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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
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CO	Confidential, only for members of the consortium (including the Commission Services)	

List of Acronyms and Abbreviations

Acronym/ abbreviation	Resolution
CCS	Cartographic Competence Scheme
EPO	European Patent Office
ERA	European Research Area
EUROSTAT	European Statistical Office
FORTH	Foundation for Research and Technology - Hellas
GDP	Gross Domestic Product
GERD	Total intramural R&D expenditure
HEI	Higher Education Institutions
IEA	International Energy Agency
JAP	Joint Action Plan
MW	Mega Watt
NUTS	Nomenclature of territorial units for statistics
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaics
RE	Renewable Energy
RES	Renewable Energy Sources
RTD	Research and Technology Development
RUE	Rationale Use of Energy
SMEs	Small and medium-sized enterprises
SWOT	Strenghts, Weaknesses, Opportunities and Threats
TT	Technology Transfer

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1. Introduction

The present document illustrates the Comparative Analysis conducted for the INRES network. The network's performance with regard to research development and political framework conditions supporting the exploitation of Renewable Energy Sources (RES) is being illustrated.

The report basis its analysis on the Cartographic Competence Schemes and the subsequently elaborated Regional RES-ID Cards. Especially the RES-ID Cards provide an insight into the RES performance of the three regions, illustrating information on the legal and political framework conditions and the expertise of the scientific and industrial communities in the RES field. The objective is to present the regions in a comparative way, allowing for the finding of complementarities and differences with regard to the regions' political, research and industrial performances.

The Comparative Analysis shall be a supporting tool for the elaboration of the Joint Action Plan, a strategy that is currently being elaborated by the project consortium. The Joint Action Plan recommends concerted actions to be initiated at INRES level, so as to move the three regions forward in terms of their performances in the RES field, contributing at the same time to the competitive position of the RES industry at European level. The concrete actions to be inserted in the Joint Action Plan will be based on the results of the Comparative Analysis.

The outcome of the Comparative Analysis is the result of an intense discussion process initiated among the project partners and regional key stakeholders operating in the RES sector. In the following background information to the rationale of the project and its activities as well as a detailed overview on the content of the report is provided.

2. Background to the Report

The EU and the world are at a cross-roads concerning the future of energy. Climate change, increasing dependence on oil and other fossil fuels, growing imports, and rising energy costs are making societies and economies vulnerable. In the complex picture of energy policy, the renewable energy sector is the one energy sector which stands out in terms of ability to reduce greenhouse gas emissions and pollution, exploit local and decentralised energy sources, and stimulate world-class high-tech industries.

The EU has compelling reasons for setting up an enabling framework to promote renewables. They are largely indigenous, they do not rely on uncertain projections on the future availability of fuels, and their predominantly decentralised nature makes societies less vulnerable. It is thus unquestionable that renewable energies constitute a key element of a sustainable future.

Sustainable energy development becomes particularly important for insular regions as these are often not energy connected to the mainland or have only weak links to energy grids. As being often famous tourist destinations the appropriate exploitation of environment and energy resources becomes vital especially during the peak tourist seasons when a higher energy demand is required, both in terms of quantity and quality.

Looking into the future, one of the most important objectives has to be the guarantee of energy supply and the development of strategies promoting energy efficiency particularly achieved through the exploitation of renewable energy sources. This objective has been set by the European Commission in its *Europe 2020 Strategy*[1], proposing as one main EU objective the realisation of the "20/20/20" climate/energy targets (further details are provided in Chapter 4). The strengthening of the European Union's competitive position in the RES field depends mainly on the sector's scientific and industrial performances as well as on its flexibility especially with regard to the political supporting framework.

The INRES network seeks to make a contribution to this endeavour by realising a stronger interaction among the sector's key actors (science, industry and government) at regional and trans-regional level. The stronger collaboration aims at coordinating research approaches and policies that facilitate research and innovation development within the three project regions Canary Islands, Crete and Samsø. In addition, the project targets to increase the regions' investments in RTD for the RES industry's growth so to be able to keep up a leadership position in the development and application of renewable energy at global level.

From a political point of view, INRES activities are in line with the 'EU Renewable Energy Policy' which targets to source 20% of energy needs from renewables, including biomass, hydro, wind and solar power, by 2020 (Europe 2020 Strategy). Since the RES sector's development is mainly based on technological development, its success is based first of all on knowledge. This becomes even more important when bearing in mind the EU's long term strategic goal, i.e. the Union to become the *most competitive and dynamic knowledge-based economy in the world*, capable of sustainable growth with more and better jobs and greater social cohesion.

[1] Europe 2020: A strategy for smart, sustainable and inclusive growth. Communication from the Commission, 03.03.2010.

INRES implements concrete steps towards the realisation of the European Research Area (ERA) and the efficiency and innovative impact of Europe's research efforts. Through enhanced cooperation among the three island regions, enterprises, in particular SMEs, are stronger involved in the definition of future research activities and policies concerning the sustainable development of the RES industry. In addition, the interaction among research organisations, industry and governmental institutions generates mutual expectations, introduces new approaches and consequently innovative dynamics that accelerate the development of new products and services.

In this context, INRES is also responding to the EU cluster policy and in this regard to the European Cluster Memorandum[2] launched in January 2008 and marked as an important step towards further encouraging cluster development. A better coordination of framework conditions for innovation is underlined, achieved through *improved science-industry linkages and world-class innovation clusters as well as the development of regional clusters and networks*.

[2] The European Cluster Memorandum, Promoting European Innovations through Clusters: An Agenda for Policy Action, January 2008.

3. Methodology

The main objective of the present report is the comparison of different working concepts and strategies of regional policies within the INRES network, particularly with regard to the knowledge-based development in the RES sector. The technological progress as well as the economic growth of sector-relevant SMEs operating in the three island regions are assessed in a comparative way, giving insight also on the political supporting schemes favouring the exploitation and promotion of renewables.

The document has been developed by INNOVA being the technical partner in the project and expert in benchmarking and regional policy and strategy analyses. A strong contribution was provided by all project partners through consultation taken place during project meetings and further email exchanges. Furthermore, the analysis incorporates questionnaires that have been used for gathering the opinion of research and industrial key actors as regards the main interest areas and needs for a further efficient RES development.

The report is structured following a methodology based on two examination levels including a third section which presents the final remarks:

- The first examination level (Chapter 4) gives background information on the regional state-of-the-art of the INRES network in terms of a knowledge-based development relating to the RES industry. In a first step, the current situation of the three regions is analysed by means of an empirical comparative study. Here, the main focus lies on the indicators that have been identified through the regional data collection and the elaborated Regional RES-ID Cards. In addition, success stories of adopted RES technologies and technology transfer in the three regions are illustrated. Further on, in a second step, the regions are examined with regard to the parameters “research and innovation” and “participation and clustering”, two significant features for a dynamic knowledge society combined with the sustainable development of the RES industry.
- The second examination level (Chapter 5) includes the European dimension, starting from an overview on the most important RES players in Europe. Success cases are demonstrated that support the successful adoption of renewables in further island regions outside the INRES network. Furthermore, based on the results of the analysis, recommendations for the three regions are outlined for pushing forward their development in the RES field and for increasing their economic impact and competitiveness. In this context, the most important measures to be initiated in the three regions are highlighted.
- The final section (Chapter 6) presents conclusions and final remarks with regard to the further development of the RES industry in the INRES regions.

4. The present situation in the three regions: regional state-of-the-art in terms of innovation and development in the RES sector

The complete picture of each region in terms of main RES actors, the political framework supporting innovation and development in the sector as well as the expertise of the regional research and industrial communities has been presented in the Cartographic Competence Schemes (CCS) and the Regional RES-ID Cards elaborated for all three project regions (deliverables 2.2 and 2.3). The following chapter deals with a comparative analysis of the three project regions with regard to their economic and innovation performance, focussing in particular on the RES sector. To this end a set of specific indicators has been collected.

In its **Europe 2020 Strategy** the European Commission puts forward as one of the three mutually reinforcing priorities the objective of ensuring *sustainable growth, i.e. promoting a more resource efficient, greener and more competitive economy*. To this end, the Commission proposes as one main EU objective the realisation of the “20/20/20” climate/energy targets, which are illustrated in the following table for the three regions’ countries.

Table 1 – The “20/20/20” climate/energy targets

Target: The "20/20/20" climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right)				
Greenhouse gas emissions, base year 1990 (Index 1990 = 100)				
	2006	**2007**	**2008**	
Spain	149,9	153,9	142,3	
Greece	124,6	127,7	122,8	
Denmark	104	97	92,6	
Share of renewable energy in gross final energy consumption (%)				
	2006	**2007**	**2008**	***2020***
Spain	9,1	9,6	10,7	*20,0*
Greece	7,2	8,1	8,0	*18,0*
Denmark	16,8	18,1	18,8	*30,0*
Energy intensity of the economy (Gross inland consumption of energy divided by GDP (kilogram of oil equivalent per 1000 Euro))				
	2006	**2007**	**2008**	
Spain	187,13	183,91	176,44	
Greece	178,96	171,44	169,95	
Denmark	110,13	105,65	103,13	

Source: EUROSTAT

According to the table and the targets set for 2020, Denmark is the best performer followed by Greece in terms of greenhouse gas emissions and energy intensity as energy efficiency indicators, and by Spain with reference to the country’s renewable energy share in gross final energy consumption, in particular with regard to the objectives set for 2020.

Chapter 4 elaborates a performance analysis at regional level by presenting the three project regions with regard to their advancements in the RES field and in relation to their innovation and knowledge building context. In detail, the chapter presents:

- a brief overview on the main indicators selected to describe the current situation of the three regions and to provide a general idea on the regions' knowledge-based development and a comparison among them in view of their performance in the RES sector;
- a comparison of the regional SWOT analysis elaborated for each region;
- regional success stories in terms of technology transfer dynamics;
- the positioning of the regional economies with respect to the parameters "research & innovation" and "participation & clustering".

4.1 Main indicators describing the knowledge-based economy in the three regions

Table 2 illustrates the main quantitative and qualitative indicators in terms of economic development and regional growth, political supporting mechanisms for the RES sector and commitment to research and innovation activities in the three regions. For the specific case of Samsø, quantitative indicators collected through the EUROSTAT database are representative for the Central Denmark region (Midtjylland) to which Samsø belongs, thus the data does not reflect completely the peculiar island situation.

Table 2 – Summary of main economic and innovation indicators

	Canary Islands	**Crete**	**Samsø** ***(Central Denmark)***
Geographical area	7.447 km^2	8.336 km^2	114 km^2 *13.053 km^2 (Central D.)*
Population (2009)	2.076.585	608.810	ca. 4.000 *1.247.732 (Central D.)*
Density	279/km^2	72/km^2	38/km^2 *94,8/km^2 (Central D.)*
GDP at current market prices at NUTS level 2 ***Euro per inhabitant (2007)***	20.700 €	20.000 €	*39.600 €* *(Central Denmark)*
Economic sectors' contribution to the GDP (%)	Service: 83% Industry: 16% Agriculture: 1% (2008)	Service: 78% Industry: 12% Agriculture: 10% (2010)	Service: 75% Industry: 5% Agriculture: 20% (2010)
Total intramural R&D expenditure (GERD) in (% of GDP)	0,62 (2008)	0,94 (2005)	*1,75 (2007)* *(Central Denmark)*

- Business enterprise sector (% of GDP)	0,14	0,08	*0,96 (Central Denmark)*
- Government sector (% of GDP)	0,19	0,42	*0,02 (Central Denmark)*
- Higher education sector (% of GDP)	0,29	0,45	*0,76 (Central Denmark)*
Human Resources in Science and Technology (% of active population)	29,3% (2009) 29,5% (2008) 32,4% (2007)	23,5% (2009) 26,1% (2008) 26,0% (2007)	*42,8% (2009) C.D.* *42,7% (2008) C.D.* *39,8% (2007) C.D.*
High-tech patent applications to the EPO (per million of inhabitants)	0,626 (2007) 0,512 (2006) 0,548 (2003)	1,659 (2006) 3,044 (2005) 2,221 (2003)	*10,656 (2007) C.D.*
Policies addressed to the RES sector	▪ Energy Plan of the Canary Islands (PECAN) 2006-2015 for Wind and Solar energy ▪ Second Canaries Plan of Research and Development, Innovation and Dissemination 2007-2010 (II PECIDI) ▪ Plan of Renewable Energies 2005-2010 (Spain) ▪ Action Plan of the Strategy of Saving and Energy Efficiency in Spain 2008-2012	▪ National legal framework for supporting RES adoption ▪ Operational Competitiveness Programme 2007-2013 ▪ Investment Incentives and Laws for energy investments incl. all forms of RES, energy savings, and RUE	▪ Danish Climate and Energy Policy o Energy policy agreement from 2008- 2011 o Promotion of Renewable Energy Act 2008 o Security of energy supply 2009-2025
Knowledge creation and dissemination	▪ 2 HEI and 2 Research and Technology Institutes ▪ Business incubators ▪ ITC as important TT agent ▪ RICAM Cluster	▪ 3 HEI and 5 Research centres (FORTH) ▪ Science & Technology Park STEP-C ▪ > 30.000 students ▪ Business incubators	▪ No universities and research institutions on the island ▪ Knowledge creation mainly through SEA (main RES promoter) ▪ Wide network of manufacturers and distributors with large potential for TT
Relevance of the RES sector to economic development (2010)	▪ Strong growth potential ▪ Significant mix of renewable resources ▪ ca. 100 companies operating ▪ Big annual increase of energy demand during	▪ Strong growth potential ▪ Strong and well balanced mix of renewable resources ▪ over 200 million Euros of investment costs ▪ Big annual increase of	▪ Strong exploitation of wind energy, followed by bioenergy

	summer peak hours	energy demand during summer peak hours	

Source: EUROSTAT

Summary of key findings:

- The main macroeconomic quantitative indicators (GDP, R&D expenditure, Human Resources in S&T, High-tech patent applications) show that the **economic performance** of the Central Denmark region in which Samsø is located, is the strongest one among the three regions, followed by Crete and with a slight distance by the Canary Islands. It is interesting to notice that the 'GDP per capita' in all three regions is around 10% less than the respective national average. Furthermore, the GDP of the Canary Islands and Crete is around two times less compared to the one of Central Denmark. As regards in particular R&D expenditures and their related outputs, Crete is performing better than the Canary Islands, filling more high-tech patents over the last five years.
- For the regions under study, the **prospective demographic trend** over the long term is "stagnation" which means low birth rates and an increase in the proportion of elderly people. Against this backdrop, the population of the Canary Islands and Crete has been increasing during the last years while Samsø has been suffering from a strong population decrease which is above the national average (10% vs. 7%). As a matter of fact, there are relatively few middle aged citizens on the island leading into the "missing" generation between 20 and 30 years, i.e. inhabitants younger than 50 are literally underrepresented on the island.
- Concerning the **economic sectors' contribution** to the regional GDP, it can be stated that all three regions are reliant on the service sector as main pillar forming the regional income (≥ 75%). In this regard, tourism nowadays represents the main economic activity on the three islands. In particular the Canary Islands and Crete are well known tourist destinations, especially for the Europeans living on the mainland. About 10 million tourists are visiting the Canary Islands all over the year, while Crete is being visited by around 2 million tourists each year mostly during the summer time. As regards Samsø, the island records 500.000 tourist overnight bookings per year, and the number is increasing.
- The European Commission's target of spending **3% of GDP on R&D**, as set as objective in the Lisbon Agenda and recently renewed in the Europe 2020 Strategy, has not been reached by the regions by 2010. Central Denmark among the three regions with 1,75% of R&D expenditure of the GDP in 2007 is the best performing region. With particular regard to Crete, it has to be pointed out that the R&D expenditure, even if not reaching the 3% ratio, is above national average (0,94% compared to 0,59% at national level in 2005[3]). The R&D expenditure in the Canary Islands is the lowest one of the three regions. Concerning the distribution of contribution to R&D development among different regional actors, Central Denmark is characterised by a strong private R&D investment and an extremely low

[3] More updated official data is not available yet. According to information provided by the Greek INRES partners, the numbers for 2009 do not differ significantly from the ones of 2005.

R&D investment from governmental side. In the Canary Islands and Crete the higher education sector holds the highest share in R&D spending (in Crete even higher than in the Canary Islands).

- Comparing the **R&D performance** in general of the three regions, it can be stated that the cost-benefit ratio in terms of R&D expenditure and R&D output is most efficient in Central Denmark followed at a great distance by Crete and then by the Canary Islands. The latter region in fact is not investing satisfactorily in R&D activities as already said before (in total only 0,62% have been invested in 2008), resulting in smaller R&D outputs compared to the other two regions. An indicator underpinning this circumstance is the trend of high-tech patent applications. On average, the number of high-tech patents filed in the Canary Islands is only a third of the ones filed in Crete even if the Canary Islands over the years account for a higher number of human resources involved in science and technology. As concerns particularly the situation of Samsø, it has to be pointed out that the R&D performance demonstrated for the whole Central Denmark region cannot be considered representative for the specific context Samsø is embedded in, taking into account that the island lacks higher education institutes and research institutions due to its demographic gap. Research on the island is mainly conducted by inventing and implementing practical and innovative solutions, while knowledge is being created and diffused principally through SEA, the island's energy agency which represents the main local innovation catalyser. This particularity will be described more in detail in the following section 4.2..

- The three regions are characterised by a **strong presence of enterprises of small dimension** (SMEs). Especially within the **RES sector**, the majority are micro SMEs with less than 10 employees. The activities of these companies are mostly developed in the areas of installation, manufacturing, and engineering and R&D. Renewable energy systems mostly exploited are wind energy on all three islands, and solar systems (both photovoltaics and solar thermal) especially in the Canary Islands and Crete. Further energy sources utilized are bioenergy mainly in Crete and Samsø, and water energy especially in Crete and with increasing importance also in the Canary Islands. Geothermy is being exploited mostly in Crete. Most of the manufacturing companies of the RES sector, only a limited number on each island, are dedicated to the manufacturing of photovoltaic modules and solar thermal collectors. With particular regard to the Canary Islands, the promotion of wind energy through companies is not in line with the island's potential for wind power. This is mainly due to bureaucratic barriers and the missing commitment from governmental side.

- As addressed above, all three regions demonstrate according to different indicators a **significant RES penetration** in their territories. Environmental concerns result in particular strategies for exploiting efficiently the indigenous renewable energy resources towards the goal of reaching energy supplies with stable offer, low cost and environmental friendliness. Also the fact that all three islands are tourist destinations supports the importance of ecologically and economically sustainable energy supplies. In general it can be observed that the energy consumption on Samsø is rather steady while the energy demand in the Canary Islands and Crete is increasing especially during the summer time when most of the tourists visit the islands.

- In the Canary Islands, the RES sector is composed of around 100 companies and is mainly developed in wind and solar energy. However, the wind energy contribution to the annual electric demand is relatively low compared to the potential the Archipelago is offering. Next to the already mentioned bureaucratic barriers, a further reason for this are the small and medium electrical grids that limit the production of wind power. The total wind power installed in the Canary Islands by 2010 was 142,85 MW. The use of solar energy has been also increasing during the last years through the installation of solar thermal panels and of photovoltaic systems (the solar thermal surface installed by 2010 is approximately 110.000 m^2, the total photovoltaic power by 2010 is 123.847 kWp). Water is increasingly becoming an important energy source, used in combination with wind energy. Bioenergy is only fairly utilised with 12,096 MW of power generated from biomass and 1,6 MW from biogas in 2010.
- In Crete different RES systems are exploited with investment costs of over 200 million Euros in 2010. The solar energy sector has been experiencing a strong development during the last years, above all solar thermal energy has contributed to the fast economic development of the RES industry and R&D and innovation activities in the region. The solar thermal surface installed up to day (January 2011) is 400.000 m^2, producing 1,8% of the total energy demand. Regarding photovoltaic systems, over 250 installations with a potential of over 15 MW have been installed in lighthouses and hotels set up and new installations are currently under construction. Concerning wind energy, the total wind power installed corresponds to 24 wind parks with an energy potential of 167 MW, four more wind parks are under construction. Wind energy provides 15,4% of the total electricity generation. Bioenergy is exploited primarily through biomass, making up 9% of the total final energy consumption. In addition, two pilot plants for biogas production have been established. With regard to water energy, two small hydro installations of 0,6 MW have been installed, and pilot projects for pump storage systems are currently under study. Finally, concerning geothermy (shallow geothermy), 5 installations have been implemented in the region.
- With average wind speeds ranging from 6.5 to 7.5 meters per second, Samsø is ideal for wind power. 11 wind turbines on land with a size of 1 MW each cover the electricity consumption. In addition, the island has 10 offshore wind turbines in the sea south of Samsø. Each of these turbines is 2,3 MW and reaches 103 metres up from sea level to the upper tip of the wings, providing a large boost to the renewable energy production. The offshore turbines are more productive: they produce 3.500 MWh of electricity per MW of capacity while the land-based turbines generate a third less power per MW. Bioenergy is mainly exploited through four district heating plants running on straw and wood chips covering more than 70% of the heating demand. Up to today, only 35% of the local biomass resources are exploited, and there is a large biogas potential (40,28 GWh when supplemented with energy crops). The exploitation of biogas for the ferries is currently in progress. Finally, solar energy contributes very little to the island's energy

production, some solar panels are installed in home installations (0,139 GWh in 2005 compared to 107,3 GWh of wind energy).

- Concerning the **political and institutional backing of the regions in terms of research and innovation development and policies addressed to the RES/ energy sector**, the Canary Islands as autonomous community is the only of the three islands with policies managed at regional level. The *Second Canaries Plan of Research and Development, Innovation and Dissemination 2007-2010* (II PECIDI) expires at the end of 2010 and the third plan is currently under development. With particular regard to the RES sector, the region also manages its own energy plan, the *Energy Plan of the Canary Islands 2006-2015* (PECAN) especially addressed to wind and solar energy. On the contrary, policies implemented in Crete and Samsø depend on the national framework, thus the two regions have limited capacity to plan and implement policies for R&D and innovation and energy/ RES concerns. This implicates also minor power and control in influencing the priority areas of policy making. As regards particularly the Danish context, during the last years with a governmental change a diminished national focus on RES research can be even observed. Concerning Crete, the region has been making efforts in elaborating a well documented energy policy-programming plan. Within the first semester of 2011, a President is going to be elected for the Region of Crete, entailing a complete reorganisation of the regional administration and thus, resulting also in more responsibilities at regional level.
- The **establishment of networks and clusters**, and the interaction and knowledge flows within them are most advanced in the Canary Islands. On Samsø networking and clustering activities are taking place mainly through straight contacts than through entities that have been expressly set up for this purpose. Being a small island, personal contacts are easy to keep and in this sense they are considered the most efficient instrument for transferring knowledge to the island community. On the contrary, both the Canary Islands and Crete dispose of significant infrastructures for research and technology development and of intermediary organisations for technology transfer (in the Canary Islands the main agent is ITC; in Crete technology transfer is mainly supported by STEP-C). However, on both islands technology transfer and the promotion of innovation are still rather weak due to a weak understanding between researchers and industry complicating the setting up of joint projects. As regards especially the RES sector, the Canary Islands made a step ahead by establishing the cluster RICAM (Association of Canary Islands companies in renewable energies, environment and water resources), an organization uniting companies, public bodies and R&D entities and aimed to push the entire region forward from a technological, environmental and economical point of view in the areas of renewable energy, environment and water resources.

4.2 Comparative SWOT analysis

As already mentioned in the introduction of this chapter, one of the first INRES activities was the elaboration of regional CCS and RES ID-Cards, aimed to present a detailed description of the current situation in the RES sector. In order to evaluate the regional context in which the development of this industrial sector is shaped and planned, a SWOT analysis has been performed for each island region, investigating on both the scientific and industrial performance and on the political scenario. The analysis was carried out by the relevant regional project partners, i.e. regional authorities, research institutions and industrial players.

In the following tables a summary of the main Strengths, Weaknesses, Opportunities and Threats identified in each region is presented. Research and industrial perspectives which previously have been considered separately are now integrated in one SWOT. In a further step, the analysed strengths, weaknesses, opportunities, and threats across the three regions have been summarised in a common SWOT matrix in order to obtain a comparative overview of the current situation.

a) Strengths

The Canary Islands and Crete are two regions with strong knowledge creation infrastructures and highly skilled personnel. Both regions dispose of higher education institutes and research and technology centres as well as business incubators. Intermediary or bridge mechanisms have been developed in the two islands for more than 10 years. Most important key actors of technology transfer are ITC, the Canary Islands Technological Institute, and STEP-C, the Science and Technology Park of Crete which was founded as one of the institutes of FORTH. FORTH represents one of the two main national research centres in Greece for science, technology and innovation, and is located mainly in Heraklion, Crete. Especially as regards Crete, the strong education, research and innovation capacities enabled the region to reach a research intensity which is higher than at national level.

In contrast, there are no knowledge creation facilities, such as higher education institutes and research centres, on Samsø. Human resources are missing as well which is mainly based on the demographic gap the island is facing. Nevertheless, the island succeeds in being innovative, and research is mainly conducted by inventing and implementing practical and innovative solutions. The Samsø Energy Academy in this regard is the main catalyst for supporting local initiatives.

A common strength of all three regions is the strong adoption of highly innovative RES technologies (an overview on the different kind of RES technologies adopted has been provided in Section 4.1). In the Canary Islands the RES technology diffusion happens mainly through system integration and the engineering of existing technologies for off-grid and grid connected systems. In Crete, the innovative RES technologies are mostly implemented in hotel facilities. In Samsø innovation happens mainly through the adoption of 'off-the-shelf' technologies.

A further strength of all three regions are the cooperation activities in research at international level. While the regional research communities of the Canary Islands and Crete are strongly collaborating at international level, Crete above all within the framework of European funded projects, Samsø disposes of a large research collaboration network as well, in particular through contacts made by the Energy Agency and the Energy Academy.

SWOT - Strengths		
Canary Islands	***Crete***	***Samsø***
Highly skilled personnel	Highly skilled personnel in research	Public-private cooperation
Strong research base (research infrastructure)	Strong research base (research infrastructure)	Strong local networks and mutual trust among local enterprises (strong local patriotism among SMEs)
Development of innovative RES technologies by research players	Strong skills in solar thermal industry	Large research collaboration network, also at international level
International cooperation activities of regional research community	Operation of many RES production plants (wind parks, PV, agricultural biomass)	Strong involvement of regional community in RES
Adoption of highly innovative technologies in production processes and facilities	Strong international cooperation of regional research community in EU projects	Samsø Energy Academy as catalyst for local initiatives
	Adoption of innovative technologies in facilities (mainly hotels)	Strong adoption of innovative RES technologies (‘off the shelf’ technologies)

b) Weaknesses

In terms of weaknesses, the SWOT matrix below reveals that local companies operating in the RES sector on the three islands show only a low innovation commitment. One of the reasons is the small company size, the majority are micro SMEs with less than 10 employees. Based on this, companies dispose only of a low level of financial resources for conducting RTD activities and thus, have insufficient internal research bases. On the Canary Islands and Crete the insufficient innovation commitment can be further explained by the poor linkage between research entities and companies, leading to a weak understanding between companies and their innovation demand on the one side and the existing research and technology offer of the research communities on the other side. On Samsø, the lack of human resources and the funding availability only on a project-by-project basis making long-term plans not possible, are further reasons for the low innovation culture of companies.

Further to this, the illustrated weaknesses are also reasons why local companies are insufficiently orientated towards international cooperation leading to low company growth which is hampered once more through the islands’ boundaries.

As regards the research RES communities in the Canary Islands and Crete, conducted research does not support satisfactorily the development of start-up companies. One main reason for this is the low exploitation of existing funding potential by the regional research communities, existing both at European and national level, in the Canarias case also at regional level.

SWOT - Weaknesses		
Canary Islands	***Crete***	***Samsø***
Low level of financial resources for conducting RTD activities in RES from *private* side	Not enough start-ups from research results	No financial reserves of companies for conducting RTD activities
Poor linkage between research entities and enterprises (weak understanding)	Low financial resources for conducting RTD activities in the RES sector	Lack of human research resources
Low exploitation of funding potential by research community	Poor linkage between research entities and enterprises	Funding is only on a project-by-project basis, i.e. no long-term plans possible
Not enough start-ups resulting from research	Insufficient research base in companies in the RES sector	Small company size reduces focus on innovative processes
Low innovation commitment of companies	Low innovation commitment and culture of companies	Low growth caused by island boundaries
No international orientation of regional companies	No international orientation of companies	

c) Opportunities

Despite some important weak points that may hinder the economic development, also opportunities are emerging. These need to be seized in order to ensure knowledge-based development and economic growth in the RES sector in the three island regions.

All three islands, from an institutional point of view, have framework conditions that in theory would allow them to bring forward technological development in the sector and transfer research know how to industrial processes. Especially the Canary Islands are a step ahead since the region has tailor-made regional policies supporting the further exploitation of renewables and the economic growth of the RES industry. On the other side, Crete and Samsø in terms of policy making are dependent on the national framework and thus, the influence on making political decisions tailored to the specific regional needs is limited. As already mentioned earlier, Crete is going to do a considerable step forward in this regard and will obtain more power in policy making from 2011 onwards when a regional president is elected for the region, leading to a complete reorganisation of administrative procedures.

Further, with particular regard to the Canarias context, the archipelago disposes of good networking opportunities. The RICAM Cluster aims at increasing the competitiveness of its local companies operating in the fields of renewable energies, the environment and water resources. The cluster offers a good opportunity for raising awareness on public funding possibilities and bringing together research and industry and supports in this way a stronger and enhanced development of the RES industry in the region. No similar networking activities have been set up in the other two regions. Crete has been improving the number of collaboration between research and industry. Furthermore, the region has started to establish an association for photovoltaics, thus first cornerstones have been set for enhancing networking and increase technology transfer activities. Networking in Samsø works differently and happens mainly through direct contacts among islanders which is much facilitated through the small island size.

Research knowledge exists in all project regions, mostly generated through public research activities. All three regions dispose of a surplus of well educated researchers; in the case of Samsø, the island has access to researchers outside of the island. This opportunity needs to be exploited further by improving cooperation between the research and industrial communities and utilising the existing technology transfer potential. The interest of companies to adopt RES applications exists; on the Canary Islands and Crete especially the tourism sector could be exploited as test field for RES technologies. On Samsø the already positive image as RES island and the strong interest from international media make the island quite popular and interesting for being involved in research and further cooperation activities.

Finally, all three regions dispose of favourable environmental conditions for RES technology applications. As section 4.1 already illustrated, wind and solar energy are the local renewable energy sources which are mostly exploited, solar energy especially in the Canary Islands and Crete. Bio- and water energy and geothermy are further renewable sources where the islands invest, bioenergy mainly in Samsø and Crete, and geothermy above all in Crete. Where technically the potential exists, the islands need to continue their development towards the sustainable production of energy from different energy sources. In this regard, especially the work conducted by the energy agencies becomes essential since these institutions are acting as promoters of activities to incorporate the sustainable use of energy in people's thinking mentalities.

SWOT - Opportunities		
Canary Islands	***Crete***	***Samsø***
Availability of EU RTD funds for research	Availability of EU& nat. RTD funds for research and investment in RES	Availability of EU RTD funds for research
Networking possibilities (RICAM cluster)	Increasing number of collaboration between research & industry	Access to well-educated researchers outside the island
Favourable territorial and environmental conditions for adopting RES technologies	Surplus of well educated researchers	Low interest rates for bank loans, facilitating RES investments
Surplus of well educated researchers	Favourable territorial and environmental conditions for adopting RES technologies	Positive image as RES island and strong interest from international media
Increasing number of collaboration between research & industry	Strong interest for RES applications from business side	
Regional funding programmes/ grants for public-private partnerships for developing R&D projects		
REF: Economic and Fiscal Regime of the Canary Islands		
Use of the tourism sector as test field of RES technologies		

d) Threats

One of the main factors threatening the positive development of the RES sector in the three regions are the bureaucratic barriers. Complicated and long-winded procedures for accessing funding do exist followed by long decision making processes. Samsø is experiencing this barrier especially at European level and with regard to the participation to European funded projects. At national level, the island has only reduced access to public funding since the national focus on RES research activities has been diminished during the last years.

Crete highlights as further bureaucratic barrier the receiving of permissions with regard to licensing, making investments and modernisations, hindering in this way the diffusion of RES applications. What is more, if these barriers are defeated, then mostly by big companies and big hotels which play an important role in the adoption of innovative RES technologies; whereas small-sized companies are left behind.

Next to heavy bureaucracy, the development and implementation of RES technologies require high investment costs and are characterised by long periods of returns for the investments made. That is why significant investments in RES technologies especially for small companies become nearly impossible.

One threat common to the Canary Islands and Crete is the difficulty to effectively perform technology transfer activities. Even if the institutional system in the two islands is fairly developed, the real transfer of research know how to the market is hampered. This becomes particularly evident in Crete where research centres take more than 15 to 20% of the national funding available for R&D but the industry misses to absorb this benefit, above all companies operating in the service/ tourism sector. The weak interaction between research and industry leads to the development of technologies that are not completely adapted to the islands' characteristics and thus, to a suboptimal exploitation of renewables on the islands.

A further issue threatening the positive development of the RES sector in the three regions is the brain drain, in the Canary Islands above all the brain drain of researchers, whereas in Crete the situation regards both researchers and industrial players. In Samsø the brain drain can be explained with the missing research and higher education infrastructures and the related demographic gap mentioned already in section 4.1.

SWOT - Threats		
Canary Islands	***Crete***	***Samsø***
Bureaucracy barriers	Bureaucracy barriers (permissions and funding)	Bureaucracy barriers at EU level
Low awareness of regional research capacity from companies' side	Few or not used incentives for public-private partnerships	Brain drain due to small company size and island characteristics (few jobs, island depopulation)
Brain drain of research community	Low awareness of regional research capacity from industrial and political side	Diminished national focus on RES research activities during the last years
Technical solutions not adapted to	Brain drain	RES solutions demand large capital

islands' characteristics		investments and long period of returns for investments in RES technologies
High costs of investment	Isolation/ Insularity	

e) Common SWOT matrix

The analysed strengths, weaknesses, opportunities and threats across the three regions have been summarised in a common SWOT matrix in order to obtain a comparative overview of the current situation. In some cases, items involve only two of the three regions but have been included in the common SWOT anyway. This is because these items have been considered at any rate as quite important issues that needed to be mentioned in order to reflect the current scenarios of the respective regions in the RES field. Furthermore, considering that the framework conditions on Samsø are quite different from the other two regions (i.e. no existence of research infrastructure, demographic gap), some items could not involve the region.

Common Strengths	Common Weaknesses

• Strong knowledge creation infrastructure and highly skilled personnel (CI + Crete)
• Strong adoption of highly innovative technologies
  o CI: system integration/ engineering of existing technologies for operation stand alone off-grid and for operation in small and weak island grids
  o Crete: mainly in hotels
  o Samsø: 'off the shelf' technologies
• International research cooperation activities
	• Poor linkage between research entities and enterprises (CI + Crete)
	• Low level of financial resources for conducting RTD activities in the RES sector (CI and Samsø: especially from private side)
	• Low innovation commitment of companies due to small company size and insufficient internal research base
	• No international orientation of companies and low growth caused by island boundaries

Common Opportunities	**Common Threats**
• Availability of EU RTD funds for research and investment in RES (CI: also regional/ national level; Crete: also national level) • Surplus of well educated researchers (Samsø: outside the island) • Favourable environmental conditions for RES technology applications	• Bureaucracy barriers • Brain drain (CI: especially of the research community) • High investment costs and long period of returns for investment in RES technologies

To summarise, an important main strengths of all three regions is their commitment to diffuse the adoption of innovative RES technologies. Based on technical knowhow and environmental framework conditions, different RES sources are exploited. Furthermore, research collaboration especially at international level is working rather well. These strengths need to be further exploited in order to overcome main weaknesses, such as the low innovation commitment and adoption of RES technologies through companies and the missing collaboration between research and industry.

From an external point of view, public funds need to be exploited as much as possible, above all at European level. In this way, international cooperation activities will be further intensified, and above all small-sized companies will be given the chance to participate actively in research activities, to get in closer contact with research communities and to adopt innovative technologies. In this way, threats such as the brain drain and high investment costs can be diminished. The favourable environmental conditions in which the regions are embedded should in this regard act as a further incentive for getting engaged in research projects.

4.3 Success stories

The following section illustrates some success stories on successfully implemented technology transfer actions within the INRES network. Research results obtained in the RES field have been transferred to the local communities and beyond.

The Canary Islands present two success stories, one dealing with wind- and hydropower for generating energy; the other one with the supply of drinking water in isolated areas through the exploitation of photovoltaic solar energy. In fact, the second success story demonstrates how research know how developed on the Canary Islands has been successfully transferred to foreign remote areas.

The success story chosen by Crete involves the tourism sector and deals with the implementation of innovative RES technologies in hotels, underpinning the fact that tourism and environmental conservation are two concepts which need to work in parallel.

Finally, Samsø presents two success cases. The first one deals with small-scale village heating plants operating with solar energy and bio-energy resources; the second success story is about the supply of bio-fuel for transport generated through the production of rape-oil. Even though this second case from a technological point of view can be defined a success, from a practical point of view it is difficult to exploit this technology due to bureaucratic barriers.

The success stories should function as examples for other insular regions. Furthermore, they should demonstrate that the acceptance at local level and therefore, the involvement of the local community are mandatory for realising a change of behaviour and adopting successfully environmentally friendly operating procedures.

4.3.1 Canary Islands

- **<u>El Hierro 100% RES</u>**

Context

El Hierro, the smallest island of the Canaries, with a population of around 10.000 inhabitants, is staging one of the most ambitious island projects regarding energy self-sufficiency through the use of renewable energies. In a few years, El Hierro will become one of the first islands in the world to meet its energy demand using RES (Renewable Energy Sources) in an isolated electrical grid.

The 100% RES project is a key issue of the “Sustainable Development Plan” defined in 1997 by the Island Government of El Hierro, which has proven to be even more relevant since El Hierro was declared a “World Wide Reserve of Biosphere” by UNESCO in January 2000. It is a most singular project, which demonstrates that a 100% RES future is already a reality for islands.

Objectives

Design and implementation of a Wind-Hydro power station, which is an original concept that combines wind power and hydropower, using water as an economic way of storing energy. The final goal is the electric supply to the population from RES sources. Furthermore, and in order to demonstrate that the synergies between different RES can contribute greatly to increasing RE penetration into weak grids in isolated areas, PV, solar thermal and biomass programmes will also be implemented.

Process

A consortium of 7 European partners, coordinated by ITC (Instituto Tecnológico de Canarias), carried out the first steps of the project focusing on the “100% RES for Electricity Production” programme. At this stage the feasibility and economic studies for the development of the project, as well as the preliminary technical design were carried out.

As a result of these studies and thanks to the increasing public awareness on environmental issues in the El Hierro population a group of technicians and politicians convinced the Spanish Government to make the whole project a reality.

Financial resources and partners

With the initial financial support of the DG TREN of the European Commission, the initial consortium of 7 partners started the preliminary project studies.

Afterwards, the society “Gorona del Viento”, participated by the El Hierro Island’s Council (60%), the electric company Endesa (30%) and ITC (10%), was established for the development, promotion, construction, operation and maintenance of the wind hydro power station. A great amount of the total investment will be contributed by Instituto para la Diversificación y Ahorro de la Energía (IDEA- Institute for Energy Diversification and Saving).

Results

Results of the project will be that more than 80% of the electric supply of the whole island will be done by means of wind energy.

Lessons learned and repeatability

Local natural resources can be used with existing technologies for electric supply of isolated communities. The acceptance of such a project by the inhabitants of the island is important as it includes actions on the territory through civil and electric works (hydraulic infrastructure with long water pipes and high volume water reservoirs, desalination plant, control cabinets and a wind farm).

Lessons will be learned in the operation and maintenance, and it will be an example for other insular regions to follow.

- **Water supply through desalination with photovoltaic solar energy in Ksar Ghilène (Tunisia)**

Context

Ksar Ghilène is a 300 inhabitant's isolated village, located in the Sahara desert, at the south of Tunisia and belonging to the region of Kébili. The main activities of the village are agriculture (on the oasis), cattle farming and tourism. The nearest electrical grid is 150 km away, so houses are electrified by solar home systems and the street lighting works with photovoltaic streetlamps.

Prior to the current project, there was a hydraulic distribution network of water from a 30 m^3 water tank to five sources distributed along the village. However, the hydraulic infrastructures created for the drinking water well dried and until then the drinking water supply came intermittently from a well located 60 km away through tanks.

Objectives

The project aim is to produce freshwater from the existing brackish water well located in the near oasis (2,1 km), through a 50 m^3/day RO desalination unit. This unit is an autonomous system driven by a 10,5 kWp photovoltaic solar generator with energy accumulation by batteries. The whole system is control automatically and 15 m^3/day freshwater is produced and distributed in the town through five public fountains.

Process

Tunisian technicians knew about the experience of ITC (Instituto Tecnológico de Canarias) in desalinating saltwater through the use of renewable energies after participating in a training course on these issues at ITC's facilities on Gran Canaria (Canary Islands). They asked the Spanish International Cooperation Agency for its support and ITC was designated for solving the lack of freshwater supply in the small village of Ksar Ghilène.

From the very beginning, the Spanish technicians needed the help of the Tunisians who best knew the particular conditions of the desert. Because of these, the works would be distributed as followed: ITC would contribute with its technical knowledge about desalination with renewable sources providing the needed training to local technicians, and Tunisian authorities would be responsible of civil works and later operation and maintenance of the system. This was the way to guarantee the continuity of the system over the years.

In the installation of the system, a Spanish enterprise was subcontracted for providing the desalination plant, and a Tunisian enterprise with great experience in photovoltaic system was subcontracted for the PV panels.

Financial resources and partners

The project for supplying freshwater through a reverse osmosis (RO) desalination unit driven by stand alone solar photovoltaic energy has been executed within the framework of the Spanish -Tunisian Cooperation.

The partners of this project are the Spanish International Cooperation Agency (AECI), the National Agency for the Control of Energy Consumption (ANME), the Regional Directorate for Agricultural Development of Kébili (CRDA) and the Government of the Canary Islands through the General Direction for Relationships with Africa (DGRA) and the Canary Islands Institute of Technology (ITC).

Results

The Spanish-Tunisian Cooperation project carried out in the Tunisian village has been very successful. This project allows the supply of drinking water through the use of a brackish water desalination plant by reverse osmosis, driven by photovoltaic solar energy.

The desalination plant produces freshwater successfully throughout the whole year. After its first year of operation, in which ITC cooperated with the local technicians in the solution of technical problems during operation and maintenance, the system is now operating just with local support. It has greatly improved the life quality of the inhabitants of this small village in the desert.

Lessons learned and repeatability

The system aims to be a sustainable solution for the supply of drinking water to isolated areas that may have access to salt water sources. This is a feasible alternative for the developing countries that allows the survival of villages and the creation of business niches in order to use the treatment technology of wastewaters in disseminated territories and with no resources.

4.3.2 Crete

- **Candia Maris Hotel SA**

Context

Candia Maris is a five star hotel, located in west part of Heraklion-Crete (Municipality of Gazi) in Greece with 285 rooms and 140 employees and an important number of green applications and renewable technologies.

It is a member of the "Clean up Greece" organization, which participates in the activities of "Clean up the World", under the auspices of the Environmental Program of United Nations, Environmental Management System according to the demands of ISO 14001 International Standard Environmental Hotel Award 2001 for the ecological contribution to a sustainable tourism, and the "Green Planet Award".

Objectives

Candia Maris Hotel aims to become a green hotel. It adopted RES implementation with the assistance of an internal specialized team, called the Maris Green Team. This team has been founded aiming to increase awareness that tourism and environmental conservation are two inseparable concepts.

Process

The management team of the hotel had the vision to turn the Hotel from regular to green. So they developed a range of different green activities including the creation of renewable energy systems, solar panels (No= 900 , sq. m 4.800 approx) used for hot water production, pool water heating, Building Management System, P.L.C., air condition using sea water thermal energy and water recycling.

Financial resources and partners

Funding comes mainly from private resources, as well as from RTD projects at European level. The Cost of investment during the years 2001- 2006 amounted to 1.300.000,00 EURO.

Results

Part of the results of the Maris Green Team activities was the completed installation of 1.742 solar panels, 900 of which are installed at Candia Maris. The total area of installation is more than 4.800m^2. This installation for Candia Maris produces more that 600KW during winter season and more than 1.200KW during summer season, covering more than one third of total energy needs of the hotel.

Before the use of the solar panels the Hotel was consuming 2,166 MWh for water heating, consuming 47,630 lit of petrol and 449,651lit LPG. During August 2002 and March 2003 the savings were quantified by the Democritus Research Centre to 740MW or 115,529 lit of petrol. Today the Hotel uses petrol or LPG only for emergency power generators. Candia Maris has additionally invested in a central thermal control system (BMS) to monitor the installations of heating, air conditioning, lighting inside the premises, reduce energy consumption and improve their performance through predictive maintenance. This specific system has been presented to several scientific workshops as best practice.

Also, the hotel received the "*Environmental Hotel Award*" and the "*Green Planet Award*", which are distinctions awarded to hotels which practice an environmental policy and give special emphasis to water and energy management, refuse sorting, preference for supplies of products from local markets, personnel training on subjects concerning the environment.

The company has close cooperation with local research organizations (Foundation for Research and Technology) and the Region of Crete (Regional Energy Agency of Crete) to further exploit RES available technologies and introduce new innovative applications towards improving energy systems.

The return of investment per year is about 120.000,00 EURO.

Lessons learned and repeatability

Apart from the economic impact and the significant promotion of the hotel in green activities, there is also a great feedback from the clients, as they find such kind of investments very useful for the environment. The green development is crucial and the need for such initiatives is considered vital by customers and locals, adding value to the hotel and providing an important competitive advantage.

4.3.3 Samsø

- **<u>Village-heating plant in Nordby</u>**

Context

As Samsø became appointed Renewable Energy Island, initiatives were taken to start village heating plants on a small-scale basis all over the island. One of the plants was situated in the northern village of

Nordby, which has around 200 households and several summer cottages. Today about 180 houses are connected to the village heating-plant. As straw was used in two other local area heating plants, solar energy in combination with woodchips was chosen for this particular heating-plant.

Objectives

The goal of the project was to initiate a form of heating supply for the village of Nordby that was both economically attractive and based on RES-resources.

Process

A group of local entrepreneurs with very different qualifications (craftsmen, economical and social professionals) was gathered as an initiative group. The initiative group was able to establish a trustful link between manufacturers, distributors and customers. The initiative group convinced the inhabitants of the village of the advantages of the project and nearly all households joined the project.

Financial resources and partners

As a financial partner the company NRGi was involved as an Electricity Service Company (ESCO) model of ownership. NRGi is a customer-owned electricity distributor based on the mainland. Every customer has equal shares in the company. One of the objectives of NRGi is to increase the amount of energy that is being produced by means of RES-resources in its geographical working-area. NRGi finances small-scale energy projects by guaranteeing customers stable energy expenses. By guaranteeing a maximum level of expenses for customers it largely takes away fear of change and economical worries for participants in energy projects.

Results

Results of the project were that the heating in the village of Nordby is being supplied totally by means of solar energy and bio-energy resources. Solar energy alone is sufficient to supply hot-water for the village during summer. Surplus energy in summer is used for summer cottages and drying onions at one of the main onion producers in Denmark.

Lessons learned and repeatability

Existing technologies can be combined into a solution that suits particular areas or customer groups. Using existing networks within customer groups is a powerful mechanism in customers’ change of behaviour. Instead of attempts to convince customers, local change agents and opinion-leaders were very useful.

➢ Rape-oil for diesel

Rape-fields flourish on Samsø in spring

Context

On Samsø the use of local resources in local area heating plants had been highly successful. Straw, solar energy as well as woodchips were used for heating. The same strategy could be transferred to the transport-area by producing local rape-oil from the local rape-production. Rape-oil is traditionally used for frying, but can be used as a substitute for diesel with small adjustments to a diesel-motor.

Objectives

The objectives of the project were production of rape-oil from locally grown rape and supply of bio-fuel for transport on Samsø.

Process

Local farmers investigated the possibilities for making tractors and cars suitable for rape-oil. Furthermore technologies for producing rape-oil from rape were analyzed.

Financial resources and partners

Projects were started largely on an individual basis. Cooperation was limited to an exchange of experiences.

Results

Up to five cars and tractors were made suitable for using rape-oil as fuel. In the first period most of them self-burned spontaneously, but small adjustments in applications made installations less vulnerable to self-burning. The use of rape-oil did not spread to others than the initiative-group.

Lessons learned and repeatability

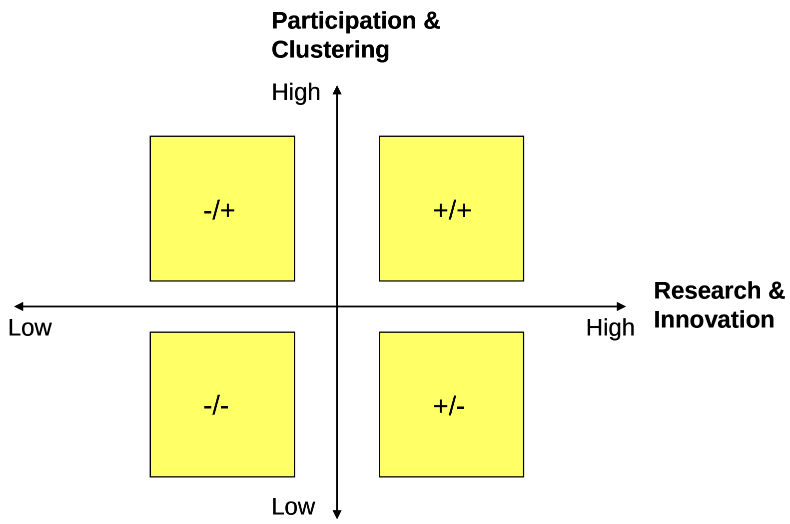
The project succeeded, but is more of a curiosity than a technology change agent. The project did not appeal or refer to a large public from the commencement of the project. No large financial partners were involved. Use of fuel is highly regulated through laws in Denmark and all fuel is taxed. The rape-driven vehicles on Samsø are not covered by the renewable energy regulations in Denmark and the rape oil is taxed as diesel, when used as fuel. Lack of legislation in an innovative area may well put up barriers for implementation of new technology.

4.4 Position of the three regions with reference to the knowledge economy parameters

The growth strategy Europe 2020 sets the goal to turn the EU into a smart, sustainable and inclusive economy. In this context, the central role of knowledge in driving sustainable development becomes evident. Regional actors can effectively participate in formulating their regions' future. The path for turning a region into one based on knowledge and that has been already recommended by the European Commission in its EU 2010 strategy is "first to establish a local research and innovation strategy mobilising all available resources and actors; and second, to embark on interregional cooperation schemes, forming networks of various types"[4].

In order to follow this recommended path, key parameters have been chosen for mapping the knowledge-based economy and society: (i) *Research & Innovation*, and (ii) *Participation & Clustering*. Figure 1 schematically shows the possible situations in which each of the analysed regions could be located.

Figure 1 – Position of scenarios regarding the parameters of knowledge development



A (+/+) = knowledge economy & society scenario quadrant (strong research and innovation and strong cohesion)
B (+/-) = strong research and innovation but low cohesion
C (-/-) = precarious social and technological situation (conflict society)
D (-/+) = low research and innovation and strong social cohesion

This section presents a summary of the position of the regions with regard to the two parameters concerning the RES sector. The regions will be presented in relation to the two main parameters of future desirable changes for the development of a knowledge-based economy and society, which in turn contributes to the positive development of the RES industry as a whole.

The current position of the regions analysed in terms of the knowledge economy development shows the following summary of key findings:

[4] As stated in the EC document "About the Regions of Knowledge" (KnowREG) Pilot Action.

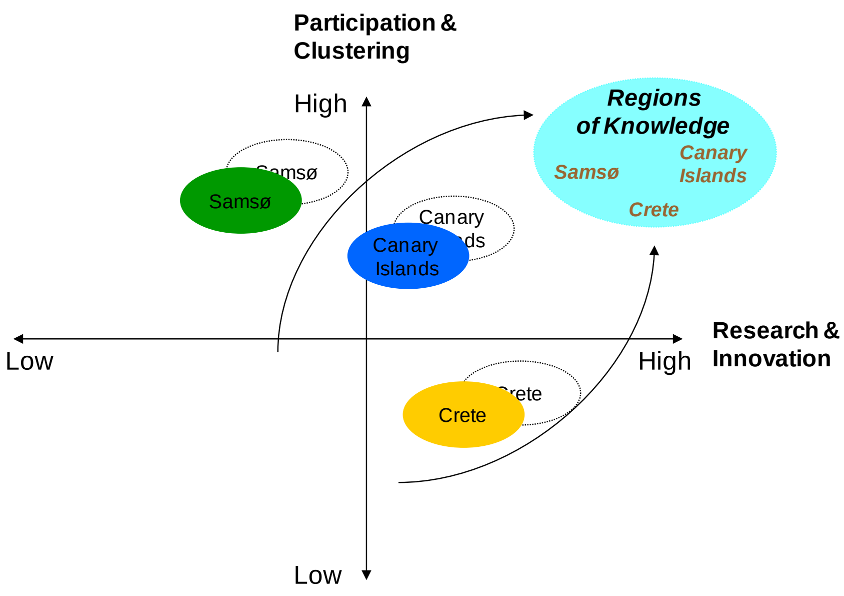
a) A low level in the research and innovation parameter for Samsø which can be related to the fact that human resources performing research are missing on the island and research institutions do not exist. Furthermore, companies, as being of rather small size, have no financial reserves for conducting RTD activities which reduces significantly their focus on innovation processes.

b) At first sight also the Canary Islands could belong to this group, when looking at the R&D expenditure related to the regional GDP and considering the comparatively low participation of the private sector in research funding. Looking though at the high number of researchers present at regional level and the strong knowledge creation infrastructure, it becomes evident that the region cannot be positioned at the same level as Samsø but has to be "upgraded".

c) Crete in terms of research and innovation is characterised by the highest R&D expenditures when looking at all three regions together and taking into comparison only the target island Samsø instead of the whole Central Denmark region. The high number of patent applications during the last years together with the strong knowledge creation infrastructure are further reasons why the region of Crete in this field is the best performing one. However, one shortcoming that needs to be mentioned is the low contribution in R&D from private side.

d) Regarding the parameter participation and clustering, Crete is positioned in the bottom half. Even if the region has the available infrastructures and intermediary organisations, inter-institutional cooperation and interaction between research and industrial players are weak. The Canary Islands can be positioned at a higher point in the diagram thanks to an organised networking approach (RICAM cluster) for overcoming the same barriers mentioned for Crete, i.e. lack in collaboration and participation. Samsø stands out in the comparison among the three regions due to its strong networking and well functioning information flows. It is however interesting to note that networking and participation do not take place through organisational systems but rather through straight direct contacts which are easily maintained because of the small island size.

Figure 2 – Current scenario of the knowledge-based economy in the 3 regions related to the RES industry



As the figure 2, the Canary Islands with regard to both knowledge economy parameters is the best performer. Nevertheless, the position of the region could be even better if research and innovation reached better performance levels and the networking approach would be further reinforced.

On the other side, while Samsø is performing well in participation and clustering, Crete is the opposite and doing rather well in research and innovation activities. Therefore, both regions need to improve the respective complement parameter so as to become a knowledge-based economy and to succeed in a sustainable and positive growth of the RES economy.

Consequently, developing the two parameters in the three regions is mandatory and will present a main issue that the regions have to consider in their policy approaches for improving their future situation.

5. The future situation of the three regions in the RES industry

This chapter presents the current development of renewable energy in Europe. Information has been gathered from the European Commission's communication on renewable energy and its progress towards the 2020 target, released at the beginning of 2011. Following the European scenario and the development and progress made with regard to different renewable energy sources, a brief overview on Europe's best players in RES application is illustrated.

Subsequently, success stories from further island regions dealing with the exploitation of RES have been selected and are illustrated. Both success cases of islands located in Europe and outside have been chosen, considered as interesting examples for further project development. The focus lies on insular regions as these geographic areas face different environmental conditions than regions located at the mainland.

Finally, based on the European scenario and regulations set at European level, main recommendations are given for sustaining the positive economic development of the RES industries in the INRES network. The recommendations tie in with the SWOT analyses developed in each region and present the result of different brainstorming sessions accomplished during the last project meetings.

5.1 Renewable energy in Europe

Renewable energy is crucial to any move towards a low carbon economy. It is also a key component of the EU energy strategy. The European industry leads global renewable energy technology development, employs 1.5 million people and by 2020 could employ a further 3 million[5].

Based on figures published by the International Energy Agency (IEA) in 2007, renewable energies cover 13,1% of *global* primary energy supply and 17.9% of *global* electricity production[6]. The IEA's World Energy Outlook 2006 foresees in its Alternative Policy Scenario that the share of renewables in global energy consumption by 2030 will remain largely unchanged at 14%. Renewables in electricity generation are expected to grow to around 25% at global level, according to the IEA.

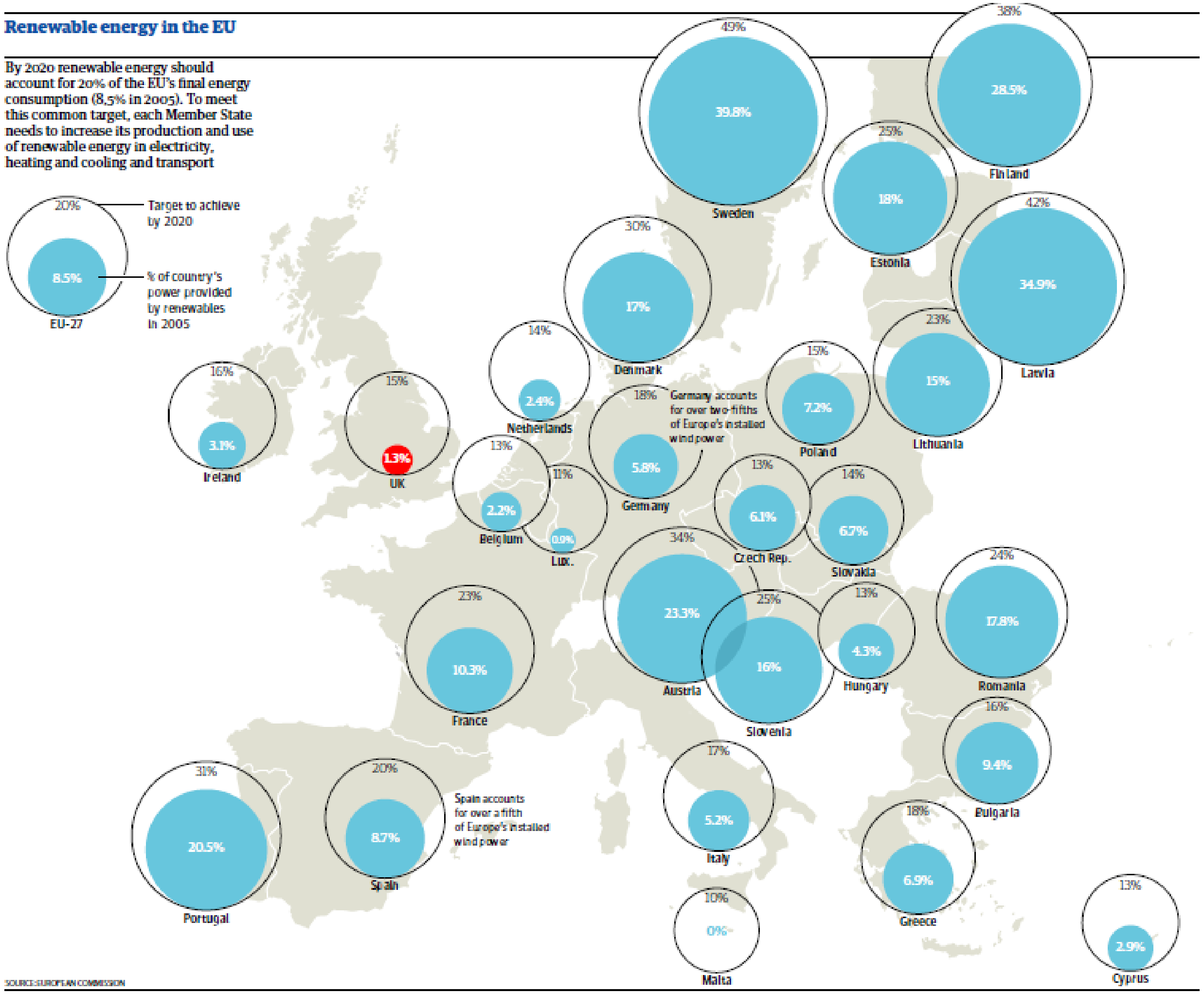
With regard to the European context, the European Commission published a White Paper in 1997 setting out a Community strategy for achieving a 12% share of renewables in the EU's energy mix. The decision was motivated by concerns about security of supply and environmental protection. The 12% target was then adopted in a 2001 Directive on the promotion of electricity from renewable energy sources, which also included a 22,1% target for electricity for the EU-15. The legislation was an important part of the EU's measures to deliver on commitments made under the Kyoto Protocol. Nevertheless, the targets were not binding and only inadequate rate of progress towards agreed targets was made. The insufficient commitment of Member States and the need to foster renewable energy development in all Member States and not only in a few were among the reasons why the European Commission changed its policy approach and adopted the Renewable Energy Directive in 2009[7].

[5] Renewable Energy: Progressing towards the 2020 target, COM(2011) 31 final.
[6] International Energy Agency (IEA), 2007.
[7] Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources.

The Renewable Energy Directive covers energy consumption as a whole and lays down legally binding rather than indicative national targets, such as the reaching of a 20% share of renewable energy in the EU's final energy consumption by 2020. Furthermore, the Directive contains provisions to facilitate the development of renewable energy, such as a legal requirement for the Member States to prepare *National Renewable Energy Action Plans*, reform planning regimes, and develop electricity grids.

This new EU Directive on renewable energies requires each member state to increase its share of renewable energies - such as solar, wind or hydro - in the bloc's energy mix to raise the overall share from 8,5% in 2005 to 20% by 2020. Figure 3 gives an overview on the situation of each member state in 2005 together with the national goals set for the year 2020.

Figure 3 – Renewable energy in the EU



Source: European Commission

As figure 3 illustrates, Denmark with a 30% target to be reached in 2020 shows the highest share of renewable energy in the gross final energy consumption of the three countries to which the INRES regions belong, followed by Spain with 20% and Greece with 18%.

According to the European Commission the implementation of the new EU Directive on renewable energies, making the revision of Member States' energy plans mandatory, seems to pay off. A comprehensive and binding regulatory framework results to be the main catalyser in driving forward renewable energy development and in achieving the ambitious targets that the EU has set itself. The recent high growth rates have resulted in renewable energy constituting 62% of 2009 energy generation investments[8].

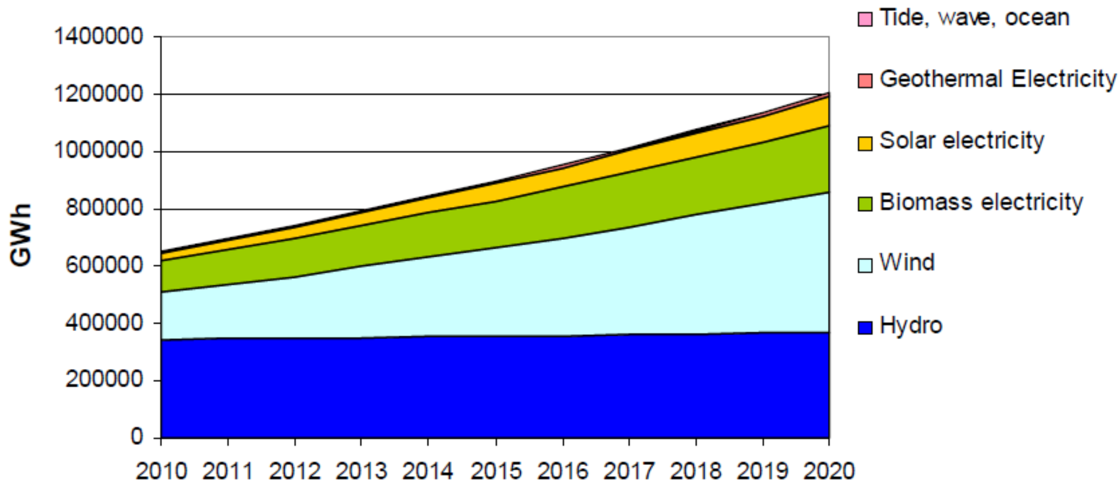
What is more, compared to past progress made within Member States, renewable energy will grow at a faster pace in the years up to 2020. Almost half of the Member States (Austria, Bulgaria, Czech Republic, Denmark, Germany, Greece, Spain, France, Lithuania, Malta, Netherlands, Slovenia and Sweden) are planning to exceed their own targets and be able to provide surpluses for other Member States. For two Member States (Italy and Luxembourg), a small part of the renewable energy needed to reach their target is planned to come from "imports" in the form of statistical transfers from Member States with surpluses or third countries. If all these production forecasts are fulfilled, the overall share of renewable energy in the EU will exceed the 20% target in 2020.

The National Renewable Energy Action Plans also provide important information regarding energy efficiency. EU energy consumption in 2020 is projected to be 95% of the 2005 level. National energy consumption estimates range from increases on 2005 of more than 20% in Cyprus, Lithuania and Malta to reductions of 14% in Germany and 9% in the UK.

Combined Member States expect to more than double their total renewable energy consumption from 103 Mtoe in 2005 to 217 Mtoe in 2020 (gross final energy consumption). The electricity sector is expected to account for 45% of the increase, heating 37% and transport 18%. The expected development in the EU in the three sectors (electricity, heating & cooling, and transport) are illustrated in the following figures 4, 5 and 6.

[8] Renewable Energy: Progressing towards the 2020 target, COM(2011) 31 final.

Figure 4 - EU development of renewable energy in electricity

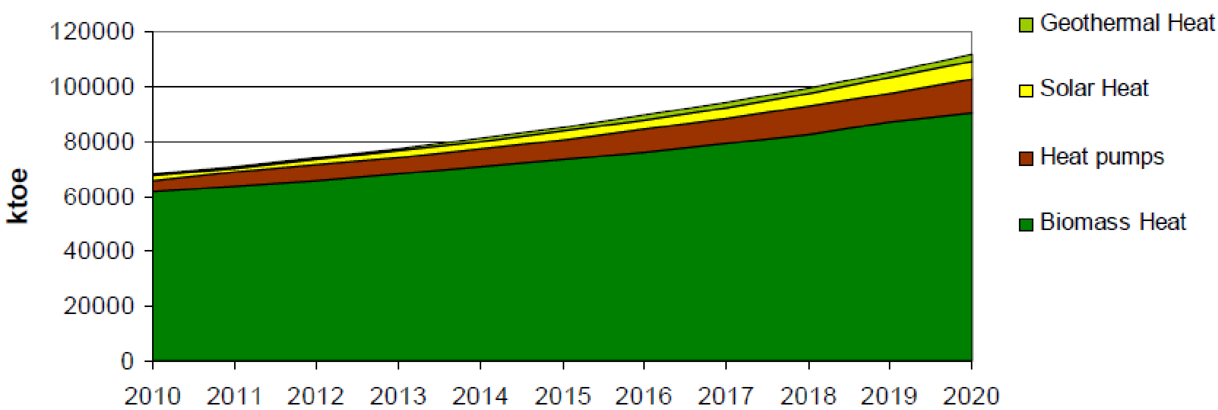


Source: European Commission, COM(2011) 31 final

According to the Commission's communication, following biomass, wind power will account for 27% projected increase in renewable energy consumption (two-thirds onshore, one-third offshore), which will generate demand for Europe's wind turbine manufacturers and associated support industries. Likewise, also the solar energy industry will grow, above all for the photovoltaics sector. Further RES technologies where quantities are currently small will face even higher growth rates. Therefore, Europe's industrial players must be ready to respond to this growing demand.

Regarding in particular the heating and cooling sector, figures 5 gives an indication of the expected growth of technologies in the next decade. As the figure illustrates, biomass will remain the dominant technology, with 50% of the growth up to 2020 occurring in energy produced from this source (half of this source will be used for heating, a third for transport and the rest for electricity).

Figure 5 - EU development of renewable energy in heating & cooling

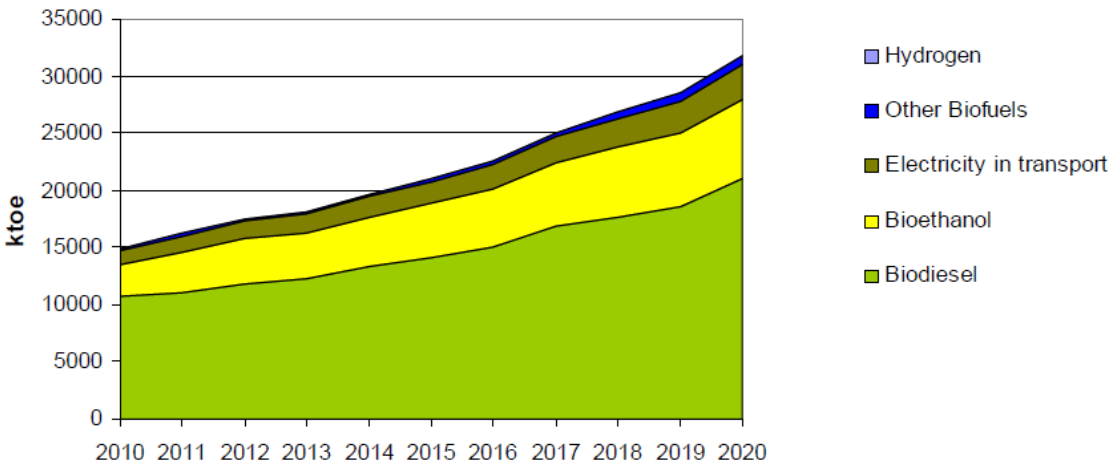


Source: European Commission, COM(2011) 31 final

In the past, only a weak market development in the heating sector could be observed, due to the lack of an adequate support framework in most Member States. With the coming years, this scenario will change thanks to the inclusion of the heating and cooling sector in the new EU Directive. In this context, Member States are already planning reforms to their grants, feed-in tariff regimes or other instruments to be adopted for the heating sector. Consequently, a strong development in Europe's biomass pellet industry, in biomass boiler technology, co-firing power plant technology and biofuels refining can be expected in the next years.[9]

As regards the development of renewable energy in transport, first generation biofuels (i.e. conventional biofuels made from sugar, starch, and vegetable oil) will be the predominant energy source over the period to 2020, supporting Member States in meeting their 10% renewable energy in transport target (cp. figure 6). Second generation biofuels and electric vehicles are expected to make only a small contribution to the renewable energy mix by 2020.

Figure 6 - EU development of renewable energy in transport



Source: European Commission, COM(2011) 31 final (Commission's analysis based on NREAPs)

Moreover, when examining the development of energy exploitation through RES at *country level* in the *European context* (i.e. including Non-Member States), data collected from EUROSTAT reveals that the best performing countries are Norway, Sweden, Iceland and Austria, followed by Latvia and Portugal, and finally by Spain and Denmark. When considering in particular the gross electricity generation from renewables, Denmark can be positioned even at a higher level and results to be the best performing country after Norway (cp. figure 7).

[9] Renewable Energy: Progressing towards the 2020 target, COM(2011) 31 final.

Figure 7 – Gross electricity consumption and generation of European countries in 2007

Electricity from Renewable Sources

Gross Electricity Consumption

2007 (in %)

	Total Share	Hydro*	Wind	Biomass	Solar	Geothermal	2010 OBJECTIVE
EU27	15.6	9.2	3.1	3.0	0.112	0.2	21.0
EU25	15.5	8.9	3.2	3.1	0.115	0.2	21.0
BE	4.2	0.4	0.5	3.3	0.006		6.0
BG	7.5	7.4	0.1				11.0
CZ	4.7	2.9	0.2	1.7	0.003		8.0
DK	29.0	0.1	18.8	10.1	0.005		29.0
DE	15.1	3.4	6.4	4.8	0.496		12.5
EE	1.5	0.2	0.9	0.4			5.1
IE	9.3	2.3	6.6	0.4			13.2
EL	6.8	3.8	2.7	0.3	0.001		20.1
ES	20.0	9.3	9.2	1.2	0.171		29.4
FR	13.3	11.4	0.8	1.1	0.003		21.0
IT	13.7	9.1	1.1	1.9	0.011	1.5	25.0
CY	0.0				0.041		6.0
LV	36.4	35.2	0.7	0.6			49.3
LT	4.6	3.3	0.8	0.4			7.0
LU	3.7	1.3	0.8	1.3	0.264		5.7
HU	4.6	0.5	0.3	3.9			3.6
MT							5.0
NL	7.6	0.1	2.8	4.6	0.030		9.0
AT	59.8	51.4	2.9	5.5	0.024	0.0	78.1
PL	3.5	1.5	0.3	1.7			7.5
PT	30.1	18.4	7.4	3.9	0.044	0.4	39.0
RO	26.9	26.8	0.0	0.1			33.0
SI	22.1	21.4		0.7			33.6
SK	16.6	14.9	0.0	1.7			31.0
FI	26.0	15.1	0.2	10.7	0.004		31.5
SE	52.1	44.1	1.0	7.0			60.0
UK	5.1	1.3	1.3	2.5	0.003		10.0
HR	23.0	22.8	0.2	0.0			
MK							
TR	19.2	18.9	0.2	0.1		0.1	
IS							
NO	106.1	105.1	0.7	0.3			
CH	56.7	53.5	0.0	3.2	0.041		

Source: Eurostat, May 2009 and Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.

Total Share = a / (b+c)
a = Gross Electricity Generation from RES
b = Total Gross Electricity Generation
c = Net Imports Electricity

* Note: Does not include pumped storage

Gross Electricity Generation

from renewables, 2007 (in GWh)

	Renewables	Hydro *	Wind	Biomass	Solar **	Geothermal
EU27	525 578	309 972	104 259	101 808	3 766	5 773
Share	100.0%	59.0%	19.8%	19.4%	0.7%	1.1%
EU25	506 652	291 132	104 209	101 772	3 766	5 773
Share	100.0%	57.5%	20.6%	20.1%	0.7%	1.1%
BE	3 993	389	491	3 107	6	
BG	2 921	2 874	47			
CZ	3 419	2 089	125	1 203	2	
DK	11 063	28	7 173	3 860	2	
DE	93 770	20 904	39 713	30 078	3 075	
EE	148	21	91	36		
IE	2 757	667	1 958	132		
EL	4 594	2 591	1 818	184	1	
ES	59 416	27 763	27 509	3 635	509	
FR	68 289	58 706	4 052	5 514	17	
IT	49 228	32 816	4 034	6 770	39	5 569
CY	2				2	
LV	2 829	2 733	53	43		
LT	581	421	106	54		
LU	295	107	64	103	21	
HU	2 023	210	110	1 703		
MT						
NL	9 146	107	3 438	5 565	36	
AT	41 865	35 993	2 015	3 837	17	3
PL	5 430	2 352	522	2 556		
PT	16 501	10 092	4 037	2 147	24	201
RO	16 005	15 966	3	36		
SI	3 377	3 266		111		
SK	4 956	4 451	8	497		
FI	24 429	14 177	188	10 060	4	
SE	78 168	66 160	1 430	10 578		
UK	20 373	5 089	5 274	9 999	11	
HR	4 278	4 236	35	7		
MK						
TR	36 457	35 851	355	95		156
IS						
NO	135 266	133 934	900	432		
CH	37 372	35 250	16	2 079	27	

Source: Eurostat, May 2009

* not including generation from hydro pumped storage, but including electricity generation to pump water to storage

** Photovoltaic Thermal

In the following, a brief overview on the best performing countries in the RES field is provided.

Norway has a higher share of renewable electricity than any of the EU member states. The country is a proponent of "green power" from renewable sources and has made efforts to make its oil sector as environmentally friendly as possible. Under its Kyoto Protocol commitment, Norway has agreed to limit its carbon emissions to a 1% increase from 1990 levels by the 2008-2012 commitment period. In a dual effort to meet its Kyoto target and to further develop technologies to make oil and gas production less environmentally damaging, Norway has been a leader in alternatives for reducing carbon emissions. As a result of high activity in the oil and gas extraction sectors, the country is relatively more energy-intensive than most OECD countries, and possesses one of the highest per capita energy consumption levels in the world.

Around 99% of Norway's electricity supply derives from the country's abundant *hydropower*. The amount of power produced in Norway is the highest in Europe, with a sum of 120 TWh per annum, followed by Sweden and France with about 65 TWh each one on a yearly basis. The country is alone accounting for more than 45% of the total European hydro power production.

Sweden is moving away from its RES-E target, i.e. electricity produced from RES. In absolute figures, RES-E production has decreased between 1997 and 2004, mainly due to a lower level of large-scale *hydro production*. Other renewable energy sources like biowaste, solid biomass, off-shore wind and PV have, however, shown significant growth.

The Swedish climate policy is characterised by a strong international commitment and close cooperation with all parts of the Swedish society; from consumers and researchers to businesses and environmental organisations. A comprehensive policy mix exists, with *tradable green certificates* as the key mechanism, which was influential in reinvigorating the innovation system for renewable energy technologies to make it what it is today. Today Sweden exhibits strong innovation in *biomass* and *biofuels*.

The existing renewable energy with green certificates bill that came into force on 1 January 2007 shifts the quota obligation from electricity users to electricity suppliers, and incorporates a new target of 17 TWh by 2016. This system creates both an incentive to invest in the most cost-effective solutions, and on the other side also a degree of uncertainty for investment decisions due to variable prices.

The energy sector of ***Iceland*** is quite unique in many ways because of its isolation from other European networks and the high share of renewable energy in the total primary energy budget. Roughly 81% of primary energy is derived from indigenous renewable sources, *hydropower* and *geothermal*. The use of fossil fuels for stationary use is almost non-existent as fossil fuel is almost only used for transport on land, sea and in the air. In fact, the electricity production in 2007, amounting to 12 TWh, was to 70% generated from hydro, 29.9% from geothermal and only 0.1% was produced from fossil fuels in backup power stations in few remote parts of the country.

In spite of high energy consumption, one of the highest per capita in the world, Iceland has still only exploited a minor part of its potential energy sources. In spite of the fact that the annual electricity production amounts to more than 30.000 kWh per capita, Iceland has only harnessed about 15% of its potential for electricity production from hydro and geothermal. Wind power has not yet been utilized at all. In 2007 geothermal energy provided about 66% of the total primary energy supply, the share of hydropower was 15%, and fossil fuels, mainly oil, 19%.

For the last three decades the Icelandic Government has emphasized the major exploitation of domestic renewable energy sources to the benefit of the people. This has lead to a considerable power intensive industry, mainly aluminium, which now consumes close to two-thirds of the electricity produced.

Iceland has reached the position of having eliminated fossil fuels from all stationary energy use (in fact 81% of the country's primary energy supply comes from RES). The government's goal is to go even further, and head towards a carbon-free future in which indigenous renewable energy will replace fossil fuels as far as possible. As all of Iceland's electricity production is 99,9 percent from renewable energy sources, the country does not really have a competitive renewable electricity market.

Austrian energy policy has focused for decades on securing a sustainable and socially-balanced supply of energy. The permanent promotion of renewable energy sources, accompanied by the enhancement of a rational utilisation of energy, is a key strategic aspect of the country's energy policy.

The Austrian energy policy has resulted in a mix of energy sources characterised by a significant importance of RES. With 65 % of electricity consumed by RES, Austria is one of Europe's leaders on RES contribution to gross electricity consumption. The most significant source of renewable energy is *biomass*, followed by *hydropower*. With 47% of the Austrian territory being covered by forests, the share of woodland is one of the highest in Europe. Consequently, the use of biomass has been extensive in Austria. The largest solid wood fraction, logwood is used by individual households. Wood chips, bark and industrial timber residues are used in combined heat and power plants and district heating plants, while pellets are increasingly being used primarily in household heating systems. At the same time, Austria is one the European leader in *solar thermal* per capita together with Cyprus and Greece.

5.2 European RES success cases

The following section presents some cases of successfully implemented RES technologies at European and international level. In line with the INRES model, success cases have been selected from further islands considering that insular regions are embedded in different ecological and geological contexts than the mainland. In fact, insular regions suffer from structural handicaps linked to their island status, the permanence of which impairs their economic and social development. These handicaps are particularly important in energy demand and security of supply. In most of the cases, there are no ways to link the islands to continental European energy production networks, making difficult the implementation of the solutions to reduce environmental costs, such as air pollution and CO2 emissions.[10]

[10] Fengzhen Chen, Neven Duic, Luis Manuel Alves, Maria da Grac-a Carvalho: Renewislands—Renewable energy solutions for islands, 23 December 2005, published in Science Direct, Renewable and Sustainable Energy Reviews 11 (2007).

Furthermore, islands often have abundant renewable resources, including solar, wind, geothermal and hydro energy, and in this regard they dispose of a strong potential to develop clean energy while increasing at the same time their energy security.

The following selection of success stories illustrates the successful adoption of renewable energy technologies adapted to the specific conditions of the respective islands, aimed to secure energy sustainability in the long run. Next to this, case studies are presented that demonstrate how awareness on renewable energy adoption can be raised in island communities and how training on energy management can be successfully implemented.

5.2.1 Hydrogen model (H_2RES model) on Porto Santo Island, Madeira, Portugal[11]

Context

Islands that have energy sources, such as hydro or geothermal energy, can easily integrate them into the power system, but those with mainly intermittent renewable energy sources (most notably solar and wind) are confronted with the necessity of energy storage. The most promising technologies are reversible hydro where geography allows, and storing hydrogen where it does not. The stored hydrogen can later be used for electricity production, and also for transport.

This success case describes the H_2RES model for optimising the integration of hydrogen usage with intermittent renewable energy sources on the example of an isolated island in the Madeira archipelago, Porto Santo. The *H_2RES model* shows that it is possible to significantly increase the penetration of renewable energy sources, even though at a relatively high cost, with a hydrogen storage technology. The H_2RES model, which includes reversible hydro and batteries as storage technologies, can serve as a valuable tool for islands' energy planning.

Porto Santo is situated in the northern hemisphere at latitude of 32° in the Atlantic Ocean, with a territory of about 42 km^2 and almost all covered with calcareous matter, especially on the northern side. The island is adorned with peaks, almost all to the north. Being one of the islands constituting the archipelago of Madeira, an ultra-peripheral insular region, Porto Santo is different from the island of Madeira. While lush green predominates on Madeira, Porto Santo is almost stripped of vegetation and the southern coast is bordered by 9 km long beach of soft sand that makes it a popular resort area. Porto Santo is inhabited by 5.000 year-long residents, most of them living in the capital, Vila Baleira, but the number increases significantly during summer months. A fluctuating population, varying from 5.500 to 20.000, has put enormous strains to the island utilities, especially to the water and electricity production, that had to be designed for the summer peak needs. As an ultra-peripheral insular region Porto Santo will most probably never be connected to the mainland electricity grid. Therefore, a strong need emerged to develop a local energy production system.

[11] Neven Duić, Maria da Graça Carvalho: Increasing renewable energy sources in island energy supply: case study Porto Santo, published in Science Direct,17 November 2003.

The plan to convert Porto Santo into the first Portuguese renewable island and to be one of 100 sustainable communities (100% renewable) in Europe implied to increase the penetration of renewable energies further, an in this context to tackle the problem of energy storage. Since there is no potential for storing excess energy in a water reservoir for later hydropower production, as in the El Hierro island (Canary Islands), or to store the surplus electricity produced from wind to the mainland grid, as in Samsø, other ways had to be found. Even with variable pitch wind turbines and better frequency and voltage control equipment, that would enable 100% of wind electricity to be delivered to the system, due to the wind quality in Porto Santo and to its intermittent nature, only up to 45% of electricity demand could be delivered from 6 MW of wind turbines. The rest would still have to come from a thermal power plant powered by fuel oil.

The potential solution to the problem is hydrogen storage. The excess wind electricity can be stored in hydrogen, by the process of electrolysis. This energy can then be retrieved, when necessary, by supplying the stored hydrogen to a fuel cell.

Objectives

The plan was to convert Porto Santo into the first Portuguese renewable island, realising in this way the objective to become one of 100 sustainable communities (100% renewable) in Europe. In order to reach this goal the penetration of renewable energies had to be further increased, an in this context the problem of energy storage had to be tackled. Since on the island there is no potential for storing excess energy in a water reservoir for later hydropower production, as in the El Hierro island (Canary Islands), or to store the surplus electricity produced from wind to the mainland grid, as in Samsø, other ways had to be found.

The H_2RES model was tested on the power system of Porto Santo and was developed to simulate the integration of renewable sources and hydrogen into island energy systems. The use of the model demonstrates the problems of increasing the penetration of renewable energy source in islands.

Process

The H_2RES model is based on hourly time series analysis of electricity demand, wind potential, solar insulation and precipitation. The *wind module* uses the wind velocity data, typically from the meteorological station, at 10 m height, and adjusts them to the wind turbine hub level, and, for a given choice of wind turbines, converts the velocities to the output. The *solar module* converts the total radiation on the horizontal surface, obtained typically from the meteorological station, to the inclined surface, and then to the output. The *hydro module* takes into account precipitation data, typically from the nearest meteorological station, and water collection area, and evaporation data, based on the reservoir-free surface, to predict the water net inflow into the reservoir. The *load module*, based on a given criteria for the maximum acceptable renewable electricity in the power system, puts a part or all of wind and solar output into the system and discards the rest of the renewable output.

The excess of renewable electricity is then either stored as hydrogen, pumped water or electricity in batteries. The energy that is stored can be retrieved later, and supplied to the system as electricity. The rest is covered from diesel blocks.

Financial resources and partners

Financial support was provided by DG RTD (Project RenewIslands) of the European Commission and the Portuguese Direcção Geral da Energia.

Results

A model for optimisation and energy planning of integration of hydrogen storage and renewable energy sources has been devised for small and medium power systems (1–100 MW). The model includes wind and solar PV modules, while others can be easily added.

The model was tested on the data for Porto Santo island, for two different cases, peak shaving (i.e. sending power back to the grid when demand is high) and 100% renewable power system. In total, four hydrogen storage test cases were run for Porto Santo: peak shaving with wind, peak shaving with wind and solar PV, and 100% renewable wind only, and wind and solar.

- *Peak shaving*: In order to compare peak shaving with hydrogen storage, between wind only and wind and solar renewable energy sources, the goal was set to have approximately similar ratios of electricity coming directly from renewables (16.5%), from fuel cells (1.8%), and the rest from diesel. In both cases the renewable hourly output to grid was limited to 30% of the system load. Both systems, wind-only and wind-solar mix, were both optimised to achieve a similar yearly output from a 500 kW fuel cell, satisfying 1.8% of the total electricity demand, or 0.45 GWh. The wind-only scenario was much more effective from the point of power installed, with 2.5 MW of wind, than the wind–solar scenario with 1.1 MW wind and 2.9 MWp of PV, due to the higher load of wind turbines. Both scenarios produced a similar total amount of renewable electricity, slightly more than 6 GWh, and a similar amount of renewable electricity was taken by the grid, slightly more than 4 GWh. With similar excess electricity, it was necessary to envisage a 50% greater electrolyser unit for the wind-only scenario, because of the stronger intermittency of wind, 1.5 MW against 1 MW, and four times bigger storage unit, 24 MWh against 6 MWh, covering 24 h of fuel cell consumption against 6 h for wind–solar. In the wind-only scenario fuel cell managed only to serve 53% of the peak time, while the wind–solar reached 62%, as defined by a threshold of 80% of moving weekly peak. It is logical that wind needs more storage, since its behaviour is significantly less periodic than solar, but more storage will mean less power installed.
- *100% renewable*: In order to satisfy all the demand from renewable source, while keeping diesel as reserve, the results were quite different. There is no longer a significant difference between the wind and wind–solar scenarios, since over a longer period the intermittency of wind is much less influential. The longer period is slightly more than a week, or 8.5 days of storage, meaning that the capacity of storage must provide for 8.5 days of fuel cell working on full load, 5.5 MW. That will actually mean a capacity of around 2 weeks of full covering of the actual load from a fuel cell. The wind scenario envisages 25 MW of wind turbines, five times the annual peak, while the wind–solar scenario envisages 11 MW of wind turbines and nearly 20 MWp of solar PV installed. Both scenarios needs an electrolyser unit of 11 MW, double the peak, and a fuel cell

that can cover the peak of 5.5 MW. The calculation was made for 1 year and does not account for the growth of demand that will certainly be significant, due to tourism. Fuel cell will serve the power system 37–41% of time, while the rest of time the full load will come from renewable sources.

The results have shown that in the case of peak shaving wind–solar mix might be more effective, but that for the case of 100% renewable wind system be certainly more cost-effective.

5.2.2 7 MW electricity generation from biogas in Psyttaleia, Greece[12]

Context

A significant chance to utilize biomass in Greece is the exploitation of biogas produced in the biological treatment plants in which a part of the produced biogas is used to cover heating requirements during the biological treatment processes and another part is used in the CHP (Combined Heat and Power) plant.

The CHP plant on biogas in the wastewater treatment plant Psyttaleia, located at 1.500 m distance from the mainland coastline, serves the capital city of Athens. The biogas is being produced from the sludge digesters at a daily rate of 72.000 Nm^3/day and can be used for producing 64 GWh of useful energy per year. The project includes biogas burning in specially designed turbines for electricity production, and the associated heat coming from the flue gas and the cooling water circuit of the turbines which will be used for sludge heating (inside the digesters) and drying (of the final product).

The produced electrical energy will be consumed for satisfying the site consumption, and any surplus energy will be sold directly to the grid.

The unit is designed with an installed production capacity of 52.800.000 kWh per year. Based on the current situation (the second stage treatment facility has not yet been completed), the production will be 37.000.000 kWh per year. From the annual production 16.000.000 kWh will be consumed locally for the needs of the sewage treatment plant of Psyttaleia while the remaining quantity will be sold directly to the Public Power Company.

Objectives

The project aims at maximising the energy use of biogas produced from treating the whole quantity of the daily wastewater production of the city of Athens (4.000.000 inhabitants) leading both to environmental and economic effects.

Process

Biogas is being produced from sludge treatment inside the digesters with a relative constant heating value. The overpressure of biogas is only 20-30 mbars and hence biogas compressor units must be used in order to raise the gas pressure to 3,5 bars, which is the required pressure for the use in gas turbines.

[12] European Commission, Directorate-General for Energy and Transport, Case study 305.

Three WAUKESHA 12 cylinder supercharged gas reciprocate machines have been installed, each one operating at 1000 rpm. The nominal power output is 2.900 KVA and the output voltage is 3,3 kV. The rejected heat from the turbine cooling water circuit is being used for supplying extra heat to the sludge digesters and hence it is improving the overall system efficiency. In addition, the flue-gas leaving the gas turbine chambers has a temperature of 400 °C and the heat content of that stream will be used in the near future for sludge dewatering and drying, thus reducing the humidity content and minimising its volume.

When the whole system will become operational, an overall system efficiency of 80% will be realised. Nevertheless, the heat requirements for sludge heating at the digesters are not constant but follow a seasonal variation. An extra cooling circuit using sea water and a heat exchanger has also been installed in order to remove the heat surplus available at the hot water circuit.

The existing site substation (20KV) is being used for supplying power to the site and also for connecting the plant substation (3,3KV/20KV) to the national grid through a sub-water power cable.

Financial resources and partners

The total budget of the scheme is 11.113.720 Euro, with EU funding (Operational Programme for Energy, Community Support Framework 1994-1999 for Greece) of 5.556.860 Euro, and EYDAP S.A. (ΕΥΔΑΠ, Athens Water Supply and Sewerage Company) of 5.556.860 Euro.

Results

The environmental benefits arising from the realisation of this project are significant in terms of air emission reduction. The daily methane (CH_4) emissions will be reduced from 20.000 Nm^3 to 0,2 Nm^3, hydrocarbons emissions from 120 Nm^3 to 0,2 Nm^3 when carbon monoxide (CO) will be held below 650 mg/m^3 and NOx below 500 mg/m^3. In addition to the reduced or avoided air emissions a significant reduction of solid wastes volume will be realised as dewatering and sludge drying will help in reducing its volume by a factor of 0,8. Currently, the sludge is being deposited to Athens main landfill at Liosia, which is facing significant capacity problems. The project will also create 20 new jobs on site contributing hence to the acute unemployment problem of the wider area.

Lessons learned and repeatability

During the design and construction phase a number of issues have been raised as briefly described in the following. At the early stages of the project significant issues arose as this was the first power plant of that kind ever installed in Greece, and in addition the nominal power output was quite significant. The solution given was to send EYDAP personnel abroad to UK and Denmark where they had accumulated experience from existing similar type of power plants. The location of the power plant and the wastewater treatment facility is quite unique as they are both situated on a small island located at 1.500 m distance from the mainland coastline. Although part of the electrical energy production is consumed locally for the site needs, the energy surplus, which is a significant part of the overall production, is sold to the grid. This itself created a significant technical barrier, which had to be overcome namely through the construction of an underwater cable connecting the island with the grid at the mainland and the associated control system. An underwater cable connection was constructed with an XLP insulated 355 cable and a second one 3 × 120 with paper insulation. Initially a small building was constructed on the island containing the hardware necessary for system control, and in addition for coupling and synchronising the generation facility with the grid. At a later stage PPC (the Public Power Company which was at that time the grid sole owner and supervisor) requested a second similar facility to be constructed at the mainland; a request, which was also fulfilled from EYDAP. PPC also constructed a cable connection between a nearby combined-cycle natural gas fed power plant and the control centre located at the mainland which made it possible to control the whole island based generation system from distance (i.e. the system is now fully automated and unmanned).

5.2.3 Training of Hotel staff on Energy Management, Madeira, Portugal[13]

Context

The Hotel Industry registered a rapid growth over the last few decades in Madeira, contributing to the increase of the energy consumption in this sector.

A software package was designed to help hotel employees gain "on the job" theoretical and practical knowledge on technological issues and methods for energy conservation, as well as learn about the efficient use of energy. This software tool was designed to be a self training software, user friendly which can be used as a continuous information source.

Objectives

One of the objectives of this project was to reduce the energy consumption in the hotel sector through the development of an educational tool/software package for the “on the job” training of hotel staff in the field of Rational Use of Energy.

Process

Once installed, and within the introduction, the user of the software is invited to select the most suitable level of access. Three levels of access are available: General Managers (for hotels with more than 150 rooms), Managers of Medium Hotels (for hotels between 50 and 150 rooms) and Technical Directors (for all types of hotels).

From the beginning, and in the planning stage, users are informed/trained about how to define goals, objectives and targets and how to measure success. The section of Energy Monitoring explains the use of energy efficiency indices, energy sources and their emissions, as well as the need to continually monitor the fuel being used.

The tool includes information on space and water heating and its impact on the energy consumed in hotels as well as the important role in the hotel planning. It also includes information on the advantages of Combined Heat and Power (CHP) in large and medium sized hotels.

[13] European Commission, Directorate-General for Energy and Transport, Case study 369.

The Catering section of the tool shows the opportunities of energy saving in kitchens, covering the following items: Food storage, Cooking, Air extraction, Dishwashing, Heating, Lighting, Maintenance and, Laundry. Further sections of the software cover the energy efficiency in leisure areas, namely in swimming pools.

Financial resources and partners

The project was co-ordinated by CRES (Greece) with the collaboration of the following partners:

- AREAM Agência Regional da Energia e Ambiente da Região Autónoma da Madeira – Portugal (Regional Agency for Energy and Environment of the Autonomous Region of Madeira);
- CREATE - United Kingdom;
- ICAEN – Spain

http://www.aream.pt

Results

The results of the pilot test were mostly positive, reporting that the CD-ROM it is a very valuable and useful tool for educational purposes, with a good presentation, very useful for training of the hotel staff in energy issues. It was also pointed out that the tool should be distributed in as much hotels as possible.

The results achieved in hotels were quite satisfactory. The application and dissemination of the educational tool (CD-ROM) at European level can improve professional skills of hotel managers and technical staff as regards energy saving, thus it should be disseminated accordingly.

Lessons learned and repeatability

This programme shows that energy management can lead to lower costs, to improve the environment, to improve the customer comfort and satisfaction and to achieve higher profitability.

Besides the services offered to customers depending largely on the energy consumption, it is possible to achieve a desired level of comfort in hotels and, at the same time, achieve considerable energy savings.

As this educational tool can be used in any type of hotel, it is expected that the issues in the field of Rational Use of Energy will be widely disseminated in the hotel sector, contributing thus to the reduction of the energy consumption and harmful emissions in Europe.

5.2.4 The Energy Strategy for Cornwall[14]

Context

Cornwall is a rural sub-region in the far South West of England. The county’s peripheral location, exposed coastal geography, social deprivation, poor housing and limited access to mains gas makes its

[14] European Commission: EU Local Energy Action, Good Practices 2007.

people particularly vulnerable to the effects of climate change, rising energy prices and security of supply issues. Yet Cornwall has sufficient renewable energy resources (solar, wind, marine, hydro and biomass) to supply and even exceed the county's energy demand. Since 2001, the Cornwall Sustainable Energy Partnership (CSEP) has brought together a cohesive team of local councils, agencies, energy professionals and renewable technology suppliers. In 2004, CSEP published 'Action Today for a Sustainable Tomorrow — The Energy Strategy for Cornwall'. The strategy commits to a doubling of Cornwall's renewable electricity generating capacity to 93 –108 MW within 2010, and the implementation of domestic energy efficiency programmes across the sub-region.

Objectives

The Energy Strategy for Cornwall is based on a 32-point action plan. This aims to: Provide healthier, warmer homes for Cornwall's communities; Reinvest in the local economy; Aid economic development through support for cutting edge technologies; Reduce carbon emissions; Help deliver local, national and international renewable energy targets; Incorporate greater energy efficiency & renewable energy in buildings; Support the use of natural resources while minimising negative environmental impacts; Provide energy awareness and training programmes; and Incorporate sustainable energy considerations in all policies and strategies.

Key actions include the formation of an ESCO (Environmental Services Company), implementation of domestic sustainable energy programmes, exemplar projects, model planning policies, a wave power generation test bed, training and education programmes, public and private sector renewable vehicle fleets and a single-gateway advice service for businesses.

Process

The process started in August 2003 with the development of a project brief. Consultants were appointed to produce a draft document, which was discussed by CSEP partners at a series of meetings. Responses were submitted both online and on paper. In March 2004, CSEP analysed and incorporated the comments received, and after further discussion and minor amendments the final document was released. 70 partners then signed up to help deliver the strategy's 32-point action plan, before its official launch by the Energy Minister on 21st July 2004.

The strategy is a living document that is monitored on a quarterly basis by the CSEP Steering Group and Task Groups, with regular updates and progress posted to the CSEP website. The strategy is reviewed and revised as necessary by the whole partnership every two years. CSEP aims also to produce a children's' version of the strategy in partnership with local education providers.

Financial resources and partners

The development, design, printing and launch of the strategy cost a total of EURO 32.153. The CSEP office sourced funding, managed the project and facilitated the consultation process. Funding was provided by the Cornwall County Council and the Office of the Deputy Prime Minister (ODPM) partly through the award of an Energy Deprivation Local Public Service Agreement (LPSA), which was prepared by the CSEP office.

The Energy Saving Trust part-funded the consultation process. Further contributions were provided by the Local Authority Support Programme and CSEP partners (particularly Community Energy Plus) who provided substantial in-kind support in the form of staff time. The 72 signatory partner organisations include County and District Councils, the Chamber of Commerce and Industry, the NHS Trust, Housing Associations, Voluntary Sector organisations, Universities, Environmental NGOs and agencies, other development agencies, and businesses involved in solar energy, wind energy, hydro power and sustainable building.

Results

The strategy commits the partnership to doubling Cornwall's current renewable electricity generating capacity to achieve a sub-regional target of at least 93 –108 MW within 2010 (this is derived from the South West region's target of 11-15% within 2010). It also commits the partners to rolling out CSEP's domestic energy efficiency programmes across Cornwall by 2010.

Since the launch of the strategy in July 2004, strong progress has been made on many of the actions including the development of a thriving microgeneration industry, community wind turbines, free insulation, ground source heat pumps for housing associations, solar energy in schools, and a host of other activities.

In recognition of their proactive partnership, Cornwall's seven county and district/borough councils jointly won the SW Green Energy Award for Most Proactive Local Authority in November 2004. As a result of CSEP's work in Cornwall, awareness of the environmental and economic impacts of energy policies is very high. And by working in partnership, local organisations have gained greater access to major grants.

Lessons learned and repeatability

The success of the Strategy for Energy in Cornwall demonstrates how partnerships can be a powerful tool for changing the 'energy landscape' of an entire region. This joined-up approach to implementing local sustainable energy strategies could be repeated across many areas of Europe. In particular, the Cornish Strategy is an excellent model for regions where socioeconomic issues (such as, fuel poverty and security of supply) can be met by energy saving and widespread microgeneration.

Inspiring leadership, careful planning and good communications are all essential to drive forward multi-sector consultation projects in which diverse organisations are responsible for delivering key milestones. A wide-reaching consultation period is important to raise awareness of energy issues and opportunities among potential partners. Involving all partners in forming the strategy from the start gives them a sense of ownership. And a flexible approach helps to accommodate the differing views of diverse organisations. The CSEP has already received numerous requests from energy agencies and local authorities in the UK interested in replicating this approach, and shares information and ideas with similar partnerships in other areas.

5.2.5 The ERGAL Project – a sustainable energy system for Galapagos, Ecuador

Context

The energy system in the Galapagos islands becomes increasingly unsustainable as the following factors demonstrate:

- The flow of fuels coming from the mainland is growing, making the Galapagos absolutely dependent on “imported” energy and creating a fragile energy system with constant safety problems due to uncertainty and vulnerability of the supply chain that faces external contingencies;
- The lack of supply and demand diversification as well as the concentration of energy transformation processes in a few units and technologies determine an extremely vulnerable energy system and considerably limit the freedom of action;
- The lack of investment in the maintenance and renewal of power generation and distribution of electricity have accelerated an obsolete process of power generation and in the distribution of installations;
- The wasteful energy consumption habits resulting in an enormous waste of resources which are still fed by governmental subsidies;
- Transport, handling and the use of fuels are constant factors of contamination in the Galapagos.

In the framework of these threatening conditions, the Ministry of Energy and Mines (at present Ministry of Electricity and Renewable Energy) launched in April 2007 an ambitious programme under the name “Zero Fossil Fuels in Galapagos”. The ERGAL project (Sustainable Renewable Energies project for the Galapagos) has been implemented in the framework of this initiative.

Objectives

The Zero Fossil Fuel initiative has the objective to gradually eliminate the use of diesel fuel on the islands and is based on two strategic guidelines:

1. In the short term, the electricity demand on the island should be based on renewable energy sources, achieved through the installation of wind and photovoltaic systems for the generation of electricity and the installation of thermal generation power plants that use biofuels. The aim is to reach by the year 2015 the disappearance of fossil fuels in the generation of electricity.
2. In the long run, the Zero Fossil Fuels initiative strives towards a gradual substitution of fossil fuels in the remaining sectors of economic activity, especially in transport, fishing and tourism related activities. This endeavour implies a technological change that affects both the social and economic environment and involves the participation and commitment of different stakeholders. In this context, several complementary alternatives are being explored through pilot projects. One of these projects regards the gradual conversion of internal combustion diesel engines to engines operating on biofuels, diesel powered vehicles modified to use

biofuels and the establishment of standards that will permit the introduction of electric powered and/ or hybrid vehicles to the islands.

Process

The ERGAL project consists of the implementation of renewable energy systems in the four inhabited islands of the Archipelago: Santa Cruz, Floreana, San Cristóbal and Isabela.

The conditions for implementing the renewable energy systems in the four islands are stipulated in separate agreements between the National Government and the cooperation agencies involved. Each project is being carried out in a separate manner, under the overall coordination of the Management Unit of the ERGAL project. The following table illustrates the envisaged RES installations on each island, including the institutions that are responsible for their financing next to the contribution coming from the National Government.

FLOREANA	SAN CRISTÓBAL	ISABELA	SANTA CRUZ
➢ Photovoltaic station (30 kW) ➢ Dual generators biofuels-diesel ➢ Optimisation of fuel storage system	Wind energy park (2,4 MW)	➢ Photovoltaic station (350 kW-500 kW) ➢ Dual generators Biofuels-diesel ➢ Optimisation of fuel storage systems	➢ Wind energy park o Phase I:2,5 – 3,5MW o Phase II: 6 – 7MW o Phase III: >15 MW ➢ New thermal station dual power generation Biofuels-diesel ➢ Transmission lines Baltra-Puerto Ayora
▪ Government of Ecuador ▪ Spanish Cooperation ▪ NGOs	▪ Government of Ecuador ▪ E8 Group ▪ UNF	▪ German Government (through KfW)	▪ Government of Ecuador ▪ GEF ▪ UNF

Financial resources and partners

In addition to the contribution provided by the National Government, which at present amounts to approximately US $ 12 million, the renewable energy projects under way on the four islands enjoy the financial support of several cooperation agencies:

- ➢ The Global Environment Facility (GEF) contributes with $ 3,2 million for the co-financing of the wind energy project Baltra – Santa Cruz in addition to a contribution of approximately $ 500.000 for studies and operating expenses of the Project administration Unit;
- ➢ The German Government, through the German Bank for Development (KfW), makes a non-reimbursable contribution of EURO 7,86 million for the photovoltaic project and improvement of fuel storage systems of the Elecgalápagos plants in Puerto Villamil.
- ➢ The e8 Fund (fund financed by a group of power generating companies of industrialised nations) has contributed with a donation of $ 5,5 million for the construction of the wind park on the island of San Cristóbal;

- The United Nations Fund, UNF, has contributed a donation of $ 1 million towards the co-financing of the construction of the wind park in Santa Cruz ($ 650.000) and San Cristóbal;
- The Spanish Agency for International Cooperation , through its Araucaria-Galápagos Programme and the Basic Autonomous Energy Services Association-SEBA (Spanish NGO) contributed 179.000 Euros for the photovoltaic project of Floreana island.

Results

Baltra – Santa Cruz

An integrated energy system has been developed for Baltra – Santa Cruz. Baltra is a small island making part of the Archipelago which is situated North of Santa Cruz. The project includes the construction of a wind park and the execution of a transmission line from Baltra to Puerto Ayora, the capital of Santa Cruz, as well as the relocation of the thermal power station in Baltra.

The construction of the wind park has been planned in three stages, each one will permit a gradual increase in the levels of complexity of system design and operation as well as penetration levels of wind generated electricity into the network. The parameters are as follows:

Stage	Capacity (MW)	Diesel Reduction	Year of Operation	Investment	Status
Phase 1	2,5 – 3,5	25% - 35%	2009	$6,0 - $7,5	International bidding under way
Phase 2	6,5 – 7,5	50% – 60%	2012	$6,0 - $8,0	Pre-feasibility studies
Phase 3	>20 MW	90% - 100%			

The transmission line from Baltra to Puerto Ayora has the following features and includes submarine sections, underground sections and areas that correspond to agricultural activities intervention. Therefore, strict criteria to reduce environmental impacts to a minimum have been adopted.

Characteristics	
Length	45 km
Investment	$4,0 - $5,0 million
Financing	Government of Ecuador – Ministry of Electricity
Operation	End of 2009
Status	Final design of layout (April 2008) Tendering process and start of construction (October 2008)

Floreana

Characteristics	
Capacity	28 KW (60% diesel reduction)
Investment	$ 800.000
Financing	Ministry of Electricity Galapagos National Park Galapagos Electric Company

	Spanish Cooperation and NGOs
Status	The system is in operation since 2006.

San Cristóbal

Characteristics	
Capacity	2,4 MW (around 50% diesel reduction)
Investment	$ 10 million
Financing	Government of Ecuador (40%) E8 Group (50%) United Nations Fund – UNF (10%)
Operation	Started in October 2007
Status	The wind park is operated and managed by the Wind Energy Commercial Company of San Cristóbal - EOLICSA

Isabela

Characteristics	
Capacity	500 KW (to be defined)
Technology	Photovoltaic system for the generation of electricity coupled to the distribution network of Puerto Villamil
Investment	$ 5 million (approximated)
Financing	Government Government - KfW
Operation	End of 2009
Status	Final design studies (May 2009) International Tendering process, supply and installation (August 2009)

Lessons learned and repeatability

A complex experimentation system must be developed that within a few years will permit the elimination of depredating energies of the Archipelago, maintaining its fragile and unique biodiversity in close harmony with population demands.

The challenges faced by the energy development in the Galapagos require an integral vision, a systematic approach and a long term projection. Therefore, a sustainable energy alternative must take into consideration the following fundamental thoughts:

- The gradual usage of indigenous renewable energy sources (solar and wind energy) may allow a decrease in dependence of fossil fuel supplies from the continent;
- The diversification of energy sources and energy conversion technologies may support the realisation of a flexible and robust energy system with less vulnerability to technical contingencies;
- Increase efficiency levels in transformation processes and final uses of energy;

- The reduction of risks of pollution arising from the transport, handling and the use of fossil fuels, achieved through their substitution with biodegradable plant origin fuels with lesser impact on the natural environment.

5.3 Recommendations for a future positive development of the three regions in the RES industry

The development of the future scenarios and actions to be implemented in order to foster the development of the RES industry and of a knowledge-based economy as a whole have been mentioned already in the Regional RES-ID Cards.

A key action to be adopted is the stronger investment in research, technological development and innovation for enhancing economic growth, strengthening competitiveness and boosting employment in the RES industry. RTD investment has to focus on the development of critical and dynamic technologies that support the European RES industry in competing successfully on the global market. In line with the call for investing more in RTD and innovation goes the requirement to improve from political side the framework conditions that can give positive incentives to research and industrial players to exploit the potential of renewables. Technological development and innovation processes can be further accelerated through the improved interaction among regional key players, allowing for increased technology transfer activities.

Based on the analysis performed and brainstorming sessions taken place during the last project meetings, main recommendations for exploiting RES most efficiently in the three regions have been identified, as illustrated in the following tables.

a) Political framework

All three regions express the need of creating a favourable legal and regulatory framework, particularly addressed to benefit enterprises. Often enterprises, especially of small size, are hampered in conducting research activities and/ or implementing renewable energy installations due to heavy bureaucratic burdens. The Canary Islands in particular ask for less regulation through the administrations and for incentives that support the RES exploitation. One support scheme mentioned are financial incentives for final users that can motivate the purchase of RES systems. Two further recommended policy interventions concern the abolishment of cups and call for tenders for grid connected RES systems as well as the permission to allow net metering for RES systems, thus to agree to energy consumption and production at the same energy connection point.

The other two island regions, Crete and Samsø, mention as a main concern the setting up of regional policies for R&D and energy consumption. Crete has already made progress in this regard by reorganising its regional administration by nominating a president within the first semester of 2011 which leads to the transfer of responsibilities from national to regional level. Central Denmark, the region where Samsø belongs to, still depends on national programme planning. Especially with regard to RES, the region has experienced during the last years, due to a change in government, less allocation of funds to the sector. One proposal that was made by the Samsø team for reaching higher influence in policy planning regards specifically the role of the Samsø Energy Agency (SEA). SEA should get in more direct contact with the Municipal Board who often lacks information related to possibilities offered through RES and consequently, would need recommendations and support from SEA so as to exploit best possible the existing benefits resulting from RES.

All three regions ask for a better integration and coordination of energy policy at EU level. Member States should coordinate their decisions about RES applications, usage and their diffusion so as to reach a higher impact at European level. Last but not least, the signing of the *Pact of Islands* through the Mayors is a further proposal made by all three regions. The Pact of Islands, implemented within ISLE-PACT, is committed to develop Local Sustainable Energy Action Plans, with the aim to meet the EU's 20-20-20 targets, and asks for a political engagement of island authorities to meet these objectives.

Figure 8 – Recommendations for a future positive RES development – Political framework

Canary Islands	Crete	Samsø *(Central Denmark)*
	Political framework	
▪ Favourable legal and regulatory framework for enterprises • More incentives for(private) R&D • Simplification and unification of administrative procedures for RE installations ▪ Creation of an energy tariff and regulatory electric system independent from Continental Spain ▪ Introduction of financial support schemes to help final users purchase renewable energy systems ▪ Improved regional territorial planning for energy infrastructure ▪ Abolish cups and call for tenders for grid connected renewable energy systems ▪ Allow net metering for RES systems ▪ Integration and coordination of energy policy at EU level ▪ Mayors signing the *Pact of Islands* under ISLE-PACT	▪ Favourable legal and regulatory framework for enterprises and individuals ▪ Improved regional territorial planning for energy and environmental infrastructures ▪ More incentives for public and private R&D ▪ Implementation of regional policies for R&D and energy concerns ▪ Integration and coordination of energy policy at EU level ▪ Mayors signing the *Pact of Islands* under ISLE-PACT	▪ Favourable legal and regulatory framework for enterprises ▪ More (regional)/national fund allocation to RES sector ▪ Implementation of regional policies for R&D and energy concerns ▪ Direct approach from SEA to Municipal board ▪ Integration and coordination of energy policy at EU level ▪ Mayors signing the *Pact of Islands* under ISLE-PACT

b) Innovation, technology transfer and education

As concerns innovation, technology transfer and education, the training on RES for companies' staff, graduates, and municipal officers is an important issue for all three regions. Samsø in this regard expresses the wish to set up further energy academies on the other islands, based on the experiences made through the work accomplished within the Samsø Energy Academy.

Furthermore, the crucial importance of a sensitive treatment of intellectual property has been underlined by all three regions. In a knowledge-based economy, knowledge is the most valuable asset. Safeguarding intellectual property enables the innovative enterprise to benefit appropriately from new solutions. It is not an attempt to block know-how transfer, but to manage it in a controlled process, so that imitators are not enjoying a free ride, whereas the inventor bears the cost of the initial investment.

As regards in particular the Canary Islands and Crete, a better exploitation of the regional technology transfer potential needs to be realised (Samsø, due to missing research and higher education institutions on the island, does not perform internal technology transfer activities). The Canary Islands mention in this context the important role of the cluster RICAM which should increase its collaboration with the research community so as to accelerate the transfer of knowhow from research to industry. Additionally, the greater compliance of university studies offered in the RES field to the islands' needs, especially to the regional industries, is one more important issue that needs to be tackled in the two regions. If university programmes are not in line with industrial demand, technological innovations from public research institutions will hardly get into the internal market and will be addressed to regions outside the islands, thus not supporting the economic growth of the 'internal' economy.

Figure 9 – Recommendations for a future positive RES development – Innovation, TT and education

Canary Islands	Crete	Samsø *(Central Denmark)*
Innovation, technology transfer and education		
▪ Creation of public/ private Technological Centre in the RES field for better exploitation of the regional TT potential ▪ Increased collaboration between research and industry (e.g. RICAM) ▪ Better adaptation of university curricula to island needs ▪ Training on RES for companies' staff, graduates, and municipal officers ▪ Protection of IPR	▪ Better exploitation of regional TT potential ▪ Better adaptation of university curricula to island needs ▪ Training on RES for companies' staff, graduates, and municipal officers ▪ Protection of IPR	▪ Training of companies' staff, graduates, and municipal officers ▪ Creation of energy academies at international level ▪ Protection of IPR

c) *RES penetration*

All three island regions have concrete goals for the future that aim at boosting further the exploitation of RES. The Canary Islands and Crete ask for a stronger internationalisation process of local companies and for the stronger dissemination of research results among companies. Especially the Canary Islands request a stronger focus of research activities on island characteristics. Next to the shortcoming already mentioned before (i.e. technological innovation finds purchasers outside of the island), the insufficient exploitation of the potential derived from renewables is being pointed out by the island region, in particular as concerns the strong potential of wind energy in the archipelago. Samsø indicates again the importance of training and better education in the RES field.

Further, more technology specific recommendations have been listed by each region, tailored to the islands' environmental contexts. The Canary Islands, based on the considerations described previously, intend to exploit better the wind energy potential and in this regard, proposes to implement offshore wind energy installations, based on the model already realized in Samsø. Furthermore, local companies are pushing for the implementation of small 100kW wind turbines instead of setting up big wind parks.

Due to administrative regulations this objective could not be realised in the archipelago. A further recommendation is the promotion of BIPV (Building Integrated PV) installations.

Crete also aims for small installations for wind, solar and PV energy as well as for the installations of helio-thermic systems. The enhanced energy efficiency for non-residential buildings is a further recommendation made by the island. Green buildings especially in administrations and schools should be realised in order to reduce the overall impact on the environment and reach productivity gains.

Samsø goal is to become a 100% fossil free island. As the experiences gained through INRES demonstrate, huge steps have been already implemented in order to reach this ambition. Further recommendations mentioned in order to realise this goal are the improved exploitation of biogas in the transportation sector, in particular in the ferries that connect the island with the mainland, the replacement of oil furnaces by heat pumps (first steps towards this direction have been already made), the implementation of a second offshore wind farm, and the better exploitation of solar energy (in combination with heat district plants) and the enhanced development of the PV sector on the island.

Figure 10 – Recommendations for a future positive RES development – RES penetration

Canary Islands	Crete	Samsø *(Central Denmark)*
	RES penetration	
▪ Internationalisation of companies ▪ Enhanced dissemination of research know how among companies ▪ Research stronger focused on island characteristics (boosting wind energy exploitation) ▪ Implementation of offshore wind energy ▪ Promotion of small wind energy installations (< 100 kW) ▪ Promotion of BIPV installations (Building Integrated PV)	▪ Collective representation of companies and better internal organisation (in progress) ▪ Internationalisation of companies ▪ Dissemination of research deliverables and know how among companies ▪ Promotion of small installations for wind, solar and PV energy ▪ Installation of helio-thermic systems ▪ Green buildings	▪ Transportation: improved exploitation of biogas through ferries ▪ Implementation of a second offshore wind farm ▪ Solar energy (in combination with heat district plants) and pushing of the PV sector ▪ Replacement of oil furnaces by heat pumps ▪ Fossil free island ▪ "Satellite" Island (increase international networking) ▪ Training and education

Summing up, the goals of the INRES islands can be best achieved by realising two main basic requirements:

➢ The support from political side: both in terms of removing bureaucratic burdens and offering financial incentives, so as to respond better to the principles set in the new EU Directive on renewable energies and in the Energy Policy of the European Union as a whole. The enhanced channelling of public funds to the sector for undertaking research and development activities and supporting the growth of small and medium-sized companies as key players of the RES industry, can boost the positive development of the sector's growth and motivates industry in becoming more active in terms of investment in technological innovation and private research performance.

- The improved interaction among regional key players, allowing for increased technology transfer activities and training: better cooperation among government, industry and science is mandatory in order to make research activities corresponding to industrial needs and exploit advanced technologies through the market. Enhanced training activities as well as the better adaptation of university curricula to industrial and island needs are mandatory in order to respond more efficiently to market requirements and push technological innovations into the market. Clustering and networking activities are therefore the cornerstone for a future positive development of the RES industry.

6. Final remarks

The EU is working to reduce the effects of climate change and establish a common energy policy. As part of this policy, European Heads of State or Government agreed in March 2007 on binding targets to increase the share of renewable energy. By 2020 renewable energy should account for 20% of the EU's final energy consumption, making part of the 'Europe 2020 Strategy'. To achieve the targets in an economical and resource efficient manner, and to pave the way for much bigger shares of renewable energy in the years after, the EU needs to continue to invest in research for advanced renewable energy technologies, and needs to continue to bring down the costs of offshore wind, photovoltaic power, electric cars, and second-generation biofuels. Win-win solutions to develop renewable energy projects that bring wider environmental benefits need to be promoted through adequate research programmes, aimed to offer a stable and predictable environment for the financing of renewable energy.

The projected expansion of electricity from renewable sources carries a number of implications. First, it highlights the need to accelerate the modernisation of the electricity grid. Urgent interventions are necessary to prepare the grid for the integration of significant volumes of electricity produced from renewable sources, facilitating grid balancing, flexibility and distributed generation. Electricity systems have to become more interconnected and flexible, and new infrastructure development and reinforcement will be necessary, including the deployment of smart grid technologies. The Energy 2020 Strategy highlights how the rise of electricity produced from renewable sources also has implications for the electricity market as a whole. Multiple, flexible, smaller scale distributed forms of electricity generation need different grid and market design rules compared to traditional large, centralised power sources. One of the greatest challenges regarding the grid infrastructure is to connect the offshore potentials, mainly wind, foreseen in the Northern Seas of Europe, developing the electricity network both off- and onshore.[15]

The market integration of renewable energy should ideally occur in a manner that ensures resources are developed where it makes most economic and environmental sense. Factors such as distance to consumption centres, implied grid needs and issues related to public acceptance and job creation clearly also play a role and cannot be ignored. In any event, support schemes should over time be adapted to apply best practice so as to avoid undue market distortions and excessive costs.

The cross-regional comparative analysis presented in this document shows that all three island regions are making efforts in contributing to the expansion of electricity from renewable sources, and in this endeavour all of them are facing similar challenges. The Canary Islands and Crete present results which are more alike, which is due to the fact that both have similar characteristics related to demographic factors, infrastructures, and environmental conditions. The conditions found on Samsø are somewhat different: the island in fact has only around 4.000 inhabitants and does not dispose of higher education and research centres for which reason research activities do not really take place. Nevertheless, the island succeeds in reaching its objectives thanks to the strong participation of the local community in RES concerns and the active networking among RES players.

[15] Renewable Energy: Progressing towards the 2020 target, COM(2011) 31 final.

An important main strength detected in all three regions is the commitment to diffuse the adoption of innovative RES technologies by exploiting different RES sources, based on the existing expertise knowledge and environmental framework conditions. The diffusion of RES innovation in the islands together with an increased cooperation with further islands need to be enhanced in order to overcome detected weaknesses, such as the low innovation commitment of companies and the weak collaboration between research and industry, the latter as regards the Canary Islands and Crete.

A further main aspect to strongly take into consideration is the better exploitation of public funds, if not sufficiently available at national/ regional level, above all at European level. Following this approach, international cooperation activities will be further intensified and in particular small-sized companies will be given the chance to participate actively in research activities, to get in closer contact with research communities and to adopt innovative technologies.

The above said clearly demonstrated that networking and clustering activities are the cornerstones for a future positive development of the RES industry, supporting the expanding of business operations. In this regard, the regions' research and industrial communities need to interact more directly with the regional and national policymakers in order to achieve acceptance of their needs and interests and find a way in carrying out their activities for supporting the economic development.

The INRES network is on the right track to start off concrete actions to strengthen skills, knowledge and capacities, in particular by involving the relevant public administrations and energy agencies, that ensure an adequate governance for the efficient delivery of renewable energy investment programmes and projects. A Joint Action Plan will be implemented after the project's end. The plan will include measures to be adopted for tackling regional problems through concrete activities, reaching higher performance levels and thus also economic growth in the long run.

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