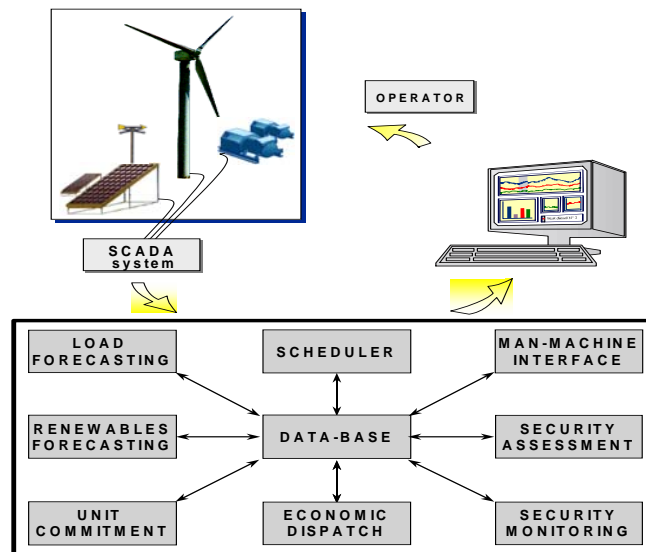
The increase in wind power production on the island for this month is 2.3% capable of increasing the wind power penetration on the island by 0.13%.

The additional cost is the O&M additional cost, that is estimated at about half of the average operational cost of the island and the pay-back amount for the 9 desalination units of the plant that operate for this month for this purpose. Taking into account that if this measure is not taken, for the same amount of water, 1 additional unit during the hole month would be required, this cost is reduced to 8 desalination units. These units are about 15times the size of Milos desalination plant. Thus, about 200,000€.

**b) Small and weak grids**

*i) On-line dynamic security assessment tools*

Using on-line dynamic security assessment tools can provide aid to the operators of an island power system to quickly evaluate the danger of frequency deviations that could lead to a collapse of the power system. In such a way, they can place limits to RES penetration even more efficiently for various potential disturbances. Such an example is the MORE CARE tool [v] whose architecture is shown in Fig. 2. The execution cycle is shown in Fig. 3.



**Fig. 2 More Care Architecture**

On-line security assessment of the most important and crucial, according to the operator’s point of view, disturbances such as machine trip, wind loss etc. In such a case the operator is timely informed on insecure operating points and modifies, via the scheduling functions its program accordingly.

The funding for this EU program was 1.5 mil € for the period 2000-2003. Taking into account that :

- a) The prototype- research nature to be performed

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The expected benefits are :

- 100MW can be installed with this approach additionally to 40MW that could operate without this approach. (i.e. 250% increase in installed capacity). This would correspond to increase of wind power production from 125GWh to 383GWh per year.
- If all the wind parks in the area comply with this rule, the installed capacity can reach 100MW (i.e. 300% increase in installed capacity). This would correspond to increase of wind power production from 125GWh to 421GWh per year (237% per year).

### *Energy storage*

Another example of facing insufficient grid capacity is the one presented in [vii] and a Norwegian Island. If the connection line is of capacity 5MW, and the installed wind power capacity is 10MW, there is 20% wind power curtailment. With properly sized and operating storage device [viii], the revenues are increased by 16% compared to no storage solution. Storage solution can be more viable if its installation cost is not higher by 1,06mil\$ compared to grid expansion solution.

### *Probabilistic Load Flow*

Due to the stochastic nature of many of RES, powerful tools for quick assessment of potential problems with the grid are required. Probabilistic Load Flow (PLF) may be one of them [ix,x], since they can rather quickly assess the possibility of violating the voltage limits of the nodes, especially overvoltages, and the possibility of exceeding the thermal limit of the line. With such studies, there can be more appropriate sizing of the RES installation in the area, and make appropriate sizing of the additional solutions, storage devices, interruption contracts etc.

Cost of the solution : The resources for conducting such a study depending on the complexity of the network and the number of the different scenarios to be examined. However, for an experienced team this is less than 1.5 Person months/

Impact on RES increase: Can be significant in some cases especially when combined with the measures described above.

### *Geographical Information Systems (GIS)*

Finally, Geographical Information Systems (GIS) can help in overcoming not only this barrier but also some of the social barriers. As an example is the interconnection of Northern Cyclades with the mainland Transmission System, an investment in the order of 400 million € that can significantly increase wind power penetration.

To identify however the most promising sites regarding wind power capacity, proximity to the network and avoid potential problems with restrictions in installation site [xi], use of a GIS tool is essential.

Two installation sites with excellent capacity factors, 61% and 59% respectively, but with distance 4.4km and 0.6 km from the transmission line respectively present wind power cost

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34.9 €/MWh and 32.9€/MWh respectively. So GIS application has helped in identifying better installation site than the one with the higher capacity factor.

The cost of such a study is mainly the time required for such a study, and can be in the order of 100,000€. It is assumed that such a study will be undertaken by companies/institutions that have already experience and licence of using such tools.

The increase in wind power penetration ranges from 0-100%. This depends whether the initial siting of the RES plant has been carefully selected or not. For sure such a solution may alleviate restrictions of the legislative environmental framework.

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## 5 HYDROGEN STORAGE

Hydrogen, as an energy vector for storing and applying RES to specific applications such as transport, has the following general advantages:

- **RES-Hydrogen power systems:** Hydrogen is a clean energy carrier that can be produced from any primary energy source including RES.
- **Security of energy supply:** Hydrogen opens up access to a broad range of primary energy sources, including fossil fuels, nuclear energy and, increasingly, renewable energy sources (e.g. wind, solar, ocean, and biomass), thus enhancing energy security through increased diversity. Hydrogen and electricity also allow interoperability and flexibility in balancing centralised and decentralised power, based on managed, intelligent grids, and power for remote locations (e.g. islands).
- **Air quality and health improvement:** Power generation fuelled by hydrogen is zero-emission devices at the point of use, with consequential benefits for local air quality.
- **Greenhouse gas reduction:** Hydrogen produced from RES could eventually help to eliminate greenhouse gas emissions from the energy sector.
- **Ensure economic competitiveness:** Development and sales of energy systems are also major components of wealth creation, creating substantial employment and export opportunities, especially for the industrialising nations.

Specifically in regard to economic barriers, H2 technologies are faced with the following obstacles:

- **Cost of technology (RES – Hydrogen):** Costs of hydrogen technologies today are much higher than their fossil-fuel counterparts. This is the biggest barrier to the uptake of hydrogen technology. The reasons for high cost have to do with technological maturity. The biggest factor, however, is the lack of economies of scale. Mass-commercialisation is needed for hydrogen to be competitive with conventional technologies:
  - ***Technological maturity*** – Unlike combustion engines, which have had a century to be improved and refined, hydrogen technologies are relatively immature. Researchers are working on improving performance, and developing cheaper methods of production.
  - ***Critical mass, economies of scale*** – Hydrogen production units and Fuel Cells are not produced in any great number. They have to be designed and manufactured virtually bespoke. This results in very high unit costs. A critical mass – a minimum

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number of units produced and delivered – is needed to bring costs down and to demonstrate feasibility, preparing for self-sustaining development.

This ‘chicken-and-egg’ relationship between production and consumption is one of the most fundamental challenges of commercialising a technology that competes with a mass produced incumbent.

Possible solutions to overcome economic barriers are:

- **High capital cost:** The cost of equipment should be lowered through the creation of a niche market for RES-hydrogen demonstration projects, especially in islands. The creation of a rising market will result in a decrease in the cost of production through economies of scale. Subsidies on the capital cost of RES-hydrogen based power systems will also play an important role in decreasing high capital cost of the respective systems.
- **Lack of funding:** Financial incentives with grants and subsidies from local and national government should be provided especially for RES-hydrogen based power systems.
- **O&M cost:** At present O&M cost is increasing with lifetime, therefore actions on decreasing this cost category for RES-hydrogen power systems are of major importance. The target is to keep the total O&M cost between 0.56–1.12 cent €/kWh\*) as an average value over the entire lifetime of 20 years. To overcome this barrier the following actions should be taken: 1) R&D activities aiming to decrease the cost of spare parts for hydrogen energy equipment, 2) training of personnel on the best and most efficient operation of the integrated systems, 3) providers and installers of complete RES-hydrogen power systems should develop and organise specific sections that are specialised on service and support of the respective installations.

As for regulatory level, some issues regarding H2 technologies deployment are:

- **Regional Attitudes and Policies:** compared with national or EU level strategies - are often more targeted, driving a number of regional synergies and supported by a range of strong local drivers such as:
  - Job creation
  - Innovation and technological development
  - Diversifying away from declining industries
  - Environmental policy objectives (such as clean air)
  - Improving quality of life
  - Improving the image of the region, for example by reducing emissions and introducing novel technologies in high profile projects

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The importance of these drivers will differ between regions. If a strategy is based upon good foundations and is implemented successfully, ultimately, a region could develop a self-sustaining cluster on sustainable energies, technologies and services,

- **Linking with National Level and EU Level Policy:** National and EU policies guide the direction of existing and funding streams. They also provide a clear message to businesses regarding the public sector's commitment to supporting developing markets. Showing how the project contributes to the pursuit of regional, national or European policy goals, such as improving the local air quality or reducing CO2 emissions, can be of crucial importance for business development, obtaining funding, buying-in of stakeholders and public acceptance.

Some policies and policy objectives with relevance for hydrogen projects at EU and national level are:

- EU Joint Technology Initiative on Hydrogen and Fuel Cells <https://www.hfpeurope.org/hfp/jti>
- EU HyRaMP (Hydrogen Regional and Municipal Platform, established in Spring 2008)
- Commitments to reduce greenhouse gases (Kyoto, Council conclusions of March 2007 etc.)
- Specific policies such as energy taxation, renewable energy promotion, the emission trading scheme or energy efficiency regulations

Relevant social issues include:

**Safety issues:** For many decades, hydrogen has been produced and used for commercial and industrial purposes, with an exemplary safety record. Normally, in these commercial and industrial environments, only well-trained personnel come into contact with hydrogen. Should hydrogen become more widely used as an energy carrier, contact with laypersons demands different fail-safe routines and technologies. As with today's energy carriers, no absolute measure of safety can be provided; only relative safety levels can be offered. At this stage, only a small number of hydrogen and fuel cell systems and components are in operation today. Consequently, very limited data is available on the operational and safety aspects of these new technologies and demos are required to understand hydrogen's behaviour and to support the development of technologies for the detection and safe management of unscheduled hydrogen releases or incidents involving hydrogen systems.

The relevant properties of hydrogen differ considerably from conventional fuels and the derivation of rules for its safe usage is not straightforward but relies on careful interpretation of the interacting effects. Whilst many aspects of hydrogen are well known, knowledge gaps have existed for several decades, e.g. conditions for ignition, flame acceleration, detonation of

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heterogeneous mixtures, structural protection and other mitigation strategies such as ventilation. Therefore, it is necessary to build trust by demonstrating safety not only in the large demonstration projects but also by the way in which this vital topic is addressed. Understanding hydrogen and hydrogen system safety needs is critical for local government officials, fire officers, and the general public. Emergency personnel must be informed of the special properties of hydrogen and trained in the methods used to respond to accidents involving its use.

Public perception and confidence in hydrogen relies on credibility, transparency and individual benefit. Improving the understanding of hydrogen's physical properties will help to communicate safety on a technical and objective basis.

**Regulation/standards:** Hydrogen is in common use as a feedstock in a range of industries. Its use there is tightly regulated, and safety is paramount. However its use in energy systems is still very novel, and appropriate regulations and standards have not yet been developed. Significant efforts are underway to develop regulations and harmonise these across countries. The lack of internationally recognised codes, regulations and standards slows down the development of new hydrogen and fuel cell products and projects.

When dealing with the increasing complexity of technology, codes and standards are essential elements that facilitate safe and efficient exploitation of new innovations. Starting with the codes of practice that usually explain the basic functions for safe handling and problem-preventive maintenance, trouble-free operation can be ensured.

In theory, the codes can be different for each product or at least for each manufacturer, but they usually share at least some basic elements that are constructed around the generic features and functionality of the technology and build a common understanding among people of how to deal with this type of product or system.

Regulations have to establish the legal requirements for certification and type approval, and should be consistent with the standard relevant to the corresponding topic. Standards should not be created for subjects where regulations (legal requirements) are necessary (mandatory), in order to avoid inconsistencies or contradictions. The process of developing standardisation/regulatory procedures for emerging technology should be based on the identification of technical items to be treated in the standards and on the validation of the standards themselves in terms of practical application and consistency with the real behaviour of the products.

In the event of hydrogen becoming an energy carrier which is to be deployed as widely as present-day fossil fuels, a number of issues must be resolved as regards regulations, codes and standards (RCS) which are key market enablers. The introduction of hydrogen use and fuel cell technologies into the market also requires the amendment of existing regulations and standards or creation of new ones. If these aspects are not appropriately considered, RCS become a barrier to the early introduction into the market and both the community and hydrogen systems may encounter resistance from insurers. An adequate level of standardisation and regulation is

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vital in ensuring the safe deployment of hydrogen technologies in the market. New technologies not yet recognised in codes and standards are needed to ensure safety in order to commercialise hydrogen as a fuel.

The realisation of harmonised and internationally consistent RCS will enable insurers to assess and manage those risks associated with new and innovative hydrogen technologies, thus facilitating commercialisation. There is a need to understand the measures most urgently required in Europe relating to hydrogen RCS so as to fulfil the goal of industry and politics to create a commercial hydrogen energy and fuel market by 2020. Because of their transnational nature, EU research projects help to develop the technical knowledge which is required to support regulatory development, both at a European level and for local approval.

**Public acceptance:** There is a concern that people will be reluctant to adopt hydrogen technologies, even once they meet cost and performance-competitiveness, due to unfamiliarity and fears about safety. How serious this concern really is remains unclear. But it is clear that the public will need to be trained and educated as hydrogen technologies require different operational procedures.

The use of hydrogen as an energy carrier is relatively new and, as such, may be vulnerable to inaccurate public perception. It is vital to address public perception concerns when introducing hydrogen technologies into society. Addressing these issues inappropriately can lead to opposition to the technology and potentially costly delays and enforced changes to proposed initiatives. Consumers must embrace hydrogen and fuel cell technologies before their benefits can be realised. It has to be demonstrated to the wider public that the safety risks associated with hydrogen can be reliably managed and that hydrogen can bring many other economic and environmental advantages.

Promoting public awareness of science and technology has always been a very important issue for European research. To achieve widespread public acceptance of hydrogen use, it is necessary to target different key audiences to identify and analyse their concerns and to provide information and research to improve their understanding of these new energy systems. In the case of hydrogen, conducting public perception studies and developing communication and awareness strategies at national & topical level will ensure that there is a coordinated effort to develop and inform communities and foster support throughout the whole of Europe.

Awareness, education and training measures are required for citizens as well as for the groups required to build the new technologies and assist their operation in the market. These measures need to be coordinated, together with economic and legislative instruments (incentives, subsidies, laws, regulations, etc.). Appropriately targeted information campaigns can dramatically reduce the likelihood of misinformation, and negative perceptions throughout the community.

**Political will:** A key finding is that hydrogen is not yet sufficiently high on the agenda of policy makers. These policy makers do play a crucial role in the process of developing and implementing the required policy incentives that enable hydrogen to smoothly enter the energy

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system under sound economic conditions. Demonstration projects can play a crucial role in raising the awareness of policy makers. In addition, it is of utmost importance to inform the policy makers about the prospects of hydrogen, the initial barriers that have to be overcome as well as on the type, characteristics and support level of the policy framework.

- **Lack of standard systems:** This should be overcome through the standardisation of both components and the overall RES-hydrogen power system as well. Technical committees under International Standardisation Organisation (ISO) are currently working on the production of standards for hydrogen technology equipment, but this process has shown a significant delay. Therefore the first step is to finalise standards for equipment such as electrolyzers, fuel cells etc. and then come up with a proposal on the standardisation of the overall system.
- **Safety issues:** 1) Establish pilot/demonstration projects, 2) Assure safe and reliable hydrogen applications, 3) Close current gaps in development of harmonized regulations, codes and standards for hydrogen, 4) Build consumer confidence in hydrogen end use.
- **Public acceptance:** Increase public awareness and acceptance of hydrogen technologies through the realization of demonstration project in co-operation with local communities. The development of dissemination campaigns on the importance of hydrogen as a clean energy carrier and the establishment of training seminars for the public and the users of RES-hydrogen based power system will result in overcoming this barrier.
- **Lack of decision makers' awareness of benefits of technology:** Consultation with national and local energy policy makers will help in increasing awareness on the environmental and social benefits of hydrogen energy technologies. Dissemination activities aiming this target group will facilitate overcoming of this important barrier.

Market aspects that should be considered are:

**Consumer uptake:** Early markets will be ones where hydrogen's current weaknesses are less of a barrier, and where its strengths are more relevant. Some examples of characteristics which satisfy these criteria are:

- ***Remote areas with high energy demand.*** It is possible that areas may be able to exploit local energy resources by manufacturing hydrogen to meet local energy demands.
- ***Applications with high daily usage.*** When a piece of equipment is used heavily, its capital cost plays a less important role than its operating and fuel costs.

Both criteria are fulfilled by Milos case.

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## 6 CONCLUSIONS

This Report on Deliverable D3.2 of the STORIES project includes information regarding barriers stopping the development of renewable energies and the deployment of energy storage technologies, in different European islands and remote regions. The barriers have been identified, and a set of recommendations to overcome them have been analyzed, trying to determine the implementation cost of each of them, and the benefits that will derive, in terms of increase RES penetration. This information will be useful for optimizing cost-effective strategies to foster the use RES-storage system integration in these regions. The identified barriers have been separated in five categories:

- Grid capacity and management
- Economic
- Regulatory / legislative frameworks
- Social, including public awareness and externalities
- Market issues

The small and weak electrical grids are a main obstacle to maximum RES penetration in island regions. The need to have back-up conventional power on stand by for when the wind stops blowing or the sun does not shine, is an important cost that has to be supported by local utilities. Besides high percentage penetration of intermittent RES generated electricity induces stability problems in the islands electrical systems. Technical barriers are the most objective and difficult barriers to be overcome. The elimination of some existing barriers will only be possible through more intensive R&D efforts to look for solutions related to energy storage and reinforcement of grid stability expose to high penetration of intermittent RES sources.

Regarding economic barriers, developing new renewable resources will require large initial investments to build infrastructure. These investments increase the cost of providing renewable electricity. Besides, renewables developers and customers may have difficulty obtaining financing at rates as low as may be available for conventional energy facilities. Financing costs can greatly affect the price and competitiveness of wind energy, since most of the cost is in capital and little is in operation. Solutions to economic barriers should aim at supporting the developers of RES by reducing the risk of their projects, and practical policies that focus more on subsidies to RES generation, and the elimination of existing ones for fossil fuels and nuclear power.

Full value of distributed generating technologies is not always well assessed. Small renewable energy systems for distributed generation can help avoid, not only investment in new

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conventional generation power and fossil fuel consumption, but also investments to upgrade transmission or distribution lines. Renewable technologies are sometimes cost-effective when this integrated value is considered, and it is important that this vision be shared by regulatory authorities, which are able to contribute to define a framework that gives priority to RES development. Solutions to regulatory barriers have to consider that in many islands utilities control a monopoly on electricity production and distribution, and that in the absent of a legal framework that guarantees protection of independent power production and that gives priority to RES generation, new projects fro RES production are at a disadvantage. It is also important that regulators simplify all bureaucratic procedures that reduce the transaction cost that relatively small RES projects have to support.

RES will be unable to compete on a level playing field with conventional generation until new policies are adopted to internalize the public costs of these fossil fuel sources. Emission fees or caps on total pollution, with tradable emission permits, are examples of ways to internalize the costs of pollution, creating a more level arena for renewables.

General public usually have insufficient information to make informed choices on energy use. Most utilities provide little or no information about their emissions or the fuels they use. Because renewable technologies are relatively new, most customers know little about them. Even local electricity companies may be unfamiliar with renewables. Most utilities have not studied how renewable resources could fit into their systems or what local resources are available. Most of the social induced barriers have to due with the lack of effective awareness activities to explain the economic, social and environmental opportunities of RES. This is true not only for the general public, but also to policy makers and regulators which in most cases lack the minimum understanding of theses technologies to make sound policies.

Market barriers could be considered “market distortions” that unfairly discriminate against renewable energy. Market failures will limit the development of renewables unless special policy measures are enacted to encourage that development. Solutions to overcome market barriers should make emphasis in the need to support commercialization of RES systems faced by all obstacles that new technologies have when competing with mature technologies

The approach for the elaboration of this report has consider the issues which are limiting the deployment of RES and energy storage systems, analysis of possible actions that could contribute to improve the situation, and the definition of cost effective strategies. The report has been divided in four phases:

- Thorough analysis of the existing situation, and identification of existing technical, economic and political (regulatory) barriers
- Analysis of possible solutions to overcome each of the barriers identified
- Estimation of the cost associated to the implementation of each of the proposed solutions

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- Estimation of the impact of each implemented solution, towards the goal of maximizing RES penetration in weak grids of island and remote regions

Given the difficulties to establish the impact of each of the proposed solutions, a methodology with reasonable criteria has been used to estimate the cost and the benefits of implementing each of them. The objective is to define cost competitive strategies for maximum RES penetration in islands. The methodology will be applied to two case studies, La Graciosa island in Spain and Milos in Greece, to produce the optimum cost efficient strategy for overcoming existing barriers and promoting RES in these two islands.

La Graciosa is a small volcanic island located to the north of the island of Lanzarote and given its physical dimension, its reduce population, and the wind and solar radiation conditions, the island gives an excellent site for testing solution for 100 % renewable energy supply. It has plenty of solar and wind resources, and currently it is supplied of water and electricity from neighbouring Lanzarote. The total cost for eliminating barriers that could allow for a maximum penetration of RES in this island has been estimated at approximately 4.350.000 €

Milos is a 151 km<sup>2</sup> island located in the Aegean Sea. Has a small resident population of 5,000 which grows five fold during the summer months due to tourism. This volcanic island has significant geothermal resources, as well as important solar and wind potential. Nevertheless currently electricity generation in Milos is mainly based on oil products. The total cost for eliminating barriers that could allow for a maximum penetration of RES in this island has been estimated at approximately 5.050.000 €

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