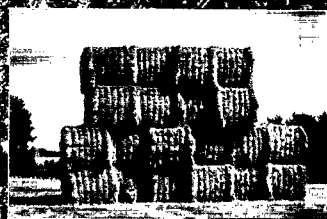
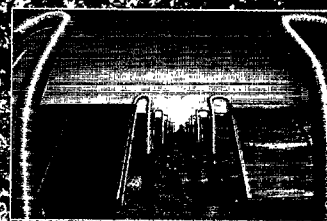


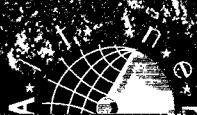
Renewable Energy Islands in Europe

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Renewable Energy Islands in Europe

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Renewable Energy Islands in Europe

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Foreword

This publication includes a compiled presentation of various aspects concerning the possible transformation of some European islands into renewable energy communities and these projects were presented by a selection of pioneer islands at the first European Seminar on Renewable Energy Islands, held on the Danish island of Samsø, 29th-30th June 1998.

This issue has increased in importance with the presentation of the ambitious EU-White Paper: "Energy for the future: Renewable Sources of Energy" which was adopted in 1998.

One of the key elements of the strategy for an accelerated implementation of renewable energy is to transform 100 localities within Europe into communities which are to be 100% self-sufficient with renewable energy before 2010.

In line with this strategy, the Danish Government appointed the island of Samsø towards the end of 1997 to be the first "official" Danish, renewable energy island. This is to serve as a demonstration project for other local communities, both in Denmark as well as in the rest Europe and, eventually, on a world-wide basis.

On a global scale this issue is not of less crucial importance and, on the basis of the Samsø-seminar, a global conference on renewable energy islands is therefore scheduled to take place in Denmark in 1999.

The intention of this publication is that it can be an inspiring tool for everyone involved in renewable energy island projects and that it can serve as a basis for networking and the exchange of information and ideas in general between islands, authorities and others.

The publication is supported financially by the EU ALTENER Programme and the Danish Energy Agency.



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Renewable Energy Islands/ Communities in a European Context

In the EU-White Paper: "Energy for the future: Renewable Sources of Energy" which was adopted in 1998, the European Commission outlines the new community strategy and action plan for the goal of achieving a 12% penetration of renewables in the Union by 2010 as an ambitious, but yet realistic objective. The present contribution from renewables is less than 6% of the Union's overall gross domestic energy consumption.

By Jan Büniger
Danish Energy Agency

As one of the key elements of the strategy for further implementation of renewable energy in the EU, the Commission proposes the implementation of 100% renewable energy in 100 communities all over Europe.

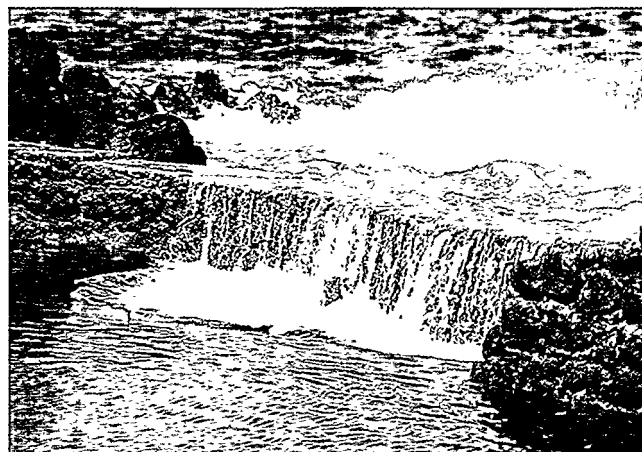
Furthermore, such a deployment of renewables can also be a key feature in regional development with the aim of creating jobs and achieving greater social and economic cohesion within the European Union. For reasons of scale and varying degree of isolation from the common infrastructure, the costs of fossil fuels are higher in Europe's remote areas. With regard, for instance, to smaller islands, the costs of imported fossil fuels are usually equivalent to a substantial proportion of the total value of imports. Thus it has been estimated that energy often accounts for more than 15% of all imports of the islands in Europe. Fuel imports are therefore a great drain and a significant constraint on local development as they drain out vital capital that otherwise could serve local growth.

This implies that a number of pilot communities, regions, cities and islands should be selected from those which reasonably aim at 100% self-sufficiency from renewable energy sources. These pioneer collectivities, in order to feature as credible pacemakers, should be of varying size and characteristics.

On a small scale, the units could be new neighbourhoods in residential areas, recreational areas, small rural areas, or isolated ones such as mountain communities - or smaller islands. On a larger scale, "solar cities" should be established, as well as large rural areas and administrative regions which can benefit from an existing sense of community. Also larger islands are expected to be used as pilot projects. A total of 1,500 MW newly installed renewable energy plant capacity in 2010 is estimated to be a possible result of the proposed RE-Community scheme.

The new ALTENER II programme is the European Union's non-technological programme aimed at promoting the use of renewable energy sources within the Union, and the programme has been designed to be an integrated part of the Community strategy and action plan as outlined in the White Paper. Therefore possible support for the local implementation of the RE-Community scheme naturally falls under the scope of ALTENER II.

On a preliminary basis some of the possible pioneer candidates to participate in the overall RE-Community scheme for the next decade are presented in this brochure.



The Danish Concept - Renewable Energy Island

A dramatic shift to renewable energy on a large scale is economically unrealistic in the short term. However, seen in a longer perspective, it would be of high interest to demonstrate the possibilities of a small community to base its entire energy supply on renewable energy sources.

By Jan Büniger
Danish Energy Agency

Therefore, as a part of the Danish Action Plan ENERGY 21 from the Danish Ministry for Environment and Energy, it was in 1996 decided that the government would work on the designation of a local area - probably an island - which over a shorter period would be prepared to change its supply of energy to local renewable energy sources. This would also include the transport sector. As the barriers for the further use of renewable energy in Denmark for several sources are mainly of a non-technical character, the demonstration and use of innovative forms of organisation, financing and ownership of plants are to be given high priority.

The initiative must be seen in the light of the important role which renewable energy - combined with substantial energy savings and improved efficiency - has been given in the Danish energy supply system in a longer perspective. ENERGY 21's objective is that renewable energy should contribute with 35% of the gross energy consumption in Denmark, including the transport sector, in 2030.

As a result of this commitment the Danish Island Samsø in 1997 was selected amongst five competing islands to become the first Danish candidate as an island, within the next decade, to be powered and fuelled by renewable energy only. Renewable energy

presently covers 12-15% of the total energy consumption on Samsø - excluding the transport sector - which is also equal to the present share of renewable energy supply for Denmark as a whole. The project should hopefully become a Danish shopping window for demonstrated energy technologies and solutions, also internationally.

Apart from being an important step forward to increase the utilisation of renewable energy the concept of selecting renewable energy islands/communities should - also in an European and international context - be seen in a broader perspective.

Islands and other remote communities are often difficult and costly to supply with energy using conventional sources and means. Long distances or difficult terrain can be obstacles for the transmission of electricity as well as for the transport of fuels. This makes a secure, conventional supply of energy to such communities more expensive than to locations close to the main electricity grid or pipe systems.

However, it also makes the increased use of locally available renewable energy sources all the more favourable. The use of renewable energy sources cannot only solve the supply problem but also provide a boost for the local economy and provide jobs as the energy is produced locally. These benefits, together with the environmental advantages, make renewable energy an important element in the creation of a sustainable development.

Thus it is the hope of the Danish Government, that the Samsø project will be a showroom for solutions to the many challenges which are facing the international society, authorities, planners, and not least the inhabitants of such local communities.

Seminar About Renewable Energy Islands - Held on Denmark's Renewable Energy Island, Samsø

At a European seminar, 80 participants from 14 countries were presented with 10 different island societies and their plans and possibilities for using renewable energy resources. The seminar was launched in June 1998 on the Danish renewable energy island of Samsø, and this was supported by the EU's ALTENER programme and the Danish Energy Agency. The islands represented a wide selection of islands which, in some way or another, have become engaged in renewable energy, from the Orkney Islands in the north west and Gothland in the north east, to Madeira, Cape Verde and the Canary Islands in the south east and Crete and Arki in the south east corner of Europe.

By Iben Østergaard
Renewable Energy Information Centre, DTI Energy

In addition to the decidedly island societies, there were presentations of various ingredients or strategies which could be used for renewable energy, such as electric vehicles and high electricity coverage with wind power. Furthermore, the network between the island societies was presented, and a basis was created for building up cooperation and exchange of experiences between the islands.

In the articles on pages 15 to 50, there are closer presentations of each of the islands as well as the remaining topics which were discussed at the seminar, whilst this article sums up the seminar as well as the conclusions which were drawn.

Great difference

The purely practical and technical solutions in comparison with covering an island's energy consumption with renewable energy are only one side of the matter and other, more social influences must be clarified, as well as the local development possibilities, for example: in the form of employment and new tourism. One thing which was apparent from the seminar was that there are great differences in how much the local

populations are involved in the energy plans. On Samsø, the plan is that the population must be sworn in, and Søren Hermansen from Samsø Energy and Environment Office recounted that they were starting up with civic meetings, a kind of hearings in the areas which are proposed as district heating areas. Also on Gothland, the population is involved in the energy work, whilst C. Helmis from Greece said that the population of the island of Arki were neither asked nor involved in the energy plans. But, despite the differences - or perhaps precisely to build a bridge over them - the seminar set the scene for an on-going extension of the international cooperation and exchange of experiences between renewable energy islands all over the world, and many bonds were created. In this connection, attempts were made to establish a more in-depth network between the smaller renewable energy islands in which, for example, Samsø is participating. In addition, a world conference about renewable energy islands is planned, which is to be launched in Denmark in 1999. (See more details about this on page 54).

Gothland - more workplaces

On Gothland, there is widespread use of district heating which, during the course of time, has been based on 11 different sources of energy, principally wood chips and biogas. There are more than 100 wind turbines which produce 77 GWh - corresponding to 10% of the electricity consumption. In addition, there are plans to exploit wind power at sea, where there are already five wind turbines.

Keith Boxer, from Gothland Municipality, said that, as regards the social influence from the renewable energy, this had created quite a lot of workplaces and that renewable energy had also extended the possibilities for tourism. Because of the wind turbines there were now many more visitors on the south west part of the island, with the side effects which give rise to increased sales of souvenirs and local handicrafts as

well as increased turnover in cafes and restaurants. Furthermore, the wind turbines also give a welcome, extra income for the farmers, who rent out land for wind turbines. The population is to a wide extent involved in the development, also on the ownership side, and it has proved to be a very successful model in which the inhabitants themselves own the wind turbines, which are sold as shares. Also businesses which are major consumers of electricity have invested in wind turbines, and just like the ordinary consumers they thus produce their own electricity. This has in fact made them less sensitive towards price increases for electricity which makes them more competitive. Gothland is perhaps the participating island from which the inhabitants of Samsø can learn most, since the conditions on Gothland are, to a high degree, comparable with conditions on Samsø. In any case, Samsø has more in common with Gothland than the islands from southerly latitudes.

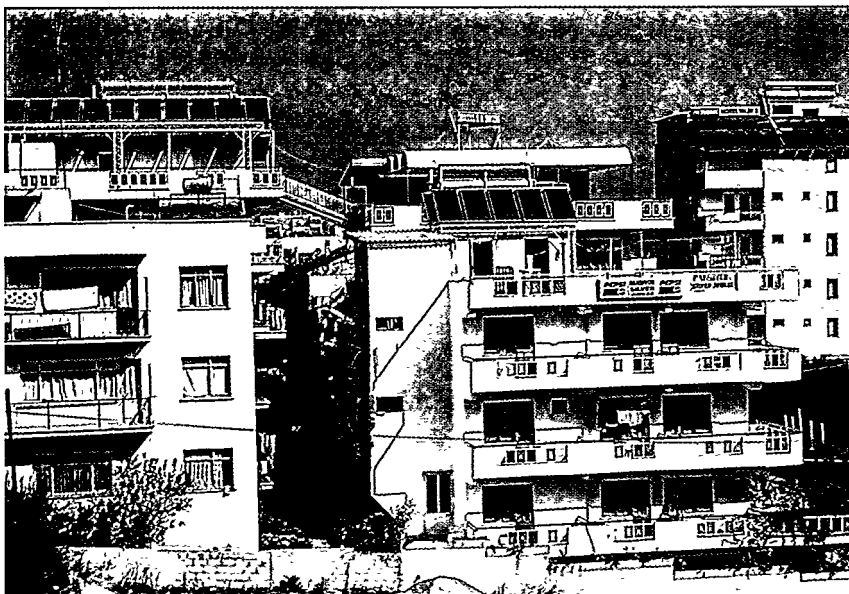
Crete - stable energy supplies

On West Crete, Johannes Plessner Marliani is project-appointed at C.A.R.E., a centre for renewable energy which has been set up by the German solar research institute, Jülich. On Crete, renewable energy can, according to Marliani, have a positive influence for the population, since the exploitation of new energy sources will bring about new possibilities in many

trades. The Centre is focussing on renewable energy accessories for agriculture, as well as refrigeration chambers powered by solar cells. Such storage chambers make it possible to store agricultural products, and the solar cell plants have proved to be 22% cheaper than a connection to the electricity grid. This is just a single example that renewable energy will be able to give a "lift" to the main trades, agriculture and tourism, for example: on the basis of the infrastructure which follows along. But, first and foremost, renewable energy will be able to assist in improving the present unstable and scanty energy supply - and this in itself will be a big advantage for the population's well-being and the possibilities in most trades. The lack of water and electricity is in fact a serious disincentive for both tourism and agriculture.

Some 20% of all households have solar collectors, and 6.6 MW of wind power have been installed. There is a very great wind potential and it is guaranteed that a further 90 MW will be installed. According to Marliani, it is otherwise a big problem that the overall electricity supply company, Public Power Cooperation, does not permit a larger share of renewable energy in the energy supply. On the other hand, C. Helmis, CRES, who presented the small island of Arki, informed that the public legislation should permit independent and self-employed producers of electricity which would act encouragingly on renewable energy.

So the opinions and experiences in the same country were divided as regards this point.



In the mediterranean area the solar potential is large.

Hydroelectric power on Madeira

On the Portugese island of Madeira, there is a very big potential for renewable energy, and hydroelectric power is already being exploited to a high degree. Melim Mendes, vice-president for the regional Energy and Development Agency, recounted that 25% of the electricity consumption was already covered by hydroelectric power, and 2.5% by wind power and that there were in addition a number of small solar heat systems. There are plans to

enlarge up to a coverage of approximately 30% with hydroelectric power, and 3% with wind power, which is also abundant. One of the problems with the solar heat systems is that they are expensive to acquire and of poor quality. And this is also a shame in an area with such a huge potential for solar energy.

Ærø - another renewable energy island

Ærø is another renewable energy island which now covers approximately 15% of its energy consumption with renewable energy. Ærø is a good example of how the development and implementation of renewable energy have taken place with a significant contribution from the local population since the beginning of the 1980s. At that time, enthusiasts built solar collectors in their garages and the local smiths were involved in the construction of wind turbines. Then came the information phase, in which information for consumers and authorities was important, and Ærø has now reached the implementation phase in which it is to achieve a coverage of 15-100% renewable energy. As Ide Seidelin, Ærø Energy and Environment office, recounted: "Even though we did not become Denmark's official renewable energy island, the objective is still to cover our energy requirement 100% with renewable energy." One of the methods can be to replace the 22 old wind turbines with new ones, by means of which 100% of the electricity consumption will be covered by wind-powered electricity, as against 13% at present.

On Ærø, the development has to a high degree been characterised by many local forces and, for example, the solar heating plant at Marstal which covers 8,000 m² is a result of local, solid hard work.

Electric cars

There were not just representatives from island societies who were participating in the seminar, so Sigrid Muntwyler from Switzerland was responsible for a very inspiring contribution about the status of electrically powered vehicles in Switzerland. She recounted how the technologies within two areas are being coupled together - renewable energy and electrical vehicles, so that they form a synthesis for the benefit of the environment. She also presented various vehicles



John Crawford and René Karottki listening to results and experiences presented by Søren Hermansen, Samsø Energy and Environment Office.

- right from what was almost a bicycle with an auxiliary motor, to very advanced, comfortable vehicles. Switzerland is far ahead in experiments to promote electrical vehicles, such as planning and siting re-charging stations and the introduction of lead-free petrol areas for the benefit of the local environment. Electric cars are especially an advantage for the local environment, whilst on a global level they cause more SO₂ emissions than ordinary cars due to the metal processing for the batteries. The participants at the seminar did not just see the cars for themselves - they also got the chance of driving the electric cars, which Citroën Denmark had placed at the disposal of the seminar. They could also enjoy Samsø's countryside and renewable energy resources in peace and quiet, without exhaust gases - and even in dry weather!

Local engagement

René Karottki from the Forum for Energy and Development as well as John Crawford, the leader of Islenet (a form of cooperation between island societies) rounded off the seminar with overall considerations and conclusions. As one of the main points, it was concluded at the seminar that, for example, it was very important to have local engagement and possibly, locally owned projects. Søren Hermansen, Samsø Energy Office, who held the concluding contribution at the seminar, was completely in agreement: "It is im-

portant to let the individual person be his own entrepreneur, by undertaking the responsibility and feeling the connection with what is beneficial for oneself and for the mutual project."

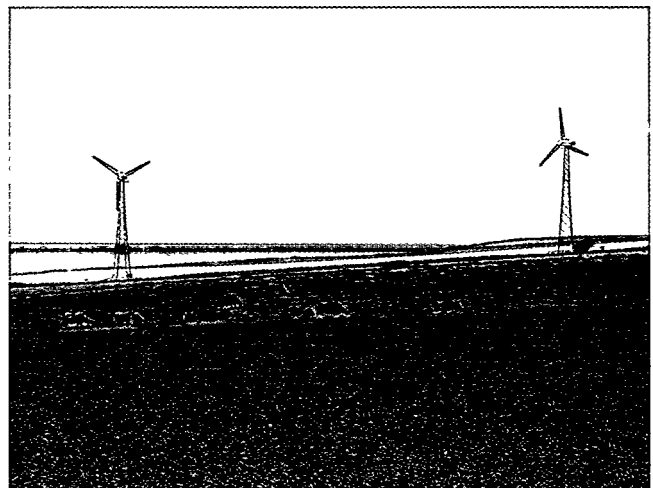
René Karottki emphasised that, on a global level, many islands have a natural interest in acting in an environmentally correct manner, since the islands will be the first victims of the climatic changes which the increased CO₂ emission can bring about. Islands will therefore naturally be models for the rest of the world. But there are also other grounds. An independent production of energy assists social and economic development. Small islands are often already unattractive for traditional energy suppliers, and this results in high energy prices. John Crawford supplemented this by informing that in Islenet it has been ascertained that the islands are generally 80% dependent on imported oil, as against a 45% oil-dependence on the mainland, and the transport expenses are furthermore 60% higher on the islands than at other places. This makes renewable energy and energy savings even more attractive and competitive.

But, despite this, it is often the finance which is the problem. John Crawford referred to the EU's "White Paper" which now recommends 12% renewable energy in the energy supply, and has suggested that a number of pioneer societies should be developed, for example on islands round about in Europe. He thus recommended that the island societies should go in front in this development, and should also be aware of the possibilities for support which both the EU and the individual member states have made available.

René Karottki warned against creating new hindrances in the form of building up new monopolies, and instead both he and John Crawford pleaded for local ownership, which will give a local general view and control. "Successful energy management most often occurs where there are local forums for information as well as the exchange of experiences and opinions -

forums which can create the basis for establishing locally owned energy projects", said John Crawford. And this is just what the inhabitants of Samsø are planning to do. In the first instance in the form of meetings with local citizens in the areas which have been laid out for district heating - meetings which are to inform the local citizens and give them the possibility of influencing the development before the sequence has taken place. The results and experiences from Samsø will be followed closely in other European island societies, and the seminar has set the scene for ongoing cooperation between possible renewable energy islands.

The EU Commission's ALTENER programme, the Danish Energy Agency and Samsø Municipality, with Mayor John Sander Petersen leading the way, were hosts for the seminar, which was arranged by the Renewable Energy Information Centre, at Danish Technological Institute. Samsø's renewable energy plan will be especially mentioned in the subsequent article, after which in-depth articles will follow regarding the remaining islands which were presented at the seminar.



Ærø - a good example of how the development and implementation of renewable energy have taken place with a significant contribution from the local population since the beginning of the 1980s. Replacing the old wind turbines on Ærø will mean self-sufficiency with electricity.

Small Islands - Renewable Energy Forerunners

- Small islands are among the first victims of climate change, and thus have a natural interest in sustainable energy actions.
- The average production cost per kWh at diesel power stations in small island states can easily be 4-20 times as big as typical productions costs in for example Denmark.
- An independent energy production contributes towards social and economic development.
- Be cautious with creating new hindrances for renewable energy in the form of building up new monopolies.

By René Karotki
Forum for Energy and Development

The global island agenda

Several international events in the 1990s have focussed on the particular situation of small island states when it comes to global environmental issues, including sustainable energy.

An important reason for this is the fact that small islands are among the first victims of climate change, induced by intense CO₂ emissions from industrialised countries. The consequences for small islands are property damage from an increased number of devastating cyclones, as well as in rising sea levels, coastal erosion, declining bio-diversity (e.g. from coral bleaching) etc. And such events are not just belonging to the distant future. Already today, international insurance companies have pulled out of many small island states because of increased risk of cyclone damage.

This vulnerability is the basis for the strong and active position of the Alliance of Small Island States (AOSIS) in the negotiations of the UN Framework Convention on Climate Change, most recently in the climate meeting in Kyoto, Japan, December 1997.

The sustainable development of small islands has been on the global agenda for some time, at least from the beginning of the decade.

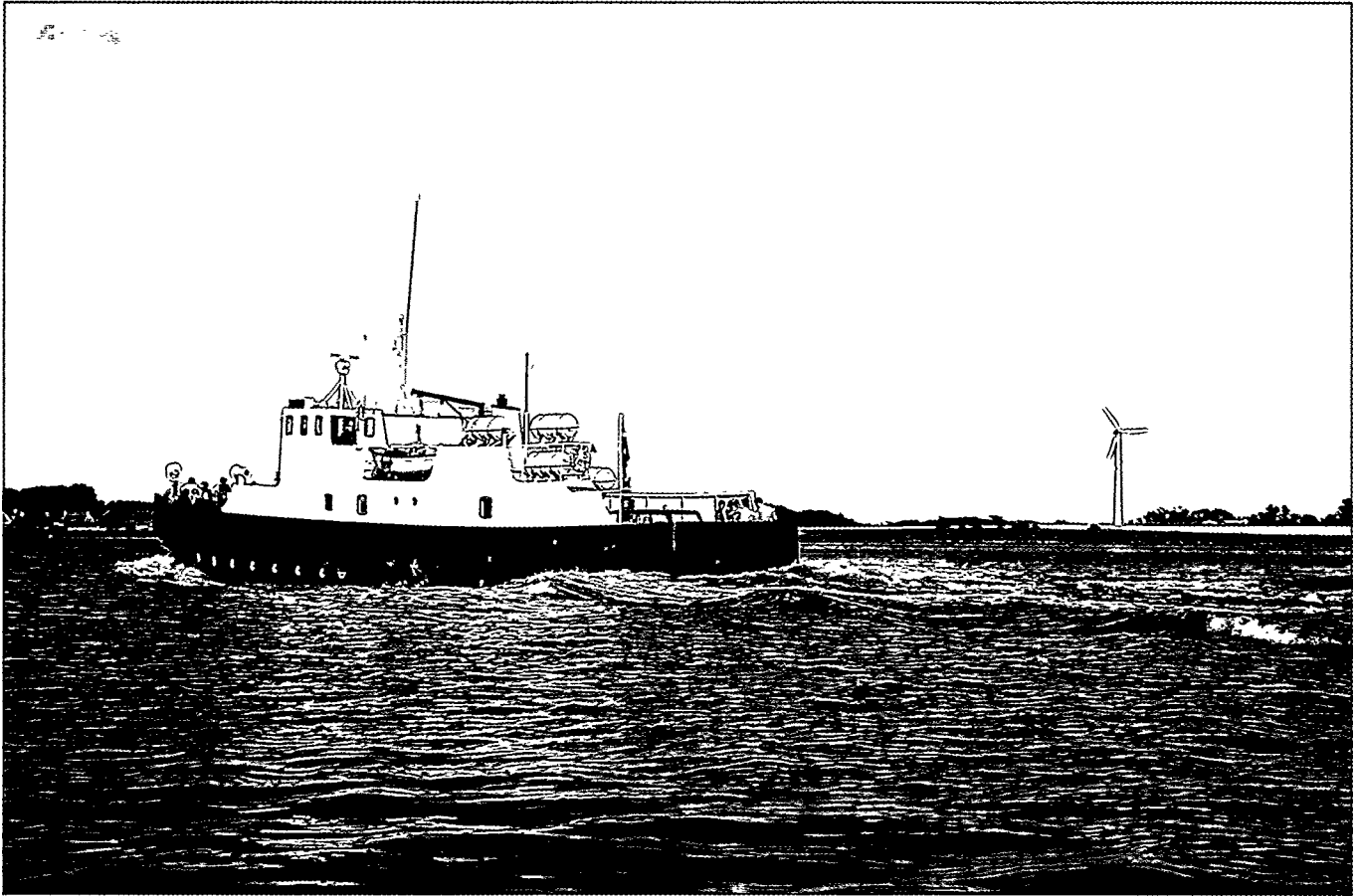
The UN Conference on Environment and Development (UNCED), Rio de Janeiro 1992, made special mention on Small Island Developing States (SIDS) in its action plan, known as Agenda 21, and decided to call for a special conference on the sustainable development of SIDS.

This conference was held in Barbados in 1994. The Plan of Action adopted in Barbados notes that SIDS are heavily dependent on imported petroleum products, mainly for transport and electricity generation, and on indigenous biomass fuels for cooking and crop drying. Among the important measures mentioned are public education and awareness programmes, promotion of energy-efficient and renewable energy technologies, and on international transfer of technologies.

The UN Commission on Sustainable Development (CSD) reviewed the Barbados Programme of Action at its 1996-session, and concluded that, in general, the attempts to develop decentralised renewable energy technologies have had limited success, but that solar PV-systems and solar water heaters have found some use. It recommended to put emphasis on options that have shown some promise: PV for remote islands, solar water heaters in urban areas, hydro power, wind power and enhanced use of biomass fuels.

In June 1997, a special session of the United Nations General Assembly (UNGASS) was devoted to the further implementation of UNCED's Agenda 21.

UNGASS reaffirmed the commitment of the international community to the implementation of the Barbados Programme of Action and decided to schedule a full and comprehensive review of the Programme in 1999. UNGASS further mentioned the need for effective financial support from the international community to the SIDS for building infrastructure and human capacity and for facilitating access to information and technology transfer.



The remoteness of the small islands implies high transportation costs for e.g. fossil fuels.

Why should small islands be forerunners in renewable energy?

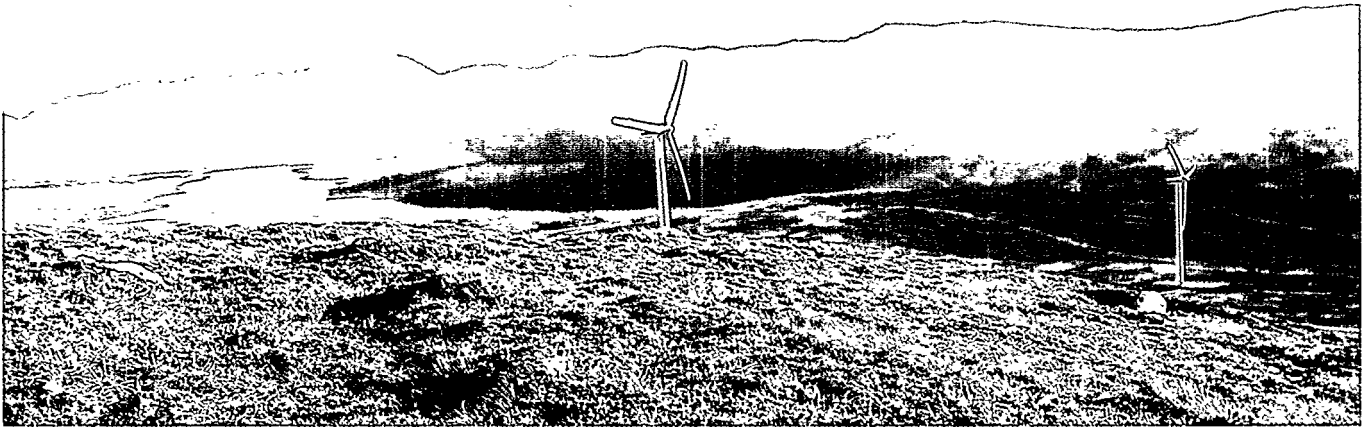
From the small island perspective, the motivation is double-sided. Apart from seeing sustainable energy as a necessary element in their own social and economic development, the island states want to demonstrate to the rest of the world, in particular industrialised countries, that they intend to follow the same sustainable energy path, which they, for example in the context of the climate negotiations, want the industrialised countries to follow.

Coming to their indigenous situation, small islands (and remote communities in general) face many common challenges when it comes to energy and development. With their small size they constitute a marginal market for international suppliers of energy and energy services, and they are often not able to obtain beneficial prices from bulk purchases. In addition, their remoteness implies high transportation costs for e.g. fossil fuels.

This situation often creates a more competitive situation for energy-efficient and renewable energy technologies, compared to traditional fossil fuel based technologies. As a reference, the average production cost per kWh at diesel power stations in the small island states of the South Pacific is 20 US cents. On remote islands it can be up to 100 US cents. This compares to typical production costs of storage systems, such as 5-6 US cents in Denmark.

From purely economic considerations, small islands and remote communities can thus often justify investments in sustainable energy. It should be noted, however, that limited possibilities for financing are often a barrier for such investments.

The limited energy consumption of small island states does not constitute an environmental problem on the global scale, for example, when it comes to CO₂ emissions and the related climate change. But there are environmental problems on a local scale, that can mo-



tivate sustainable energy initiatives. One is noise and air pollution from diesel generators. Another is the risk for polluting the often limited and vulnerable ground water resources from spillage of diesel oil during transportation and storage.

Exchange of experience

On many small islands, traditional use of biomass for cooking may be a problem, both resource-wise and because of indoor pollution from smoke. There may be innovative solutions to this problem available for sharing among small islands, for example in increasing the availability of firewood by tree planting, increasing the efficiency of stoves and developing alternative sources of cooking energy, such as briquettes from organic residues, biogas and solar stoves. The general limitations in this area are that the traditional fuel, such as wood, is often collected free of charge, that the alternatives need to be paid for, and that solutions can be very specific for the cultural environment.

Generation of electricity from renewables, including biomass, is likely to be a more obvious area for collaboration. Many islands have substantial experience in the use of biogas, small hydro, wind power and PV-systems, that could be the basis for exchange of experience. Recent systems developed on some islands indicate that the penetration of fluctuating renewable energy electricity, such as wind power, can be much

higher at diesel powered island grids than previously expected.

Apart from the technical issues, many islands have promising experience on organisational models for implementation, ownership, financing etc., also including strong elements of local participation. Such successful 'delivery models' are often specific to a particular culture, but may serve as inspiration for others. Among these models are locally owned co-operatives, models developed by traditional power utilities and models developed by local authorities. An example is the locally owned wind turbines where the owners are organised in wind turbine guilds. In this way 100.000 people in, for example, Denmark are shareholders in wind turbines and it is a model which is used on Gothland as well.

In the context of global renewable energy developments, the role of small islands can be crucial. They can in the short term be important showcases for continental economies, demonstrating technical and organisational models available for a substantial, maybe total, supply of energy from renewables. While not all models may be fully applicable, they can still be important sources of inspiration, create awareness and stimulate a necessary change of attitudes among continental citizens and decision makers. More networking and joint co-operation projects among islands with a strong ambition in renewables may significantly strengthen the role of islands as global forerunners for renewable energy.

Samsø - The Danish Renewable Energy Island

Within the next ten years Samsø's energy supply will be converted to renewable energy. Amongst the building blocks in this reorganisation, there are four new district heating areas mainly supplied by biomass, and wind power could compensate for the overall typical "problem child": fossil fuel for transport. Besides this, energy savings are a very important issue. The idea is that there should be local involvement in the projects, for instance local workshops have been set up, out in the district heating areas. In the light of this, working groups will be formed which will put their influence on the project, for instance concerning ownership. Also in relation to wind turbines, "citizens meetings" are being held concerning ownership, acceptance, visual impact and the possibilities for both onshore and offshore wind farms, etc.

By Aage Johnsen
Samsø Energy Company

Competition between five islands

Samsø is an island geographically located almost exactly in the heart of Denmark, with an area of 11,400 hectares. The population is about 4,400 inhabitants. Total gross energy consumption is about 900 TJ per year, almost entirely based on fossil fuels. The consumption corresponds to the equivalent of about 4.8 tonnes of oil per person per year.

In connection with the competition between five Danish islands arranged by the Danish Energy Agency in the spring of 1997, a plan for a total conversion of Samsø's energy supply system to renewable energy sources during the course of 10 years has been outlined. The plan for Samsø, which was drawn up by the consultant firm PlanEnergy, the utility company ARKE and various participants from the local community, was chosen as the best project. In the energy plan, great importance has been attached to savings in all energy-consuming sectors and after this the renewable sources: the sun, the wind and various types of biomass will be exploited on a large scale.

Samsø

Presentation by:
Aage Johnsen.

Size of island:
114 km².

Number of inhabitants:
4,400.

Energy consumption and maybe how the consumption is covered:
900 TJ based on fossil fuels.

Percentage covered by RE:
13% of the heat consumption is covered by the collective straw-fired district heating plant. 5% of the electricity is produced by wind turbines.

Other characteristics of the island:
The island was chosen as renewable energy island in Denmark in a competition between five Danish islands arranged by the Danish Energy Agency.

Potential for RE:
The wind resources are significant, but there is only space for 15 biggish wind turbines on land as well as a corresponding number offshore. The biomass resources are at present being charted more closely.

Plans for exploitation of RE:
The plan is that Samsø should cover its energy consumption 100% with renewable energy by the year 2007.

Special benefits:
Job-creation: 440 man-years of jobs during the establishment phase and 35 permanent man-years for operating and maintaining the plants.

How is the population involved in the development of renewable energy supply:
Samsø Energy Company was set up to implement the plan and the company consists of a broad diversity of representatives from Samsø: the municipality, farmers association etc. A secretariat will deal with general communication. Also the Samsø Energy Office deals with local involvement in the project through local workshops in the district heating areas. Some 55 people have applied to establish a wind turbine, however, only 15 will be established.

Special problems to be dealt with:
310 TJ is used in the transport sector, and this will be hard to substitute 100% by renewable energy. (In addition to a 5% general reduction, a 15% reduction should be obtained by using electrically powered vehicles. In spite of this there will still be an annual consumption of about 250 TJ of fossil fuel which will be compensated for by an offshore wind farm.

Heating requirements and production

Roughly one-third, or 340 TJ, of the energy consumption is used for heating buildings. This requirement can be reduced by 20% by additional insulation and renovation of buildings, as well as by introduction of energy control in companies and public buildings.



Tunø Knob offshore windfarm between Samsø and Jutland.

At present, 13% of the island's heating requirements are covered by a collective, straw-fired heating plant. Four new plants would increase the collective heating supply to 65% of the total requirements as follows:

- 1) "The string of pearls", a CHP plant on the eastern coast with a connected output of about 6.5 MW, will be based on surplus heat from ferries, waste disposal gas, bio-gas - from manure (28,200 tons per year) and various organic wastes (3,800 tons per year) - and wood chips (1,750 tons per year).
- 2) "Straw", a heating plant - connected output about 6.3 MW - will be based on straw (3,300 tons per year) and surplus heat from large companies.
- 3) "Bio-gas", a CHP plant - connected output about 2.4 MW - will be based on bio-gas - from manure (8,400 tons per year), energy crops (2,000 tons dw per year), potato tops (1,300 tons dw per year) - and wood chips (460 tons per year).
- 4) "Wood chips and sun", a heating plant - connected output about 3.9 MW - will be based on wood chips (1,900 tons per year) and a central solar heating plant (1,800 m²).

Buildings in the open countryside account for the rest of the heating requirement and will be supplied by individual systems such as heat pumps, direct electricity, solar heating, solid fuels, farm-based bio-gas

plants and household wind turbines. In some cases "neighbourhood heating systems" will be used.

All the types of biomass utilized in the collective and individual systems are present on the island, except for wood chips which in future must be cultivated - as willow crop - much more extensively and possibly within sensitive agricultural areas.

Transport consumption

Roughly 310 TJ per year is used in the transport sector for ferries, cars, buses and trucks etc. Information campaigns and reorganisation, for example: energy control, improved maintenance, improved driving techniques and new forms of cooperation, should make it possible to reduce the consumption by more than 5%.

Consumption can be reduced by a further 15% if service vehicles and half of the private cars on the island are replaced by electrically powered vehicles. As mentioned above, the energy consumed by the ferries can be utilised more efficiently by using surplus heat for district heating.

Despite the reduction and conversion to electrical cars, the transport sector will still consume about 250

TJ of fossil fuels per year, of which the ferries account for one-third.

Electricity consumption and production

The total consumption is 29 MWh, including electrical heating. About 5% of this is produced by wind turbines on the island. Of the gross energy consumption, electricity consumption accounts for 230 TJ per year. Intensive saving campaigns, the introduction of energy control and replacement of obsolete electrical appliances will make it possible to cut this consumption by 25%. However, future consumption will still increase slightly, due to the introduction of electrically powered vehicles and the use of heat pumps for individual heating systems. The future consumption can be covered by the following sources:

- Land-based wind turbines (15 x 750 kW): 75%
- Large bio-gas plants, CHP (2): 21%
- Farm-based bio-gas plants, CHP (5): 2%
- Household wind turbines (15): 1-2%
- Solar cell plants (70, installed output 35 kWp): 0-1%

In addition, an offshore wind turbine farm can be established comprising 15 x 1.5 MW turbines, constructed in order to compensate for the continued import of fossil fuels for the transport sector.

Environmental factors

Implementation of the plan will completely put an end to emissions of sulphur dioxide, particles and carbon dioxide from energy consumption on Samsø. In addition, emissions of nitrogen oxides can be expected to fall by about half.

Financial factors and employment

The total cost for implementation of the energy plan is about DKK 590 million, of which offshore wind turbines account for about 40%. In order to ensure com-

petitive economy for consumers, a total subsidy of about DKK 70 million is needed. However, at the same time the island will save about DKK 50 million per year on fuel and electricity imports. The plan's direct effect on employment will be about 440 man-years during the establishment phase, and about 35 permanent man-years for operating and maintaining the plants.

Organization

"Samsø Energiselskab" (Samsø Energy Company) has been set up to implement the 10-year energy plan. This company consists of representatives of Samsø Municipality, the Commercial Council, the Farmers' Association and the Energy and Environment Office. The company has set up a secretariat to coordinate the future projects and activities. The secretariat will also collaborate with the Danish Energy Agency, ARKE - the utility company, PlanEnergy and other consultants who may be called on. In addition, the secretariat will deal with general communication in relation to the project.

Status

A number of activities have been set in motion during the late summer of 1998.

A dynamic energy-planning tool is being drawn up, and a more precise examination of the present biomass resources must be carried out, as well as a projection of the resources within various scenarios.

For the purpose of energy savings, an energy control will be carried out in all the dwellings in the town of Ballen, and an exhibition about energy in the open landscape will be launched during the autumn. Furthermore, the previously mentioned "citizen groups" will be established in at least the four district heating areas, since - as the Mayor of Samsø, John Sander Petersen says: "If the objectives are to be achieved, then it is crucial to have the hinterland in place."

Renewable Energy and the Impact on Local Economy on Gothland

Gothland is a Swedish island situated in the Baltic Sea. A few years ago the island was dependent on the mainland for its energy supply, which at that time was very unstable. A step away from dependency was taken when the largest town on the island introduced a district heating system. This system has used many different kinds of energy sources, of which most of them were renewable. Next to this was a group of wind power enthusiasts who got the idea of installing wind turbines on the base of selling shares in wind turbines as a financing method. The result is that Gothland has more than 100 wind turbines today. Renewable energy is not only an asset to nature but is also a good economic strategy. Renewable energy gives work opportunities, energy independence from the mainland, know-how and other benefits. In the municipality of Näs, an agreement was made that the owners of the wind power turbines should invest 1% of the value of wind power production in a fund for local development.

By Ulf Johansson
Gothland County

Gothland is the largest island in the Baltic Sea. There are about 60,000 inhabitants living on the island, where there are 15 towns and villages of which Visby is the largest and also the financial and administrative centre. The main sources of income are the public sector, tourism and agriculture.

Until a few years ago the island was very vulnerable and dependent on the mainland for its supply of energy. One single direct current cable supplied Gothland with electricity and delivery disturbances were more or less an everyday event. Now this has changed. The important step to become more independent from the mainland took place when the regional Energy Company, GEAB, decided to build up a modern district heating system in Visby. This heating system has, during the course of recent years, used 11 different sources of energy, most of which are re-

Gothland

Presentation by:
Keith Boxer.

Size of island:
3,100 km².

Number of inhabitants:
60,000.

Energy consumption and maybe how the consumption is covered (TJ or GWh):

The total amount of consumed electricity is 770 GWh.

Percentage covered by RE:

District heating uses several sources of energy, mainly renewable energy such as: wood chips, methane gas etc. Wind turbines produce 77 GWh corresponding to 10% of the electricity consumption.

Other characteristics of the island:

Income: Public sector, tourism, agriculture.

Potential for RE:

There is a high potential to use wind resources because of Gothland's position in the Baltic Sea.

Plans for exploitation of RE:

Wind power at sea. There are already five offshore wind turbines.

Special benefits/impacts from renewable energy:

Renewables have created jobs and new possibilities for tourism, and they provide an extra income for farmers.

How is the population involved in the development of the renewable energy supply:

Wind turbine shares have been sold to the public - which have proved very successful. Jobs are being created, farmers rent out land for wind turbines.

Impacts/benefits from renewable energy/short conclusion:

It has led to job creation, an increase of visitors on the island and extra income to farmers. In the municipality of Näs the owners of the wind turbines invest 1% of the value of the power production in local development.

newable. Some examples are wood-chips, residues from the forest industry and methane gas. Later there were district heating systems in three other towns, which were all based upon renewable energy resources.

The introduction and exploitation of wind energy marked yet another important step towards the introduction of renewable energy. Some enthusiasts got the idea of creating a wide base of ownership of wind turbines. By doing this they could raise the necessary investment capital and at the same time increase pub-



By creating a wide base of ownership of wind turbines it was possible to raise the necessary investment capital and at the same time increase public awareness and interest in renewable energy. In 1997 windpower supplied 10% of the demand for electricity on Gotland.

Public awareness and interest in renewable energy. This created interest in wind power and today Gotland has more than 100 wind turbines. In 1997, wind power supplied 77 GWh or about 10% of the demand for electricity. The next step is the installation of offshore wind turbines where there are already five of such turbines.

Another example of using renewable resources is the cement factory, CEMENTA, on the northern part of the island. Excess heat from the factory is not only exploited in the district heating system but also for supplying a large greenhouse with relatively low-cost heating. This makes it possible to grow high quality tomatoes and cucumbers.

Impacts on local economy

Various aspects of the impacts on local economy which the use of renewable energy resources can have are listed under following categories:

- Work opportunities
- Energy prices

- Energy dependency
- Investments
- Know-how
- Distribution of wealth

Work opportunities

Investments in exploitation of renewable resources have created jobs, not only for construction workers, but also for maintenance and surveillance personnel. For example, the district heating system in Visby has four workers employed. The interest in wind turbines has increased the number of visitors in the southwestern part of Gotland where the majority of the wind turbines are located. This seems to have had a positive effect on the service sector.

Besides this, renewable energy has also enabled small local farmers to earn a valuable extra income in areas where the economic conditions for farming are not very favourable. The local farmers can have an extra income by renting land for wind turbines or selling wood-chips.

Energy prices

By the introduction of the many different kinds of energy sources, the sensitivity for external price changes has decreased. There are many possibilities for using the source of energy which is the cheapest on a day-to-day basis. As a result, the costumers on Gothland pay less for the energy than the costumers living on the mainland. The hundreds of islanders and companies who have invested in wind turbines now benefit financially. They are more or less independent of fluctuations in energy prices and, as far as the companies are concerned, it makes them more competitive on the market.

Energy dependency

As an overall advantage Gothland has become more independent of mainland energy sources. The two high quality cables to the mainland, which secure the electricity supply are, however, mainly used as an important tool for exporting renewable energy. Visby has also had benefit from the district heating system. The air quality is higher than few decades ago and the inhabitants are more independent of imported fuels.

Investment in infrastructure

Investment in the energy infrastructure is the long-term, strategic contribution to the economy. New regional and local grid investments have been made,

new cables to the mainland, and improved roads in peripheral areas are some of the investments made. Another example is the “HVDC Light” project, which ABB and GEAB are involved in. This is a project which aims at the installation of a 50 MW underground cable from the south-western part of the island to Visby. This in order to handle the power generated from wind turbines.

Know-how

The renewable energy sector is an expanding sector, which requires highly skilled people. This gives opportunities to export know-how and attract more skilled and well-educated people.

Distribution of wealth

The distribution of wealth is seen as an example in the municipality of Näs on the south-western coast of the island. Näs was interesting because of its windy position but the local people started to discuss whether they would have any benefit from harvesting the local resources. This led to an agreement that the owners of the wind turbines should invest 1% of the value of wind power production in a fund for local development. This does not only compensate for the disturbances created by the wind turbines, but it also helps to sustain life and a more positive attitude towards wind power production in this part of the island.

Renewable Energy on Madeira

Madeira is a group of Portuguese islands the primary energy consumption of which is covered mainly by fossil fuels, but also renewables - mainly hydro. This leads to a significant dependence from abroad, however, this dependence is lower than the average on European islands. Due to the relatively small dimensions of the energy system, alternatives like nuclear power or gas pipe lines are not thinkable. The small dimensions of the electricity grid could represent a problem when introducing renewable energy resources because the system is not able to deal with problems like disturbances introduced to the grid. However, renewable energy is considered as an alternative to fossil fuels, and the potential is significant concerning solar, wind and waste resources. Wind farms and a new hydroelectric plant have been established and more is planned to come.

By Jose Melim Mendes
Regional Agency for Energy and Environment of Madeira

Madeira is a group of four Portuguese islands situated in the Atlantic Ocean, 800 km off the coast of Africa, 980 km from Lisbon and 850 km from the Azores. Only the two of the islands are inhabited and the population is about 260,000 people on a territory of 797 km². The main income sector is primarily concentrated upon tourism, transport, communication and other service sectors. Agriculture and fishing are also two other important sectors where agriculture, due to very difficult topography, is mainly for own consumption.

The energy characteristics

The energy characteristics of the islands are a significant dependency on imported energy resources, which are mainly oil products. However, 15% of the energy consumption comprises local resources: biomass, hydro, wind and solar energy. The electricity production primarily derives from diesel power plants with a contribution of electricity from new hydro schemes and new wind parks, which represents about 33%.

Madeira

Presentation by;
Jose Melim Mendes.

Size of Island:
797 km².

Number of Inhabitants:
260.000.

Percentage covered by RE:
15% covered by biomass, hydro, wind and solar energy. 33% of the electricity production is covered by renewable energy. This is mainly hydro, and 2.5% is covered by a capacity of 5,790 kW wind turbines. There is a reasonable number of solar thermal plants.

Other characteristics of the island:
The main activities are tourism, transport, communication.

Potential for RE:
Hydro, biomass and solid waste. Also good wind - solar potential.

How is the population involved in the development of renewable energy supply:
The renewable energy plants (wind turbines) are mainly privately owned.

Special problems/advantages:
The electricity price is assured for eight years by the Portuguese Government and by the obligation of the public electricity grid to receive electricity from private producers.
Due to the weak electrical grid capacity there is a limitation in the use of, for instance, wind power.
For thermal solar, the barriers are high costs and sometimes poor quality of the plants.

The local energy resource of high value is the use of hydroelectricity and forest biomass to produce heat in the residential and industrial sectors. Both wind and solar sources represent a high potential and have a huge development potential in the future.

The exploitation of solid waste as a resource is at the moment being considered in an incineration waste treatment plant.

The recent development is the construction of a new hydroelectric plant and wind farms. The hydroelectric plant "Multipurpose Scheme of Socorridos" has a capacity of 50 MW. The total capacity of the installed wind turbines is 5,790 kW, which represents 2.5% of the electricity capacity in the islands. The majority of these wind farms are private, but one wind turbine is

owned by the public utility. These initiatives were supported by a guarantee of the electricity price for eight years from the Portuguese Government and from an obligation of the public grid to receive the electricity.

Barriers

The main obstacle for the development of renewable resources in the production of energy is the integration of the energy produced into the public grid. The small dimension of the energy system creates a limitation in the capacity to receive - in acceptable conditions - electricity produced by wind energy. The high fluctuations in the electricity demand throughout the day set limitations on electricity reception from wind power turbines. On the other hand, it is common amongst electricity producers who use conventional energy resources, that they sometimes have difficulties in accepting new initiatives. These difficulties often appear as fear in relation to the introduction of new technologies, the behaviour of which is sometimes unknown.

In connection with solar power, the main barrier is the weak acceptance due to high costs and sometimes poor quality of equipment and installation.

Perspectives

There are good perspectives in the use of renewable energy resources for different purposes. For instance, wind energy can be applied for sea

water desalination and pumping. The use of waste as a source for producing electricity is very interesting and the use of solar power, both thermal and photovoltaic installations, is also worth multiplying. Also for hydro energy there are still sites with feasibility for energy valorisation.



There is a contribution of electricity from new hydro schemes which represents about 22% of the electricity consumption on Madeira.

Canary Islands - The Strategies

For the seven Canary Islands situated in the Atlantic ocean, considerations concerning energy supply are of special interest, and renewable energy has special relevance for such remote societies. The Canary Islands have, however, not yet implemented renewable energy on a large scale, but a renewable energy plan 1996-2002 is mainly focussing on wind, solid waste and solar energy as viable resources. Besides this, it also points out the potential in biomass and hydro-electric energy. This article describes the Canary Islands in general while the following article concentrates on the smallest island, El Hierro, and their actions towards sustainable energy development.

By Sinda Hernández González
The Government of the Canary Islands

Sustainable energy development

Energy supply constitutes one of the necessary factors for the development of human activity. For this reason, the energy policy should be directed towards ensuring a sufficient supply of energy with the necessary and sufficient economical and environmental guarantees. These considerations acquire special relevance in the Canary Islands.

The Canary Islands are a Spanish Autonomous Community, situated much nearer the African Continent than to Europe. The Islands are situated in a privileged location for using renewable energy resources, specially solar and wind resources. The geographical characteristics of the Canary Islands, dispersed over several islands, quite far from each other and from the supplying sources give rise to energy problems. The economic development of the Canary Islands is mainly focussed on the services sector and to ensure the development of this sector, it is important to have a high quality of energy supply, which renewable energy can bring about.

Additionally, there is the problem of the water supply, the structural shortage of which is a manifested fact in

Canary Islands

Presentation by:
Sinda Hernández González.

Size of island:
7,275 km².

Number of inhabitants:
850,000.

Other characteristics of the islands:
The Canary Islands are dispersed into several islands quite far from each other. As a result of this, there are energy supply problems. The main economical structure on the islands is the services sector, which depends on a high quality energy supply.

Potential for RE:
The potential for RE as primary energy is a progress of about 8 times the present value, mainly in the areas of wind energy and solid waste.

Plans for exploitation of RE:
The objectives is primary:
Wind energy: 29.6% progress until 2002, of total RE progress.
Solid Waste: 64.7% progress until 2002, of total RE progress.

the Canary Islands, as well as the increasing necessity to produce potable water from sea water, which is very energy-demanding.

The Renewable Energy Plan of the Canary Islands (PERCAN), which stretches the time period to 1996-2002, is based on the advantages which renewable energy has, among which the following can be highlighted:

- Improving the guarantee of energy supply, favouring energy diversification and the use of domestic sources.
- Lowering the effect on the environment.
- Favouring or encouraging the development of industrial and economic activities at a regional level.
- Facilitating the availability of infrastructures and knowledge in order to incorporate renewable energy efficiently.

The PERCAN draws together criteria and measures to be taken into account for ensuring the introduction and use of renewable energy technologies. This article constitutes the basis on which future actions for

the exploitation of renewable resources in the Canary Islands must be carried out.

The potential of electricity production based upon Renewable Energy is estimated to increase by about ten times the production capacity in 1994 by the year 2002. It is mainly the areas of wind energy and utilisation of solid waste, which represent the largest progress.

The objectives developed in the PERCAN, have been adopted both to the energy policy developed at a national level through the Saving and Energy Efficiency Plan (PAEE), whose temporal horizon reaches the year 2000, and to the indicated objectives at an EU level for the year 2005.

PERCAN Strategies 1996-2002

Wind Energy

Establishment of high power wind farms in areas which are most suitable. The most suitable areas should be based on an environmental impact study in co-operation with the *Consejería* of Territorial Policy. The selection of the best suitable areas should also be based on a stability study of the grid in co-operation with UNELCO. In the areas with no connection to the grid, studies should be carried out regarding the possibilities of using wind turbines as water pumps. These studies should be carried out in co-operation with the *Consejería* of Public Works, Housing and Water. Finally, demonstration projects should be planned.

Mini-hydraulic and Geothermal Energy

A study should be carried out in co-operation with the *Consejería* of Public Works, Housing and Water about

the possibilities and potentials of mini-hydraulic and geothermal exploitation.

Solid Waste Energy

Solid Waste as a energy resource should be promoted among the companies who are handling the waste and disposal of the waste. Besides that, PERCAN should participate in the framework of future planning concerning an efficient use of solid waste.

Thermal Solar Energy

Establish an Operation Agent the purpose of which is to manage the PROCASOL (Canary Islands Programme for the promotion of thermal solar systems). This Operating Agent should also sign contracts with the installers of thermal solar energy equipment which includes technical, commercial and financial requirements, in order to guarantee installation standards. To promote and increase the use of thermal solar energy in certain sectors there is a need for legislative development towards favouring thermal solar energy in, for example, new houses and hotels. This includes promotion and campaigns in various media with special campaigns directed at the hotel sector. This also includes demonstration projects.

Photovoltaic Solar Energy

Realisation of studies, the purpose of which is to determine the potential photovoltaic rural applications. These studies should mainly be focussed on applications isolated from the grid.

Biomass Energy

Feasibility studies, experiences, pilot and demonstration projects should be carried out concerning the use of energy crops in the production of, for example, bio-fuels as well as utilisation of forest and farming waste.

Full Supply for El Hierro by Means of Renewable Energies

One of the Canary Islands is the Island El Hierro, which is the smallest and least populated. El Hierro originates from volcanic activity and is about 270 km² in size and with a maximum height of 1500 metres above sea level. An ambitious, rewarded energy plan from 1986 has not been implemented on El Hierro; however it seems more plausible that a redefined project may now be implemented.

By Honorato Lopez Torres
Instituto Tecnológico de Canarias

Sustainable development project

A large part of the island represents an undisturbed natural asset, which measures have been implemented to preserve. The government of El Hierro is promoting a sustainable project in order to promote economic development based on farming, fishing, traditional crafts and rural tourism with orientation towards autonomy and environmental protection. The idea is to develop and test environmental sustainability techniques on a full scale basis and use El Hierro as an experimental place. The outcome of the project is to ensure adequate living conditions for the population while ensuring environmental sustainability. Basically the project focuses at the following processes:

- The water cycle
- The energy process
- The waste cycle
- Farming activities
- The marine environment
- The natural environment

The electrical system

The electricity system of El Hierro is independent and isolated from the other Canary Islands due to technical difficulties. As a result, the electrical system is an integral system which includes generation, transformation and distribution facilities. The maintenance cost of such an integral system is very high. The main

El Hierro (Canary Islands)

Presentation by:
Honorato Lopez Torres.

Size of island:
270 km².

Number of inhabitants:
8,000.

Other characteristics of the island:

One of the Canary Islands, which are situated in the Atlantic Ocean on a privileged location for tapping some renewable energy sources, especially solar and wind. Scarcity of fresh water is a growing problem in spite of the efforts being made to increase the seawater desalination capacity at the cost of consuming energy. The islands have very small, isolated electrical systems that require maintenance as well as management operation and service quality similar to that of a continental scale system.

Energy consumption and maybe how the consumption is covered:

The primary energy consumption is 119,5 GWh per year, supplied by means of oil products plus small contributions from renewable resources. The production of electricity was about 20,1 GWh in 1997 generated by wind turbines, mainly, by diesel groups.

Percentage covered by RE:

280 kW wind capacity generates about 964 MWh corresponding to 5,3% of the total electricity consumption.

Potential for RE:

It is possible to cover almost 100% of electricity demand using wind-hydro systems. It is foreseen to that the use of thermal energy will be increased.

Plans for exploitation of RE:

The main plan is focussed on the supply of electricity by means of wind-hydro systems. A project is currently being carried out, in order to define the concrete parameters of the system, that is based on a wind park that will elevate water from the low reservoir to a higher one.

Special benefits/impacts/problems/ advantages from renewable energy:

The main benefits of installing a wind-hydro system in El Hierro are environmental ones as well as increasing the guaranty of energy supply.

How is the population involved in the development of renewable energy supply:

The authorities and population have already made a firm comprise with the sustainable development of their island, but a special effort is needed in order to obtain a massive support to the project.

generating power source is diesel fuel engines, which have a capacity of 7000 kW. On El Hierro there are also two wind turbines with capacities of 100 and 180 kW respectively. In 1996 these two wind turbines generated about 5.3% of the total electricity produced. This was generated during more than 3400 equivalent hours of operation. This gives an idea of the wind power potential of the Island.

In 1996 the total generated power amounted to 18.2 million kWh. The growth rate in electricity consumption was about 5% from the previous year.

Renewable energy plan 1986

As early as 1986 the renewable energies department of the Utility Unión Eléctrica de Canarias (UNELCO) suggested the idea of supplying the island with electric power by exploiting renewable energy resources. The idea was to build a wind farm that would inject part of the generated power into the grid and would accumulate any surplus by elevating water from a lower reservoir to a higher one. The idea, which was submitted to the EU for financing, was finally not implemented for various reasons.

Redefined renewable energy plan

The present gradual liberalisation of the Spanish electricity market has changed the circumstances and it is more plausible that projects of this kind may now be

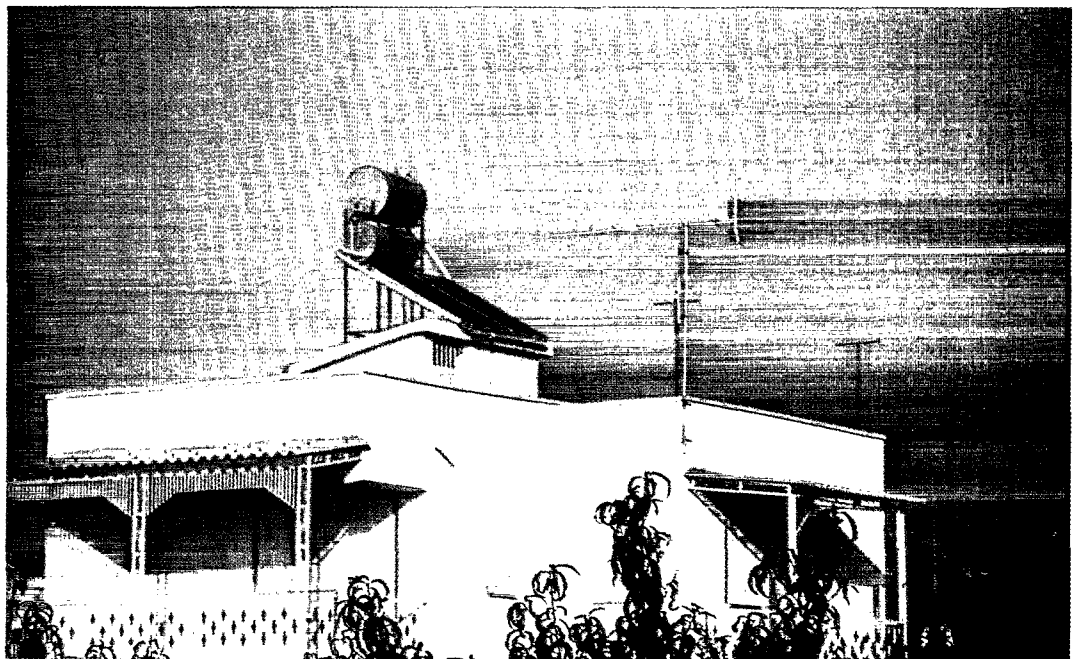
implemented. This has led to the creation of ITC (Instituto Tecnológico de Canarias) which has retaken the idea and begun a redefinition of the project.

The first idea was designed 12 years ago and the present demand for electricity has increased by 2.7 times. Also the siting of a wind park should be considered again because the areas of protected spaces have increased during recent years. A system designed for sustainable production of energy should avoid performing works in protected areas.

The knowledge of El Hierro has increased during recent years. A wind map has been drafted, which gives a better position to propose alternative sites for placing wind parks. The technical characteristics of wind turbine generators have also been developed in recent years, which should also be taken into account when redefining the project.

ITC has taken the first step towards redefining the project and initiated the preliminary technical works in co-operation with UNELCO and other companies.

The level of solar radiation received by the Canary Islands is very high.



System Consequences of Large Scale Utilisation of Wind Power

It will be possible over the period up to the year 2030 to develop well-functioning power and heat supply systems where 75-100% of the electricity supply will be based on Danish renewable energy resources. However, the average production cost of electricity is expected to increase.

By Poul Erik Morthorst
Risø National Laboratory

Large-scale utilisation of wind power imposes new constraints in the electricity and heat supply system, which unless taken care of might generate economic and technical problems. By nature wind power is a fluctuating energy source. Low wind speeds and consequently low power generation may occur at times of peak electricity demand. On the other hand, there might be plenty of wind-produced electricity at times when electricity demand is low.

A situation where wind power production corresponds to 50% of the annual electricity demand in Denmark is shown in Figure 1. The wind power production in certain periods substantially exceeds the demand for electricity. Furthermore, Figure 1 shows that very substantial fluctuations occur in the wind power production. Such fluctuations impose strong requirements on the regulation capability in the rest of the supply system.

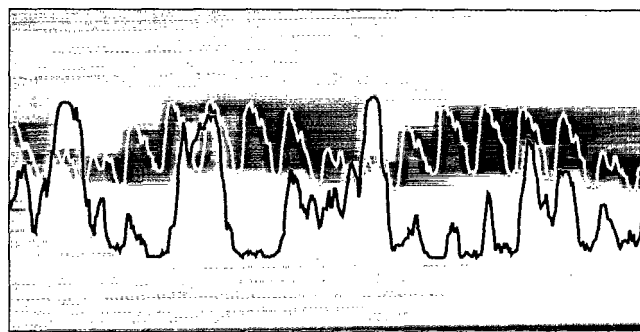
Several possibilities exist for solving the problem of excess electricity production. Regulating the wind power production downwards in periods of high wind speeds is one way of resolving the problem - electricity export may be another option.

These are some of the issues analysed in a project concerning options for large-scale utilisation of renewable energy for power and heat production in the future Danish energy system. The project has been carried out in collaboration between Risø National Laboratory and the electricity utilities ELKRAFT and ELSAM.

The project addresses technical and system development challenges that arise if regional renewable energy resources are to form the main energy inputs in the future Danish power and heat supply. System development strategies are formed that cover a time scale up to the year 2030. The main focus in the analyses is on the long-term aspects. Based mainly on fluctuating inputs from renewable energy technologies such as wind power and photovoltaic and biomass, supply strategies are described which are capable of providing the same quality of electricity supply as exists at present. CO₂-emission reduction and average production costs of electricity in future systems that integrate large scale renewable energy utilisation are evaluated.

Scenarios

A scenario approach is used, where basic aims in society at large form the starting point for the analysis. Economic growth, fuel price developments, energy



Electricity demand — Production from wind power

Figure 1. Wind power production and electricity demand in a selected period. The upper curve shows the varying electricity demand in one-hour time steps during a two-week period in springtime. The fluctuating wind power production, shown as the lower curve, is based on power curves for the average wind capacity in an assumed future system and typical wind conditions. The installed wind power capacity is close to the peak power demand in the system.

Case Studies - Techniques

demands, and energy supply strategies are derived in accordance with fundamental aims for society at large.

In the so called green scenario, an essential goal is to achieve substantial CO₂-emission reductions and strategies for energy conservation and - supply are developed. The analyses focus on the years 2005 and 2030. In the "The Green Society" a main goal is to achieve a renewable energy utilisation covering 75% or more of the expected Danish electricity demand in the year 2030. A milestone towards this goal is to reach a 25% coverage of the electricity demand in the year 2005 from renewable energy sources equally divided between wind power and biomass.

A number of models have been used to carry out the analyses. These include a scenario-model for energy, economic and environmental analysis of the overall system, supply system simulation and optimisation models and, finally, a model to undertake dynamic load flow analysis of the electricity grid.

Case Studies - Techniques

% of electricity demand	S1	Supply strategies S2	S3
Wind power	50%	25%	50%
Photovoltaics	0%	0%	15%
Biomass	25%	50%	35%
Total	75%	75%	100%

Table 1. Supply strategies for utilising renewable energy resources in the year 2030.

Three long-term electricity supply strategies for utilising renewable energy sources have been set up, as shown in Table 1. The S1 and S2 strategies put the main emphasis on wind power and biomass utilisation, respectively, and each strategy aims to cover 75% of the electricity demand from renewables in the year 2030. The third strategy, S3, combines the three main renewable energy supplies in Denmark and aims to cover the total demand for electricity by the year 2030.

Wind power and excess power generation

Improved design and efficiency are expected to reduce the specific costs of electricity from wind turbines by about 25% during the period. Future wind turbines will be about 2.5 MW in the year 2030 and

they are expected to operate at maximum efficiency over a wide wind speed range utilising variable speed and active pitch control.

It is assumed for the technical analyses of future Danish electricity supply systems that the interaction with the electricity systems of our neighbouring countries will be kept at the present level. In this way the analyses are equivalent to those performed for an isolated island system. Thus the need for increased regulation capability in the system, mainly due to the large capacities of fluctuating wind power, must be supplied from within the Danish system during the period up to the year 2030.

Excess electricity production will increase as the coverage from fluctuating renewable electricity produc-

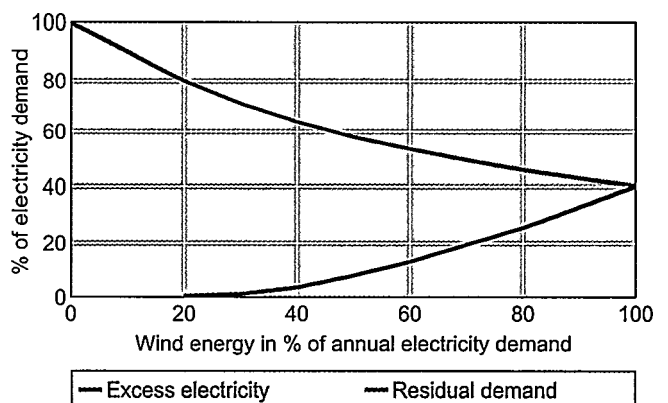


Figure 2. The excess electricity production as a consequence of increasing wind power production for Danish conditions.

When wind power generation exceeds approx. 20% of the total electricity demand, excess electricity production starts to emerge. This is shown on the lower curve in figure 3. Accordingly, when wind-based electricity covers approx. 50% of the total electricity demand excess production will be close to 10%, increasing to approx. 40%, when electricity production from wind power corresponds to total demand. The upper curve of figure 2 shows the percentage of electricity demand that is not covered by wind power, and thus has to be produced by conventional power plants. Even though wind power in energy terms corresponds to 100% of demand, only approx. 60% of the wind-generated electricity can be directly utilised, requiring that approx. 40% of electricity demand be supplied by other means.

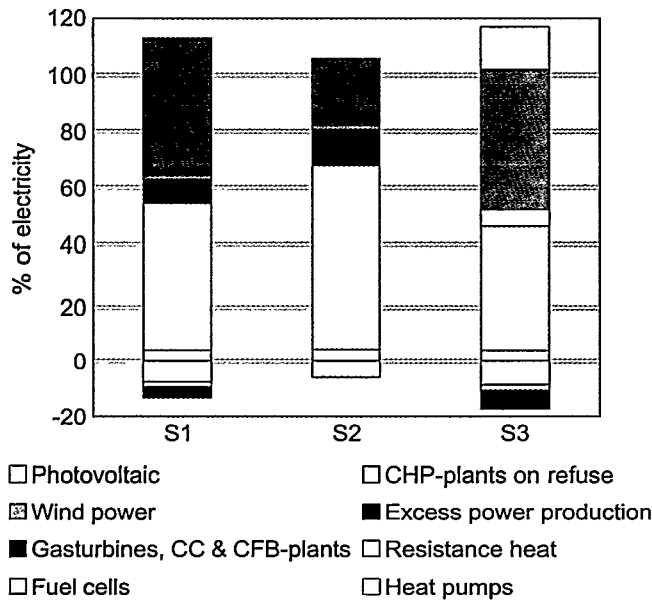


Figure 3. The percentage of different technologies covering electricity demand and "excess" electricity utilisation "Excess" electricity production and additional electricity production to operate heat pumps are included both above and below the x-axis. Approximately half of this excess production in the wind strategy S1 and in the strategy S3 (wind, biomass and photovoltaics) is consumed by the heat pumps, and in the biomass strategy S2 all of this excess production is absorbed by heat pumps. What remains of the "excess" electricity production is highly irregular in time and fluctuates strongly in power. A fraction of this is recovered as resistance heat and what now remains the system is unable to use. Such losses occur in strategies S1 and S3. In practice, however, this potential production will not be generated. The wind turbine capacity in such situations must be able to regulate the production downwards in order to maintain stability on the national grid. However, the percentage of total electricity production lost through excess production is fairly small, amounting to approx. 6% in S1 and 8% in S2.

tion from wind power increases. Excess generation may increase further due to system constraints and limited regulation capability related to other production capacity in the system.

Power supply and regulation capability

The desired combination of high regulation capability and high efficiency for the electricity production points

in favour of gas-fuelled technologies. Gas technology is assumed to play an important role in the future energy system, where high energy efficiency and system flexibility will be essential.

In "The Green Society" the main new technologies introduced on the longer term are biomass gasification, IGCC and fuel cells on natural gas and syngas. Based on these technologies, the biomass utilisation in the system can be expected to yield high efficiencies for electricity generation.

Heat storages (of about one day capacity) are utilised to decrease/eliminate constraints in the combined heat and power production. Furthermore, the heat storage capacities are used in combination with heat pumps. "Excess" electricity production from, for example, wind turbines is partly recovered by heat pumps to supply the district heating systems. If further heat production is required, the heat pump capacity is used and electricity production is raised to supply the heat demand.

CO₂-emission and production costs

The achievable CO₂-emission reductions in the energy system as a whole and in particular in the combined heat and power sector are substantial in the strategies analysed. In the year 2030, CO₂-emissions from the power/CHP sector are reduced by approx. 85% and 88% in strategies S1 and S2, and 100% in S3 relative to the 1992 level. For the energy system as a whole in the year 2030 the emissions are reduced by 60-70%, which also includes the effects of energy conservation measures outside the CHP-sector in "The Green Society".

A main conclusion is that it is possible to develop well-functioning power and heat supply systems in which 75-100% of the electricity supply is based on Danish renewable energy resources. However, the average production cost of electricity in the year 2030 is expected to increase from 30 to about 65% dependent on the strategy, relative to the 1992 level. The composition of the average production costs in the strategies in the year 2030 is changed towards increased investments and a reduced dependence on fuel costs.

Orkney Sustainable Energy Limited

The Orkney Islands are a part of the Scottish community. The islands have perfect conditions for using wind power as a source of electricity. But at present denationalisation of the Scottish electricity system has had the effect that renewable energy is having a bad time competing with other electricity sources such as nuclear power. However, it has been proven that new wind turbine techniques are economically viable and can therefore well allow further wind energy development.

By Richard Gauld
Orkney Sustainable Energy Limited

Historical context

The use of wind energy has a long history in Orkney Islands. The first use of wind energy was mainly to provide water for agricultural purposes. During the course of time, the gradual electrification led to the installation of diesel engines and the establishment of an island grid. As a result of the installation of the grid people moved away from using coal to electric heating. This led to the recognition that the present power station was not sufficient, which inspired the North of Scotland Hydro Board to investigate the possibilities of renewable energy. This investigation concluded that wind power was feasible and a project involving a prototype, three-bladed wind turbine was set into action. Unfortunately the project had to be curtailed because of a badly chosen site.

Later, a 3 MW wind turbine was designed which was installed at Burgar Hill in 1983. In 1987, when the wind turbine was commissioned, it had provided around 5-10% of the annual energy requirement, despite the fact that it never operated at its full potential.

In 1993, a denationalisation the electricity industry took place in Scotland and the Scottish Hydro Electric decided to stop all involvement in wind energy. At the same time an undersea cable was laid, thus connecting Orkney with the mainland of Scotland, which provided electricity.

Orkney

Presentation by:
Richard Gauld.

Size of island:
970 km².

Number of inhabitants:
21,000.

Other characteristics of the island:
Wind energy has been an important part of the Orkney economy over the last century.

Energy consumption and maybe how the consumption is covered:
120 GWh. Electricity is mainly imported from Scotland in summer, with local diesel generation in summer.

Percentage covered by RE:
A 3 MW wind turbine provides 5-10% of the electricity consumption with first class electricity - on windy days the wind turbine covers 20% of the consumption.

Potential for RE:
Feasibility studies have indicated that a rational use of renewable energy, installing wind turbines at locations with high electricity demand, may well allow further wind energy development.

Plans for exploitation of RE:
There is planning permission for a new, large machine, yet the planning officials have indicated that smaller machines would be preferred.

Special benefits/impacts/problems/ advantages from renewable energy:
Further development of wind energy on Orkney has not been successful, principally due to the recalcitrance of the public electricity supplier which favours nuclear power. There is a perception that small single machines would be of more direct value to community sustainability than larger projects. However, the present electricity trading structure in Scotland is favouring larger projects.

How is the population involved in the development of renewable energy supply?
The 3 MW machine is operated on a commercial basis by Orkney Sustainable Energy Ltd., using local companies in cases of necessary repair and maintenance.

Short conclusion:
Wind energy conversion in general has been recognised as a commercially viable mechanism for producing environmentally benign electricity. Future development indicates that wind energy conversion will continue to improve, allowing a more rational use of wind turbines to reduce energy costs in areas with high demand.

In 1992, it was discovered that the 3 MW wind turbine had a serious fatigue crack on one of the blades. This crack was so serious that it was decided to shut down the turbine.

At the AMSET centre at De Montford University in Leicester, a group of wind energy supporters decided

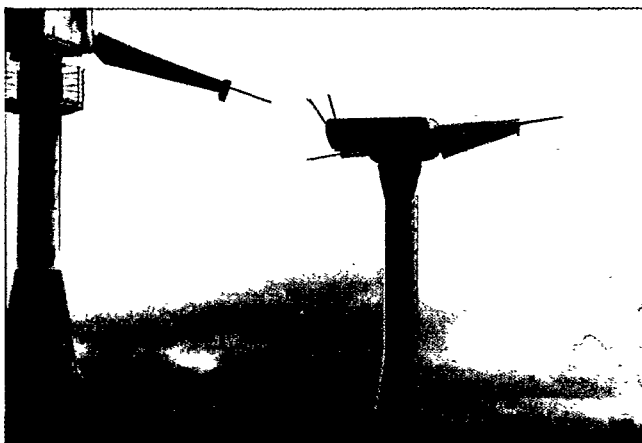
that the wind turbine was a valuable asset, which justified restoration. The repairs were completed in 1995 and were managed by Sustainable Resources Ltd. and local companies. Since then the turbine has been operated by Orkney Sustainable Energy Ltd. on a commercial basis and has produced a total of 17 GWh.

The design of the 3 MW wind turbine

The 3 MW wind turbine was designed to provide electricity for a group of isolated islands with an isolated grid. Therefore the electric power had to be of the highest standard. The turbine was designed to have a constant generator speed allowing a degree of rotor speed variability. This was achieved by using a variable speed electric rotor/generator, which drives a secondary differential gearbox. This technique has not been carried through to modern turbines because it produces excess noise and it is costly. (Recently produced wind turbines have the same advantages but have a new "gearless" system.)

The energy system of Scotland

The Scottish energy system is based upon the obligation to take the full output of the established Scottish Nuclear Plants. It is also based upon using the lowest cost of electricity and there is no obligation to pur-



The wind turbines on Bargar Hill.

chase electricity from private generators unless this is supplied at no more than the marginal cost of £0,014 per kWh. This has made it difficult for any organisation to develop compatible, renewable energy techniques. Over a 20 years lifetime period of a modern wind turbine, it will only produce electricity at a unit cost of £0,02-0,03 per kWh. This makes it difficult to sell wind-produced energy but it should be noted that the true benefit of renewable energy has been ignored.

The perspective

A feasibility study has been completed for the North of Scotland Water Authority and this has shown that smaller wind turbines in co-operation with Water Treatment Plants would reduce the amount of electricity drawn from the grid.

Wind turbines installed at sites with typical demands of 75 kW to 100 kW would have a pay back time period of seven years, which would give savings regarding electricity costs for the remaining lifetime of the turbine.

The energy development on the Orkney Islands can take two different paths. One path leads in the direction towards large turbines at central places. This would require a strong grid connection with considerable cost implications. The advantages with large, single wind turbines are the considerable energy production with minimal use of land resources.

An alternative path is smaller, decentralised turbines, which could result in an unacceptable density of wind turbines. This could result in disruption of natural fauna. With this in mind the smaller wind turbines would be easily maintained by local contractors, with a centralised storing of parts.

These are all questions for which we have no answer but at the moment there is a perception that small single turbines would be of more direct value to community sustainability.

High Penetration of Wind Energy in the Cape Verde Islands

Evidence has been provided from the operation of the wind farms on Cape Verde:

- That wind power is technically and economically feasible at the present wind energy penetration levels, which for the first 6 months of 1995 were 24%, 19% and 11% in Sal, Mindelo and Praia, respectively.
- That on average for the 3 years, 1995-97, the wind energy penetration in Mindelo has been 14% with a record high average capacity factor of the three wind turbines for the total period of 55.6%, i.e. average power output for each of the three Nordtank 300 kW wind turbines has been 167 kW.

Finally, comparison with actual data shows that modeling of power system performance with relatively high wind energy penetration is possible with acceptably low uncertainties.

By Jens Carsten Hansen
Risø National Laboratory

Cape Verde has wind energy resources from the trade-winds providing a strong northeasterly flow for most of the year. Wind turbine technology enables extraction of energy from the wind for conversion into electricity. The potential and feasibility depends on choice of technology, siting and design of wind farms and of the integration and operation of the wind farms in the power system. Projects since the early 1980s have documented the technical and economic feasibility of today's wind energy technology for Cape Verde. Three wind farms were installed in the main power systems of Cape Verde in 1994. A significant fraction of the electricity consumed is now produced from the wind. (Modeling has shown that further expansion of these wind farms is technically possible and economically attractive for Cape Verde.)

Step 1 Wind Farm - 2.4 MW - 15% wind energy penetration

On Cape Verde, electric power has until recently been

Cape Verde Islands

Presentation by:
Jens Carsten Hansen.

Size of island:
4.033 km².

Number of inhabitants:
400.000.

Other characteristics of the island:
Situated far from the mainland. One of the poorest countries in the world. No reservoirs of fossil fuels.

Energy consumption and maybe how the consumption is covered:
Electricity consumption used to be covered by diesel power stations using gasoil and heavy fuel. Now there are also wind turbines corresponding to 2.4 MW.

Percentage covered by RE:
10% wind energy penetration.

Potential for RE:
Excellent conditions for solar and wind energy. Strong wind for most of the year means that expansion of wind energy to 40-50% could be profitable. The mean solar insolation is 5,4 kWh/m²/day.

Plans for exploitation of RE:
The government of Cape Verde is pursuing initiatives to develop the use of renewable energy sources.

How is the population involved in the development of renewable energy supply?
The small size of the archipelago may foster a distinct feeling of identity among the population and creates the right environment for spurring self-sufficiency.

almost entirely supplied from diesel power stations using gasoil and heavy fuel. This situation changed in 1994 when wind farms with a total capacity of 2.4 MW (called the Step 1 Wind Farms) were installed at the three major island grids as part of a project jointly funded by the Capeverdean and the Danish governments. The fraction of the total electricity consumption supplied from the wind in the first year of operation, i.e. the "wind energy penetration", was 15%. The wind energy penetration from the 2.4 MW wind farms is decreasing due to the increase in consumption of electricity. The penetration levels have been achieved without any special wind farm controller except for the standard wind turbine controllers in each machine. Wind farm control actions have been manual, exercised by the diesel power plant operators.

The total technical availability has been high (92-98%), and the total duration of outages due to remote stops has been very limited. Extremely high monthly capacity factors around 70% achieved in Mindelo are surely among the highest in the world for a wind farm of standard type of wind turbines.

A conservative strategy has been applied, which ensures sufficient technical minimum load on the spinning diesel engines - i.e. 30% of nominal capacity – and initially no firm capacity by wind turbines. It has proven possible, at these wind energy penetration levels, to ensure sufficient spinning reserve capacity and at the same time acceptable operation conditions for diesel engines. At high wind energy penetration levels, some wind turbine capacity has to be shut down in periods of high wind speeds and low consumption, which is what happened particularly in Sal in 1995. No serious technical problems and black-outs have been encountered.

It is evident that at the very steady wind conditions in Cape Verde, wind farms provide a relatively reliable power.

It is also evident that wind power fluctuations decrease with increasing output power, the more wind turbines the more different the wind they work in will be.

The total annual fuel saved by the 2.4 MW Step 1 Wind Farms amounts to almost 2000 t, which has a higher value for Cape Verde than world market prices of fuel due to the high local handling costs. Fuel costs for the Power Company and for the Cape Verde so-

ciety have been found to be of the order of twice the world market price.

Feasibility study for step 2

In parallel with the construction of the 2.4 MW Step 1 Wind Farms, a feasibility study for further expansion of the wind farms with a Step 2 at Praia, Mindelo and Sal has been carried out. This feasibility study has been monitoring the implementation of the Step 1 Wind Farms, and it has measured the consequences of the introduction of this quite significant amount of wind power capacity into the power systems. Subsequently power system modeling has been carried out. Actual data available from Step 1 have been used for validation of models and assumptions as well as for generating best estimates of forecasts of consumer loads, fuel prices and power system development plans for the next 20 years. Conclusions regarding the cost-benefit are based on modeling of the power systems using the computer model WINSYS taking into consideration the performance and operational requirements of wind turbines, diesel generating sets and transmission systems as well as variations in time of consumer loads and wind power production. WINSYS is a computer model specially developed for simulating power system performance with high wind energy penetration. Validation of WINSYS has been made by comparing actual data with WINSYS modeling results for the Step 1 Wind Farms. The modeled results and actual data compare well. Deviations between model and reality in fuel savings are less than 10%. Analyses of the dynamic stability and transient behavior of the power systems have not been included in the feasibility studies, but will be necessary before any further expansion with wind power capacity.

The power systems with and without the Step 2 wind farms of varying sizes have been compared. The optimum number of Step 2 wind turbines in each of the wind farms is determined as the number resulting in the lowest levelized production cost of energy from the Step 2 Wind Farms. Optimization on cost of wind energy makes the most attractive wind farm project, but it may not be the optimum size for the society, since larger wind farms may provide further reduction in cost of energy from the entire power system. The lev-

Case Studies - Techniques

	Sal	Mindelo	Praia
Available diesel capacity (MW)	4	11	12
Disel fuel type	gas oil	heavy fuel	gas oil
Installed wind turbine capacity (kW)	600	900	900
Avg. wind speed at hubheight (m/s)	7.4	10.4	7.8
Annual wind energy production (MWh)	1440	4390	2500
Annual power system load (MWh)	10120	32800	39870
Avg. wind energy penetration (%)	14	14	6.3
Avg. wind turbine capacity factor (%)	27	56	31
Annual diesel fuel savings (t)	340	970	615

Table 1. Operation statistics for Step 1 Wind Farms at Sal, Mindelo and Praia power systems - averages for 3 years: 1995-1997.

Case Studies - Techniques

elized production cost (LPC) is the cost of one production unit (kWh) averaged over the wind farm's expected lifetime, which is determined from the results of the WINSYS modeling in accordance with the guidelines IEA. Table 2 summarizes assumptions and results for the optimum Step 2 Wind Farm capacities. It appears from Table 4 that the economic result of the proposed project becomes attractive at the given assumptions. The fuel savings alone actually are sufficient to create a positive result. In fact, the economic optimum size of wind farms for Cape Verde would be larger than the proposed wind farm sizes for Step 2.

	Praia	Mindelo	Sal
Step 2 Wind Farm capacity (kW)	1800	1200	600
Potential energy output (MWh/y)	5350	6744	1578
Annual utilized energy (MWh/y)	4777	5863	1440
Wind farm investment (DKK/kW)	5800	5800	5800
Other investments (DKK/kW)	2817	3067	2767
Total investment (DKK/kW)	8617	8867	8567
O&M (% of wind farm investment)	2.5	2.5	2.5
Retrofit cost (% of wind farm investment)	10	10	10
Salvage value (% of wind farm investment)	0	0	0
Capacity credit (%)	24	44	18
Annual fuel savings (ton/y)	1046	1331	306
Diesel plant operation time savings (h/y)	282	1306	82
Levelized production costs (DKK/kWh)	0.40	0.22	0.43

Table 2 Summary of assumptions and results of WINSYS modeling for power system operation with Step 2 Wind Farms.

Environmental impact of wind farms in Cape Verde is mainly the reduced pollution and emissions. The estimated annual emission savings due to the Step 2 Wind Farms are shown in Table 3. (The emission factors used are obtained from CORE Environmental Data Base by SEI/UNEP.)

	Praia	Mindelo	Sal
Step 2 Wind Farm capacity (kW)	1800	1200	600
Annual fuel savings (ton/y)	1046	1331	306
Annual CO ₂ savings (ton/y)	3138	3993	918
Annual SO ₂ savings (ton/y)	63	80	1
Annual NO _x savings (ton/y)	63	80	18

Table 3 Estimated annual reduction in CO₂, SO₂ and NO_x emissions due to Step 2 Wind Farms.

Possibilities for replication of the Cape Verde experience

On basis of two case studies there is good reason to believe that wind farm projects similar to those in

Cape Verde may be feasible in Kupang and Rarotonga. A condition for the feasibility is that real world market value of diesel fuel is assumed by the Governments and used in the feasibility analysis. However, wind measurements on the sites are necessary to determine the actual wind resource. Keeping the uncertainties in mind, it is interesting to note that Rarotonga and Kupang are in areas of the globe, which traditionally have been considered low-wind areas. However, in some such places topographic features may be found creating locally sufficient wind resources to make wind power feasible, provided that the local cost of conventional electricity generation is high.

Conclusions

Accurate power system modeling at conservative assumptions shows good prospects for expanding the Step 1 Wind Farms at Cape Verde with a Step 2. The Step 2 Wind Farm sizes giving the least cost of energy have at the given assumptions been determined to be 1.8 MW at Praia, 1.2 MW at Mindelo and 0.6 MW at Sal - giving a wind energy penetration of 25-30% in the first year of operation. Implementation of these three wind farms will reduce Cape Verde's dependence on imported fuel oil significantly and contribute to reducing the cost of electricity in the country. The project will serve as a demonstration showing that power systems may be expanded with wind energy up to significant penetration levels without adding expensive control systems and without jeopardizing power system reliability.

Although the environmental impact is small on a global scale, it should be included in evaluation of each project. The proposed internalization of the external savings due to environmental benefits which improve the economics of the proposed project by 40%, measured as the increase of the project's internal rate of return when including external environmental savings of 0.10 DKK/kWh.

It is seen from the results of the economic analysis, that the optimum wind farm sizes for Cape Verde are even larger than the proposed sizes. Due to the lack of international experience with wind energy at these high penetration levels in MW size power systems, the uncertainties and project risks may seem too high for

commercial investors. However, in view of the international need for such a pilot and demonstration project, attempts should be considered to attract funding from international organizations.

Finally, examples have been described showing that numerous island power systems exist world wide, which are similar to the Cape Verdean systems with

relatively high costs of conventional electricity generation and sites with sufficiently favorable wind conditions to make wind power feasible. Keeping the uncertainties of these preliminary studies in mind, it has been found that even in areas, which traditionally have been considered low-wind areas, locally sufficient wind resources may be found to make wind power feasible.



Extremely high capacity factors around 70% achieved in Mindelo are surely among the highest in the world.

Electric Vehicles in Remote Areas

The transport sector is in general a sector with increasing energy consumption. This is definitely also the case on many islands, because a lot of the transport is required just to come to and from the mainland - and besides this, collective transport is often not so well developed on the islands. Electrical vehicles can be a tool to reduce energy consumption in the transport sector for two reasons: 1) Electrical vehicles are very energy-efficient 2) The electricity can be generated from renewable energy. And with a range of approx. 100 km, modern electrical vehicles do not demand a lot of charging possibilities.

By Sigrid Kleindienst Muntwyler
Engineer's Office Muntwyler

Electrical vehicles are a wide concept which ranges from what is almost a bicycle with an auxiliary motor, to very advanced, comfortable vehicles. Switzerland is far ahead in experiments with electrical vehicles, as well as planning and siting re-charging stations and the introduction of petrol-free areas for the benefit of the local environment.

Electric vehicles (EVs) are more and more an option for application niches worldwide. In Switzerland, the idea of electric vehicles was influenced by the worldwide first solar-mobile race, the "Tour de Sol", which was run between 1985 and 1993. This race convinced the Swiss public as well as the Swiss government that the idea of highly efficient, non-polluting vehicles was realistic, and that, with some promotion, this vehicle could become a real alternative to conventional internal combustion engine (ICE) cars.

Increasing energy consumption in transport sector

The idea gained even more stringency due to the Swiss clean air act which was implemented in 1986 with the goal of reducing the emissions of air pollutants to the level of 1960 by 1995. These measures

Electrical vehicles driven by renewable energy link two technologies, so that they form a synthesis for the benefit of the environment.

The efficiency of EVs is high. Therefore EVs are ideal consumers even for alternative energies where the efficiency is low (e.g. photovoltaics with about 10%) and the costs are high.

Electrical vehicle: 2-seater consumes 10 kWh per 100 km.
Combustion car: 2-seater consumes 50 kWh per 100 km.

have been successful, at least to level down most of the harmful substances, with the exception of the CO₂ emissions, above all caused by the ICE traffic. The second impetus came from the national campaign "Energy 2000" which had the goal of reducing the overall energy consumption and to provide the annual increase of energy consumption by renewable energies. Evaluations of the energy consumers revealed that the transport sector was the only one in which the energy consumption was still increasing.

The Swiss Federal Office of Energy therefore decided to launch a promotion programme "Lightweight Vehicles" (among many others, a programme striving for the reduction of fuel consumption of conventional cars). "Lightweight" in this case is defined via the energy consumption of the vehicles. The goal is an average consumption of 7 kWh/100 km for two-seaters and about 10 kWh/100 km for four-seaters. This goal is achievable. Swiss prototypes have already achieved these values, and production vehicles are very close. The TWIKE (a two-seater) consumes 10 kWh/100 km, lightweight four-wheelers (Ligier Ambra, Microcar) have consumption rates between 14 and 16 kWh/100 km. Thanks to the efforts of the Federal Office of Energy, Swiss people are looking at electric vehicles as an option for meeting their mobility needs.

Electrical vehicles - first generation



Danish "city-el": about 1100 items sold in Switzerland.



Swiss TWIKE: more than 250 items sold.

Three generations

The great market success of small, purpose-designed, first generation EVs such as the Danish "city-el" or the Swiss "TWIKE" is due to their image as "Solar-mobiles". Their features are low vehicle weight, one or two seats, low energy consumption rates and a new design combined with a new "mobility philosophy" (driving for fun without a bad conscience). On the other hand, this fact also consolidates the idea of a vehicle being less safe, having insufficient range and being a plaything for specialists. The Swiss EV promoters are therefore making great efforts to spread information about EVs of the "second generation" (e.g. EVs from the French car industry) or even the "third generation" (such as, for example, the Japanese vehicles like Honda EV Plus). These vehicles are fitted with advanced batteries (NiCd or NiMH, NaNiCl or even Li-ion) allowing ranges from 100 km and up-

wards. The Citroën "Saxo électrique" is a good example of an electric vehicle of the "second generation". It is fitted with an 11 kW DC motor (maximum power 20 kW), a NiCd battery with a capacity of 100 Ah and an on-board charger. This enables a maximum speed of 90 km/h and a range of 75 km (CEN TC 301 standard). Its energy consumption is 20 kWh/100 km (standard measuring of the Automotive Department of the Biel Technical College using a modified ECE cycle). This is more than enough for the "average car user" driving less than 20 km per day. Potential users in remote areas have to evaluate their mobility needs more carefully, including the topography during their journeys (gradients), the climate (battery heating in winter), charging facilities on their daily routes, etc.

Safety

The question of safety is answered by a series of crash-tests with lightweight vehicles. The results of these crash tests have left their marks on Swiss prototype design and are acknowledged by the safety experts of the car industry worldwide. As regards electric vehicles of the "second generation" the safety standards for conventional cars have been maintained.



Citroën Saxo électrique: EV for everyday use.

450 recharging stations

In general, EV application is limited by the performance of the electric vehicle. This is, of course, also valid with regard to "remote areas". In Switzerland, EVs are mostly used as commuter vehicles in city agglomerations. With this application, range is no problem, and in case it is, there is a dense network of

about 450 charging possibilities, which are offered by public charging stations as well as private households, all of them listed in the so-called "LEMnet" list available for every EV user. But there is an interesting application in the so-called "Swiss car-free resorts" which certainly has some relevance for islands.

Swiss car-free resorts

"Free of cars" means the total renunciation of individual transport and the greatest possible renunciation of internal combustion engines. This is the verbatim regulation which forbids the use of ICE vehicles (with few exceptions) in nine resorts in Switzerland. This is technically made easier by the topography: "car-free" resorts are situated at the ends of valleys (e.g. Zermatt) or on plateaus which can be reached by funiculars. Most of them have never admitted ICE vehicles in their history. "Car-free" does not mean "free of traffic": electric vehicles are permitted. Nevertheless every EV user has to obtain a permit, so that no unnecessary vehicles drive around (by the way, this is also valid for horses and carts!). The application of electric vehicles in car-free resorts is specific and therefore a special vehicle type has been developed, which could be named the "Zermatt EV type". The vehicles are designed for battery exchange, the range is not the foremost consideration. They need (or even must) not be fast, as there is a general speed limit of 20 or 30 km/h. They must only have a good load capacity to transport guests and their luggage, and a hill climbing ability for gradients up to 15%. The measurements are defined (4 m length maximum, 1.4 m width maximum) as well as the design ("no futuristic design"). The types most often used are constructed by local car electricians or manufacturers specialized in electrical commercial vehicles such as lift-trucks, small tippers or platform vehicles.

Mountain Cars

The special Zermatt electrical vehicles for mountain driving are fitted with DC drives of between 24 and 48V and about 10 kW rating, mostly split up in two motors. Four-wheel drives are a necessity as well as independent suspension. The lead-acid batteries are built in a trough to make it easier to change the battery set. The

battery capacities are between 18 and 35 kWh, mostly 20 kWh. The vehicles do not have on-board chargers, they are recharged by external chargers in special stations which, of course, results in a more elaborate procedure. Especially taxis need 2-3 battery sets per day. The "insular" solution of the car-free resorts has its price: the "Zermatt EV type" costs between CHF 75,000 and 90,000. (40,000 - 48,000 ECU).

EVs in "well-defined areas"

"Remote" in the sense of a "well defined area" has also been one of the evaluation points for the selection of the test municipality for the Swiss EV fleet test. The so called "Large Scale Test for Lightweight Electric Vehicles" takes place in Mendrisio, a small community in the Ticino. The lake "Lago di Lugano" and foothills of the Alps form the boundary of the plain in which Mendrisio is situated. This enables a clear identification of the daily trips of the test drivers and a defined base for evaluation of the energy consumption. By the way, it is obvious that islands with well defined extensions are a perfect test field. Rügen (almost an island) for the German field test and Jersey as the European test area of the Toyota RAV4 EV prove this assumption.

Very Energy efficient

In the context of "clean islands" the question of the energy source for electric vehicles is of some importance. The electrical vehicle in principle surpasses the internal combustion vehicle by far as regards energy efficiency. The transformation efficiency of an EV is about 75-80% and this means that 75-80% of the power goes to the drive wheel (whereas ICE vehicles with about 15% are rolling heating). EVs are therefore ideal consumers even for alternative energies where the efficiency is low (e.g. photovoltaics with about 10%) and the costs are high. The Austrian supplier "Oberösterreichische Kraftwerke" has evaluated the possible driving distances per month by only consuming PV energy produced by a 30 kW PV plant. The vehicle is a company electric vehicle with already "pre-historic technology", a FIAT Panda elettrica consuming on average 35 kWh/100 km. The mileage could be doubled by using a highly efficient lightweight electrical vehicle and advanced technology.

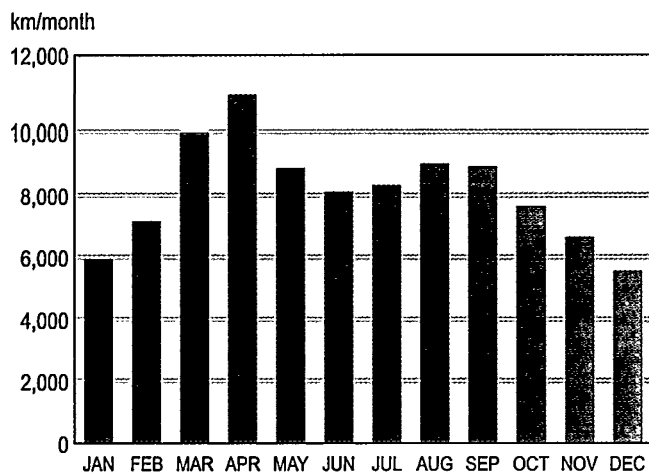


Table 1. Mileage attainable for EVs using PV current.

Calculations made in the context of the Tour de Sol proved that a 3 kWp PV installation produces the energy for an annual mileage of 15,000–18,000 km for an electrical vehicle consuming 25 kWh/100 km. Of course the question of the energy consumption is qualified when taking the primary energy into account. Nevertheless, it is possible to calculate with a factor four when comparing electrical and internal combustion engine vehicles.

Emissions

In Switzerland, the question of the energy source for electric vehicles and the effects on the air pollution has been investigated by the Institut für Energie- und Umweltforschung (IfEU) in Heidelberg, by order of the Swiss Federal Office of Energy. The study is a con-

tinuation of the evaluation of the electrical vehicles used in the e-mobile-test on Rügen. The energy mix of Germany, Switzerland and the European UCPTE serve as a base for the calculations. The IfEU distinguishes between emissions with local (SO₂, CO, NO_x), regional (SO₂, NO_x, NMHC) and global effects (CO₂ and primary energy). The result is, that EVs produce no local emissions. As regards the regional and global effects, electric vehicles cause more SO₂ emissions than ICEVs because of the metal processing (especially of Cadmium) for the batteries.

A 3 kW Photo Voltaic plant can supply 10 cars driving 1000 km per month, even in the winter.

Conclusions

Mobility for renewable energy islands is a matter of linking existing technologies (e.g. available electrical vehicles and renewable energies) and a matter of extensive planning, including individual mobility needs and the infrastructure meeting these needs. Switzerland can serve as a model for some aspects (as, for example, car-free resorts, the implementation of Government EV promotion etc). Switzerland also is interested in making the results of research available within the framework of the "Large Scale Test with Lightweight Electric Vehicles in Mendrisio". This concerns questions regarding EV technology, acceptance and mobility as well as the complex of energy consumption and effects on the air pollution.

Renewable Energy on Two Greek Islands: Arki and Crete

J. Plessner Marliani: Changes can be expected if the Public Power Corporation allows a higher percentage of renewable energy generation.

C. Helmis: The law on electricity generation which enables independent and self-sufficient auto-producers to exploit renewables for the generation of electricity.

By
C. G. Helmis (Arki Island)
CRES
&
Johannes Plessner-Marliani (Western Crete)
Solar Institut Jülich

On West Crete, Johannes Plessner Marliani is project-appointed at C.A.R.E., a centre for renewable energy which has been set up by the German Solar Research Institute, Jülich. The centre is focussing on renewable energy accessories for the agricultural sector. The photovoltaic cells have proved to be 22% cheaper than a connection to the electricity grid.

C. G. Helmis, Vice Director, CRES, Centre for Renewable Energy Sources - the Greek national body for the promotion of renewable energy sources.

Energy supply in Greece

The current Greek energy consumption in 1996 was equivalent to 295 TWh with an annual growth of 1.4% per year. The major energy source is the recently introduced natural gas. Some 5.4% of the total consumption comprised renewable resources, which are mostly based on biomass from forests (64%). Hydro-electric power has contributed with approximately 27% and the rest - 9% - comes from wind, solar heat and geothermal energy.

The case of Arki Island

The Island of Arki is a very small island with a population of 50 people in wintertime and 200 people in summer time. The island has been chosen to be a pilot

Arki Island

By:
C. G. Helmis.

Number of inhabitants:
50 (200 in summer).

Percentage covered by RE:
There is a 27 kWp PV-plant in connection with a 100 kVA diesel generator.

Potential for RE:
High wind resources (and good solar conditions).

Plans for exploitation of RE:
The PV plant is going to be expanded to 37 kWp.

How is the population involved in the development of renewable energy supply?
The population is not involved.

Minimization of the diesel consumption is a must as independence from fossil fuels is a requirement due to the remoteness of the area, high transportation costs and the environmental factors. Photovoltaics provide reliable power supply in remote communities. Due to the PV-project, the inhabitants have increased their income, and tourist activities, etc have increasing trends as the island becomes famous.

The project is replicable as there are more than 200 islands in Greece of about the same size and population as Arki.

Due to topology in certain (distant) areas PV-plants are economically viable.

Tools for implementation of RE in Greece are :
Legislation regarding electricity generation which enables independent bodies to exploit renewables for the generation of electricity.

project island for further development of renewable energy supply. CRES have been chosen to conduct the project. The reason for selecting Arki Island is because of the existence of a 27.5 kWp hybrid station in connection with a 100 kVA diesel generator. This system is planned to be expanded to 37.5 kWp. Because of the size of the island it is a must to minimise the diesel consumption.

The case of Crete - mainly Western Crete

The economic situation in Western Crete is characterised by two main sectors, agriculture and tourism. The development during recent years has been such that, even though Crete has a favourable climate for agricultural products like olive oil and wine of high quality, there has been migration from the rural areas to the

Western Crete, Greece

Presentation by:
Johannes Plettner-Marliani.

Energy consumption and maybe how the consumption is covered:
1260 GWh by steampower, gas and diesel generators.

Percentage covered by RE:
Hot water systems for households: 20% of the households are equipped with these systems. Electricity production: 16,6 MW wind converters are working, percentages on overall electricity is not available. Future plans: 5 MW PV Amoco/Enron, 52 MW Solar thermal Pilkington, 90 MW wind converters.

Other characteristics of the island:
High seasonal peaks. Unreliable power supply. Agriculture and tourism are dominating.

Potential for RE:
There is a relatively large solar and wind potential (8-9 m/s).

Plans for exploitation of RE:
Efficient waste water treatment; evaluation of benefits for farmers to rent out their land to wind farms, co-generation of electricity and heat; desalination plants. 90 MW wind power will be realised on Eastern Crete. 220 MW is proposed.

Special problems/benefits:
Public Power Corporation does not allow a high percentage of renewable energy. Population can benefit from energy for special applications such as cooling, refining of products, energy for water supply, PV for remote houses, TV-receiver/transmitter. Exploitation of renewable energies can facilitate and enable economic activities in agriculture and tourism, partly by leading to further infra-structure on the island. Integrated concepts are necessary for the realisation of real improvement.

Short conclusion:
Exploitation of various forms of renewable energy can facilitate and enable economic activities in agriculture and tourism, partly by leading to further infrastructure on the island. Integrated concepts are necessary for the realisation of real improvement.

cities. This migration has taken place because of lower living standards and income in the rural areas. In the cities, the tourism activities bring economic benefits.

Two main natural resources are necessary for activities in the sectors of agriculture and tourism: energy and water. In agriculture, water is often not available and agricultural activities are often far away from the electricity grid. Furthermore, the quality of the electricity supply is often very bad or insufficient - and this fact has a bad influence on the tourist sector.

Renewables on Crete - mainly Eastern Crete

The electrical energy supply on Crete is based upon two main production places. The electrical energy system is mainly generated by steam power units (60%), gas turbines (21%) and diesel generators (19%).

Overall, renewable energy plays a minor role. On Eastern Crete there are 6.6 MW of installed wind power - but the potential is very large, and 90 MW of wind power are going to be established. Also within solar energy, Eastern Crete is in front with a 52 MW solar thermal plant and a 50 MW photovoltaic plant - the largest in the world.

Solar collectors are very common for heating water, and on Western Crete about 20% of the households have solar collectors. These collectors are mainly produced and installed by local companies.

Renewable energy resources in agriculture and the tourism sector

The use of renewable energy in agricultural activities can usually be a cost-effective solution. In 1997, the Centre for the Application of Renewable Energies (C.A.R.E.) was initiated in order to find solutions for specific problems in agriculture. The C.A.R.E. centre came up with the following examples of solutions:

- Photovoltaic, energy-supplied cooling storage which allows the farmers to store their products locally.
- Photovoltaic or wind-powered electricity for supplying television receivers/transmitters. This allows the transmission of television signals to remote areas where establishment of a power grid would be very expensive.
- Re-use of treated waste water for irrigation purposes by the use of photovoltaic energy.
- Thermal energy derived from bio-gas production from whey is used to run a new dairy and cheese production at C.A.R.E.
- Installation of a treatment plant for olive oil, waste water and an energetically optimised waste water treatment plant for human waste water with bio-gas production for self-sufficient energy supply.
- Evaluation of the benefits for farmers who want to rent out their land for wind farms.

In the tourist sector it is important to have a reliable energy supply of high standard. Installation of wind farms could give this supply, and in low consumption periods the generated power could be used to produce fresh water. Furthermore, excess heat from, for

example, food cooling could be used for purposes where heat is required. For example, at archaeological sites renewable energy as well as photovoltaic energy could be used as an energy supply, which could bring development and accessibility for tourists. This could lead to the creation of more jobs in rural areas.

An advantage for welfare and well-being

The aforementioned is just one of the few examples that renewable energy will be able to “give a lift” to the two main trades: agriculture and tourism due, amongst other things, to the infrastructure which follows along. But, first and foremost, renewable energy will be able to contribute towards improving the present unstable and scant energy supply - and this, in itself, will be a great advantage for the well-being of the population

and the possibilities in most of the trades and businesses. The lack of water and electricity is, as already mentioned, a serious disincentive for both tourism and agriculture.

The population can benefit from energy for special applications such as cooling, refining of products, energy for water supply, PV for remote houses and TV-receivers/transmitters.

The changes towards the use of renewable resources are only possible on a large scale if the Public Power Corporation allows a higher percentages of renewable energy. Further development and demonstration have to be carried out as regards small applications of renewable energy in rural development, which also involve information and education.



Solar collectors are very common for heating water, and on Western Crete about 20% of the households have solar collectors.

Ærø, Denmark

On Ærø we have worked with renewable energy since the early 1980s, and it was therefore natural that Ærø took part in the competition about being the 100% RE Island. Although Ærø did not achieve the honour of being the Danish 100% RE Island the work continues with the goal of 100% RE. What we intend to put into practice first is: wind to cover 100% of the electricity consumption, three district heating plants, neighbourhood heating including solar heating, increasing the amount of biomass and finally energy savings.

By Ide Seidelin
Ærø Energy and Environment Office

Ærø

The island of Ærø is situated in the Southern archipelago of Denmark, with 7,600 inhabitants and an area 90 km². We get our income from tourism (300,000 visitors per year), agriculture (high milk-production), seamen and craftsmen working all over the world, shipbuilding, and schools for young people (the Danish speciality: "folkehøjskoler" or "folk high schools").

The History

Ærø is a good example of how the development and implementation of RE have taken place in rural districts. We have been working with RE since the beginning of the 1980s when enthusiasts developed solar collectors in a garage and the local blacksmiths took part in building wind turbines.

At the end of the 1980s we came into the second phase as RE-technologies became more and more developed. This phase we could call the information-phase where information to the consumers and the authorities was the most important part of the job. Example:

- Local blacksmiths had to learn about RE: how to install solar collectors and how to sell them.
- Information aimed at the consumers: what is solar heating and where to buy it.

Ærø

Presentation by:
Ide Seidelin.

Size of island:
90 km².

Number of inhabitants:
7.600.

Other characteristics of the island:
Rich farmland, flat open country, no forests, good wind conditions, 3 small towns.

Energy consumption:
Electricity plus heating was in 1996 184000 MWh. RE-installations: 15% of the total energy production came from RE-sources in 1996. Ærø is grid-connected to the mainland (electricity supply).

Potential for RE:
80-100% estimated.

Plans for exploitation of RE:
Ærø som Vedvarende Energi Ø, forprojekt (100% RE-Island, 1996, report only in Danish).
Sustainable Energy on Ærø, april 1998 (newsletter in English and Danish).

Special benefits:
Local jobs, improved local economy, development in rural district, "green island" image.

Problems:
Restrictions on using coastal land for energy plants and energy crops.
Lack of biomass.

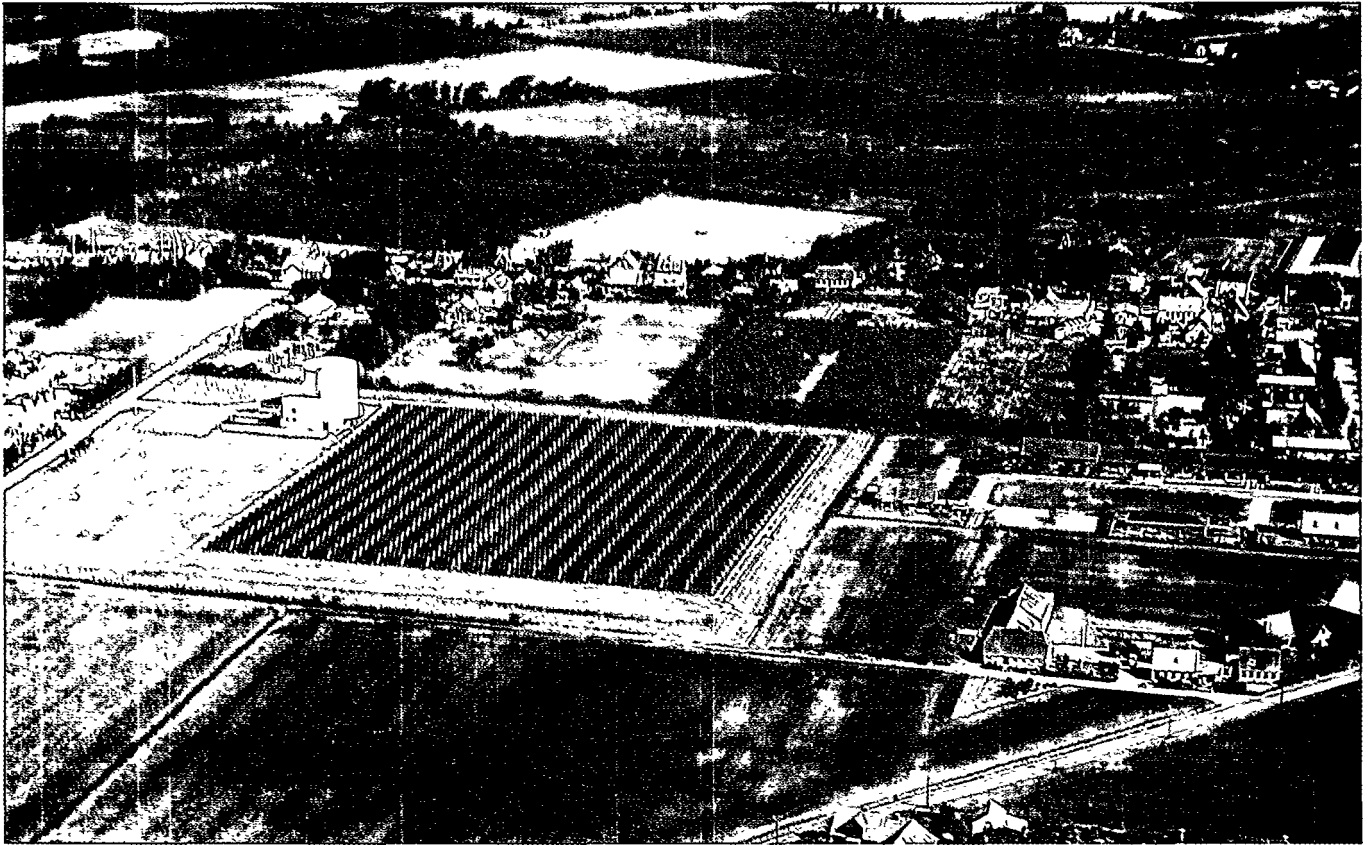
The population:
The local RE-Organisation represents all political parties and groups interested in preserving energy.
The RE-Organisation invites people to join discussions and groups when concrete actions are to be taken.
The consumers own the district heating systems, the utility and the windmills.

Short conclusion
Ærø is heading for 100% RE.

With the RE Island Initiative we must say we are on the doorstep to a third phase - we might call it a phase of implementation. This RE Island Initiative is rather unique as politicians in the government as well as on a local level have, for the first time, decided to implement RE on a large scale.

100% RE Island - on Ærø

Ærø took part in the competition of being the 100% RE Island. And during that process the RE Organisation Ærø was formed. The members are:



Marstal has the World's largest solar heating system.

- The Mayors of the two municipalities
- The Chairman of the local Farmers Association
- The Chairman of the local Electricity Utility Company
- The Managers of the two District Heating Companies
- The Chairman of the Energy and Environment Office (NGO)

The RE Organisation was behind a report like the one made for Samsø. The Ærø-report was carried out by two Danish companies, Rambøll and Plan Energy.

The report is not available in English. In order to get from 15% RE to 100% RE you have to read the headlines in the brochure "Sustainable Energy on Ærø". Although Ærø did not achieve the honour of being the Danish 100% RE Island, the work is continuing with the goal of 100% RE.

The Danish Energy Agency has financed my job for a period of six months. During that period we shall work

on a plan of action. Where to start and the selection of participants.

We have not finished that work, but what we *intend to put into practice first is:*

Wind

Our 22 old wind turbines cover 12-13% of the electricity requirement. During the coming years they should be replaced with fewer and bigger wind turbines up to max. 100% of our consumption. We have no plans for off-shore wind turbines. The owners will be private as well as shareholders in a mixture of private, district heating plants, and the municipalities. The local utility company will sell and buy shares in a buffer function.

District heating

There are three small towns which are big enough for the supply of district heating. Two of the plants are already established.

Ærøskøbing

520 consumers. Existing straw-fired boiler which covers about 80% of the demand. Besides which they own three of the 22 wind turbines. Future plans: a thermal solar plant with an area of 4,500 m² which will cover 15% of the consumption. About 2,000 m² will be operational in the autumn.

Marstal

1,150 consumers. Existing boiler fuelled by waste oil. Marstal also has the world's largest thermal solar heating system covering 8,000 m² and producing about 13% of the consumption. The 13% is equal to the need during the summer months. At present, they are working on the construction of a smaller seasonal, underground storage. If it proves to be possible to store solar heat during a longer period, the plan is to increase the solar plant to cover 50% of the district heating.

Søby

380 consumers. New plant to be built. The idea is 40% solar heating and a boiler fuelled by wood chips or straw. A group of citizens has formed an initiative-group. Recently, we were on a trip to Northern Jutland to visit biomass plants and a manufacturer of solar plants. The next step is to make the first calculations in cooperation with a consultant. This pre-design-work will be presented at a public meeting in the autumn. After the meeting a decision will be taken whether to go ahead with the project or to drop it.

Neighbourhood heating

A smaller project where one of the municipalities has taken the initiative. The plant will supply some bigger buildings and 20 private houses. The idea is 75% solar heating and 25% wood pellets. The plans will be presented for the people in the area in August when we will hear their opinion of the project.

Why solar heating?

There are several reasons for these initiatives with a high percentage of solar energy.

- 1) The plant in Marstal is technically and economically a success.

- 2) The people on Ærø are very proud of the plant in Marstal - they feel they are a part of the success themselves. So that is a way to follow.
- 3) On one square metre you can produce 100 kWh by solar heat or on one square metre you can produce 5 kWh by biomass.
So if the storage problems in solar plants could be solved, solar heat is to be preferred for obvious reasons.
- 4) The island is bare. There are only a few hectares of forests, and trees in one row along the fields. The soil is rich, so the farmers have ploughed their fields right down to the coastal line with only a few metres left for nature.
The surplus of straw is already being used in boilers. Energy prices for energy crops are not competitive with the prices for wheat or barley.
Conclusion: we have a lack of biomass. To work out how to deal with that is a real challenge for us.

Increasing the amount of biomass

Test project in cooperation with farmers: energy obtained from cutting down hedges (and planting new and better ones).

Other project ideas for the future could be:

- Energy crops on land owned by the municipality.
- Wood from waste: increasing amounts in refuse from private households.
- Planting new forests or energy crops on sites where the preservation of groundwater is necessary due to pollution with pesticides or fertilizers.

Energy savings

The more you reduce the energy demand the less land is occupied with wind turbines, photovoltaics and thermal solar plants:

- During the coming years our energy advisor plans to visit the private households.
- Information will be given to small enterprises, hotels etc. (Energy savings in businesses are supported financially by the government).
- Training of salesmen and craftsmen.

The open land problem

Individually heated houses and farms:

- Many people have to act individually and at the same time
- Organisation is therefore needed

In the coming years we shall try to develop new organisations.

Other motivations

Implementation of RE with the reduction of CO₂, SO₂ and NO_x is of course a goal. Other important motivations to join the 100% RE Island project are:

Local employment:

- Turning “black” jobs into “green” jobs.

- A few new jobs in the long term (operating plants and collecting biomass)
- More energy savings give more jobs over a period
- Energy tourism (“quality-tourism”)

Economy:

- The payment for heat and electricity remains in circulation on the island
- Extension of wind turbine power is an extension of economy

Development:

- Being in front of RE-development gives the opportunity of having attractive jobs and exchange of experiences with people in other parts of Denmark as well as with other countries.

Green Image

- RE is a part of a development towards “Green Island” and should be coordinated with local farmers’ plans of a “100% Organic Island”.



In Ærøskøbing the strawfired boiler covers 80% of the heating demand.

Renewable Energy Plan for the Island of Minorca

The Island of Minorca is a small island with 65,000 inhabitants. The protected areas of Minorca occupy 46% of the land and in 1993 UNESCO declared Minorca as a Biosphere Reserve. With this declaration Minorca was converted into an international reference for sustainable development. This led to the formation of a Sustainable Development Plan, which also included a renewable energy plan. This plan involved the formation of a management body to promote and accelerate the implementation of renewable energy. The primary aims are wind power and solar energy.

By Cipriano Marin
International Scientific Council for Island Development (INSULA)

Presentation of Minorca

The Island of Minorca has 65,000 inhabitants, its area is 720 km² and the main economical interest is tourism. Minorca receives more than one million tourists per year which is a challenge for sustainable development. In 1993, UNESCO declared Minorca as a Biosphere Reserve, which converted Minorca into an international reference for sustainable development. The consequence of this nomination was the establishment of a Sustainable Development Plan with aims on medium and long terms. One of the elements of the plan was the Renewable Energy Plan, which marked the line of energy actions to be taken.

A plan of this kind is relevant in perspective to more than 500 inhabited islands in Europe with more than 14 million citizens. This relevance is even highlighted in the European Commission's White Paper on renewable energy resources, the United Nations Conference on Island and Small Island States and the 1st European Conference on Island Sustainable Development, which gives the principles that inspired the plan.

The objects of the plan

The Renewable Energy Plan for the island of Minorca has first of all agreed on the following objectives:

Minorca Island

Presentation by:
Cipriano Marin.

Size of island:
720 km².

Number of inhabitants:
65,000 inhabitants.

Other characteristics of the island:

The economic activity of Minorca is concentrated on tourist activity. In 1993, UNESCO declared Minorca a Biosphere Reserve, which has converted the island into an international reference for sustainable development.

Energy consumption and maybe how the consumption is covered:
Primary energy consumption is 1,4 TWh per year. The production of electricity is about 0,6 TWh.

Percentage covered by RE:
Very low, about 1% of total energy consumption.

Potential for RE:
Wind: 9 MW could be established. There is a large solar energy potential.

Plans for exploitation of RE:
Plans for exploitation of wind and solar energy. The potential for biomass energy is small due to little industrial/urban waste and difficult accessible agricultural-forest systems.

Special benefits/impacts/problems/ advantages from renewable energy:
Non-renewable energy sources must be considered as provisional solutions, inadequate to solve the long term energy problems.

Short conclusion:
It is possible and necessary to focus on renewable energy as the future energy source on Minorca. The main focus should be upon wind and solar energy, which should be promoted by a legal body created by the Consell Insular de Minora, INSULA and UNESCO.

- Identification of the amount of sources of renewable resources to mobilise
- Identification of the economic and technical potential to develop
- First forecast of the degree of mobilisation and the interest of the actors concerned
- Identification of political priorities for renewables in the context of island sustainable development

Different aspects have been considered concerning the possibilities and potential of the various renewable energy sources. One of the considerations is the so-called eco-dilemmas in the implementation of renewable energy technologies. The possible environ-

mental impacts caused by the incorporation of renewables have been analysed in detail. In addition, the planning criteria included the following:

- Employment creation
- Promotion of the small and medium-sized local businesses
- Qualification of the business and labour staff

The potentials of different renewable energy resources are listed as follows, where biomass has been left out because of its negligible potential:

Wind energy

A model has showed that the wind potential, in connection with grid stability, is 9 MW. This could be exploited with the creation of wind turbine farms based on 500-600 kW turbines.

Solar

There is at present a research programme involving a 42 kW photovoltaic solar panel but the current high cost limits the possibilities of grid connection. This is not the case if the use of photovoltaic solar panels is on a small scale, where the quality of services predominates the cost. This could be in protected areas, traditional applications for the rural world and in connection with communication.

Thermal solar energy has a large potential of 1,060 toe per year (approx. 123 Mwh per year) on the basis of a 15,100 m² solar panel. The objective is about 8,000 m² of solar panels.

Action Strategies

The strategies in the plan for using renewable energy resources on Minorca are primarily based upon the following aspects:

- Specific information to market actors
- Establishment of a service of guidance and support for renewable energies

- Support for environmental management

Furthermore, specific activities concerning the specific renewable source must be set in action.

Wind energy

Viability and environmental impact studies of sites for wind turbines

Solar energy

- Special training for thermal solar system installers
- Information and training for designers, architects and the building sector
- Making demonstration projects, which exemplify solar concepts through new public buildings
- Campaigns towards the hotel sector aiming to use solar energy
- Starting pilot projects concerning the integration of photovoltaics in, for example, traffic signs and communications

Plan Management

The management of the plan should be carried by a body created by the *Consell Insular de Minorca*. This body should promote renewable energy with support from the international organisations involved, INSULA and UNESCO.

It is the role of this body to create co-operation between public and private actors, to identify the possibilities and potentials in different sectors, to assist with technical assistance and to identify additional financial resources.

In addition to this it is the duty of this body to coordinate promotion and campaigns regarding the possibilities and prospects of renewable energy.

Furthermore, it is very important that regulatory and legal actions are taken. For example, is it important to incorporate the renewable energy concept in Minorca's institutional logo.

Future Prospects for Energy Management on EU Islands

- Islands in general have 80% dependence on imported oil products as opposed to an average 45% oil dependence on the mainland
- Transport costs are generally 60% higher in isolated areas
- Community ownership offers one of the greatest future prospects for renewable energy developments on islands
- A successful and visible project is a good tool to get the momentum for energy management going on an island
- Successful energy management often occurs where there is a forum which groups local energy developers

By John Crawford
ISLENET

Energy management. What is this term that has become increasingly fashionable in Eurospeak these days and what does it mean to the future of energy planning in islands? Perhaps the most simple definition is this; it is the integrated planning and development of energy saving and renewable energy sources. The future here is potentially bright for islands but successful energy management does not happen overnight. It is a process developed over time and a number of different stages. This article attempts to address these stages and offers positive suggestions for those islands with an interest in future development of energy management.

As we have heard on the renewable energy seminar, different islands have reached different levels of development as regards energy management. We can, however, conclude that all island authorities should consider more seriously the potential development of actions aimed at energy saving. At the same time, they could reflect, as is the case in Samsø, on an increased production of energy from locally available and sustainable sources. This may seem obvious to those living here but from the Atlantic to the Mediter-

anean and from the North Sea to the Aegean there are a number of isolated areas which could adopt a more imaginative and progressive attitude to their energy problems. The reasons are simple; global climate change debate and rising fuel prices. You only have to look at the facts. Islands in general have around 80% dependence on imported oil products as opposed to an average 45% oil dependence on the mainland and transport costs are generally 60% higher in isolated areas.

You have to start somewhere and to get the ball rolling, islands could do worse than establish a coherent policy and strategy for the development of energy management. Local authorities are best placed to promote the benefits of energy management at this level - think locally but act globally! Such a policy depends to a large extent on political commitment and authorities should adopt, where appropriate, legislation for promoting energy management actions. There is also nothing quite like a successful and visible project to get the momentum for energy management going on an island. If nothing exists locally then islanders can learn a great deal from the work of other areas which have already established projects. Networks such as ISLENET seek to encourage these practices.

Misconceptions and the lack of independent know-how are major barriers to the implementation of energy management policies, as is poor communication between local energy actors such as power companies, energy planners and local consumers of energy. To add to that, in many areas, those in favour of renewable energies are still seen as being far out ide- lists not to be trusted. A key development area therefore lies in improved public image and raising of awareness. Producers and consumers must be informed and educated so that policies have an impact. If not, the effort of producing sustainable energy policies will be wasted and the initial momentum lost.

It is worth noting that successful energy management actions often occur where there is a forum which

Case Studies - Local Aspects

groups local energy developers. Regular meetings stimulate ideas and allow people to find out what is happening in the local energy world. A forum is an excellent method of circulating ideas and information. It also provides an excellent basis for project ownership and locally owned community projects have been successful on islands like Gothland, Ærø and Bornholm. Community ownership offers one of the greatest future prospects for renewable energy developments on islands.

There is a wealth of ideas for energy management projects but coming up with sufficient finances can be prohibitive for many potential operators. It is important to make local politicians, financiers and investors more aware of the financial implications of energy management. This can help overcome the perceived weaknesses of energy saving and renewable energies such as long payback periods and risky investment. People are often unaware that given the right development climate, many energy management technologies are now commercially viable. Many EU local authorities and Member States now manage programmes which promote energy efficiency and renewable energy. The European Commission also operates several programmes which provide important incentives to energy management. SAVE, ALTENER, JOULE-THERMIE and the EC Structural Funds can provide support at different stages throughout the development cycle of energy management projects, for instance, from feasibility studies to research and development to installation itself.

At the local level, the future of successful energy management therefore lies to a great extent in the hands of local people. This means the local development of integrated planning, education and awareness campaigns, increased financial support mechanisms and the take up of concepts such as local community ownership.

On a wider scale, there looms on the horizon a great deal of EU legislation being formulated and implemented in terms of energy and environmental policy and this has a huge potential impact on the future of

islands - not all of it good. Islands are often not taken into account during the formation of legislation and this affects their ability to implement policy at a later stage as compliance with directives has a potential negative local effect. It is important, in turn, to point out that islands have been officially recognised in the EU Amsterdam Treaty as meriting special consideration and that the socio-economic status of these areas should not be further aggravated.

The EU is placing a great deal of emphasis on the development of energy and environmental policies. This includes Directives on the opening up of an internal market for electricity and gas and proposals for fiscal and taxation policies as well as environmental directives on pollutants. Surely islands represent a unique market and should be given special consideration. On a more positive note, the EU is also seeking to develop policy in areas such as energy efficiency and renewable sources where islands have a major role to play and this should be considered as a positive area for future development. The EC White paper on Renewable Energy Sources, for instance, looks to increase the market share of RES from 6-12% and has proposed the development of pilot communities around Europe under the Fifth Framework Programme. Islands take note!



It is important to point out that islands have been officially recognised in the EU Amsterdam Treaty as meriting special consideration and that the socio-economic status of these areas should not be further aggravated.

Sustainable Energy Plan for 27 Small Danish Islands - An Altener Project

Small islands and other small and isolated communities constitute special problems regarding the supply of energy. Supply routes can be long and costly to implement and operate and the demand for energy is quite small, which often results in inadequate or costly energy supply. This situation together with the increasing awareness of the environment and the steady progress in energy savings and renewable energy technologies are the justification of the project entitled: "A sustainable energy plan for the Small Danish Islands". The project identifies and recommends environmental and sustainable energy solutions for 27 small Danish islands organised in "The Danish Association of Small Islands".

The technical-economical results from the study show that a number of measures contributing to a sustainable energy supply for the small Danish Islands seem cost-effective. Most prominent are energy savings for both heat as well as electricity, grid-connected wind turbines for electricity production and collective heat supply, in decreasing order of cost-effectiveness.

The project ran from November 1995 to May 1997, and was carried out by the consultants Dansk Energi Analyse, P. A. Energy, Darup Associates with the Ærø Energy and Environment Office as project manager. The project was supported by the ALTENER programme and the Danish Energy Agency.

The islands are characterized by:

- Populations between 6-2000 people.
- No bridge-connection with the mainland.
- No local administration.
- 26 islands are connected to the electricity grid by undersea cables.
- Oil and electricity are the main heating sources. One island is connected to the gas network.
- Local RE-resources.
- Most of the islands are bare, like Ærø, and wood for wood-burning stoves has to be imported

- Some islands have a surplus of straw.
- Good wind conditions.
- 7-10% more sun than the average.

Three islands were selected as "model-islands": Bjørnø with 40 inhabitants, Aarø with 210 inhabitants, Fejø with 625 inhabitants. A study was carried out for each island, and the experiences were used as "Inspiration Brochures" for the 24 other islands.

The experiences were as follows:

- Use of energy per household is on average up to 2/3 compared to the national average - mainly due to old houses and a high capacity of freezers.
- An economically viable scope for energy conservation is limited to some electric appliances and for upgrading the insulation of the houses.
- Wind energy is apparently the only economically and financially attractive renewable energy application on a reasonably large scale.
- Bio-gas applications cannot be recommended due to insufficient scale of operation - there is too little manure to work up on the islands.
- The biomass potential is uncertain as farmers of course want to make the best commercial use of their land - energy crops are not economically viable.
- There is - among the islanders - a wish for and a will to change the energy situation towards an environmentally more sustainable state.
- The main recommendations for the islands are to start out forming "energy cooperatives" in order to learn how to cooperate in the field of energy. Obvious target areas for such cooperatives are wind turbines, energy conservation measures and biomass utilization. When the cooperative has proven itself in one area it can extend its scope of activities to more radical or difficult areas such as setting up and running a communal "district heating" system, growing energy crops, etc.

Other Initiatives



Egholm - one of the 27 small Danish islands.

- The ultimate goal could be to develop the energy cooperative into a real island-covering energy company or a joint micro utility taking care of all the energy, water, sewage, waste and other related needs on the island.

The implication on a European level is that the methodology developed in the project, as well as the concrete recommendations of the project including organisational structures, seem well suited for application

on a European level and in the context of local communities with a strong identity.

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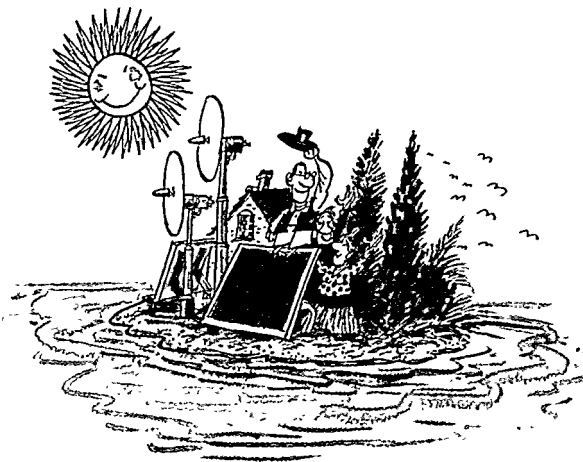
Renewable Energy on Small Islands - Worldwide

During 1997-1998, the Danish organisation Forum for Energy and Development examined the dissemination of renewable energy on some of the world's many small islands. The examination comprised 100 relevant islands with areas ranging from 600 km² to 10,000 km². The overall objective was to make a global review of renewable energy initiatives on these small islands. In April 1998, this review resulted in a report entitled "Renewable Energy on Small Islands".

THE COUNCIL FOR SUSTAINABLE ENERGY

Renewable Energy on Small Islands

April 1998



Forum for Energy and Development



The main finding of the report is that by far the majority of the world's islands are to a high degree dependent on fossil fuels for their energy supply, especially for transport and production of electricity. However, there are a number of small and medium-sized islands which get a considerable share of their energy requirements covered by renewable energy. For example, 160% of the electricity production on the German island of Pellworm (1,000 inhabitants) is covered by wind turbines and photovoltaics, and wind turbines cover 100% of the production of electricity on the Chinese island of Nan'ao (70,000 inhabitants). A further 13 islands amongst the islands examined get more than 25% of their production of electricity covered by renewable energy.

This report was drawn up at the request of the Danish Council for Sustainable Energy, an independent council which advises the Danish government and parliament in connection with the implementation of sustainable energy solutions. It is the hope of the council that this report will be instrumental in preparing for future global cooperation and networking amongst renewable energy islands.

The report can be obtained from:

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First Global Conference on Renewable Energy Islands

The first global conference on renewable energy islands is to take place 1st - 3rd September 1999 (tentatively) in Denmark. The main objectives of the conference are to exchange experiences achieved by using renewable energy resources and to create awareness of the potentials of renewable resources. Furthermore, the objective is to create a platform for future co-operation and the establishment of renewable energy island networks.

The background for the Danish Council for Sustainable Energy to take the initiative for the global conference is the governmental choice of the island Samsø to be the Danish Renewable Energy Island. The Council found that this fact could be a good platform for global cooperation including, for instance, exchange of experience, information and joint development programmes. In order to develop such an international co-operation it was decided in 1996 to work towards an international conference on renewable energy islands in 1999. A report regarding a survey of renewable energy on small islands (page 53) as well as the European renewable energy seminar held on Samsø in June 1998 (page 8) can be viewed as being a step on the way towards global cooperation.

Some 150 participants from national and local governments, NGOs, energy companies, utilities and re-

search institutions, regional and global organisations and representatives from the United Nations will be invited to the conference. International media are also expected to be present.

Themes to be discussed in plenum and in workshops are local development issues, education and awareness, local and global agendas for energy, environment and innovations, local participation and financing.

The preparation of the conference will be organised by the Forum for Energy and Development in cooperation with other agencies and companies in Denmark. The Forum for Energy and Development has wide knowledge concerning renewable energy on small islands. It has also co-operated for several years with the Alliance of Small Island States and with small islands in the Pacific Ocean.

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