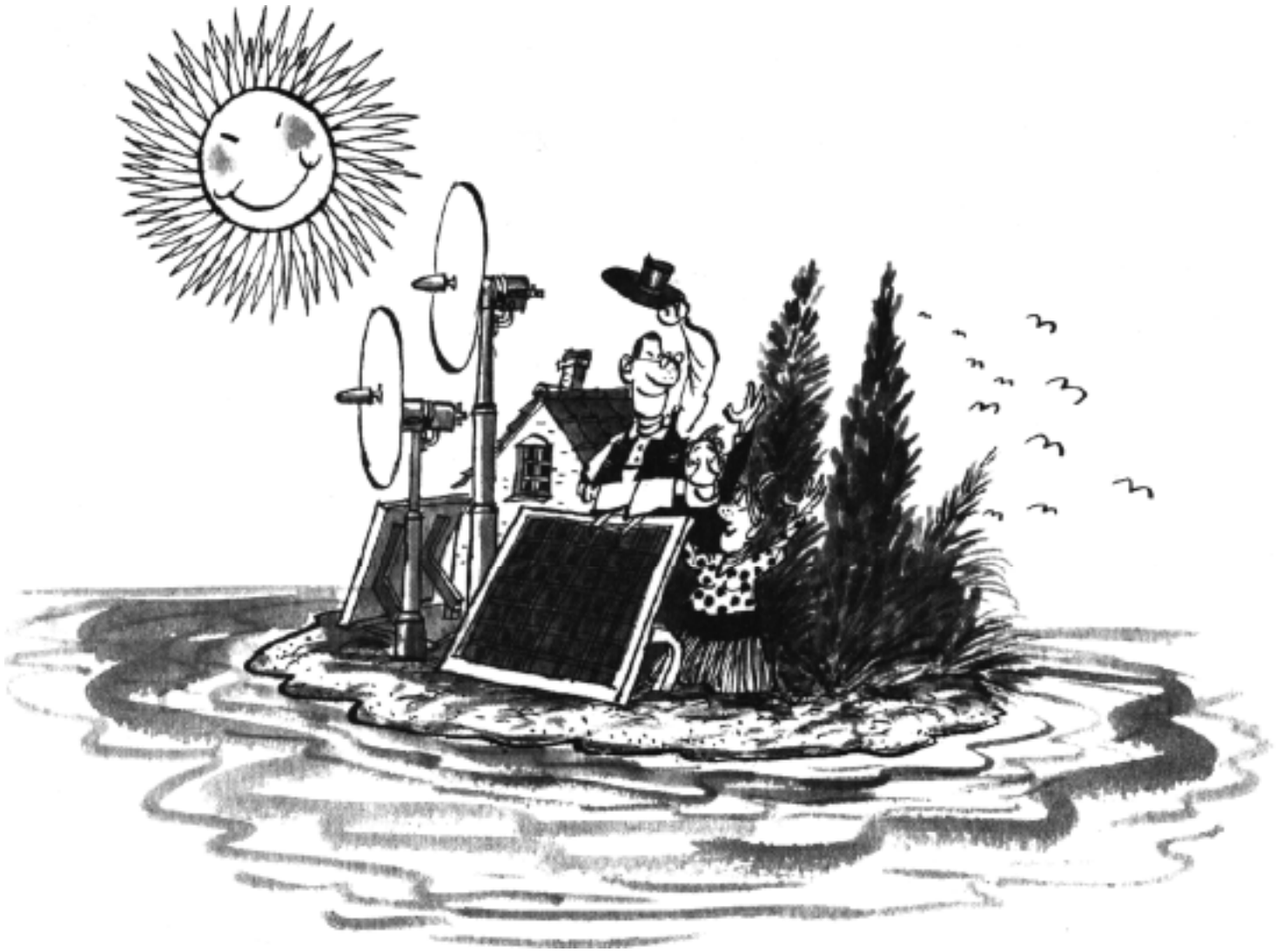
THE COUNCIL FOR SUSTAINABLE ENERGY

Renewable Energy on small Islands

April 1998



Forum for Energy and Development

Renewable Energy on Small Islands

by

Thomas Lynge Jensen
Forum for Energy and Development
Copenhagen
Denmark

Printed by
Tolvfireogtres, grafisk center

1st print, April 1998: 200 copies

ISBN: 87-90502-01-9

Table of Contents

ABBREVIATIONS 2

PREFACE ON BEHALF OF THE DANISH COUNCIL FOR SUSTAINABLE ENERGY 3

PREFACE BY THE AUTHOR 4

1 SUMMARY OF MAIN FINDINGS 5
1.1 The Island Energy Issues 5
1.2 Renewable Energy Islands 6

2 INTRODUCTION 10
2.1 Scope of Review 10
2.2 Terminology 10
2.3 Methodology 11
2.3.1 First Phase of the Review 11
2.3.2 Second Phase of the Review 11
2.4 Precautions of the Review 12
2.4.1 Regarding Reviewed Islands 12
2.4.2 Regarding Medium Islands 12
2.4.3 Regarding Perception of Renewable Energy Initiatives 12
2.4.4 Regarding Level of Detail 13
2.4.5 Regarding Information 13
2.4.6 Regarding Use of References 13
2.5 Structure of the Report 14

3 NORTH PACIFIC 15

4 SOUTH PACIFIC 41

5 THE CARIBBEAN 63

6 NORTH ATLANTIC OCEAN 89

7 SOUTH ATLANTIC OCEAN 127

8 BALTIC SEA 143

9 THE MEDITERRANEAN 165

10 THE INDIAN OCEAN 175

ANNEXES:

Annex 1 Terms of Reference (in Danish) 185
Annex 2 Main Internet Databases Used 189
Annex 3 Cover Letter and Questionnaire Used 191
Annex 4 References 197

ABBREVATIONS AND ACRONYMS

AC	alternating current
AD	anaerobic digestion
C	centigrade
CINP	Channel Islands National Park
DC	direct current
DSM	Demand Side Management
ECU	European Currency Unit
EDF	French Electricity Board
EPA	Environment Protection Agency
EU	European Union
FNQEB	Far North Queensland Electricity Corporation
GWh	gigawatt hour (one million of kilowatt-hours)
HES	Hawaii Energy Strategy
ISLENET	European Islands Energy and Environment Network
KEPCO	Korea Electric Power Corporation
km	kilometre
km2	square kilometre
kV	kilo volt
kVA	kilo volt ampere
kW	kilo watt
kWp	kilo watt peak
m2	square meter
m3	cubic metre
mph	miles per hour
MW	megawatt (1,000 kW)
MWh	megawatt hour (1,000 kWh)
NIE	Northern Ireland Electric
NGO	non-governmental organisation
NOx	nitrogen oxides
PECAN	Renewable Energy Plan of the Canaries
PV	photovoltaic
R & D	research and development
RE	renewable energy
REI	Renewable Energy Island
REP	Renewable energy plan
RES	Renewable energy sources
RET	renewable energy technologies
SOx	sulphur oxides
sqft	square feet
toe	ton of oil equivalent energy
TOR	Terms of Reference
UNDP	United Nations Development Programme
USCG	U.S. Coast Guard
V	volt
W	watt
Wp	watt peak

PREFACE ON BEHALF OF THE DANISH COUNCIL FOR SUSTAINABLE ENERGY

This review of Renewable Energy Island (REIs) is an attempt to give an overview of initiatives within renewable energy on islands around the world.

In its action plan - Energy 21 - the Danish government has decided that a Danish island as a demonstration project should become self sufficient from renewable energy sources, including transportation, within 10 years. In November 1997 the Danish island Samsoe was officially selected - among 5 candidates - to become a REI. The Danish REI is a good starting point for global co-operation among similar initiatives to exchange experience and information and to plan and implement collaboration programmes.

The Danish Council for Sustainable Energy, which is an independent council for advising the Danish government and parliament in connection with the implementation of Energy 21, has initiated this review of REI.

The council considers that the government's idea of a Danish REI is a useful way to make future energy-systems visible and concrete and to implement and demonstrate models that can be used, not only on islands at home and abroad, but in principle everywhere. If politicians should be inspired to aim for a broader use of renewable energy as part of a sustainable development, it is necessary to demonstrate renewable energy in a large scale and in an integrated and organised from, placed in a well defined area - as e.g. a smaller island.

To look further into this matter, it has been decided to elaborate this report, to be used as a tool for future co-operation. The Danish Council for Sustainable Energy has furthermore decided to organise an international REI-conference in 1999. The purpose of this report as well as the conference of 1999 is to prepare for future global co-operation and networking among REIs.

On behalf of the Council for Sustainable Energy,

Lars Davidsen
Member of the Danish Council for Sustainable Energy

PREFACE BY THE AUTHOR

This is the first edition of the report and there will be a new addition in the Spring 1999. This second edition will also be available on the Internet. So corrections or additions to the information mentioned in this report or descriptions of new island cases is *very welcome*. If convenient the questionnaire in Annex 3 can be used. Material should be sent to the project manager Forum for Energy and Development at the address mentioned below.

This report has been made from request by the Danish Council for Sustainable Energy. The project ran for 8 months from 1st of September 1997 to 1st of April 1998.

Project manager was Forum for Energy and Development, and consisted of the following team: Svend E. Ladefoged (Project responsible) and Thomas L. Jensen (Project executioner)

Forum for Energy and Development subcontracted minor parts of the execution of the project to the following consultants: Niels Lyck (Organisation for Renewable Energy, Denmark) and Penehuro Lefale (private consultant, West Samoa)

The project has been supervised by a Steering Committee with the following members: Jan Bünger (the Danish Energy Agency), Lars Davidsen (the Danish Council for Sustainable Energy), and Rene Karottki (the Danish Council for Sustainable Energy).

This report can be obtained from the project manager:

Forum for Energy and Development
Landgreven 7
DK-1301 Copenhagen K
Denmark

Tel: +45 33 12 13 07
Fax: +45 33 12 13 08
E-mail: inforse@inforse.dk

The consultants wish to express a sincere appreciation of the response provided by the many people who participated in this review.

The consultants especially wish to thank the manager from the European Islands Energy and Environment Network (ISLENET) Mr. John Crawford and Ide Seidelin from Aeroe Energi- og Miljoekontor.

1. Summary of Main Findings

1.1 The Island Energy Issues

Even though there are conditions, which separate islands from each other the "island factor" is present - circumstances, which are unique to islands compared to the mainland (or large islands). They face a series of shared difficulties, needs and problems.

Some of the characteristics of the "island factor" are:

- insularity
- a limited range of resources
- small markets
- specialisation of economies
- diseconomies of scale
- fragility of eco-systems

The majority of islands also have some circumstances in common regarding energy - particular problems regarding production and distribution of energy. The island energy issues are characterised by:

- *major reliance on imported fossil fuels*
- *small-scale generation of electricity*
- *high distribution costs*
- *under-use of renewable energy resources in comparison with the potential*
- *integration of renewable energy sources in most island cases is an economically feasible solution qua their relatively high energy prices*

Most small islands around the world today are dependent on imported fossil fuels for the majority of their energy needs especially for transport and electricity production.

For reasons of scale and isolation, infrastructure costs (including energy) are higher. For small islands the costs of fossil fuels are usually equivalent to a substantial proportion of the total value of imports. It has e.g. been estimated that energy often accounts for more than 15% of all imports in the islands in the European Union. Fuel imports are thus a great drain and a significant constraint on development - they crowd out vital capital and social expenditures and inhibit the achievement of much needed growth.

Successful efforts by islands to reduce energy imports, either through the achievement of energy efficiency or the use of locally renewable energy resources, could therefore make a significant contribution to economic development. As it is specified by the European Islands Energy and Environment Network (ISLENET): "It is in the interest of islands to engage in policies, which favour the promotion of energy management. That is to say, they should consider in their energy planning, the promotion, on the one hand, of energy efficiency and energy saving actions, whilst on the other hand, they

should seek to develop, where appropriate, renewable energy sources as means of power. There are of course many obstacles, which impede the development of energy management in islands, however, experience proves that the advantages outweigh the disadvantages".

1.2. Renewable Energy Islands

The table below summarises some of the findings on the use of renewable energy on selected small and medium islands.

In the table the islands are specified regarding:

- name
- size of population
- area
- percentage of total energy demand from renewable energy sources
- percentage of total electricity production from renewable energy
- percentage of installed electricity capacity from renewable energy sources
- if the island has an renewable energy plan (REP)
- renewable energy sources (RES) most utilised today

The following should be kept in mind when reading this table:

- the islands are prioritised in regard to the percentage of electricity production coming from RES.
- only those islands where it has been possible to get quantitative information regarding RES's contribution to electricity production is mentioned.

Island	Population	Area	% of Total Energy Consumption from RES	% of Electricity Production from RES	% of Total Installed Electricity Capacity from RES	REP	Primary RES Utilised
Pellworm (Germany)	1,000	37 km2		160% (1997/1998)		Yes	Wind and PV
Nan'ao Island (China)	70,000	200 km2		Nearly 100% (1997)			Wind
Fair Isle (UK)	70	6 km2	65% (1997)	Max 80% (1997)		Yes.	Wind
La Desirade (Gouadeloupe , France)	1,500	20 km2		80% (1997)	36.2% (1997)	Yes	Wind
Rathlin Island (Ireland)	120	17 km2		70-80% (1994)			Wind
Reunion (France)	600,000	2,512 km2		63% (1996)			Hydro, and biomass
Mara Island (Korea)	27 households			59% (1994)		Yes	PV
Hahwa Island (Korea)	48 households			55% (1994)		Yes	PV
Dominica	119,648	750 km2		50% (1995)	51.4% (1992)		Hydro
Faroe Islands (Denmark)	48,871	1,399 km2		41.8% (1997)	36.6% (1997)		Hydro
Flores (Azores, Portugal)	4,316	143 km2		40% (1996)			Hydro
Madeira (Portugal)	260,000	794 km2	15% (1997)	33% (1997)	32% (1995)	Yes	Biomass, hydro, solar thermal, and wind
Marie Galante (Guadeloupe, France)	13,000	158 km2		30% (1997/1998)		Yes	Wind
Hawaii (Hawaii)	137,291	10,433 km2		29% (1995)	27% (1997)	Yes	Geothermal, hydro, wind, and biomass
S. Miguel (Azores, Portugal)	124,649	759 km2		29% (1996)			Geothermal, and hydro
Kauai (Hawaii)	55,983	1,430 km2		26% (1995)	38% (1997)	Yes	Biomass and hydro
Ascension		82 km2		20-25% (1996)			Wind

Island	Population	Area	% of Total Energy Consumption from RES	% of Electricity Production from RES	% of Total Installed Electricity Capacity from RES	REP	Primary RES Utilised
Island (UK)							
Mauritius	1,127,068	1,860 km2		20% (1996)		Yes	Hydro, and biomass
King Island (Australia)	1,800	1,250 km2		18% (1997/1998)			Wind
Moen (Denmark)	11,500	217.3 km2	25% (1996)	15% (1996)		Yes	Biomass and wind
Maui (Hawaii)	105,336	1,883 km2		14% (1995)	26% (1997)	Yes	Biomass and hydro
Aeroe (Denmark)	7,600	90 km2	15% (1996)	12% (1996)		Yes	Solar Thermal, biomass and wind
Thursday Island (Australia)	4,000	4 km2		10.4% (1997/1998)	7.2% (1998)		Wind
Gotland (Sweden)	58,000	3,100 km2		10% (1997)		Yes	Wind
Santa Rosa Island (USA)		212 km2			54.5% (1996)	Yes	Wind and PV
Sao Jorge (Azores, Portugal)	10,216	246 km2		9.6% (1996)			Wind
Bornholm (Denmark)	45,000	587 km2	20% (1997)	7.3% (1997)		Yes	Biomass and wind
Graciosa (Azores, Portugal)	5,190	61 km2		8.7% (1996)			Wind
Oahu (Hawaii)	870,761	1,554 km2		6% (1995)	5% (1997)	Yes	Biomass and hydro
Coconut Island (Australia)	200	0.5 km2		5% (1997)	22.6% (1997)		PV and wind
Samsoe (Denmark)	4,400	114 km2	12%	5% (1996)		Yes	Wind and biomass
Flinders Island (Australia)	1,350	950 km2		5.7% (1997)	4.5% (1997)		Wind
S. Maria (Azores, Portugal)	5,921	97 km2		5.1% (1996)			Wind

Based on this and other findings the following can be concluded:

> *Despite the fact, that the majority of islands around the globe today, are dependent on imported fossil fuels for the majority of their energy needs, especially for transport and electricity production, there are some small and medium islands, which have a significant proportion of their energy needs covered by renewable energy*
>
> *Further today there already exist a few islands, which meet some of the characteristics of a REI.*

Among others the following islands have today a very extensive use of renewable energy sources: Channel Islands National Park (USA), La Desirade (Gouadeloupe, France), Nan'ao Island (China), Pellworm (Germany), and Reunion (France).

Among others the following islands have ambitious renewable energy goals in the short and medium term: Aeroe (Denmark), Bornholm (Denmark), Guadeloupe (France), Samsoe (Denmark), Galapagos Islands (Ecuador), Gotland (Sweden), Madeira (Portugal), Marie Galante (Guadeloupe, France), Nan'ao Island (China), and Pellworm (Germany).

2. Introduction

2.1 Scope of the Review

The overall objective of the review is to make a global review of renewable energy initiatives on small islands (see Terms of Reference Annex 1).

The review should more specific include information about the following items:

1) Description of the island:

- size
- population
- energy consumption
- energy supply

2) Description of the initiative:

- technology
- organisation
- financing
- education
- time
- results

2.2 Terminology

This section will define the concepts "island", "renewable energy", "Renewable Energy Island", "small island" and "medium island".

The concept of "island" can have both political and geographical dimensions.[1] Political dimensions in terms of "island" being an economic, social, cultural, and institutional entity, independent from a mainland area. Geographical in terms of "island" being an entity surrounded by water. In this report the concept "**island**" will be delimited to geographical dimensions and the definition is more specific "...tracts of land smaller than a continent, surrounded by the water of oceans, seas, lakes, or streams."[2] The term does not cover submerged areas and land cut off on two or more sides by water, such as peninsulas. Neither, does the term cover areas land-tied by dam, but ist does cover areas land-tied by bridge.

Renewable energy is "...energy obtained from the continuous or repetitive currents of energy recurring in the natural environment".[3] Renewable energy resources are capable of regeneration (e.g. biomass) or subject to continual flows (solar, wind, hydro). Renewable energy resources are often more

[1] Official paper from Conference of Peripheral Maritime Regions (CRPM)
[2] NASA Thesaurus
[3] Twidell and Weir (1986) in Boyle (1996).

sustainable than fossil resources, but may in some cases not be sustainable (e.g. overuse of biomass leading to deforestation and use of hydro having adverse downstream effects). [4]

Renewable Energy Island (REI) is an "...island...which over a period of a few years will be prepared to change 100% to renewable energy. This will also include the transport sector."[5]

A **small island** have in this review been delimited to an island smaller in area than the Danish island "Bornholm". Bornholm's total area is app. 600 km2. A **medium island** have in this review been delimited to an island between 600 km2 and 10,000 km2 (i.e. between the size of the Danish island Bornholm and the size of the American island Hawaii).

2.3 Methodology

2.3.1 First Phase of the Review

The first phase of the review consisted in collecting and systemising existing materials regarding renewable energy on islands. Publications (books, reports, papers, etc.) and the Internet was used as sources.

The following type of organisations was contacted and asked to provide existing and relevant information (i.e. publications and contacts) regarding renewable energy initiatives on islands:

- international organisations
- regional organisations
- national organisations
- private companies
- non-governmental organisations

The following kind of information available on the Internet was used in the review:

- information on Home Pages
- information on databases

For a specification of the most used Internet databases see Annex 2.

2.3.2 Second Phase of the Review

During the first phase of the review it was discovered that the quantity and quality of some of the information from publications and the Internet was limited. Therefore it was decided to supplement this information with information collected from a distributed questionnaire (see Annex 3).

[4] Wardrop (1994)
[5] Energy 21. The Danish Government's Action Plan for Energy 1996.

All in all app. 160 questionnaires was sent out to relevant persons or organisations.

2.4 Precautions of the Review

The are some precautions that is important to keep in mind when reading this review or using some of the information, regarding:

- the reviewed islands
- regarding medium islands
- the perception of renewable energy initiatives
- the level of detail
- the information
- the use of references

Each of the precautions is specified below.

2.4.1. Regarding Reviewed Islands

Even though the perspective of this report is global it does off course not mean that the findings are exhaustive. It only means that it has cases from all over the world. The report does not pretend to have reviewed all existing islands with initiatives on renewable energy.

2.4.2. Regarding Medium Islands

Even though the study is focusing on small islands, some medium islands are reviewed.

The criteria used is that these medium islands should:

1. either have a significant proportion of their energy needs coming from renewable energy sources today
2. or plan to have a significant proportion of their energy needs coming from renewable energy sources in the near future, i.e. within 10 years

A significant proportion of energy needs is in this context delimited to either:

1. 4% of total energy demand
2. 4% of total installed electricity capacity
3. 6% of total electricity production

2.4.3 Regarding Perception of Renewable Energy Initiatives

Renewable energy initiatives have been delimited to initiatives involving modern renewable energy technologies. Islands that e.g. have all of their energy needs covered from more traditional renewable energy such as burning of biomass for cooking are not classified as renewable energy

initiatives and thus not reviewed in the report. If this criteria was not applied there would be many REIs today (e.g. some tropical islands).

2.4.4 Regarding Level of Detail

There is great diversity regarding how detailed the presented information is. For some islands there is a very detailed description of the overall energy situation and the renewable energy capacities, and for other islands there are only a description of the overall energy situation. This is due to the fact that a great number of different sources and references have been used.

The diversity has consequences for the format used to present the information. The format changes a little, depending on the availability of information.

2.4.5 Regarding Information

Some data are not up-to-date or may even be incorrect, because it has not been possible to cross check the quality of the available information.

It was often experienced during the review that is was not possible to get correct address, fax number etc. of relevant organisations (even though the Internet was used extensively) or that all-ready contacted organisations did not respond to request for information.

As a guiding principle it has been chosen to use information dating back from 1992 and onward in this report.

2.4.6 Regarding Use of References

There are only two places where it is explicated what references are used. It is in the previous section 2.2 about terminology and in forthcoming tables containing information not obtained from own findings.

The reason for this procedure is twofold:

1. A lot of the information in the following pages is information composed of existing information and own findings, and it would be practically impossible to state every time there is a change in reference.
2. Because a lot of the information is compound information, explicating every reference used will take a lot of space.

This review is mainly a desk study based on already available information. *Most of the information presented is from other sources*.

The sources used are presented in Annex 2 (Main Internet Databases Used) and Annex 4 (References).

2.5 Structure of the Report

The review is presented in the following areas:

- the North Pacific
- the South Pacific
- the Caribbean
- the North Atlantic Ocean
- the South Atlantic Ocean
- the Baltic Sea
- the Mediterranean
- the Indian Ocean

The reviewed islands are ordered alphabetically in each of the areas.

North Pacific

Bering Island (Russia)
Channel Islands (USA)
Hawaii (USA)
Korean Islands
Miyakojima Island (Japan)
Nan'ao Island (China)

Bering Island (Russia)

General Information:

Population: approx. 1,000

Area (km2): approx. 1,100

Berging Island is part the Commander Islands and it is located approx. 250 km east of the Kamchatka peninsula.

Energy Information:

Nikolskoye, the main town on the island, is supplied with electricity from a diesel-fired power plant located in the western part of the village neighbouring the fur farm and one of the three heating plants.

The power plant consist of 6 identical systems, each consisting of a turbo-electric diesel engine with a rated capacity of 320 kW and one generator of 400 kVA. Of the six diesel generator sets, only three were in operational condition (November 1996) and a fourth set was planned to be repaired before the winter 1996. The remaining two sets were damaged beyond repair.

All electricity is produced at 400 V. A large part of the electricity is distributed directly to the end user directly from the busbar at the power plant, however, a 6 kV grid does exist for distribution to consumers in the more distant part of the village.

In 1995 2 x 250 kW MICON wind turbines was installed and in August 1996 they was connected to the grid. This wind power project in describe below.

Wind turbine Demonstration Project. Phase 1: Data Collection and Assessment Report

General Information:

In June 1993 a letter of intent to establish wind turbines on the Commander Islands was signed by the Russian Ministry of Protection of the Environment and Natural Resources and the Danish Environmental Protection Agency (EPA).

NEED, represented by the Danish organisations ELSAMPROJET and Folkecenter for Renewable Energy carried out the project.

The project was proposed to compromise two phased:

- Phase 1: an appraisal mission to the Commander Islands

- Phase 2: physical realisation of the project if the conclusions of phase 1 were positive

Achievements:

The overall conclusions of the work done during phase 1 was that it was both possible and sensible to install wind turbines on the Commander Islands. More specific it was found that:

- wind conditions are very good on Bering Island, giving reasons to anticipate a high energy production from the wind turbines, probably app. 3,500 equivalent full power hours per year. This compares favourably with good Danish sites having 2,000 to 2,500 equivalent full power hours.
- there are good siting possibilities near Nikolskoye
- the existing electricity system in Nikolskoye can accomodate a wind system of a foreseen capacity (3 x 150 kW)
- construction, operation, and maintenance facilities on the island are present to a sufficient degree
- an agreement was signed with the local authorities on the realisation of the project, specifying both the Danish and the Russian contribution
- both time table and budget for the project proposal seem to be realistic

Project Duration and/or State of Advancement:

The report was finished June 1994.

Wind Turbine Demonstration Project. Phase 2: Project Realization

General Information:

After completion of Phase 1 and authorisation was given to proceed with the physical realisation of the project, two MICON 250 kW wind turbines were purchased and shipped to Bering Island in March 1995.

The equipment reached the island in July 1995, and during the autumn the towers and nacells were erected. Cables and grid connection were not finish until August 1996.

During 1995 two Russian delegations visited Denmark to discuss details of the project and to be familiarised with the equipment and installation, operation and maintenance.

In September 1996 a group of Danish engineers visited Bering Island, organised the remaining erection and installation work, and tool care of commissioning. After commissioning the local staff were trained in the operation and maintenance of the turbines as well as operation of the complete wind/diesel system. The turbines were left in automatic operation.

The grant from the Danish Energy Agency was 5.32 million DDK with a maximum of 4 million DDK to be used for hardware. Project expenditure was 5.07 million DDJ with 3.88 million DDK used for hardware.

For more Information Contact:

Organisation:	Folkecenter for Renewable Energy
Address:	P.O. Box 208 DK-7760 Hurup Thy Denmark
Tel.:	+45 9795 6600
Fax:	+45 9795 6565
E-mail :	fcenergy@inet.uni-c.dk
Internet address:	http://www.gaia.org/los/folkecentre/

Channel Islands National Park (USA)

General Information:

Channel Islands National Park (CINP) is located just off the coast of Southern California. It consist of the following islands:

- Anacapa Island (2.8 km2)
- Santa Barbara Island (2.64 km2)
- Santa Cruz Island (245.5 km2)
- San Miguel Island (37.7 km2)
- Santa Rosa Island (213.6 km2)

Renewable Energy:

It is one of the least visited of the national parks in the USA and the isolation makes the logistics of providing facilities and energy for park operations both costly and difficult.

One of the goals of the national park is to eliminate where ever possible any reliance on non-renewable energy. As new facilities are constructed it will defer the use and incorporate renewable energy technologies wherever possible.

Currently is app. 60 energy applications in operation. These range in size from single module installations powering remote communications, weather stations and lightning/ventilation for pit toilets to a large scale hybrid wind/PV system on Santa Rosa Island.

In the following pages some of these renewable energy installations on each of the Channel Islands will be specified.

Anacapa Island

General Information:

Anacapa Island (2.8 km2) has hiking trails, a visitor center, lighthouse exhibits, primitive campground, picnic area and offer opportunities for scuba diving, bird watching etc.

The National Park Service facilities support the resident Ranger and maintenance staff, who live on this island. Annually over 15,000 visitors, primarily spending the day, while a few camp.

Renewable Energy Installations:

1. The main 4.3 kW PV array was installed in 1983, reconfigured in 1987 and has since reduced diesel consumption by 96%. The monthly usage on the island is now less than 25 gallons, used primarily for a tractor and crane operations. The 48 volt DC system incorporated 80 Siemens M-75 panels, 2 Trace 4084 inverters, 24 GNB Batteries and an Ananda Power Center with the existing diesel generators as backup, to provide 120/240 Volt AC power to island residences. Both facilities utilise Sunfrost refrigerators and fluorescent lightning to reduce energy demand.
2. To provide electricity to the visitor center and bunkhouse a small solar array was installed in 1994. This system of 16 Siemens M-55 panels, 2 Trace DR 2414 inverters, Excide batteries and an Ananda Power Center reduced the demand on the main PV system.
3. Prior to 1992 the U.S. Coast Guard (USCG) ran 10 kW diesel generators, 24 hours a day to operate the lighthouse and aids to navigation. These continually running generators were costly to operate at this remote location due to servicing, fuel delivery and caused environmental problems due to pollution and fuel spillage. There the USCG reconfigured the lighthouse, implemented conservation measures and concerted the system to operate as a stand alone PV system. This installation saved the delivery and consumption of over 7,000 gallons of diesel per year. The system installations costs of US$ 17,345 were paid back in just under two and a half years and since 1995 the facility has been operation cost free and without damage to the environment.
4. Other Park Service operated PV system on the island included battery charging for communications equipment, lighting and ventilation on the campground pit toilets, battery charging to operate a underwater video program and a radio repeater station for the Ventura County Sheriffs Department.
5. A side goal is to seek funding for the usage of Bio-Diesel to make the island petroleum free. With annual petroleum consumption around 300 gallons the concept of operation totally of renewable resources is within the islands grasp.

Other initiatives:

The eastern part of Anacapa Island is only app. 0.65 km2 in size and have no water resources. Water must be tanked once a year. In 1992 there was installed low flush toilets and it reduced the islands water demand by 65%.

Energy and Environmental Savings:

With the implementation of conservation measures, renewable energy production and energy management Anacapa Island has experienced a deferral in the consumption of 14,700 gallons of diesel fuel per year, a reduction of 98%.

These savings are fiscally significant. Environmentally they deferred the following annual exhaust emissions:

1. 175 Tons of Carbon Dioxide
2. 8,453 Pounds of Nitrous-Oxides
3. 323 Pounds of Total Susoended Particulates
4. 720 Pounds of Hybrocarbones
5. 420 Pounds of Sulfur Dioxides
6. 11,925 Pounds of Carbon Monoxide
7. And the use and generation of 120 gallons of motor/hazardous waste oils.

Santa Barbara Island

General Information:

Santa Barbara Island (2.64 km2) has hiking trails, a visitor centre, picnic area, primitive campground and offers opportunities for hiking, bird watching, scuba diving etc.

Renewable Energy Installations:

1. In 1990 the new ranger station was constructed which incorporated a 5 kW stand-alone PV array. This 1,850 sqft facility provides a visitor centre, 4 bunkhouse and a two bedroom apartment for the resident ranger. The PV energy system, consist of 80 Siemens M-75 modules, 48 Trojan T-105 batteries, a SES Controller and Westec 5084 inverter. There are no backup power supply and the system provides all electrical energy to the ranger station. When the facility was constructed it incorporated passive daylighting, massive insulation, fluorescent lighting and utilises "Sunfrost" refrigeration. Since its construction average total electricity consumption has been under 3kW per day, less than a standard household refrigerator. The array saved an estimated 4,000 gallons of diesel per year and reached payback in January 1994 and since then has been operating cost free.
2. Other renewable energy applications on the island include a fixed USCG aid to navigation, a Handar Weather Station, Dock battery charging, 3 Pit

Toilet fan/lighting systems and battery charging for marine bird telemetry research.

Santa Cruz Island

General Information:

Santa Cruz Island (245.5 km2) is primarily owned by the Nature Conservancy. The Park Service on the east-end offers hiking, wildlife observation, kayaking and camping.

Renewable Energy Installations:

1. Currently the only National Park Service facilities are on the east-end on the island and consist of two small ranger stations powered by 12 volt DC PV systems. In addition three 24 volt systems provide water for the ranger stations and irrigation.
2. On the Nature Conservancy owned property, the US Navy operates a radar station which receive a majority of its electricity from a 150 kW PV array. In addition they have installed a 10 kW array for water pumping and a 30 kW array to provide electricity to the nature Conservancy's facilities. These systems have been installed by Southern California Edisions Off Grid PV Program. This program provides non grid connected customers with electricity from PV under a lease program.
3. Other renewable energy installations on the island include three communication repeater stations, 4 remote power systems and a water pumping application.

San Miguel Island

General Information:

San Miguel Island (37.7 km2) has a primitive campground, hiking trails, and offers ranger led hikes, marine mammal observation, beach exploration and bird watching.

Renewable Energy Installations:

1. Current renewable energy applications include the ranger station with its 12 volt DC hybrid wind/PV system, a Grundfos water pumping system, a 12 PV power system for the research station, a Handar weather station, three pit toilet fan/lightning systems and a US Navy 12 volt weather station.
2. A 2,200 sqft ranger station which incorporate a hybrid 900 watt wind/4 kW solar power system, solar water preheat, rainwater collection for toilet flushing, all low flush toilets, 9 solar tube skylights, 3 sunfrost refrigerators

and low volt fluorescent lightning throughout. Recycled copper was utilised in the manufacturing of the roofing shingles.

Santa Rosa Island

General Information:

Santa Rosa Island (212.6 km2) has hiking trails, primitive campground and offers beach exploration, wildlife observation, Ranger led hikes and vehicle tours, and kayak camping. It is the one of the Channel Islands with the most ambitious renewable energy projects.

Energy Supply Before:

When the National Park Service purchased Santa Rosa Island in 1986 they also assumed responsibility for the utility operations. Included were 35 kW diesel generators, which ran year round. Annually this accounted for 8,760 hours of run time and the direct consumption of 17,500 gallons of diesel fuel and 120 gallons of motor oil.

Due to the logistics of supplying fuel to an island 45 miles offshore there is added cost for fuel delivers. For every 2400 gallons of fuel delivered it takes one boat trip consuming 350 gallons of fuel and 36 employee man-hours. The hidden costs mean that the generation fuel is app. 57% more expensive that mainland fuel - estimated cost for providing electricity was 0.53 US$ per kWh.

The following is the annual exhaust emissions from the diesel generator:

1. 208 tons of carbon dioxide
2. 10.063 pounds of nitrous-oxides
3. 385 pounds of Total Suspended Particulates
4. 875 pounds of hydrocarbons
5. 500 pounds of sulfur dioxide
6. 14,200 pounds of carbon monoxide
7. Generation of 120 gallons of hazardous waste oil and 87 fuel/oil filters

Renewable Energy Installations:

In 1994 Channel Islands began seeking funding to install an alternative energy system to reduce operation of the generators on the island. In March 1995 a grant from the Federal Energy Management Program allowed Santa Rosa Island to start the design and implementation of the hybrid wind/PV/diesel system. This details of project is mentioned below, but first an overview of other renewable energy installations on the island:

1. A hybrid wind/PV water pumping system, 5 pit toilet, lightning/ventilation systems, 1 Handar weather station, two PV boat hoists on the pier and a PV attic fan on an ozone monitoring station.

2. In 1994 all the flush toilets in the ranch area were replaced with low flush units, which reduced energy demand for water pumping and effluent lift pumping, and as well greatly reduced repair cycle/costs on the ginder pumps.
3. They are investigation acquisition of an electric/PV cart/vehicle for the use in the ranch area to reduce diesel usage.

Santa Rosa Island Hybrid Wind/Photovoltaic (W/PV) Project

Objective:

The objectives of the project is to:

1. Promote the mandate for energy reduction by utilising renewable energy sources
2. Promote the use of renewable energy technology through demonstrated utilisation of hybrid wind/PV
3. Protect the environment through reduction of noise and exhaust pollution from existing generators and from the potential of an accidental diesel spill in a fragile marine environment
4. Reduce energy consumption through utilisation of advanced lighting technology, efficient refrigeration and alternative heating loads.
5. Reduce the overall costs of providing electrical generation at a remote island location.
6. Promote the publics understanding of and support for the application of alternative energy technology and utilisation of conservation measures.

The project will demonstrate the utilisation of technology in the application of a Bi-Modal inverter. The system will be a hybrid to utilise the abundant solar and wind resources available on the island without sole reliance due to regular weather changes of summer fogs and fall doldrums. As part of the overall package energy conservation measures are included to reduce demand on the system and demonstrate the ability to operate facilities with minimal energy consumption.

As part of the Grant Agreement with the County of Santa Barbara Air Pollution Control District the project will be made available for public education and demonstration purposes. In addition regular park visitors will be presented with information on the project and conservation principles.

General Information:

The hybrid wind/PV power system consist of the following components:

1. A 30 kW three phase bi-modal inverter serves as the core of the system.
2. A system controller that automatically monitor system demand, power generation from solar and wind, and battery state.

3. Two 10 kW wind generators serves as the primary power source.
4. A 12 kW fixed solar array mounted on the roof of the electrical and fuel storage buildings and racked alongside provide DC output for battery charging.
5. A 300 kW battery bank, which serves as a large capacitor in the system store excess energy produced during high production periods and smooth out time differences between peak demands and production.
6. The existing 35 kW diesel generators serve as backup for the system.

Below are specified the estimated costs for the project:

Equipment Costs:	291,137 $
Site Work:	3,450 $
Labour:	28,000 $
Conservation Costs:	37,994$
Total Project costs:	**375,294$**

The financing of the part of the project focusing on renewable energy (equipment costs, site work and labour) is app. as follows:

Santa Barbara County Air Control District:	9%
Channel Island National Park:	13%
Sandia National Laboratories:	4.5%
Federal Energy Efficiency Fund Grant Proposal:	73.5%

Achievements:

The project is expected to:

1. Reduce annual diesel fuel consumption on the island by 20,500 gallons. That is 94% less than the level in 1994.
2. The avoided electric energy usage due to conversation measures is estimated to be 21,492 kWh per year.
3. The project has an estimated payback time of nine years and an expected life of 25 years.

Over the 25 years life span of this project 343 fuel transfers involving 411,250 gallons of diesel fuel will not be required. The energy costs for the island will be reduced from around 38,000$ per year to only 2000$ and the hybrid system will have a net savings of over 500,000 $.

Project Duration and/or State of Advancement:

As of 11/12 1996 the Solar Array was installed, the batteries was in place, 2,400 lf of wire was buried and the wind tower bases (15 yards of concrete each) was installed.

The 11.4 kW array provides 25-30% of the daily energy needs on the island.

For more Information Contact:

Organisation:	Channel Islands National Park
Address:	1901 Spinnaker Drive Ventura California USA
Tel.:	+1 805 658-5730
Fax:	
E-mail :	chis_interpretation@nps.gov
Internet address:	http://www.nps.gov/chis/

Hawaii (USA)

General Information:

Island	Population	Area (km2)
Hawaii	137,291	10,433
Kauai	55,983	1,430
Lanai	2,989	364
Maui	105,336	1,883
Molokai	6,838	673
Oahu	870,761	1,554
Hawaii Total	1,179,198	16,635

Energy supply:

Hawaii depends on imported oil for over 80% of its energy consumption. This makes Hawaii the most vulnerable state in the USA to the disruption of its economy and way of life in the event of a disruption of the world oil market or rapid oil price increases.

However, Hawaii is considered one the leading states in the USA in the availability of alternate energy resources and in the development of their use in producing electricity and other forms for energy.

This focusing on renewable energy can be seen in the installed renewable generation capacity and in electricity production:

Conventional and renewable generation capacity (1995):

Island	Conventional Capacity (kW)	Renewable Capacity (kW)	% Renewable of Total Capacity
Hawaii	154,000	55,856	27
Kauai	96,000	58,250	38
Lanai	10,760	0	0
Maui	196,700	67,450	26
Molokai	9,100	0	0
Oahu	1,650,000	85,600	5
Hawaii Total	2,117,760	267,156	11

(Source: "Hawaii Renewable Energy Data Report 1995", PICHTR, 1997)

Electricity production, by island (1995):

Island	Total Production (million kWh)	Renewable Sources (million kWh)	% Renewable of Total Production
Hawaii	995	287	29
Kauai	492	126	26
Lanai	28	0	0
Maui	1,189	168	14
Molokai	37	0	0
Oahu	7,822	443	6
Hawaii Total	10,563	1024	10

(Source: "The State of Hawaii Data Book 1996")

As can be seen in the table below are the renewable energy resources most utilised for electric production in Hawaii as a hole in 1995, biomass (65.9%), then geothermal (21.8%), hydro (10.1%) and finally a small contribution by wind (2.2%).

Renewable electricity production, by source, by island (1995):

Island	Biomass	Hydro	Wind	Geothermal
Hawaii	3.8%	12.5%	5.9%	77.7%
Maui	91%	9%	0%	0%
Oahu	98.6%	0%	1.4%	0%
Kauai	58.7%	41.3%	0%	0%
Hawaii Total	65.9%	10.1%	2.2%	21.8%

(Source: "The State of Hawaii Data Book 1996")

Renewable Energy Plan:

Hawaii has the *very extended and elaborated energy plan* "Hawaii Energy Strategy" (HES) from 1995, where among other things renewable energy, energy efficiency and energy conservation are integrated and important elements. The transport sector is included in the part of the energy plan focusing on renewable energy.

The following are the overall objectives of HES:

- Increased diversification of fuels and sources of supplies of these fuels;
- Increased energy efficiency and conservation;
- Development and implementation of regulated and non-regulated energy development strategies with the least possible overall cost to Hawaii's society;

- Establishment of a comprehensive energy policy analysis, planning, and evaluation system;
- Increased use of indigenous, renewable energy resources;
- Enhanced contingency planning capability to effectively contend with energy supply disruptions.

Wind Projects in Hawaii:

Hawaii has some of the best conditions in the world for wind power. Although most of the wind farms are small compared to mainland installations in the USA, they contributed 22.77 MWh of electricity in 1993.

There are 7 major wind power stations currently in Hawaii. Together these facilities have a combined generation capacity of app. 23 MW in 1994.

Hawaii's Wind Energy Capacity, by Island (1994):

Island	Location	No. of Units	Capacity in Each (kW)	Total Capacity (MW)
Hawaii	Kahua Ranch	18/1	17.5/10.0	0.3
Hawaii	Kahua Ranch	3	25	0.15
Hawaii	Lalamilo	120	20	2.3
Hawaii	South Point	37	250	9.3
Total		**179**		**12**
Molokai	Moomomi	3	100	0.3
Total		**3**		**0.3**
Oahu	Kahuku	13	600	7.8
Oahu	Kahuku	1	3,200	3.2
Total		**14**		**11**
Hawaii Total		**196**		**23.3**

(Source: "Hawaii Energy Strategy Report", 1995)

Photovoltaics:

Grid Connected PV Installations:

The state of Hawaii has taken advantage of an opportunity to become involved with a nation wide Photovoltaics for Utility Scale Application (PVUSA) project. This project was launched in 1986 with the primary goals of assessing PV technologies in a utility setting and to transfer PV technology knowledge to the U.S. utilities. The Hawaii system was installed near Kihei, Maui inside the U.S. Air Force Satellite Tracking compound.

The system installation was completed in October 1989, and consist of 1,210 tandem-junction (two-layer) thin-film amorphous silicon modules (total area of

497m2). The rated capacity of the system is 17.56 kW (ac), but has achieved a maximum power output of 21.3 kW. The system produces power that is used by the island's electricity utility.

Another grid connected PV application was initiated by Hawaii Electric Light Company (HELCO). This project involved the installation in December 1995 of a 15 kW (AC) grid connected commercial roof top application on the County gymnasium in Kailua-Kona. The intent of this system is to provide an opportunity to evaluate building integrated PV systems and the application of PV as a demand side management technique for commercial buildings, as well as to determine any potential distribute generation benefits.

The modules used are rated at 285 watts, and three 6 KW inverters are employed. This particular installation covers app. one quarter of the roof area and the costs about US$ 145,000, not counting the data acquisition equipment

Off-grid PV Installations:

Numbers that represent the precise penetration of small non-grid connected PV systems are not available. However it is estimated that there are app. 1,000 off-gird residential PV systems on the island of Hawaii.

Solar Thermal:

Since 1976, the state of Hawaii has attempted to encourage the residential and commercial use of solar heating by offering various income tax credits to people who installed such devices. The actual rate of this credit has varied over time, but the cumulative effect of this policy has resulted in app. 60,000 solar water heaters as of 1994. These systems save over 498,000 barrels of oil per year.

In 1996, Hawaiian Electricity Company (HECO) announced a 36US$ million program to encourage the use of solar water heaters. The goal is the installation of 20,000 new solar water heaters in order to reduce energy consumption and the construction of expensive new power plants. HECO will provide app. 800US$ rebates fir each new solar thermal system installed. Funds for these refunds will be raised by a electric customer surcharge amounting to app. 2US$ per month for a typical family on Oahu.

Solar Thermal Projects:

1. Solar thermal is used conspicuously in one particular commercial venture, Hawaii Solar Dried Fruit of Rainbow Harvest Inc. This business in Pahoa on the Big Island specialises in drying tropical fruit using solar energy. The process plant has several large solar dryers and the estimated that the annual solar energy used in probably equivalent to the energy content in 50-100 barrels of fuel oil.
2. Solar thermal energy has also made significant contributions to the public housing sector. In August 1991, installation was completed on one of the

largest residential solar water heating systems in the U.S.A. located at the Mayor Wright Homes public housing project in the Liliha neighbourhood of Honolulu. This system consist of 780 solar panels on the project's 35 buildings and was paid for on a 50-50 cost share basis by the federal and state governments. This system has reduced the hot water heating costs by more than half for the 2,400 residents of this housing project.

3. The United States Navy has 29 neighbourhoods for its personnel stationed in Hawaii. recent upgrades of these units have included the utilisation of solar water heaters. Within the next five years, at least 1,100 of those houses will be revitalised with packages that included solar water heaters.

Biomass:

Biomass, especially the burning of bagasse, has always been an important part of Hawaii's energy supply. It is currently the largest source of Hawaii's renewable energy, and the generating capacity of facilities that consume biomass to produce electricity once exceeded 299 MW.

Sugar Company Facilities:

As the profitability of the sugar business is currently in decline, many of the sugarcane mills have ceased or reduced operation, which will result in a erosion of Hawaii's biomass generating capacity. In 1995 there were app. 144 MW of electrical generating capacity supplied by Hawaii's sugar company facilities. In 1997 this figure had fallen to 97.75 MW and Kauai and Maui is the only sugar producing islands in Hawaii.

Below is specified the remaining Hawaii sugar mill generation capacity (1997):

Island	Sugar Company	Generation Capacity (MW)
Kauai	AMFAC Sugar - Kauai West	7.50
Kauai	AMFAC Sugar - Kauai East	25.00
Kauai	Olokele Sugar Co.	4
Kauai Total		**36.5**
Maui	Pioneer Mill Co.	9.25
Maui	Hawaiian Commercial and Sugar Co.	52.00
Maui Total		**61.25**
Hawaii Total		**97.75**

(Source: "Hawaii Renewable Energy Data Report 1995", PICHTR, 1997)

Municipal Solid Waste:

1. Honolulu Project of Waste Energy Recovery (Oahu). The City and County of Honolulu contracted with Honolulu resource Recovery Venture (HRRV) in July of 1985 to design, construct and operate a waste to energy facility. The reason for this contract was to preserve the beauty of the island of

Oahu and to conserve land, which would otherwise be rapidly consumed by continued land filling of solid waste. Operation commenced in December 1989, and the facility has a firm power contract to provide 46 MW to the island's electricity grid while processing about 600,000 tons of solid waste annually.

2. Kapa'a Energy Partners (Oahu). There is another energy project at the City and County of Honolulu's Kapa'a sanitary landfill. In 1989 the Kapa'a Energy Partners installed a machine to burn the landfill gas generated by the anaerobic decomposition of the refuse of this dump and make electricity for sale to the island's electric utility. Peak production has been MW. Exhaust heat from this turbine is ducted to the neighbouring Ameron HC & D Quarry where it is used to dry aggregate. The heat is purchased by the quarry owner at price based on the diesel fuel oil saved at the quarry by not burning it for this drying process.
3. Macadamia Nut Husks (Big Island). In 1982, Mauna Loa Macadamia Nut Corporation installed a boiler in their nut processing plant near Hilo on the Big Island that was capable of using nut husks as a fuel. This boiler provided process heat to the factory and is also used to power a 750 kW generator that provides electricity to the facility. This electricity is not sold to the electric utility.

Geothermal:

Current state policy provides for the development of geothermal energy as a potential resource exclusively for the island of Hawaii. Geothermal energy has been viewed as the best near-term indigenous resource to meet the island of Hawaii's base-load energy needs. The island's geothermal resources offer significant potential for development.

Puna Geothermal Venture developed a 25 MW geothermal plant in the Kapoho area of Puna on the Big Island. This plant represents the first commercial geothermal plant in Hawaii and production of electricity commenced on April 22, 1993. In 1996, this plant was re-rated to 30 MW.

Hydroelectricity:

Hawaii has nearly 32 MW of hydroelectricity power production capacity. Over half of this capacity in on the Big Island, with the rest split more or less evenly between Maui and Kauai. There are no hydroelectricity generation facilities on any of the other islands.

Almost 50% of the hydroelectricity generation capacity is owned by Hawaii's sugar companies. Independent power producers account for about 40% of the hydroelectricity, and the remainder is owned by the electricity utility on the Big Island.

The sugar companies have utilised hydroelectricity power since 1897. All of the electricity from these plants is used for sugar plantation's need with the rest being sold to the island's electric utility. Generally, the hydro plants on a

plantation are operated in conjunction with the steam power plants at the sugarcane mills.

Below is a listing of the major hydroelectricity generation facilities on each island (1995):

Location	Stream	Generation Capacity (kW)
Hilo, Hawaii	Wailuku	1,875
Hilo, Hawaii	Wailuku	750
Hilo, Hawaii	Wailuku	750
Hilo, Hawaii	Wailuku	400
Hilo, Hawaii	Ainako	7
Haina, Hawaii	Hamakua Ditch	800
Hawi, Hawaii	Kohala Ditch	350
Waimea, Hawaii	Waimea/Waikaloa Pipeline	37
Hilo, Hawaii	Wailuku	12,000
Big Island Total		16,969
Waimea, Kauai	Waimea	1000
Waimea, Kauai	Kekeha Ditch	500
Lihue, Kauai	Wailua Ditch	500
Lihue, Kauai	Wailua Ditch	800
Wainiha, Kauai	Wainiha	3,700
Kalaheo, Kauai	Alexander Res.	1,000
Kaumakani, Kauai	Makawii	1,250
Kauai Total		8,750
Kaheka, Maui	Wailoa Ditch	4,500
Paia, Maui	Wailoa Ditch	900
Hamakua, Maui	Wailoa Ditch	400
Lahaina, Maui	Kauaula	400
Maui Total		6,200
Hawaii Total		**31,919**

For more Information Contact:

Organisation: Department of Business, Economic Development & Tourism
Energy, Resources, and Technology Division
Address: P.O. Box 2359
Honolulu
Hawaii 96804
USA
Tel.: +1 808 587 3807
Fax: +1 808 586 2536
E-mail : mkaya@dbedt.hawaii.gov
Internet address: http://www.hawaii.gov/dbedt/ert/ert_hmpg.html

Korean Islands

General Information:

The Republic of Korea (South Korea) has about 4,000 islands along its coastlines, of which 518 are inhabited.

The status of the electricity supply in 1992 on the 518 inhabited islands are shown in the table below:

Composition	Grid Network	Diesel Generation	Non-electrification
Under 50 Homes	90	132	74
More Than 50 Homes	39	24	3
More Than 100 Homes	119	37	0
Households in Total	83,045	12,283	583
Households in Percentage	86,6%	12,8%	0,6%
Islands in Total	248	193	77
Islands in Percentage	48%	37%	14%

(Source: "Strategy and Status of Remote Island PV Application in the Republic of Korea", 1992)

Energy Plans for Islands:

1. A government programme to install 24-hour operating diesel system to supply electricity to islands with more than 50 households has been implemented in the period 1990-1995. As can be seen from the table this programme will includ three islands (household total on these three islands is 202).
2. On islands with less than 50 households it was planned after 1996 to install PV systems, which will be competitive with diesel systems in terms of generation costs and efficiency. As can be seen from the table this programme will include 296 islands (household total on these 296 islands is 2,962).

PV Installations in Korea:

Although the technology for production and application of PV systems has been developed as a result of research and development in Korea, PV generated electricity is not competitive with public power supply. Consequently, the present applications of PV systems in the Republic of Korea has been limited to areas:

1. Stand-alone systems for lighthouses, telecommunications, telemetering etc.
2. Electrification of remote islands, where electrical power is not available from the existing mainland electric power grid.

Below are specified the PV projects on Hahwa Island, Mara Island, Ho Island, and Hawado Island.

Hahwa Island

General Information:

In 1988, a 20 kWp PV power system was installed at Hahwa, in the Yeochun locality. Due to the increasing power demand it soon became necessary to upgrade the system to 25 kWp.

In June 1995 there was installed an extra 35 kWp PV generation system, together with improvements to the peripheral systems (power converter, batteries etc.).

Achievements:

The 25 KWp system became operational in August 1990 and provided 70.5% of the power required by the Island's 48 households between December 1990 and November 1991.

Because of increased power demand, the system could only supply 55% of the power required during 1994. Therefore the operation time of a diesel generator to provide auxiliary power has been increased.

Mara Island

General Information:

Since 1991, Korea Electric Power Corporation (KEPCO) and Korea Institute of Energy Research (KIER) have collaborated in constructin a 30 kWp PV system for Mara Island. Mara Island is the most southerly island of Korea.

The system supplies electric power to the 27 households on the island for 24 hours daily. The power electronics were specially designed using the experience gained with the Hahwa Island PV system. The output voltage of the inverter was set at 110 V to be compatible with most electrical appliances used in homes on the island.

Achievements:

In 1992 the system was able to provide 81% of the islands power, but due to increasing power demand the PV system only provided 59% in 1994.

Several problems caused by the increasing electrical demand and terminal voltage drop during transmission, led to the installation of a 220 V step-up transformer, a battery charger, and a 3-phase diesel generator.

Ho Island

General Information:

The system developed by KEPCO for Ho Island, in the Boreong locality, has 100 kWp class power rating and is the largest stand-alone PV system in Korea.

The PV array provides power during the daytime, a battery system supplies power during the night, and a diesel generator delivers the energy need for long days and during poor sunlight.

Completed in January 1993, the system delivers electric power to app. 234 people in 63 households, schools, churches, etc. for 24 hours daily.

Achievements:

The load has steadily increased on the Ho Island due to improvement in the standard of residential living and the increasing number of summer visitors. The PV system has shown a consistently better performance than the diesel generation system in terms of reliability. This is because there is now considerable experience in the design of PV systems and the Ho Island system includes an improved power converter (inverter) design.

Hawado Island

General Information:

Another typical example of how PV systems can be used to supply electricity to remote islands is the 25 kWp PV system installed on Hawado Island, located off the south west coast. The system has a 10 kW back up capacity from a diesel generator, and was designed to operate under local weather and load conditions.

The system has been in operation since 1988 and it supplies power for lightning, television and refrigeration for the 48 households on the island. In 1991 the system was donated to the local government, which is responsible for maintenance.

Specifications of the system:

Solar Cell:	25 kWp
Storage Battery:	320 kWh
Power Controller:	30 kVA
Inverter:	3 x 5 kVA
Control Panel:	System controller 1 unit
Load	AC 110V

Miyakojima Island (Japan)

General Information:

Population: N.A.

Area (km2): app. 167 km2

The island is located app. 300 km. south of Okinawa Island.

Photovoltaic Power for Small Islands by Okinawa Electric Power in Miyakojima

Objective:

The Okinawa Electric Power supplies many remote islands, which have to be provided with electrical power by small diesel generators with a capacity less than 1,000 kW or through undersea cables with comparatively high construction costs. The costs of power supply for these islands are at least three times higher than those for the main island of Okinawa.

The objective of this project is to demonstrate an independent power supply system that can steadily and economically provide electricity in isolated islands.

General Information:

As a mean to supply power to remote islands, the Okinawa Electric Power Co. has endeavoured for many years to develop PV power generation technology. In Miyakojima Island, the company, in co-operation with Mitsubishi Electric Corporation, is conducting a demonstration project of an independent 750 kW PV power generating system.

The hybrid system consist of:

1. A 750 kW PV generation system.
2. A lead acid battery storage system having a capacity of 3,058 kWh.
3. A 300 kW diesel generator.

The total area of the PV plant is 18,000 m2 of which app. 11,000 m2 is taken up by 12,107 PV modules. Each module has an output of 62 W and a conversion efficiency of about 12% on average. The cells were supplied by five PV manufactures, with single crystalline type in majority.

Measures taken to safeguard the plant against the typhoons frequently striking Miyakojima, include a low tilt angel of 15 degrees for the arrays and the sealing with a silicone compound to prevent salt damage.

During the daytime, the station supplies energy from the PV system and stores surplus energy in the storage batteries for the use during the night or at times when the solar radiation is insufficient to meat demand. When the energy in the batteries falls below 20% of their storage capacity, the diesel generator automatically starts and continues to generate until the energy stored in the batteries, reaches 30% of their capacity.

The independent power supply system is designed to provide power for a village consisting of 250 customers having an ordinary load pattern with an annual average load of about 90 kW and a peak demand of about 200 kW. The hybrid power generating system is expected to supply 682 MWh/year from the PV system with a capacity factor of the system of 11.9% and 126 MWh/year by the diesel generator.

Achievements:

Since starting, the system has operated smoothly according to the designed performance. This project demonstrates the feasibility of introducing independent new generation systems to isolated islands where the power supply, are extremely high.

Project Duration and/or State of Advancement:

The construction started in 1992 and was finished in 1994.

For more Information Contact:

Organisation: The Okinawa Electric Power Company Incorporated

Address: 5-2-1, Makiminato
Urazoe-shi
Okinawa
Japan

Tel.:
Fax: +81 98 876 8531
E-mail :
Internet address:

Nan'ao Island (China)

General Information:

Population: 70,000

Area (km2): App. 200 km2

Energy Information:

The island is connected to the mainland via two underwater cables. If the island experience shortage of electric power it will be imported to the island from an oil thermal power station on the mainland, and if the wind turbines, produces excess power it will be exported to the mainland.

Nan'ao Island in the Guangdong province in is one of the best sites for wind generating in China. The island is hilly with heights of more than 500 m. and has rich wind potential with annual average of more than 10 m/s. It is typical of a lot of islands off the Chinese coast, where wind energy is most suitable for electric power production, due to an increasing need in electricity production supply, especially in the fast developing economy of the coastal areas.

The power purchase price for wind energy on the island equals US$ 0.08 kWh (1997), the price paid for the conventionally produced electricity from the oil thermal power plant on the mainland.

Renewable Energy Installations:

Currently the following wind installations exist on the island:

1. Three Sentic Mark-3 turbines. They where the first turbines installed on the island.
2. An 8.7 MW wind power plant, consisting of 43 Nordtank turbines.
3. In 1995 there was erected 16 Nordex N27/250 turbines with a total installed capacity of 4 MW. These turbines produced more than 7 million kWh of electric power in 1996.
4. In the end of 1997 Nordex almost was finished with the installation of a second set of Nordex turbines. 13 x 250 kW turbines with a total installed capacity of 3.25 MW.

At the end of 1995 Nan'ao Island already produced more than 40% of its power demand from wind energy. At the end of 1997 the total installed wind capacity was app. 16 MW (from app. 75 turbines) and almost all of the electricity on the island was produced from wind power.

24 MW Wind Plant

General Information:

In August 1997 there was signed a US$30 million contract between the Dutch utility NUON and three Chinese partners - China Fuling Wind Power Development Corporation, Shantou City Electric Power Bureau and Nan'ao Zhenneng Wind Power Development Corporation.

The wind plant will consist of 40 Nordtank 600 kW turbines with a total installed capacity of 24 MW. It will be the biggest wind power plant in China, constitute 25% of the total installed wind energy capacity in China.

NUON will furnish 55% of an initial funding of US$ 10 million, while its Chinese partners will furnish the remaining 55%. The contract will last for 25 years. NEG Micon will supply equipment, site construction, installation of turbines, and plant operation for five years after its completion.

Project Duration and/or State of Advancement:

The wind plant will be completed in May 1998 and operational in June 1998. The project period will be 20 years.

For more Information Contact:

Organisation: NOUN

Address:

Tel.:
Fax:
E-mail : noun@noun.nl
Internet address: http://www.nuon.nl/

Electric Car Project

Objective:

China has just started a project for building electric cars. The overall target of the electric car project in the Ninth Five Year Plan period (1996-2000) included:

1. To manufacture electric cars with both Chinese characteristics and international standards, and making preparations for the industrial production of electric cars in the 21st century.
2. To build a base for building economical and practical electric cars with an annual production capacity of 3,000-5,000 cars.

3. To set up two or three pilot areas for operation of electric cars including infrastructure facilities, maintenance and service experiments, production, marketing etc.
4. To formulate preliminary policies, laws, regulations and technological catering to the requirements of electric car development.

One of the chosen pilot areas is Nan'ao Island.

General Information:

Peugeot Citron Group:

France's Peugeot Citroen Group has agreed to help China develop mass-produced electric vehicles. The French firm, which is the partner in a joint venture with Dong Feng Motor in Shiyan, Hubei Province, will test electric vehicles at Nan'ao Island.

Efforts will focus on the development of a 20-25 seat electric minibus, a 3.5 ton electric van, a smaller 1.6 ton delivery van, a 5-6 seat taxi, and a small electric vehicle capable of recharging itself at special powered parking spots.

General Motors:

The world's largest motor vehicle manufacturer GM Motors (GM) announced in the end of 1997 that it will run a fleet of electric cars and trucks charged on wind energy on Nan'ao Island. The demonstration project will be the first ever zero emission transport system anywhere involving a car or van.

The vehicles to be shipped to the island are two-seat EV1 and the S-10 pick-up trucks. The three year electric car demonstration project will begin in 1998.

For more Information About Wind Energy on Nan'ao Island Contact:

Organisation:	Zhen Neng Wind Energy Co, Ltd Attn. Zhang Zhen Gui
Address:	Houzai Nan'ao County P.C: 515900 Guangdong Province China
Tel.:	
Fax:	+86 754 6803467
E-mail :	
Internet address:	

Organisation:	Shantou Fuao Wind Power Co., Ltd. Attn. Chen Shao Yi
Address:	2/F., No. 44 Jinhu Road Shantou P.O.: 515041 China
Tel.:	

Fax: +86 754 8322104
E-mail :
Internet address:

South Pacific

Coconut Island (Australia)
Flinders Island (Australia)
Galapagos Islands (Ecuador)
King Island (Australia)
South Pacific Islands
Thursday Island (Australia)
Tuvalu
Republic of Kiribati
Western Samoa

MAP

Coconut Island (Australia)

General Information:

Population: 200

Area (km2): 0.5

Coconut Island is located in the Torres Strait between Australia and Papua New Guinea.

Energy Information:

Until 1987 the only electricity available to the 200 inhabitants came from small noisy diesel generators scattered throughout the community. The electricity on the island is now generated by a hybrid wind/solar/diesel system. The system consist of:

- 1 x 25 kW peak solar array
- 10 kW Bergey type Westwind wind generator
- deep-cycle batteries
- 2 x 30 kVA three phase inverters
- 2 x 60 kW diesel generators

Installed Electricity Capacity by Source 1997:

Source	Installed Capacity	Percentage of Total Installed Capacity
Diesel	120 kW	77.4%
Renewables	35 kW	22.6%

An average of 15 kW is generated by the solar panels while technical problems have limited the average output of the wind generator to only 5 kW. A new controller was installed in 1997 and it should have improved the wind generator's output. The highly corrosive atmosphere on the island have contributed to slight deterioration of the solar panels and corrosion of the wind turbine tower.

In 1997 the renewables in the system accounted for 5% of the total generated power. Annual savings of AU$ 3,500 in fuel are realised due to the renewables in the system.

For more Information Contact:

Organisation: Far North Queensland Electricity Corporation Limited (FNQEB)

Address: P.O. Box 358
Cairns 4870
Australia

Tel.: +61 70 502 777
Fax: +61 70 502 707
E-mail : enquiries@fnqeb.com.au
Internet address: http://www.fnqeb.com.au

Flinders Island (Australia)

General Information:

Population: 950

Area (km2): 1,350

Flinders Island is located app. 50 km off the North East tip of the Tasmanian mainland.

Energy Information:

The island is not connected to the mainland.

Most of the island's electricity is supplied from diesel generators, but a significant part is from wind power.

Installed Generated Electricity Capacity in 1997, by Source:

Source	Installed Capacity	Percentage of Installed Capacity
Diesel	1,700 kW	95.5%
Wind	80 kW	4.5%

Electricity Production by Source in 1997:

Source	Production	Percentage of Total Production
Diesel	3,300 MWh	94.3%
Wind	200 MWh	5.7%

End User Cost per Unit of Energy

Unit	Cost
Diesel Oil	US$ 0.53
kWh Electricity	US$ 0.12
LPG pr kg	US$ 1.61

Renewable Energy Installations:

The are installed two grid connected wind turbines on the island: 1 x 25 kW and 1 x 55 kW. The 55 kW turbine was commissioned in May 1988 and the 25 kW was commissioned in June 1996.

The organisation of the turbines is as follows:

Finance	Private
Ownership	Private
Operation and Maintenance	By contract with a private firm

The trial 750 kW wind power plant on the "neighbour" King Island (Australia) may result in more wind power being installed on Flinders Island.

Renewable Energy Plan:

There is not an overall renewable energy and energy efficiency strategy for the islands, but there is a renewable electricity and electricity efficiency produced by the Hydro-Electric Corporation. The transport sector is not included in these strategies.

The objective is to maximise the supplementation of electricity grid diesel generation with renewable energy sources such as wind generation.

Hydro-Electric Corporation also has various Demand Side Management strategies.

For more Information Contact:

Organisation: Hydro-Electric Corporation
Project Manager Robert Stewart
Address: GPO Box 355D
Hobart
Tasmania
Australia
Tel.: +61 3 62 30 5272
Fax: +61 3 62 30 5277
E-mail : rob.stewart@oa.hydro.com.au
Internet address: http://www.hydro.com.au

Galapagos Islands (Ecuador)

General Information:

Population: 12,000

Area (km2): 7,882

Galapagos Islands is located app. 1000 km West of mainland Ecuador.

Galapagos Islands consists of the following major islands: Española, Fernandina, Genovesa, Isabela, Marchena, Pinta, Pinzon, San Cristóbal, Santa Cruz, Santa Fé, Florena, and Santiago.

Below are specified population and area for the four islands where the main part of the population lives:

Island	Population	Area (km2)
Isabela	1,080	4,589
San Cristobal	4,000	558
Santa Cruz	6,000	986
Florena	100	173

Energy Information

None of the islands are connected to the mainland.

All of the energy supply is from fossil fuels. Below are specified total energy supply in 1997:

Island	Total Energy Supply
Isabela	800 MWh
San Cristobal	4,100 MWh
Santa Cruz	6,300 MWh
Florena	15 MWh

Below are specified end user price in US$ per unit of energy in 1997:

Island	Diesel Oil (Gallon)	kWh Electricity
Isabela	0.7	0.23
San Cristobal	0.7	0.2
Santa Cruz	0.7	0.18
Florena	0.7	0.23

Renewable Energy Plan:

There is a renewable energy plan for the Galapagos Islands. The overall objective is a step by step change to an environmental friendly energy system. The transport sector is not included in this plan.

The degree of self-sufficiency with renewable energy that is realistic within few years is app. 50%.

A major element of this plan is the installation of hybrid diesel/wind/PV systems on each of the islands of Isabela, Santa Cruz, San Cristobal, and Florena. The title for this major element is "Auto-sustainable Renewable Energy Program".

Common for the systems is that they will be grid connected and that there is educational efforts regarding renewable energy.

The application of the generated power will be as follows:

- on the islands Isabela and Santa Cruz the generated power will be used for light, water pumping, industry and commerce
- on island of San Cristobal the generated power will be used for light, industry, and commerce
- on the island Florena the generated power will be used for light, and water pumping

Feasibility Study Underway:

In the period February 1998 to September 1998 is there a UN funded (GEF) feasibility study regarding the installations of the above mentioned hybrid diesel/wind/PV systems. The expected outcome of the feasibility studies is:

- a description of possible system design
- a description of financial possibilities
- establishment of consulting services

For more Information Contact:

Organisation: Instituto Ecuatoriano de Electrificacion (INCEL)

Address: Avenidad 6 de Diciembre 2427 y Av. Orellana
Casilla 565
Quito
Ecuador

Tel.:
Fax: +593 2 503 762
E-mail :
Internet address:

King Island (Australia)

General Information:

Population: 1,800

Area (km2): 1,250

The island is located 85 km off the North West tip of the Tasmanian mainland.

Energy Information:

The island is not connected to the mainland grid. All of the island's electricity was until 1997/1998 generated from a 4.8 MW diesel power station. In the start of 1998 a 750 kW wind farm was connected to the existing diesel system.

Installed Generated Electricity Capacity in 1998, by Source:

Source	Installed Capacity	Percentage of Total Capacity
Diesel	4.8 MW	86.5%
Wind	0.775 MW	13.5%

Electricity demand was app. 13,000 MWh in 1997

The end user cost per unit of energy in 1997:

Unit	Cost
Diesel Oil	0.53 US$
kWh	0.12 US$
LPG pr kg	1.61 US$

Renewable Energy Plan:

There is not an overall renewable energy and energy efficiency strategy for the islands, but there is a renewable electricity and electricity efficiency produced by the Hydro-Electric Corporation. The transport sector is not included in these strategies.

The objective is to maximise the supplementation of electricity grid diesel generation with renewable energy sources such as wind generation.

Hydro-Electric Corporation also has various Demand Side Management strategies.

King Island Wind Power (Huxley Hill Wind Farm)

Objective:

The objective to reduce costs of generating electricity and reduce carbon dioxide emissions on the island.

General Information:

The electricity costs the Hydro-Electric Corporation app. 0.29 US$/kWh to generate, distribute and retail. Fuel costs alone for electricity generation are US$ 0.15/kWh which is greater than the tariff at US$ 12/kWh. Hydro-Electric studied wave, wind hydro and pumped storage options for supplementing the existing diesel generators. Wind power was found to be the most favourable option. The island's has very good wind conditions with an average wind speed of about 9.5 m/s.

A 750 kW wind consisting of 3 x 250 kW Nordex wind turbines has been built and is integrated with the existing diesel power station to form a wind-diesel power system.

The project does include educational and information efforts. The project is part of Organisations's Grenhouse Gas Reduction Project and the project is extensively promoted. A tourist information will be provided on the wind farm.

The organisation of the project is as follows:

Financing	The project is funded by the Hydro-Electric Corporation out of the organisations electricity tariff income
Ownership	Public. The Hydro-Electric Corporation is owned by the state
Operation and Maintenance	Contract with private company for the first three years of operation

Achievements:

The following achievements is being expected:

- the wind farm will by 1997/1998 generate up to app. 18% of the islands electricity production
- the wind farm will by 1998/1999 generate up to app. 21% of the islands electricity production due to improvements in the operation of the proposed wind-diesel system
- the wind farm will save US$ 375,000 per year and reduce greenhouse gas emissions by app. 2,000 tonnes per year

The project will give the Hydro-Electric Corporation an opportunity to review wind technology and its application in remote island wind-diesel power systems and possible future large mainland Tasmanian wind farms.

Project Duration and/or State of Advancement:

The phases of the project was as follows:

Phase	Time
Feasibility Study	January 1994
Design	May 1996
Tendering	October 1996
Constructing	September 1997
Termination	January 1998

On going R & D will continue until 1999.

For more Information Contact:

Organisation: Hydro-Electric Corporation
Project Manager Robert Stewart
Address: GPO Box 355D
Hobart
Tasmania
Australia
Tel.: +61 3 62 30 5272
Fax: +61 3 62 30 5277

E-mail : rob.stewart@oa.hydro.com.au
Internet address: http://www.hydro.com.au

Thursday Island (Australia)

General Information:

Population: 4,000

Area (km2): 4

Thursday Island is located in the Torres Strait that borders Australia and Papua New Guinea.

Energy Information:

The island is not connected to the main land. There are no great energy loses in the energy system.

The State owned Far North Queensland Electricity Corporation Limited (FNQEB) has been operating power at Thursday Island since 1956. The main generating plant currently comprises five diesel generating sets with a total rating of 6.4 MW. The system maximum demand is app. 2.6 megawatts and the minimum demand is app 1.0 megawatts. The current power station was commissioned in 1994 and is fully automated. In August 1997 a 500 kW wind power plant was operational and connected to the grid.

Installed Generating Electricity Capacity by Source 1998:

Source	Installed Capacity	Percentage of Total Installed Capacity
Diesel	6400 kW	92.8%
Wind	500 kW	7.2%

Expected Generated Electricity in 1997/1998 by Source:

Source	Generated Electricity	Percentage of Total Generated Electricity
Diesel	13,750 MWh	93,2%
Wind	1,000 MWh	6.8%

For the first 6 months (August 1997 to February 1998) app. 10.4% of total generated electricity came from the wind plant.

End User Cost per Energy Unit 1997:

Unit	Cost
Diesel Oil	AU$ 0.16
kWh Electricity	AU$ 0.10

One kWh of electricity costs AU$ 0.27 to generate.

Renewable Energy Plan:

There is not an overall renewable energy plan for the island, but the State Government owned FNQEB has an overall environmental policy which also include renewable energy.

The objectives regarding renewable is:

- to monitor and support research and development of renewable energy
- to utilise renewable energy sources where economically and environmentally appropriate

Thursday Island Renewable Energy Project

Objective:

The objective of the project is to reduce the use of diesel fuels and cut back the emission of greenhouse gases.

General Information:

The wind power plant consisting of 2 x 225 Vesta wind turbines is Queenland's largest wind power generating plant. The annual wind speed on Thursday Island is 7.5 m/s and is one of the best available wind resources in Queensland.

In some remote locations within FNQEB's service area, the cost of wind generation is economical when compared to diesel power plants. This is the case with Thursday Island.

The following informational and educational efforts are included in the project:

- information pamphlets distributed
- information billboards erected
- articles in local new magazine
- on local radio
- FNQEB staff fully educated in the maintenance and operation of the wind system

The organisation of the project is as follows:

Financing	Private plus government (FNQEB is State owned)
Ownership	Owned by FNQEB
Operation and Maintenance	FNQEB local staff.

The total cost of the project was AU$ 2.5 million and the payback is expected to be nine years.

Achievements:

The following is expected of the project:

- app. 300,000 litre of fuel savings per year. It equals AU$ 230,000 per year
- greenhouse gas emissions will be cut by 1,000 tonnes a year. It equals app. 10%
- 1,000 MWh of wind per year

Project Duration and/or State of Advancement:

The phases of the project is as follows:

Phase	Year
Wind Monitoring	1989
Analysis of Data	1993
Call for Tenders	1996-1996
Contract	September 1996
Project Completed	August 1997

For more Information Contact:

Organisation: Far North Queensland Electricity Corporation (FNQEB)
Generation Development Manager Fiona Morrow
Address: P.O. Box 358
Cairns 4870
Australia

Tel.: +61 7 4050 2873
Fax: +61 7 4050 2702
E-mail : enquiries@fnqeb.com.au
Internet address: http://www.fnqeb.com.au

South Pacific Islands

Utilised Renewable Energy Technologies:

Following the oil price shocks of the 1970s significant attention was focused on developing renewable sources as a substitute to imported petroleum. Although substantial resources were devoted to assessing and evaluating renewable technologies the record of renewable energy projects (excluding hydropower) in the region, particular those funded under development assistance, has been disappointing.

With the exception of hydroelectricity and electricity from agro-industries (largely from bagasse in the sugar industry), the contribution of renewable energy sources to commercial energy remains very low, accounting for less than 1% of the total requirements in 1990.

The technologies that are already technically and commercially proven in the region include:

- small scale PV systems in rural and non-grid connected areas, where they are competing against stand alone diesel and petrol generators
- solar water heating in domestic and commercial applications
- solar drying
- large-scale and mini/micro hydropower in locations where there are sufficient hydrological resources
- agro-industry waste based steam generation (e.g. bagasse in the sugar industry)

PV:

Up to 1994 approx. 4,000 small-scale stand alone PV systems had been installed in the Pacific Island Countries (PIC), typically involving two to eight panels for household lightning, water pumping, and refrigeration.

In 1994 most of the countries had about 50 to 200 house systems each (Palau, FSM, Marshall Islands, Western Samoa, Vanuatu, Cook Islands, Salomon Islands, Kiribati, Tonga, Wallis-Futuna, and New Caledonia), with more in PNG, Fiji, and Tuvalu and considerably more (2,500 estimated) in French Polynesia.

In 1994 several countries had ambitious plans for PV expansion. Tonga, Kiribati, Tuvalu, and the Marshall Islands were considering PV as the primary technology of choice for future rural electrification. The draft development plan for the Marshall Islands, for example, called for 1,500 future household PV lightning installations.

Wind Energy:

Wind energy has not been used for public power supply, and almost only traditionally been used for mechanical water pumping. A few installations of the battery charging type of small windmills (up to 1 kW) which internationally have been used in farms since 1920'ies have been used in the PICs as well, but even this type is not common nowadays expect for their use in yachts.

There have been some projects for assessing wind energy resources:

- Southern Pacific Wind and Solar Monitoring Project (1993-97). The project should identify and measure wind (and solar) resources for grid connection at 1 site in each of the 5 selected countries in latitudes south of 15 degrees south - Cook Islands, Fiji, Niue, Tonga and Vanuatu. It was initiated and implemented under the co-ordination of the Forum Secretariat Energy Division (FSED)
- DOE Fiji Wind Energy Resource Assessment Program (WERAP). The project has installed wind monitoring stations in addition to the one operated as part of the South Pacific Wind and Solar Monitoring Project. The project was started in 1991 with the purpose of enabling estimation of

cost of energy from wind and promote investment in wind energy, e.g. in Building-Own-Operate schemes.

- Pacific-Danish Environmental Education and Action Program - Feasibility Study of Phase 1 (1997). The purpose of the study was to determine the overall technical, economical and organisational feasibility of the wind energy activities suggested and, if necessary, propose adjustments to the program in order to increase its impacts and sustainability.

The Pacific-Danish Environmental Education and Action Program - Feasibility Study of Phase 1 (1997) concluded among other things the following about the potential for wind power in the PICs:

- It is estimated that a wind energy penetration of 10-20% may technically be achieved within a 10-15 years period in islands with sufficient wind resources.
- For the great majority of the island states the option of large wind farms is not relevant due to the limited size of the local power demand. Only PNG, Fiji, Solomon Islands and Samoa have power systems with installed capacities larger than 20 MW.
- The PICs seem to have a number of islands with a potential for grid connected wind turbines in the range 100-1000 kW. An estimated 30 of such islands with 24 hour public power supply systems with minimum (night-time) loads higher than 100 kW exists.
- The largest potential in PICs in terms of number of wind turbine installations is clearly in the small (<100 kW) hybrid power systems
- Wind energy resources favourable for the exploitation of wind energy have been said to be limited to latitudes south of 10-15 degrees S or north of 10-15 degrees N. This assumption may be quite uncertain. It was clear from the visits to both Cooks, Fiji and Tonga that the South Pacific Wind and Solar Monitoring Project has improved the basis for making wind resource assessments at the five measurement locations considerably. Previous estimates of the wind resources have been quite uncertain , and generally the was underestimated.

Potential for Renewable Energy:

Despite the relatively poor past performance of renewable energy technologies the prospects for increasing the utilisation of renewable energy sources in the medium to long term are very good. The regions energy resource base is large relatively to demand, particular for solar and in some countries hydro and biomass.

Barriers to the Increased Utilisation of Renewable Energy in the Pacific:

Despite the relatively poor past performance of renewable energy technologies the prospects for increasing the utilisation of renewable energy sources in the medium to long term are very good. The regions energy resource base is large relatively to demand, particular for solar and in some countries hydro and biomass.

But there are a range of barriers and obstacles, which are limiting the contribution of renewable energy in the South Pacific Islands. These vary from country to country but generally they include:

- electricity and petroleum product subsides
- inappropriate duties and charges
- lack of skilled manpower for planning. operation and maintenance
- high up front capital cost
- lack of sufficient credit and financial resources
- conservatism in relation to new technologies, particular in agro-industry and electricity power utilities

For more Information Contact:

Organisation: Forum Secretariat
Energy Division
Address: Private Mail Bag
Suva
Fiji

Tel.: +679 312 600
Fax: +679 303 828
E-mail :
Internet address:

Republic of Kiribati

General Information:

Population: 69,000

Area (km2): 823

The 33 islands in the Republic of Kiribati are divided into three main groups spanning a total ocean area of 13 million km2.

Energy Information:

Kiribati is almost totally dependent on imported fossil fuel for its commercial energy. Motor vehicle, aviation, and marine vessel fuels are imported at very high cost to the country.

For domestic energy, fuelwood is used for approx. 90% of cooking in the outer islands by most families in South Tarawa. Increasing population and the high cost of kerosene and fuelwood substitutes have led to overexploitation of fuelwood on South Tarawa and increasing dependence on nutritionally inferior procedded foods which require no cooking.

Almost all electricity generation depends on diesel fuels. An exception is the promotion of PV for outer islands.

PV systems:

Out of the 33 islands only 3 islands have been partially covered in Kiribati's PV based rural electrification programme. Since its first operating in February 1992, the solar home systems are still working, battery are still in good condition and utility fee charged to the consumers are regularly paid and collected.

In 1997/1998 total installed PV capacity is estimated to 80 kW and electricity production from PV is estimated to approx. 1,500 W or 0.2% of the current demand.

Kiribati are now embarking on a full-scale national electrification program, though little progress have been made due to lack of capital in financing the initial costs needed.

For more Information Contact:

Organisation: Solar Energy Company Limited

Address: P.O. Box 493
Betio
Tarawa
Republic of Kiribati
Tel.: +686 26058
Fax: +686 26210
E-mail :
Internet address:

Tuvalu

General Information:

Population: 9,250

Area (km2): 25.9

Tuvalu's have nine islands, which extends over 560 km from north to south. The capital island Funafuti has an area of 2.8 km2.

Energy Information:

Tuvalu depends almost wholly on imported diesel fuel for electricity generation, and motor vehicle and marine vessel fuels are imported at very high costs.

Tuvalu's base of commercial-scale indigenous energy resources is very limited, restricted exclusively to biomass and solar.

Fuelwood is used for app. 90 percent of cooking in the outer islands and also by most families on capital island Funafuti. Increased population and the high cost of kerosene and fuelwood have led to over exploitation of fuelwood, particular mangroves (an important pig feed) and an increasing dependence on nutritionally inferior processed foods which require no cooking.

The use of PV systems, has been promoted by Tuvalu Solar Electric Co-operative Society Ltd (TSECS), and have successfully been established on each of the eight outer islands. Out of the 984 outer island households in 1994, 425 or 45% households utilised PV.

In 1995 about 200 hundred additional outer island households was awaiting the provision of new PV lightning systems. With the installations of these systems the number of households supplied with PV systems would exceed the number of households on Funafuti supplied with electricity by the national utility, the Tuvalu Electricity Corporation. Additionally, a significant number of the existing members of TSECS was awaiting extra hardware and equipment such as lights, converters and inverters to operate radios and VCRs.

With access to diesel generated electricity primarily on Funafuti and the introduction of solar power to the outer islands app. 71% of Tuvalu households had some form of electric lightning in 1994.

Renewable Energy Plan:

The Government's overall energy policies can mainly be found in "Kakeega o Tuvalu: National Development Strategy 1995 to 1998". The Kakeega is the Government's over-riding statement, which outlines the community's social and economic development aspirations.

The Agenda for Expanding Energy Services (in Rural Districts)

1. Energy Pricing and Taxation:

As far as possible, pricing and taxation of energy will be set in order to maintain the financial viability of national electric utilities, reduce fiscal burden, maximise economic efficiency, encourage energy efficiency, dampen growth for growth for imported petroleum fuel, and harmonise the development of the energy sector with the environment.

2. Rural Electrification

Generally, the Government and the island community have two primary options for expanding the supply of electricity on the outer islands:

- diesel electrification

- electrification with PV systems

Advancing either option will be costly and will need to be accomplished with Overseas Development Assistance, channelled through the Tuvalu Electricity Corporation (TEC) and TSECS. Concessionary loans may be another source of finance for these institutions.

3. Future External Technical Support

The TSECS have been providing electricity service to the outer islands households since 1984. Experience has shown that PV for small rural demands can be competitive with diesel. While the quality of service provided by the latest OV installations has improved significantly, as has the quality of service provided by the TSECS management, the demand for additional electrical service on the outer islands is on the rise.

The Tuvalu Solar Electric Co-operative Society

General Information:

PV systems were first introduced into Tuvalu in 1979 to power the inter-island telecommunications system. Following the success of Telecom's solar programme, the Tuvalu Solar Electric Co-operative Society (TSECS) was formed in 1984 by the Save the Children Federation (USA) to provide small PV lightning kits to outer island households, which at that time were illuminated exclusively by kerosene lamps.

Major points of the TSECS organisation are:

- The systems are owned by the TSECS, not the users. This provides flexibility and the ability to change or upgrade systems without user investment;
- Fee collection are by the national organisation, not a local one and issues of patronage and familial ties are not generally present. Disconnects can be arranged for non-payment, something which can be very difficult with local fee management;
- The main office, headquartered on Funafuti, consist of the Manager, one or two senior technicians, and an accounts officer;
- A technician who is a full time employee at the TSECS is stationed on each island and visits each household once per month to perform technical checks and collect fees;
- Technical training is emphasised with all technicians receiving refresher training annually
- Senior technicians from the main office audit the performance of island technicians at least twice a year and are available to assist island technicians is a particular difficult problem arise;
- Users have a choice of system size and accompanying fee. Historically, the TSECS has charged A$ 6.25 per month for a one panel system and A$ 7.60 for a two panel system. Following the system upgrades in mid-1994 to

two and three panel systems with night lights, monthly fees will be increased accordingly to reflect the increased provision of service;

- Users are shareholders in the TSECS and have representation through an elected island "Branch Committee" and a national "Management Committee" made up of chairman of each island committee. The Management Committee, which is lead by a Chairman, is effectively the Board of Directors of the TSECS whose main function is to provide policy guidance, review annual accounts of revenue and expenditure, approve estimates of revenue and expenditure, and set monthly fees.

Achievements:

The Tuvalu rural PV lighting programme, as executed by the TSECS, is one of the few such projects in the world which can claim success and growth for over 10 years, and is almost certainly the oldest organisation in the world to continuously provide rural electrification with PV. The TSECS is also one of the few private organisations in the world dedicated exclusively to rural electrification by solar PV and has an organisational structure specifically evolved to provide that function.

In 1994 the TSECS provided electricity to as many private households as did the larger and better resourced diesel utility Tuvalu Electricity Corporation.

An abundant supply of year-round sunlight combined with the high cost of conventionally produced electricity at remote sites make Tuvalu a model location for PV applications. However, abundant solar resource and economic advantages are not sufficient conditions to ensure successful PV based rural electrification.

In the Tuvalu experience, eight years were required for the country's solar programme to evolve to the point where PV systems function as customers expect and are technically capable of providing reliable electrical service. It also took eight years to identify, test and install reliable PV systems and to develop the required degree of technical, managerial and organisational expertise to make the success of the programme.

The main ingredients of TSECS' success appear to be:

1. good maintenance, provided by local technicians and visiting senior technicians
2. good rate of fee collection by an impartial organisation based outside the community and use of the fees exclusively for the project
3. local user committees, which can arbitrate disputes between users and technicians about fee collections, disconnections, and poorly functioning systems and keep the users informed about the functioning of the enterprise
4. TSECS' exclusive focus on PV systems
5. availability of systems of different sizes to meet the varying electrical needs and financial resources of the users
6. continuing and competent internal and external training

7. readily available external technical support to assist with system design and training development

Based on the experience of the Pacific island countries, the main institutional lessons learned are as follows:

1. *Maintenance*. In the pacific outer island environment, user maintenance of PV systems is rarely successful, and frequent visits by trained maintenance personnel are very important. Although "handymen" working in churches, schools, and hospitals have been successful to some extent in maintaining their institutions' PV systems, rural householders generally lack the skills to diagnose PV problems and make effective repairs.
2. *Fee Collection and Management.* These should be from outside the community, because collection is lax with local organisations, and the collected funds are often spent on non-PV projects in the early years when the need for repair and replacement funds appears relatively low.
3. *Spare Parts.* These must be readily available in the field. The substantial expenditure required to maintain such stocks is necessary to prevent the long delays associated with ordering parts from headquarters or overseas.
4. *Technical Assistance*. Field technicians should have ready access to technical assistance and continuing training programs.
5. *Local Arbitration*. An arrangement for local arbitration should be made between the user and the external services suppliers, particular as regards disconnection for failure to pay fees.

For more Information Contact:

Organisation: Tuvalu Solar Electric Cooperative Society (TSECS)

Address:

Tel.:
Fax:
E-mail :
Internet address:

Western Samoa

General Information:

Population: 37,000

Area (km2): 197

Energy Information:

Electric Power Corporation (EPC) operates two separate power systems in the island of Upolu and Savai'i of which the Upolu system is by far the more

developed. The mountainous terrain and high annual rainfall makes hydro power a viable proposition and since the 1920s electricity supply in Upolu has consisted of a mix of diesel and run-of-river hydroelectric plant. There are no hydro-power plants in Savai'i.

Upolu Installed Electricity Capacity by Source, in 1993:

Source	Installed Capacity (MW)	Installed Capacity in Percentage
Diesel	8.2 MW	49.1%
Hydro	8.5 MW	50.9%

(Source: Waide, Paul: "Toward Energy Independence in Western Samoa. An Integrated Energy Study", 1995)

The actual operational capacity is considerably less because most of the diesel plant is derated due to mis-operation and insufficient maintenance, while the average output of the run-of-river hydro plants drops by up to 75% during the dry season (May to October).

Upolu Electricity Production by Source, in 1992:

Source	**Generated Electricity**	**Percentage of Total Generated Electricity**
Diesel	30.6 GWh	63.9%
Hydro	17.3 GWh	36.1%

(Source: Waide, Paul: "Toward Energy Independence in Western Samoa. An Integrated Energy Study", 1995)

The Caribbean

The Bahama Islands
Barbados
Bonaire Island
Curacau
Dominica
Grenada
Guadeloupe (France)
Puerto Rico
Roatan Island
Saint kitts and Nevis
Saint Lucia
Saint Vincient and the Grenadines
U.S. Virgin Islands

MAP

Barbados

General Information:

Population: 258,600

Area (km2): 430

Energy Information:

Barbados is heavily dependent on fossil fuels for energy production. All electricity is generated by fossil fuel-fired thermal power plants. While primary energy production is increasing, about 40% of all energy is still imported (app. 60% of which is crude oil).

Nearly 100% of the population has access to electrical service with capacity growth expected at 3.2% annually through the year 2000. Electricity rates, ranging between $0.093/kWh and $0.11/kWh in 1994 was among the lowest in the Caribbean.

Energy Plans:

In 1993 Barbados introduced the "Energy Development Plan 1993-2000" in which renewable energy has an important role.

Through the Plan, Barbados is initiating a far reaching plan to expand and diversify the energy sector by increasing domestic oil and gas production, introducing energy conservation and alternative energy, and reducing dependence on imported fossil fuels.

The plan calls for introducing unleaded gasoline, reducing dependence on hydrocarbons to produce electricity, training in the application of new technologies, and the use of regional organisations to assist in technical and financial development.

The Plan promotes the continued use of environmentally sound alternative energy sources with associated investment incentives. Private investors are encouraged to build and operate wind farms. The Plan also promote the introduction of unleaded gasoline, the continued use of bagasse to supply electricity to sugar factories and to the national grid, and demand-side management programs as an integral part of government policy.

Both solar and wind energy resources are incorporated. A recent solar resource assessment measured insolation levels of 5.4 kWh/m2/day. Average annual wind speeds of 8 m/sec. exist in selected regions of the island. Bagasse, if fully developed, could produce as much as 12 MW annually, nearly 8% of the generation capacity in 1995.

Plans are underway to increase the use of energy conservation technologies in the public sector. Legislation is being enacted to encourage the use of more energy-efficient equipment, offer incentives to companies, which produce non-conventional energy equipment, and implement national building efficiency standards.

Renewable Energy Installations:

Solar Water Heaters:

The solar water heaters in Barbados is one of the best know examples of the exploitation of a renewable energy technology in the Caribbean.

23,388 solar water heaters were installed in the period 1972-1992, app. one for every three households. The savings to the householders in 1992 alone were app. US$ 9,750,000.

Income tax concessions were allowed on the purchase of solar water heaters. These measures led to a 60% increase in sales during 1988-1993 compared with previous years.

PV:

PV is used for small telecommunications applications.

Wind Feasibility Study:

The government will in the period January 1998 to January 1999 finance a wind farm feasibility study. The objective is hereafter to build a grid connected wind farm.

For more Information Contact:

Organisation:	Ministry of Finance and Economic Affairs Energy Division
Address:	NPC Building Wilday St. Michael Barbados
Tel.:	+1 246 429 5254
Fax:	+1 246 436 6004
E-mail :	
Internet address:	

Scotland District Renewable Energy Enhancement Project

General Information:

The project is part of an effort by the government to encourage the use of renewable energy technologies and the development of Eco-tourism projects while developing new markets, creating manufacturing and job opportunities for rural people.

In November 1996 a group of rural farmers and technologists set up a farming cooperative with a interest in farming 1000 acres of land. It was also decided to establish a site in the middle of the farm lands where Renewable Energy Technologies (RET) can be used by the farms and cottage industries and at the same time demonstrate the benefits of RET to the local and regional community.

So far a limited number of re systems have been put in place. The energy needs for the farmers and proposed projects are:

Irrigation, cold storage/Ice production and baking of clay - Wind turbines will be set up to pump water to 400 acres of land as well as preserve vegetables under cold storage. The energy will also be use to power and electric kiln to be used by the local pottery businesses.

Lighting and Communications - The lighting and communications needs of the farmers will be met by remote lights and radios powered by photo-voltaic.

Energy system production capacity – Materials and training will be put in place for the farmers to construct their own solar cookers, dryers and water heaters.

Training - Training will be put in place at the site and support given to regional participants to attend a limited number of training courses.

The project is expected to: support 100 farmers/ cooperative members towards development of over 1000 acres of agricultural land; reduce the barriers to use of RET by demonstration; training of 100 rural persons in use of RE systems; develop rural RE enterprises; establish irrigation, cold storage, lighting, communications systems using RET; transfer technology by training of interested persons in governments, schools, universities, private sector and NGO community, locally and in the region; act as a model for use of RET for rural development in small island states.

The University of the West Indies will develop a graduate and short-term training RET course at site, and the GEF will support the establishment of the RETs systems. The major stakeholders in the project are:

1. Scotland district renewable Energy group
2. St.Andrew Small Farmers and Cottage Industry Cooperative
3. CERMES; University of the West Indies
4. Barbados government agencies (Energy Conservation Unit, Ministry of Environment, Rural Development Division Commission, Ministries of Tourism, Education and Agriculture)
5. Rural businesses and Farmers
6. School children
7. Tertiary students
8. Local, regional and international tourists

The estimated budget is app. US$ 769,000.

Achievements:

The Ministry of Environment/Energy Conservation unit supports the project concept.

Parts of the project have been implemented, but for the major investments in the renewable energy technologies funding are currently being sought, primarily from the Global Environment Fund.

For more Information Contact:

Organisation: Scotland District Environment Park Group
Bawden Plantation
Address: Bawden St. Andrew
Barbados

Tel.: +246 438 8076
Fax:
E-mail : caribbeanret@sunbeach.net
Internet address:

Curacao (Netherlands Antilles)

General Information:

Population:

Area (km2):

Energy Information:

Curacao's annual electricity consumption is 530 million kWh.

Wind Energy Plant Tera Cora, Curacao, Netherlands Antilles

Objective:

The objective of the project was to:

1. To demonstrate that generating electricity through wind power is a viable option for utilities in the Caribbean region, by installing the first large wind farm in the area. This involves the climatic conditions in which the turbines have to operate, the small grid in which they have to operate, the small grid in which they will be integrated and the financial constraints of the utilities.
2. To diversify the electricity production on Curacao. At that time the electricity production was generated 100% from imported oil. The island is rich on natural resources such as sunshine and it has a good wind regime.
3. To disseminate the experience gained in the Caribbean and Latin American region, and to become a show-piece for wind technology.

General Information:

A wind farm of twelve NedWind turbines 250 kW each was installed. The nominal power of the farm is 3 MW. In the design and engineering phase, corrosive environment and the humidity had to be accounted for. Special wind conditions, especially strong and fast fluctuations of the wind, which normally cause disconnection of the farm, were another noteworthy issue. Due to the location, far from inhabited areas, noise problems were avoided. Stability problems, due to a small and weak grid, and the effects of the grid fluctuations on the turbines are important topics, which have been followed. The contribution of the turbines to the peak load behaviour, and capacity credit of the wind farm, were other grid connection issues that were monitored.

Extensive monitoring, and follow up, are being performed by NedWind and the local Kobela. Along with technical issues already mentioned, the annual costs of operation and maintenance are closely monitored, to verify the assumptions made, and to project the economy of future wind farms at the region.

Achievements:

The 3 MW wind farm is the biggest wind farm in the Caribbean.

The measured availability of 93.2% and mean annual production of 9200 MWh both exceeded their estimated values. The annual equivalent full power operation hours, exceed 3000 h which is very good. In the first year after completion the wind farm supplied 1.1% of Curacao's power needs.

Mechanical problems during the first two years included malfunction of break pads (due to faulty gluing) and twisting of power cables in the tower, due to a

fault in yaw control. The observed power vs. wind speed values exceeded the power curve given by the manufacturer.

The success of this project will open large wind potential of the Caribbean area and of similar island communities, where electricity is produced by imported oil only, and which are characterised by high, durable and stable winds.

The plan is to implement a phase 2 in which another 6 MW of wind capacity will be installed.

Project Duration and/or State of Advancement:

The project lasted 39 months, from December 1991 to Marts 1995.

For more Information Contact:

Organisation: Kobela NV

Address: Pater Eeuwensweg 1
Willemstad
Curacao
Netherlands Antilles

Tel.:
Fax:
E-mail :
Internet address:

Dominica

General Information:

Population: 119,658

Area (km2): 750

Energy Supply:

Installed Capacity in 1994, by Source:

Source	Installed Capacity	Percentage of Total Installed Capacity
Hydro	7.6 MW	51.4%
Diesel	7.2 MW	48.6%

(Source: "Country Profiles. Renewable Energy and Energy Efficiency in Latin America and the Caribbean", 1995)

In 1995 hydroelectricity supplies approx. 50% of Dominica's electricity power supply.

The two newest hydro generators, located in Trafalgar and Laudat, generate 4.8 MW combined and account for 37% of total hydro output. In the future Dominica is looking at expanding its hydroelectric capacity.

The government is considering the drilling of two trial wells to exploit a potential 280 MW of geothermal capacity.

For more Information Contact:

Dominican Electricity Services (DOMLEC), which is app. 60% state-owned, controls the energy infrastructure in Dominica.

Organisation: Dominica Electricity Services, Ltd

Address: P.O. Box 13
Roseau
Commonwealth of Dominica

Tel.: +1 809 448 2681
Fax: +1 809 448 5397
E-mail :
Internet address:

Guadeloupe (France)

General Information:

Population: 385,000

Area (km2): 1,700

Guadeloupe is an archipelago of the following eight inhabited islands: Basse-Terre, Gande-Terre, Marie-Galante, La Desirade, Les Saintes, Saint-Barthelemy, Saint-Martin, and Tintamarre.

Renewable Energy Plan:

Guadeloupe is devoid of any hydrocarbon natural resources and therefore could the island be totally dependent on outside energy supplies. To free itself from this major constraint, Guadeloupe's Regional Council has decided to adopt an aggressive policy line aiming at increasing the island's energy independence by developing the abundant renewable energy resources.

The Regional Council works in close collaboration with Ademe (Agency for the Environment and Energy Management), and they firmed this up by an

agreement signed in 1994. In this agreement the major objectives is as follows:

- generate 25% of the population's energy needs by the year 2000 from renewable energy sources
- get fossil fuel energy consumption under control by replacing it with own local natural energy resources each time it is technical and economically cost-effective for the local community

This programme benefits from the French State and EU (EFRD and the THERMIE programme).

The program has also been backed by EDF (French Electricity Board) whose activity in Guadeloupe shows a large deficit because there is are a uniform price in France independent on location.

Off-grid Renewable Energy Projects

- *Solar hot water heating*: app. 10,000 private homes as well as numerous hospitals, clinics and school canteens use this energy supply. A good part of the solar water heaters on the market are manufactured in Guadeloupe. It is estimated that they have meant a saving of 20 MW of the generating power rating in Guadeloupe.
- *PV for rural power supply*: app. 2000 solar generators supply electricity to homes situated in remote sites in Guadeloupe, such as banana processing centres, farms, telephone exchanges, hertz relays, and health clinics. Consumers only have to pay a subscription fee and for the energy consumed which makes this solution accessible for rural families. This type of technology has been so reliable that all contracts benefit from a 15 years warranty guaranteeing supply, including battery renewal.

Grid Connected Renewable Energy Projects:

- *Hydropower*: five small hydropower plants located in the foothills of the Soufriére mountain range supply the Basse-Terre grid with electricity.
- *Geothermal energy*: the 5MW power plant in Bouillante, exploits the underground steam resource coming from the volcano's heat. The plant supplies the leeward coast with electricity. Recent studies have confirmed an expected output of 20 MW.
- *Wind energy*: turbines designed specially for regions exposed to hurricanes supply 80% of the electricity needs on La Desirade's and the Petite Place wind power plant in Marie Galante supply 30% of the islands electricity needs.
- *Bagasse*: a 60 MW co-generation (bagasse and coal) power plant
- *Thermal energy from combustion gas*: a unit is running at the EDF power plant in Jarry, and another one is under construction.

For more specific information on some of these projects, see later in this section and the sections about Le Desirade, Marie-Galante, and Saint-Barthelemy.

Future Renewable Energy Projects:

The following wind plant projects, among others, has been selected for construction under the second round of France's Eole 2005 wind programme:

1. Marie Galante (Petite Place): 1.5 MW
2. Marie Galante (Morne Constant): 1.5 MW
3. La Desirade 2.4 MW
4. Guadeloupe (Petit Canal) 2.4 MW

The project will be built before year 2000.

2 X 30 MW, Bagasse/Coal Power Plant

Objective:

The objective is to demonstrate that bagasse can safely and reliably be burned in high pressure boilers in order to produce massive quantities of electricity into a relatively small network.

This project deals with the construction of a power plant that will burn all of the bagasse (about 300,000 tons p.a.) supplied by the adjacent sugar mill. The burned bagasse will in return provide process steam to the mill (on average 124 tons per hour) as well as 50 MW of electricity to the island network, during the cane-crushing season.

During the rest of the year the plant will operate as a normal power plant and will burn coal and supply 55 MW of electricity.

General Information:

The basic idea behind this facility is to design a plant that can burn as efficiently as possible all the bagasse supplied by the adjacent sugar mill as it flows in, with no preliminary treatment.

The plant, fully automated, consists of:

1. Two identical boilers (140 tons of steam per hour each) burning bagasse, coal or a combination of the two fuels. Producing steam at 80 bars and 520 C.
2. Two identical steam turbines with their alternators, condensers, cooling towers.
3. All the associated equipment, like fuel handling, water treatment and ash/slag removal systems.

The plant will operate in the following fashion:

1. During the cane season, the plant burns bagasse and supplies electricity to the network and low-pressure steam (3 bars) to the sugar mill. The available power to the network is 51 MW.
2. During the rest of the year, the plant burns coal and supplies 55 MW electricity to the network.

The plant burns 200,000 tons of bagasse and 130,000 tons of coal per year while it supplies 325 GWh of electricity, and 270,000 tons of steam.

Project Duration and/or State of Advancement:

The project lasted for 40 months, from July 1993 to November 1996.

For more Information Contact:

Organisation: Societe Industr. Develop. Energie Charbon

Address: rue de Miromesnil 30
75008
Paris
France

Tel.:
Fax:
E-mail :
Internet address:

La Desirade (Guadeloupe)

General Information:

Population: 1500

Area (km2): 20

Energy Supply:

The energy supply sources on La Desirade consist of one thermal power plant and one wind farm:

1. Thermal power plant: 1 x 160 kW and 3 x 240 kW. Peak load is 420 kW.
2. Wind farm: the 500 kW wind farm meets today app. 80% of the electricity demand on the island.

The grid is 12 kilometres long. The island is connected to Guadeloupe via an underwater cable of 2 MW capacity.

Installation of a Wind Farm Coupled to the Diesel Powered grid of the Desirade Island. Phase 1: 1991-1993.

Objective:

The objective of the project was to make a full-scale demonstration on the feasibility of attaining high rates of wind energy penetration in small, diesel-powered electricity systems and quantifying the resulting fuel savings. A yearly target wind energy penetration rate of 40% was designed for a wind energy delivery of 615 MWh.

This high level of wind energy penetration was to be reached without any trouble for the complete system, as well for the diesel plant as for the customers. The cost of used wind energy was planned to be lower than the cost of saved diesel oil.

General Information:

From 1993 to 1996 the inhabitants of La Desirade have been supplied by a 144 kW wind power plant, connected to diesel generating sets. At that time it was the largest wind power plant project in the French Overseas Departments.

The twelve 12 kW wind power plants were designed by Vergnet. They can resist winds of 250 kph and may keel over during hurricanes. This happened twice, in August and September 1995.

The wind power plant was financed by:

European Union, THERMIE programme:	29.13%
Fonds Régional de la Maîtrise de l'Energie:	26.10%
EDF (the French and Overseas ulility):	26.10%
VERGNET:	16.66%

Achievements:

The feasibility of the wind-diesel concept with high wind penetration could be verified. The wind/diesel power plant on La Desirade was one of the first installations able to achieve up to 70% wind energy penetrations into a diesel powered electricity grid, whilst maintaining stable frequency, power factors and voltage. The power plant provided on average 40% of the island's electricity output in 1992.

The annual wind energy targets, together with the goal of savings in diesel oil, could be met.

Project Duration and/or State of Advancement:

The project was completed in 1993.

For more Information Contact:

Organisation: Vergnet
Address: 6, rue Henri Dunant
Ingré
Orléans
France
Tel.:
Fax:
E-mail :
Internet address:

Installation of a Wind Farm Coupled to the Diesel Powered grid of the Desirade Island. Phase 2: 1993-1996.

Objective:

The objective was to ensure total electricity autonomy, and if possible even export to Guadeloupe.

General Information:

Total electricity consumption on La Desirade increased by app. 10% a year from 1992, reaching 2,450,000 kWh in 1995, reducing the wind energy penetration to 27%. Additionally a new factor was decisive in the decision to increase the existing 144 kW of power to 500 kW: an underwater cable of 2 MW capacity was being installed by EDF between the islands of Guadeloupe and La Desirade. The presence of the cable modified the basic operation of the system on La Desirade. In particular it authorised the increase of wind power input to the system, because it was no longer limited by the minimum operation load condition of the diesel generator.

The existing 10 metre diameter turbines was retrofitted to rated powers of 25 kW instead of 12 kW, and a series of 8 turbines was added to the 12 already on site.

The second phase was financed by:

Private investors:	60%
Fonds Régional de la Maîtrise de l'Energie:	21%
SNC Eole Désirade and VERGNET:	19%

The total power plant cost (phase 1 and 2) was 1.15 million ECU and the expected payback time is 7,5 years.

Achievements:

The wind farm is unique in the world from the point of view of the high wind energy penetration: app. 80%.

This confirms the economic and technical viability of wind turbines coupled to small diesel grids. It has shown the systems value in difficult conditions where lager turbines are forbidden: no cranes, roads, or water-side quays are available. Installation and maintenance are also possible in spite of low means and low technological know-how on the island.

The operation system corresponds to the needs in many island communities of the world which present the characteristics of La Desirade: communities relying on diesel generating sets fed into small grids, which represents high costs in maintenance, fuel imports and low quality electricity supply.

The system from La Desirade, have been duplicated on Cap Verde and French Polynesia in 1996.

Project Duration and/or State of Advancement:

The project ended in 1996.

For more Information Contact:

Organisation: Vergnet
Address: 6, rue Henri Dunant
Ingré
Orléans
France
Tel.:
Fax:
E-mail :
Internet address:

Photovoltaic at the Service of Security on the Island of La Desirade

Objective:

The objective of the project is to:

1. Provide sure and reliable electricity supply for essential safety appliances in hurricane regions. Previous experience in Guadeloupe has confirmed that PV generators are far more resistant to cyclones than the main grids.
2. To promote the island as a regional example for the use of renewable energy.

General Information:

A total PV power of 21.6 kWp is installed on La Desirade:

1. 10.9 kWp is installed in eleven systems in communal facilities including the Town Hall, police station, fire station, pharmacy, hospital, canteen, schools and shops to give security of electricity supplies in case of cyclones.
2. The remaining 10.7 kWp is used in seven systems to provide demonstrations in an eco-museum, three schools and three colleges.

Technical specifications of all the PV installations on La Desirade:

No. of subsystems:	18
Total power:	21.5 kWp
Backup:	partially grid
No. of modules:	app. 475
Module description:	PHOTOWATT, BPX 47-500, polycristalline, 462 x 1042
Connection:	two in series
Support:	on racks and roofs
Crh. controler	TOTAL ENERGY
Battery:	CEAC, 24 V
Battery (Ah):	750
Battery (kWh):	18
Inverter:	MASTERVOLT, MAS 24/2500
Inverter in (V):	24 V dc
Inverter out (V):	220 V ac
Inv. power (kw):	2.5

The total investment was 430,292 ECU and EU co-financed 150,602 ECU (app. 35%).

Achievements:

The energy savings are app. 20,000 kWp per year.

Project Duration and/or State of Advancement:

The project lasted for 30 months, from September 1994 to February 1997.

For more Information Contact:

Organisation: Vergnet
Address: rue Henri Dunant 6
45140 Ingre
France

Tel.:
Fax:
E-mail :
Internet address:

Les Saintes (Guadeloupe)

General Information:

Population: 3,000

Area (km2): 13

Îles des Saintes consists of the two small islands Terre-de-Haut (population app. 1500 and area 6 km2) and Terre-de-Bas (population app. 1500 and area 7 km2).

Project Title: PV Power supply for 3 Microwave Telephone Exchanges

Objective:

The projects have makes the power supply of the telephone connection between the two small islands of Terre-de-Haut and Terre-de-Bas and the main island of Guadeloupe more reliable.

General Information:

The two islands close to Guadeloupe each have, a telephone selector station and a microwave transmitter station (each with a power consumption of about 20 kWh per day).

The former power supplies by the grid and diesel stand-by generators have been replaced by two PV systems each using:

1. Photowatt modules with a peak power of 7.36 kW
2. OLDHAM batteries (48 V, each about 96 kWh capacity)
3. an inverter for maintenance equipment (1 kVA)

The battery rooms and the switch gear rooms (charge regulators, over-tension protection and diodes) are lighted and ventilated by a supplementary 320 Wp array (8 modules) with extra batteries (12 V, 3 kWh capacity).

Other technical specifications of the systems:

Modules description:	BPX 47 402, 1042 x 465 mm, 40 Wp
No. of modules:	184
Connection:	4 modules in string, 46 parallel strings

Achievements:

The former power supply by unreliable grid connections (hurricanes) of bad quality (tension peaks) and stand-by diesel generators has been replaced by 100% reliable power sources.

The costs for the installation of the PV system where considerably higher than the replacement of the obsolete diesel generators. However the high initial investment cost is compensated by the advantages in reliability and long term savings of the PV installation.

The PV generator installed on Terre-de-Bas started operation in March 1988 and the one on Terre-de-Haut in November 1989. Both work without any major problems. Even after the hurricane "Hugo" the power supplies continued to operate.

Project Duration and/or State of Advancement:

The project lasted 44 months, from November 1988 to June 1992.

For more Information Contact:

Organisation: Photowatt International

Address: rue Saint Honore 33
Zi Champfleuri
38300
Bourgoin-Jallieu
France
Tel.: +33 4 74 93 80 20
Fax: +33 4 74 93 80 40
E-mail :
Internet address:

Marie Galante (Guadeloupe)

General Information:

Population: 13,000

Area (km2): 158

Petite Place Wind Power Plant

The 1.5 MW Petite Place wind power plant at Marie Galante was inaugurated at the end of 1997 and will app. produce about 30% of the island's electricity.

In 1998 will the 1.5 MW Morne Constant wind power plant project be implemented, and then will app. 100% of the islands electricity be covered with wind power.

Water for Cattle on Marie Galante Island with Telemonitoring PV Pumps

Objective:

The island of Marie Galante in the French West Indies has suffered from a declining cattle based agricultural economy due to erratic rainwater resources. The project aims to reserve this situation by exploiting good reserves of groundwater with 12 strategically placed watering stations supplied by PV powered bore hole pump systems.

General Information:

The bore holes require a pumping head range between 10 and 55 metres depending on water depth. Average water delivery is app. 15 cubic metres per day.

The innovative feature of the equipment was the use of a new interactive controller/recorder, which allows remote monitoring of the system data. At least one of the systems has included Enersat satellite transmission equipment to transmit monitored data to a European data station. In addition the controller can cut-off water supply if the recipient has not paid in sufficient credit for maintenance contracts.

The 12 systems are based on 4 system specifications of increasing array power, all using 8 modules in series, coupled to 4" diameter centrifugal pumps via variable frequency AC inverter.

Technical specifications of the PV installations:

No. of subsystems:	12
Power of subsystems:	3 x 768 Wp, 4 x 1152 wP, 1 x 1536 wP and 4 x 1920 wP
Total power:	16, 128 kW
Backup:	none
No. of modules:	336
Connection:	all arrays 8 modules in series
Support:	aluminium ground mounts
Max. power tracker:	included in inverter
Charge control:	not applicable
Battery:	none
Inverter:	OND 2000/4000 specific to pump system. Variable voltage/frequency PWM
Load Description:	for pump load categories to match subsystem power: • 768 Wp-TDH 30-37 metres and 10 m3/day • 1152 Wp-TDH 54-62 metres and 8-9 m3/day • 1536 Wp-TDH 71 metres and 8 m3/day • 1920 Wp-TDH 105-112 metres and 7 m3/day

The total amount of investment was 322,060 ECU and EU co-financing was 126,721 ECU.

Achievements:

The systems have operated since March 1995 without significant problems, other than replacement of 10 modules, damaged by hurricane Louis and routine cleaning of storage tanks and motors. The energy savings, is app. 20,000 kWh per year.

Project Duration and/or State of Advancement:

The project lasted for 48 months, from July 1993 to July 1997.

For more Information Contact:

Organisation: Conseil General de Guadeloupe
Address: rue de la Republique
97100
Basse-Terre
Guadeloupe
Tel.: +590 811 120
Fax: +590 819 648
E-mail :
Internet address:

Organisation: SOLELEC Caraibes
Address: Z.I. de Jarry, 41 rue H. Becquerel
FR-97122 Baie Mahault
Guadeloupe
Caraibes
Tel.:
Fax: +590 267 448
E-mail :
Internet address:

Puerto Rico (USA)

General Information:

Population: 3,810,000

Area (km2): 9,104

Energy Supply:

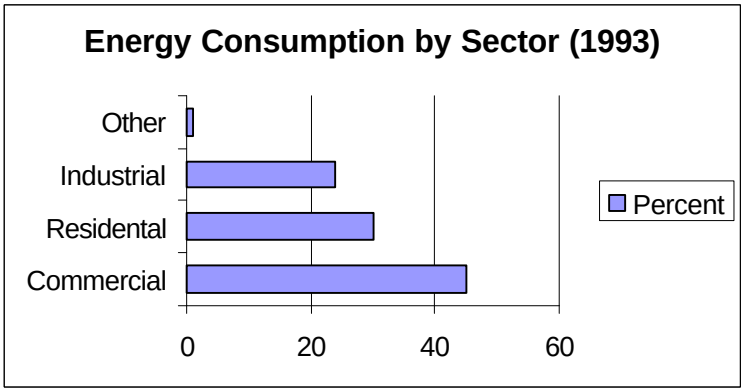
Puerto Rico relies on imported energy resources for most of it's power generation and other energy needs (app. 98% was oil in 1997).

Installed Electric Capacity in 1993, by Source:

Source	Capacity	Percentage of Total Installed Capacity
Diesel	4,000 MW	94.2
Hydro	247 MW	5.8

(Source: "Country Profiles. Renewable Energy and Energy Efficiency in Latin America and the Caribbean", 1995)

Energy Demand:



Renewable Energy Plan:

There exist a renewable energy plan for the island. It is an integrated part of the energy policy which primary objectives is to improve energy efficiency and promote development of renewable energy technologies.

Puerto Rico have received funding from the U.S. State Energy Conservation Program (SECP). SECP is a grant program under which the U.S. Government funds research and demonstration, as well as education for alternative energy technologies and energy conservation.

In 1995 there was a program to promote solar energy. The program operated a toll-free hotline, which educated consumers on solar products and their applications. Energy audits, was also performed for industry and residences to identify and implement energy conservation measures.

Renewable Energy Projects:

- a co-generation plant using sugarcane waste for generating energy
- 40,000 residential solar water heaters
- a 100 kW PV installation in Juana Diaz
- A 20 kW stand-alone PV installation at Mona Island. The government project will be implemented January-February 1998.
- the island is involved in researching the feasibility of ocean thermal energy conversion, solar thermal electric systems, and PV technologies

For more Information Contact:

Organisation: Department of Natural and Environmental Resources
Energy Affairs Administration
Address: P.O. Box 9066600
San Juan
Puerto Rico

Tel.: +1 809 723 3636
Fax: +1 809 721 3089
E-mail :
Internet address:

Saint Vincient and the Grenadines

General Information:

Population: 115,339

Area (km2): 340

Energy Supply:

The island's only utility has an installed capacity of 13 MW (1992). 60% of electricity supply is from diesel-fired turbines and 40% is from hydropower.

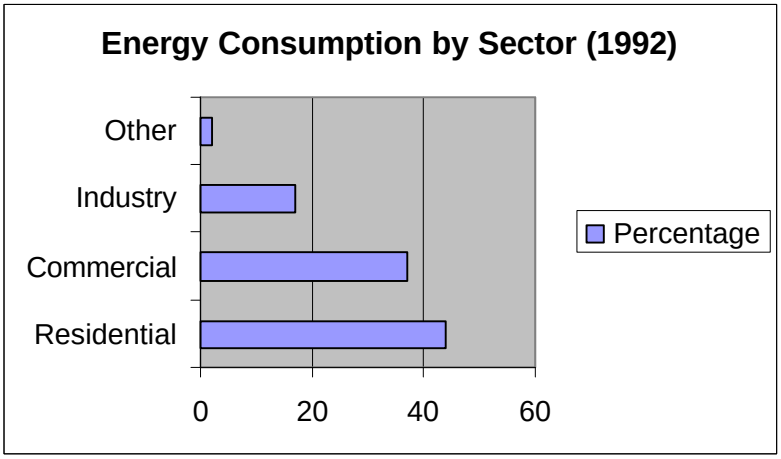
Installed Electricity Capacity in 1992, by Source:

Source	Installed Capacity	Percentage of Total Installed Capacity
Diesel	7.8 MW	60%
Hydro	5.2 MW	40%

(Source: "Country Profiles. Renewable Energy and Energy Efficiency in Latin America and the Caribbean", 1995)

App. 77% of the island's population is connected to the grid.

Energy Demand:



Renewable Energy Plan:

Several renewable energy and energy efficiency programs are underway on the islands.

Renewable Energy and Energy Efficiency Projects:

- the government have been measuring the geothermal resource on Saint Vincient
- a solar water-heater has been installed at the Kingstown hospital
- some solar stills are in use on Petit Saint Vincient
- major industries have begun to use energy efficiency technologies to offset their high demand for electricity. The company East Caribbean has consumed as much as 60% of total electricity generated in the industrial sector. The mill has installed a capacitor bank for power-factor correction, which has reduced its total demand significantly. Another example is a sugar factory, which in the past has consumed as much as 70% of the total diesel supply. This factory installed an air pre-heater for the boiler, reducing their diesel consumption by 50%. Larger firms such as the flour mill and the sugar factory have instituted conservation measures to reduces the costs of consumption.

For more Information Contact:

Organisation: Ministry of Communication and Works
Address: Kingstown
Saint Vincent

Tel.:
Fax:
E-mail :
Internet address:

Organisation: Saint Vincent Electricity Services Ltd.
Address: P.O. Box 856
Kingstown
Saint Vincent

Tel.: +1 809 456 1701
Fax: +1 809 456 2436
E-mail :
Internet address:

Other Islands in the Caribbean with Renewable Energy

Country/Island	Population	Area (km2)	Energy	Renewable Energy
The Bahama Islands	264,000	13,942	The Bahama Island relies on fossil fuel imports for their domestic energy consumption.	Primarily solar and wind technologies which are currently being utilised to some degree.
Grenada	83,556	344	Grenada is dependent upon diesel imports for the bulk of its domestic energy needs. The installed diesel-fired capacity is 16.2 MW (1995).	Currently, small-scale solar and biomass applications are being developed in the commercial and industrial sector. Solar hot water units have been deployed for turist areas. A limited number of feasibility studies have been prepared to assess hydroelectric potential on the island. The main hospital system has just completed a solar energy project for their own use, and a coconut operation is implementing a biomass generation facility.
Roatan Island	28,000	126	Roatan Island, relies 100% on imported oil for all of its power generation. The island is not connected to the mainland. The energy consumption is app. 20,000 MWh. End user cost for kWh electricity is 0.18 US$ (1997).	The electricity company on the island is currently planning a 500-750 kW wind project. The objective will be saving of fossil fuels. The turbines will be grid connected. Financing, ownership and maintenance will be private.
Saint Lucia	138, 151	616	Saint Lucia relies on imported oil for all of its power generation. The installed diesel-based power plants is 37.6 MW (1995). End user cost for kWh electricity is 0.20 US$ (1997).	There are no renewable energy and energy efficiency strategy for the island. The are few small-scale biodigestors using vegetable and/or animal waste to produce methane gas for cooking in a few households. Over 50 homes and several buildings are equipped with solar-water heaters. Geothermal test wells have been drilled - there is a potential

				for several MW. The government is planning to major projects "Saint Lucia Wind Project" (10 MW) and "Solar PV Demonstration Project". The wind assessment was started in January 1998 and the solar projects awaits approval.
Bonaire Island				App. 2.8% of the electricity supply on the island is from renewable energy. Electricity Generation by Wind Turbine a Bonaire Island: A Bouma 250 kW wind turbine operate in parallel with the 8.8 MW diesel fired grid, in order tom save diesel fuel. The annual yield is app. 360,000 kWh which corresponds to an annual saving of 80 TOE diesel fuel. The project lasted for 49 months, from August 1985 to 21 August 1989.
Saint Kitts and Nevis	40,061	269	The islands rely on import of diesel duel to meet primary and all electric generation needs. The installed capacity in 1995 was 12 MW. App. 100% of the population has access to the grid.	There are no large-scale renewable energy or energy efficiency projects on the islands. There exist small-scale applications of renewable technologies such as hydro-power, solar water-heating systems and PV.
U.S. Virgin Islands	101,352	352	U.S. Virgin Islands relies on oil import to meet the bulk of its energy needs. The Virgin Islands Water and Power Authority has an installed generating capacity of 192 MW (1992). App. 52% of the electricity is generated with gas-fired turbines.	There are numerous solar, wind energy, and energy efficiency projects on the islands. The U.S. Virgin Islands conducts these activities through a strong public-private sector partnership.

North Atlantic Ocean

Azores (Portugal)
Beginish Island (Ireland)
Canary Island (Spain)
Cape Verde
Fair Isle (UK)
Föhr Island (Germany)
Madeira (Portugal)
Pellworm (Germany)
Rathlin Island (Northern Ireland)
Scottish Islands

MAP

MAP

Azores (Portugal)

General Information:

The Azores, are a North Atlantic archipelago some 1,500 km west from Lisbon. The archipelago compromises nine islands stretching over some 600 km of ocean.

Island	Population	Area (km2)
Santa Maria	5,921	97.24
São Miguel	124,649	759.41
Terceira	55,623	381.96
Graciosa	5,190	61.66
Sao Jorge	10,216	246.25
Pico	15,178	446.36
Faial	14,823	173.42
Flores	4,316	143.11
Corvo	393	17.13
Azores Total	236,309	2,326

(Source: "Portrait of the Islands", European Community,1994)

Energy Information:

The Azores has a significant energy dependence from abroad, and as can be seen from the tables below the Azores:

- has used most of its energy on regional transport
- has utilised its renewable energy resources in a big scale
- have a big potential for further development of renewable energy resources
- have a very elaborated organisation of the energy sector

Energy Demand by Sector in 1995:

Sector	Demand	Percentage of Total Demand
Industry	33,136 toe	16.6%
Residential	34,712 toe	17.4%
Agriculture and Fishing	17,184 toe	8.6%
Regional Transport	92,138 toe	46.3%
Tertiary (without Transport)	17,895 toe	9%

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificities", European Union, THERMIE, 1997)

There are renewable energy installations on seven of the nine islands as can be seen in the table below, where the renewable energy production in 1996 for each island is specified:

Island	Total Renewable Energy Production (MWh)	Total Renewable Energy Production (%)
S. Maria	550	5.1%
S. Miguel	62,150	29%
Terceria	2,198	2.4%
Graciosa	521	8.7%
Sao Jorge	1,356	9.6%
Pico	0	0%
Faial	433	1.5%
Flores	2,534	40%
Corvo	0	0%
Azores Total	69,742	17.6%

(Source: "Electricidade dos Acores. Relatorio Anual de 1996.")

In the table below are the different renewable energy sources used in 1996 specified for each island in percentage of total renewable energy electricity production:

Island	Wind	Hydro	Geothermal
S. Maria	100%	0%	0%
S. Miguel	0%	29.8%	70,2
Terceira	0%	100%	0%
Graciosa	100%	0%	0%
Sao Jorge	100%	0%	0%
Pico	0%	0%	0%
Faial	0	100%	0%
Flores	0%	100%	0%
Corvo	0%	0%	0%

(Source: "Electricidade dos Acores. Relatorio Anual de 1996.")

In 1996 geothermal energy contributed to 20.4% of the total electricity production on S. Miguel. This share will be rising to app. 40% in 1999.

Potential for Development of Renewable Energy, by Source:

Source	Potential
Waves	High
Tidal	Low
Biomass	Medium
Geothermal	High
Hydro	High
PV	Medium
Solar Thermal	Medium
Waste to Energy	Medium
Wind	High

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificities", European Union, THERMIE, 1997)

Organisation of the Energy Sector:

Institutional Organisation:	
Regional Administrative Body	Yes
Regional Legislative Body with Competence for Regional Development	Yes
Regional Legislative Body with Competence for the Energy Sector	Yes
Regional Competence for Electricity Sector:	
Production by Regional Utility	Yes
Distribution by Regional Utility	Yes
Development of Electricity Grid	Yes
Incentives for Renewable Energy and Rational Utilisation of Energy:	
Financial Support	Yes
Specific Legislation	Yes
Regional Energy Price Policy:	
Electricity	Yes
Fuels	Yes
Information and Awareness Campaigns	Yes
Autonomous Regional Energy Organisation	No

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificities", European Union, THERMIE, 1997)

For more Information Contact:

Organisation: Electricidade dos Azores

Address: R. Eng. José Cordeiro, 6
9500 Ponta Delgada
Azores
Portugal
Tel.: +351 62 80 55
Fax: +351 62 80 44
E-mail :
Internet address:

Organisation: Regional Departement for Industry and Energy

Address:

Tel.: +351 96 26 639
Fax: +351 96 27 659
E-mail :
Internet address:

Beginish Island (Ireland)

General Information:

Population: 2

Area (km2): 0.99

Beginish Island is located at the south west coast of Ireland.

Energy Information:

Jim and Mike Casey and their dog are the only habitants on Beginish Island. They have a television, and until may 1983 they rowed across to the mainland every Sunday to attend Mass and to get the battery recharged.

Today they still go to Mass, but the sun now powers the television as well as 15 W fluorescent lights and a VHF radio. Jim and Mike are 76 and 83 years of age and their new PV system has eliminated the hardship of a life without power supply.

The whole system was installed by three men within three hours. During this time, two of them dig a pit, mixed concrete, erected the frame and bolted on the panels, while the third laid the cable and installed the household lights.

The system compromises:

- four AEG 19.2 Wp modules
- two car batteries
- a diode
- a voltmeter

Operation and maintenance of the system is performed by the two Irishmen and is now part of their daily routine. The modules are cleaned regularly and the water acid level is kept constant with distilled water.

There is no back-up power, so the brothers have to forego television, lights or the radio when the days are dim. Deep discharge of the battery is prevented by turning off all loads when the voltmeter indicated 11 V.

This PV system is simple and has been 100% trouble-free. Similar systems for other islands communities should ensure that the Casey’s mode of life survives into the twenty-first century.

Canary Islands (Spain)

General Information:

Population: 1,601,612

Area (km2): 7,242

There are seven islands with the following population and area:

Island	Population	Area (in km2)
Tenerife		2,053
La Palma	80,000	728
La Gomera	17,000	378
El Hierro	7,000	278
Gran Canaria		1,532
Lanzarote		
Fuerteventura		

Energy Information:

As can be seen from the below the energy situation in 1995 on the Canary Islands can be characterised by:

- almost 100% of the primary energy sources came from imported fossil fuel (oil)
- the most utilised renewable energy sources is solar thermal and wind
- 2% of the installed electricity capacity came from renewable energy sources, primarily wind
- 1% of electricity production came from renewable energy
- the main part of energy is used for transport
- there is a big potential for PV, solar thermal, waste to energy, and wind
- there is an elaborated organisation of the energy sector
- there is an elaborate energy and renewable energy plan for the Canary Island

Primary Energy Sources in 1995:

Source	Amount	Percentage of Primary Energy Sources
Oil	3,044,138 toe	99.6%
Renewables	12,629 toe	0.4%

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Renewable Energy, by Source 1995:

Source	Amount	Percentage of Renewables
Hydro	145 toe	1.1%
PV	57 toe	0.45%
Solar Thermal	7,008 toe	55.5%
Wind	5,419 toe	43%

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Installed Electricity Capacity, by Source 1995:

Source	Installed Capacity	Percentage of Total Installed Capacity
Thermic Power Plants (oil)	1688.1 MW	98.4%
Renewables	27.3 MW	1.6%

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Generated Electricity in 1995, by Source:

Source	Generated Electricity	Percentage of Generated Electricity
Thermic Power plants (Oil)	427,483 toe	98.7%
Renewables	5,598	1.3%

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Energy Consumption by Sector, in 1995:

Sector	Consumption	Percentage of Total Consumption
Industry and Construction	294,769 toe	13.3%
Residential	200,729 toe	9%
Agriculture	230,381 toe	10.4%
Regional Transport	1,321,271 toe	59.5%
Tertiary (without transport)	172,416 toe	7.8%
Total	2,219,566 toe	100%

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Potential for Development of Renewable Energy, by Source:

Source	Potential
Waves	Medium
Tidal	Low
Biomass	Low
Geothermal	Low
Hydro	Low

PV	High
Solar Thermal	High
Waste to Energy	High
Wind	High

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Organisation of the Energy Sector:

Institutional Organisation:	
Regional Administrative Body	Yes
Regional Legislative Body	Yes
Regional Legislative Body with Competence for Regional Development	Yes
Regional Legislative Body with Competence for the Energy Sector	Yes
Regional Competence for Electricity Sector:	
Production by Regional Utility	No
Distribution by Regional Utility	No
Development of Electricity Grid	Yes
Incentives for Renewable Energy and Rational Use of Energy:	
Financial Support	Yes
Specific Legislation	Yes
Regional Energy Price Policy:	
Electricity	No
Fuels	No
Information and Awareness Campaigns	Yes
Autonomous Regional Energy Organisation	Yes

(Source: "Promotion of Energy Efficient Technologies Matching with Islands and Ultra-Peripheral Regions Specificities", 1997)

Energy Plan:

In January 1990 the Canary Parliament approved the Energy Plan of the Canaries (PECAN). The basic objective is to improve the security of supply. To accomplish this, the PECAN points out, that actions must be directed towards the development of new energies and diversification. So renewables play a main role in the canary energy policy management, as the islands do not have any conventional energy sources.

The revised Renewable Energy Plan for the Canaries (PERCAN) is from 1996 an its main objective is to:

- present quantified objectives in the area of renewable energy in the peorid 1996-2002

- establish actuation strategies and corresponding management formulas

The quantified objectives for year 2000 is:

- 3.6% of total primary energy consumption from renewable energy
- 16% of electricity production from renewable energy

The technologies utilised in the period 1996-2002 is as follows:

- Wind Energy: app. 140 MW shall contribute with 400 GWh/year
- Solid Waste Incineration: app. 44 MW shall contribute with 252 GWh/year
- Low temperature Thermic Solar: a total surface of 36,000 M2
- PV. shall contribute with app. 450 kWp
- Initiatives will also be taken regarding biomass, hydroelectric and geothermal resources

For More Information Contact:

Organisation:	Gobierno de Canarias Consejeria de Industria y Comercio Dirección General de Industria y Energia
Address:	
Tel.:	
Fax:	+34 28 452 070
E-mail :	
Internet address:	

Organisation:	Instituto Tecnologico y de Energias Renovables (ITER)
Address:	Pol. Ind. de Granadilla. Parque Eolico 38594 Granadilla Tenerife Spain
Tel.:	
Fax:	+34 22 391 001
E-mail :	iter@iac.es
Internet address:	http://www.cistia.es/cabildotf/iter/misc.html

Cape Clear (Ireland)

General Information:

Population: 145 (1986)

Area (km2): 6.08

Cape Clear Island is located at the south west cost of Ireland.

Feasibility Study. Cape Clear Renewable Energy Trail

Objective:

The aim of the trail would be to develop new economic (business) activities on the island. Secondary benefits, would be to improve the quality of life and contribute to environmental protection.

General Information:

Market for the Trail:

The main source of income would be from fees from guided tours, training courses, workshops organisation and the sale of products. The level of the income is difficult to estimate as no similar exists in Ireland. Similar trails in Wales and in Denmark have different visitor numbers i.e. Wales 100,000 in 1991 and Denmark 5,000 in 1991. The variations in scale is based on their primary activities i.e. Wales - public tours, Denmark, training courses.

The demand for this type of trail exists because of:

- the public interest in renewable energy sources (e.g. main activity of Welsh Renewable Energy Centre)
- renewable energy is included in the curriculum of the secondary school students
- renewable energy is identified as a theme for the Outreach Campus in Skibbereen
- six renewable energy groups exist in Ireland
- None Energy Agencies have been established in Ireland since 1993. They are designed to promote renewable energy
- training courses are required by personnel from developing countries and Irish aid personnel working in developing countries

Renewable Energy Systems in the Trail:

The main categories of renewable energy systems would be:

- Wind (the 2 x 35 kW existing wind turbines on Cape Clear Island)
- Solar thermal systems
- small hydro systems
- small PV systems.19 different applications: application in boats for battery charging, domestic applications (security systems), public applications (lights), and R & D applications.

Costs:

To develop a high quality renewable energy trail would cost in excess of £ 89,000. This high cost is due to the high cost of PV modules. This trail could be installed in stages depending on the availability of funding:

- Stage 1: mini-trail in North Harbour
- Stage 2: medium sized PV systems using modules from Fota Island
- Stage 3: PV systems for R & D

Funding of Trail:

The main sources of funding for the proposed trail are:

1. Udaras Na Gaeltachata
2. LEADER
3. FAS
4. EU R & D programmes
5. Department of Energy AER Programme

Proposed Action:

- establish a mini-trail at the North Harbour to demonstrate the concept and to assess the potential market. The cost of this mini-trail would be £15,000 and would concentrate on PV application in boats, public lightning, domestic applications and water pumping
- present pilot tours, courses, workshops to groups interested in renewable energy e.g. local energy offices, schools, research groups etc.
- demonstrate pilot to funding agencies and present outline of proposed trail. If the market demand is established and finance is available the following actions will be required: prepare detailed design of the proposed system, prepare detailed costing of the proposed development, present proposals to funding agencies, discuss proposals and negotiate funding, procure systems and install, train7develop Cape Clear personnel, public launch of trail and promote to relevant markets, begin business activity.

Conclusion:

- the success of the trail will depend on the quality of the system, the quality of the personnel presenting the lectures/courses/tours and the effort used in promoting the trail
- the involvement of a Community Group, local authority, research centre and private company in the initiative is appropriate for national and EU funding
- the support of the community is essential to ensure the success of the initiative
- the long term success of the trail will be based on the operation of the trail as a business with proper marketing, training and maintenance programmes in operation

For more Information Contact:

Organisation: Hyperion Energy Systems Ltd
Attn. Dr. Sean McCarthy
Address: Main Street
Watergrasshill
Co. Cork
Ireland
Tel.: +353 21 889461
Fax: +353 21 889465
E-mail :
Internet address:

Cape Verde

General Information:

Population: 389,000

Area (km2): 4,033

The archipelago is situated off the southern Mid-Atlantic Ocean Ridge, 630 kilometer west of Gambia, Senegal, and Mauritania.

West African archipelago of 10 islands and 8 islets, divided into two groups: Northern Windward ("Barlavento"): Boa Vista, Sal, Santo Antao, S. Vicente, Sao Nicolau, and Santa Luzia; Southern Leeward ("Sotavento"): Brava, Fogo, Maio, and Santiago.

Below is a description of some of the energy/renewable energy installations on the three islands S. Tiago, Sal, and S. Vicente.

S. Tiago (Cape Verde)

General Information:

Population: 175,000

Area (km2): 991

Electricity Information in General:

The electricity situation on S. Tiago can be summarised as follows:

1. Of the 175,000 inhabitants in S. Tiago, only app. 45% has electrical supply (30% in the population of Praia, Cape Verde's capital, and other 15% in small villages supplied by isolated systems). More than 50% of the

population lives in rural isolated areas, without electric energy. I.e. the electrification process is still in the first stage
2. There are a lot of small isolated networks

Several factors have prevented the expansion of the network for the entire island:

1. There is a growing concentration of the population in urban areas, increasing the effort for their electrification
2. Insufficient production capacity, being necessary the construction of new power stations
3. Low MT voltage levels (15 kV), which makes network expansion to remote areas near impossible
4. Rugged terrain, raising the cost for MW networks
5. The population in rural areas is highly dispersed increasing the cost for distribution networks
6. Energy demand is rather low and highly concentrated in a short period, leading to low network use

Electricity Situation in Praia:

Installed electricity generating capacity in the Praia power system by source (1995):

Source	Capacity
Diesel	1 x 1,560 kW
Diesel	1 x 2,514 kW
Diesel	2 x 2,650 kW
Diesel Total	9,374 kW
Wind	3 x 300 kW
Wind	2 x 55 kW
Wind Total	1,010 kW
Praia Total	10,384 kW

The power plant in Praia is constituted by 4 diesel generators with an total installed capacity of app. 9 MW. These groups operate directly over a 15 kV busbar and are prepared to work on gas oil or heavy fuel, but presently are operating on gas oil. Internal fuel prices are settled by the government of Cape Verde.

From 1985 until recent days there were 2 x 55 kW turbines in operation, with an annual energy production of 187 MWh.

In 1994 3 x 300 kW wind turbines started operation. This project is part of the first phase of a plan to integrate wind power in the electric networks of Cape Verde. These turbines are located in Monte de S. Filipe. Some of the specifications of the wind farm, is as follows (January - June 1995):

Installed Capacity	900 kW
Avg. Wind Speed at Hubheight	8.8 m/s

Wind Energy Production	1596 MWh
Wind Turbine Availability	98.8%
Avg. Wind Energy Penetration	11%
Installed Capacity From Wind	10%

(Source: "Wind Energy in Island Grids. Experiences from Cape Verde", 1997)

The wind project was funded jointly by the Capeverdean and the Danish government.

Electricity Situation In the Rest of S. Tiago:

Scattered throughout the island there are some small isolated networks, managed by the municipal governments and whose characteristics are a product of the solutions and opportunities found to satisfy the basic needs of the municipalities.

Below is a description of some of the networks utilising renewable energy:

1. Around 4 km from Pedra Badejo, there are three 155 kVA generators and two biogas 50 kVA generators supplying a 3 km, 20 kV, MV network.
2. In Assomada there are 800 consumers supplied by a hybrid wind/diesel system composed by 1 x 250 kVA diesel generator, 1 x 125 kVA diesel generator, and 1 x 40 kVA wind generator. These consumers are supplied through a 5 km LV network, considerably degraded.
3. In S. Catarina there is a hybrid wind/diesel system composed by 1 x 52 kVA diesel generator and 1 x 55 kVA wind generator, feeding a battery system through a AC-DCAC system. The system is connected to a network supplied by existing diesel generators. Its maintenance has been problematic due to insufficient technical support.
4. In Tarrafall there is a hybrid wind/diesel system with 1 x 175 kVA diesel generator, 1 x 90 kVA diesel generator, and 1 x 55 kVA wind turbine. The system supplies app. 400 consumers and one pumping system through one LV output and two MV outputs. Also there, there are maintenance problems related to lack of technical support.
5. Matão is a small village with 180 people, which had no electricity until Vergnet set up a autonomus power station. The station is composed of a 1 x 15 kW wind turbine, 1 x 6 kVA inverter and 1 x battery for electricity storage. It feeds a small grid, which supplies electricity to houses and lights public roads.

Sal (Cape Verde)

General Information:

Population: N.A.

Area (km2): N.A.

Energy Information:

Until 1994 the electricity in the main power system on Sal Island was supplied from a gas oil power plant with a total installed capacity of 3 MW. In 1994 there was installed 2 x 300 kW wind turbines. Some of the specifications of the wind farm, is as follows (January - June 1995):

Installed Capacity	600 kW
Avg. Wind Speed at Hubheight	7.8 m/s
Wind Energy Production	893 MWh
Wind Turbine Availability	99%
Avg. Wind Energy Penetration	24%
Installed Capacity From Wind	20%

(Source: "Wind Energy in Island Grids. Experiences From Cape Verde")

The wind project was funded jointly by the Capeverdean and the Danish government.

Sao Vicente (Cape Verde)

General Information:

Population: N.A.

Area (km2): N.A.

Energy Information:

Until 1994 the electricity in the main power system in Sao Vicente was supplied from a heavy diesel power plant with a total installed capacity of 11 MW. In 1994 a 3 x 300 kW wind plant was installed. Some of the specifications of the wind plant is as follows (January - June 1995):

Installed Capacity	900 kW
Avg. Wind Speed at Hubheight	11.6 m/s
Wind Energy Production	2655 MWh
Wind Turbine Availability	97%
Avg. Wind Energy Penetration	19%
Installed Capacity From Wind	8.2%

(Source: "Wind Energy in Island Grids. Experiences From Cape Verde")

The wind project was funded jointly by the Capeverdean and the Danish government.

Fair Isle (UK)

General Information:

Population: 70

Area (km2): 6

The island is located far north of Scotland between the Shetland Islands and the Orkney Island.

Energy Information:

Energy production from different sources (1997):

Energy Source	Percentage of Production
Coal	5%
Diesel	25%
Wind	65%
LPG	5%

With wind speeds around 15 m/s, the island is ideally suited to wind energy development.

The history of power production on Fair Isle can be summarised as follows:

1. Electricity was first installed in 1962 using four 7 kW diesel generators located around the community. The power was distributed by three local cable networks.
2. In 1975 two new diesel generator sets rated at 52 kW and 20 kW were installed in central location at the Houll Quarry. This was required to meet an ever increasing demand for power from the consumers. Three cable networks were linked with 3 phase cabling.
3. In June 1982 a 50 kW wind turbine was installed, including a load management system to share power between the former and new systems. A heating circuit was installed to each consumer to take advantage of the dump load from the wind turbine (this facility was not available from the diesel generators). This system operated on the principle of guaranteed periods with time switch controls. If wind was available then continuous power was produced.
4. In 1990 the two generators, each rated at 32 kW, and capable of parallel operation, were installed to match the output from the wind turbine. This, along with a completely upgrade cable network to alleviated the problem of voltage drop to the peripheral consumers. It also provided a substantial backup to the wind turbine which produced up to 80% of the electricity demanded by the consumers.

Renewable Energy Plan:

There is a renewable energy plan for the island. The objective is to produce up to 90% of the island's electricity demand through renewable energy sources, i.e. wind, within few years. The remaining 10% will be supplied from diesel.

Fair Isle Renewable Energy Scheme

Objective:

The objective is to be 90% self sufficient from wind power by 1998.

General Information:

This project is part of the renewable energy strategy for the island.

Wind energy has been on the island since 1982, when a 50 kW WindMatic turbine was installed. It was the first stand alone autonomous system in the UK. The 50 kW turbine has been refurbished to 60kW and in January 1997 a new 100 kW turbine started operating. The 60 kW turbine will provide back-up to the new turbine. The two turbines are sited apart to take advantage of the different wind regimes.

The project is organised in the following way:

Financing:	The local electricity council, The Fair Isle Electricity Council (FIEC)
Ownership:	Owned by the islands owners, The National Trust for Scotland, and leased to the local electricity council
Operation and Maintenance:	Part time local engineer working for FIEC

Project Duration and/or State of Advancement:

The project started in 1982 and the projected ended in November 1997.

For more Information Contact:

Organisation: The National Trust for Scotland
Highland Regional Office
Address: Abertarff House
Church Street
Iverness IV1 1EU
Scotland
UK
Tel.: +44 1463 232034
Fax: +44 1463 713054
E-mail :
Internet address:

Faroe Islands (Denmark)

General Information:

Population: 48.871

Area (km2): 1,399

The Faroe Islands are situated in the North Atlantic 430 km south-east of Iceland, 600 km west of Norway and a good 300 km north-west of Scotland. The Faroes consist of 18 islands, of which 17 are inhabited. The largest island is Streymoy (373.5 km2)

Energy Information:

The majority of the energy consumed on the islands is imported oil. In 1996 the total oil consumption was 245,236 tons.

All Faroese towns and villages have electricity. As can be seen from the tables below a significant part of the electricity comes from renewable energy sources:

Installed Capacity in 1997, by Source:

Source	Installed Capacity	Percentage of Installed Capacity
Thermal Plants (Oil)	54.6 MW	63.4%
Hydro Power	31.55 MW	36.6%

Electricity Production in 1997, by Source:

Source	Generated Electricity	Percentage of Generated Electricity
Thermal Plants (Oil)	106.4 GWh	58.2%
Hydro Power	76.4 GWh	41.8%

For more Information Contact:

Organisation: Elfelagio SEV

Address: Postboks 319
FR-110 Torshavn
Faroe Islands

Tel.: +298 11366
Fax: +298 10366
E-mail : sev@olivant.fo
Internet address:

Foula (U.K)

General Information:

Population: 43

Area (km2): 12.9

Foula is part of the Shetland Islands.

Energy Information:

Heating for the islands is from peat, oil and coal and was app. 250 MWh in 1997.

Electricity Generation 1997:

Source	Percentage of Generated Electricity
Wind	50%
Hydro	25%
Oil	25%

There is not an overall renewable energy plan for the island.

Foula Electricity Scheme

General Information:

The technology used is hybrid wind/hydro/diesel system. The energy produced is for a mini-grid.

The system consist of:

- 50 kW wind turbine
- 15 kW hydro plant
- 17.5 kW diesel generator

The wind turbine is the primary generator with a the hydro electric generator acting in support during periods of clam by taking advantage of a small water catchment are naturally filled through rainfall and to which water may be pumped from below the generator. Pumped water storage allows recovery of wind turbine generated power surplus to immediate requirements through pumping to the higher elevation.

Organisation of the project:

Financing	Public plus EU
Ownership	Co-operative/trust
Maintenance	Co-operative

Achievements:

The scheme is now severely downgraded, due to poor design and maintenance and has been so for several years.

Project Duration and/or State of Advancement:

The project started in 1989 an will be ongoing.

For more Information Contact:

Organisation: Foula Electricity Trust

Address: Magdala
Foula
Shetland Islands
UK

Tel.:
Fax:
E-mail :
Internet address:

Föhr Island (Germany)

General Information:

Population: 8,700

Area (km2): 82

Föhr island is located in the on the western coast of the German State Schleswig-Holstein.

Energy Supply

The island is connected via a gas grid to the mainland.

In 1995 4,3% of the energy production was from wind power and an insignificant contribution from PV (i.e. 0.00012%).

Sun for Föhr

Objective:

The immediate objective is the installations of decentralised PV systems on private, municipal, and farming buildings. The long term objectives are specified below.

General Information:

This project has been developed by the work circle "SONNE". By entering this project the participants have committed themselves to:

1. Contribute to the reduction of emissions into the atmosphere;
2. Promote the dissemination and application of new technologies in rural areas.

These goals were formulated in agreement with the Ministry for Environment and Energy of Schleswig-Holstein.

This project is supposed to be the beginning of an overall energy strategy for the island. Based on model examples of solar energy utilisation, attempts will be made to achieve greater acceptance of alternative types of energy, in order to improve the basis for planning and installations and to bring a greater awareness of energy conservation measures in the construction industry.

The central aspects of reasoning and work in this field will be the following:

1. Utilisation of alternative energies is tantamount in the contribution to the preservation of nature, environment and climate. The holiday region "Föhr" constitute a prime example for consciously dealing with nature and the use of possibilities concerning an emission-free production of energy;
2. Artisans and planners must be convinced to adopt and apply these technologies as new factors of the economy and to utilise the methods of insulation and modern heating technology both to the farms and in the houses;
3. The special situation of an island provides possibilities for the creation of economic cycles later to be tested for their practical value;
4. Inquires into and planning of a biogas plant on the island in 1998. A concept to be developed in close co-operation with farmers and communities.

The organising of the project is as follows:

Financing:	Private, the EU programme LEADER II, and the Schleswig-Holstein Government
Ownership:	Private and public.
Operation and Maintenance:	Individual

Project Duration and/or State of Advancement:

The project started in December 1996.

For more Information Contact:

Organisation: Naturschutzstiftung "fering natüür"
Arbeitsgemeinschaft SONNE
Address: MittelstraBe 12
25938 Wyk auf Föhr
Germany

Tel.: +49 4681 3468
Fax: +49 4681 2450
E-mail :
Internet address:

Islay (UK)

General Information:

Population: 3,500

Area (km2): 611

Islay lies app. 32 km off the western coast of the Kintyre peninsula in the north west of Scotland.

Energy Information:

Islay relies on four main fuels:

- petroleum products
- electricity
- peat
- coal

Petroleum constitute the largest source of energy. There is no main gas supply, though small quantities of bottled gas are consumed.

Islay receive electricity from the Scottish mainland. Supplies are topped-up during periods of peak demand, or power failure, by a diesel generator at Bowmore power station (Islay). Electricity prices are the same as those in the rest of Scotland, but imported fuel oil and coal tend to be expensive due to transport costs.

The largest energy consumers are the distillers and the domestic market. The distillers consumes 66% of petroleum products (fuel oil accounts for 94% of their energy requirement), along with small amounts of electricity (6% of their energy requirement). Peat is used in the malting process to impart the characteristic smoky flavour to the final product.

Domestic users are the largest consumers of electricity (accounting for almost 50% of the total demand). They also burn significant quantities of peat and coal (peat currently meets app. 33% of domestic energy needs). There is an increasing demand from domestic consumers as electric heating becomes more popular because of the attractive price of electricity relative to other local alternatives, and as peat and coal-usage is in decline . This puts a strain on

the existing network and customers suffer voltage imbalances and occasional power cuts.

Wave Power

General Information:

A 75 kW wave power site is strategically located in a natural rock gully, thus minimising the cost of construction. It is fitted with 2 Wells turbine blade sets, each of which has a peripheral flywheel and which together store 2 MJ of energy at 1,5000 rpm.

Under research conditions it has been proved that the plant can successfully supply power to the distribution grid.

The Islay Energy Study

Objective:

The objective of the ETSU study from 1996 was to:

- review energy use on Islay
- to identify energy projects which would help to maintain its economy in an environmentally positive way

General Information:

In the report there is resource assessments regarding wind energy, anaerobic digestion of wastes, recycling waste process heat from the distilleries, and hydroelectricity.

Wind Energy:

With its exposed situation, high wind speeds and relatively low population density, Islay is an ideal candidate for wind energy generation schemes. However, the island is ecologically important and large tracts of land is ecologically important and large tracts of land are designated sites of special interest. Any development would therefore have to be carried out with great sensitivity.

The maximum size of a wind farm on Islay would be limited by the amount of wind-generated power that could be accepted by the existing weak rural electricity network. The maximum capacity estimated is 3 MW. A single grid connected 3 MW wind farm could supply 30-40% of Islay's electricity needs. The estimated cost of a wind farm of this size is app. £ 2.5 million. If additional were to be generated, storage facilities would be required.

Biogas:

Islay generates small quantities of solid waste including domestic refuse, agricultural and abattoir by-products and swage sludge. Liquid wastes come mainly from distilleries and whey from Islay's creamery.

At the present most waste is either landfilled or discharges into the sea. Land-spreading of bio-degradeable waste is not always an option, as this threaten groundwater supplies. Using wastes as a raw material for energy could therefore prove an attractive proposition on Islay.

Solid and liquid wastes would need separate handling. A decentralised biogas plant could process solid waste from scattered farms and industries. Such a plant might produce 100 kW of exportable electricity. This is on the low side to economically attractive, but if policy moved further towards recycling and conservation and higher landfill levies, the balance might shift.

Distillery effluent can be successfully treated using anaerobic digestion (AD) techniques. Results indicate that AD could replace 10-20% of each distillery's fuel oil demands or most of their electricity requirements. Estimates suggests that apart from one distillery all distilleries on Islay could support an biogas plant. Centralised plants would involve transportation of wastes, but could offer economies of scale.

Waste Process Heat:

Islay's distilleries consume app 100 GWh of fossil fuel each year. In a typical distillery app. 80% of the energy input is exhausted in glue gases, water from still condensers, pot ale, and spent lees.

Some waste heat is already recycled within the distillation process but research suggest that the useful heat content of waste streams from Islay's distilleries is in the region of 13-33 GWh/year. There was identified five potential applications: horticulture, fish farming, heating domestic or public buildings, cattle feed, and in-process uses.

Hydroelectricity:

Parts of Islay are mountains and rainfall varies between 1,000 – 2,000 mm a year. Some regions are therefore technically suitable for hydroelectric development. Hydropower developments on Islay would be subject to environmental controls covering water resource management, fisheries, flood defence, navigation, recreation and environmental protection.

Findings indicate that hydroelectric developments on Islay would be very small-scale (less than 100 kW), and that grid connection would be uneconomic. Hydropower is unlikely to make a significant contribution to renewable energy generation on Islay.

There is however some scope for using micro-hydro schemes to supply homes or industries directly. A 20 kW scheme costing app. £ 100,000 to build could power up to 20 homes or meet one-fifth of the average energy needs of a small distillery for 8-9 months of the year.

Achievements:

The main conclusions of the energy study was:

- wind energy has the most potential as an alternative energy source on Islay. A 3 MW wind farm could meet 30-40% of the island's electricity needs. The relevant technology is available and has a beneficial environmental spin-off. There is also production from the anaerobic digestion of waste, but further development is required before this can be generally applied
- energy storage on Islay could increase supply stability. If new energy resources (e.g. wind power) are developed, storage will be a major issue.
- the two main energy consumers on Islay are the distillers who represent a major part of the island's economy, and the domestic sector. Those should aim to increase their energy efficiency
- domestic energy savings schemes, such as home insulation, should be explored and promoted. Opportunities for further energy savings measures in the distilling industry may be limited, but means of spreading peak electricity demand by staggering distillery start-up times should be investigated

For more Information Contact:

Organisation: New and Renewable Energy Enquires Bureau
ETSU
Address: Harwell
Dideot
Oxfordshire OX11 0RA
UK
Tel.: +44 1235 433517
Fax: +44 1235 432144
E-mail : etsu.business@aeat.co.uk
Internet address: http://www.etsu.co.uk/home.html

Madeira (Portugal)

General Information:

Population: 260,000

Area (km2): 794

Energy Information:

Madeira has a significant energy dependence from abroad, but this dependence is lower than the average in the European Islands. As can be seen from the tables below Madeira:

- has used most of its energy for regional transport and in the residential sector
- has utilised its renewable energy sources in a big scale
- have a big potential for further development
- have a very elaborated organisation of the energy sector.

Energy Demand by Sector in 1995:

Sector	Demand	Percentage of Total Demand
Industry and Construction	17,179 toe	10.4 %
Residential	45,091 toe	27.4%
Agriculture	4,942 toe	3%
Regional Transport	66,992 toe	40.7%
Tertiary (without Transport)	30,540 toe	18.6%

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificity", European Union, THERMIE, 1997)

Concerning primary energy, the local resources represented app. 15% of the total demand in 1995 and the remaining was imported. Regarding installed electricity capacity renewable energy sources contributed with 32% in 1995 and 18% of the electricity production. With the operating of the new hydro schemes and the new wind parks, the percentage of electricity production from renewable energy sources had risen to approx. 33% in 1997 (30.5% hydro and 2.5% wind).

Primary Energy Sources in 1995:

Oil	188,500 toe
Biomass	16,210 toe
Hydro	5,891 toe
Solar Thermal	3,594 toe
Wind	851 toe
Total	214,609
Renewable Total	26,546
Percentage Renewable	12%

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificity", European Union, THERMIE, 1997)

Electric System Capacity in 1995:

Diesel	126.8 MW
Hydro	54.8 MW
Wind	5.3 MW
Total	187.0 MW
Renewable Total	60.1 MW
Percentage Renewable	32%

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificity", European Union, THERMIE, 1997)

Electricity Production in 1995:

Oil	**29,997 toe**
Hydro	5,891 toe
Wind	851 toe
Total	36,739
Renewable Total	6,742
Percentage Renewable	18%

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificity", European Union, THERMIE, 1997)

The main obstacle that appears (in Madeira) regarding renewable energy resources used for electricity production is the integration of the energy produced into the public grid.

The reduced dimension of the energy system means that a limitation appears regarding penetration of certain renewable energy sources, namely wind. That limitation is imposed by the capacity of the electricity grid to receive, in acceptable conditions, the generated electricity.

In Madeira, this situation is worst due to the load diagram, concerning the electricity demand, that presents high variations during the day, with a peak that can be over 80 MW, in the early evening, and can be lower than 30 MW, during dawn.

The effects on the electric grid, caused by the introduction of certain generators, are more intense during the low demand period, so that the capacity of energy reception from these generators is consequently limited by the demand during dawn.

By these reasons, the development of some renewable energies, as wind energy, is conditioned to the solution of certain existing problems, such as eventual disturbances introduced into the electric grid.

But as can be seen in the table below there is a huge potential for development of renewable energy sources on Madeira.

Potential for Development of Renewable Energies:

Waves	Medium
Tidal	Low
Biomass	High
Geothermal	Low
Hydro	High
PV	Medium
Solar Thermal	High
Waste to Energy	High
Wind	High

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificity", European Union, THERMIE, 1997)

Organisation of the Energy Sector:

Institutional Organisation:	
Regional Administrative Body	Yes
Regional Legislative Body with Competences for Regional Development	Yes
Regional Legislative Body with Competences for the Energy Sector	Yes
Regional Competences for the Electricity Sector:	
Production by Regional Utility	Yes
Distribution by Regional Utility	Yes
Development of Electricity Grid	Yes
Incentives Regarding Renewable Energy and Rational Use of Energy:	
Financial Support	Yes
Specific Legislation	Yes
Information and Awareness Campaigns	Yes
Autonomous Regional Energy Organisation	Yes

(Source: "Promotion of Energy Efficient Technologies Matching Islands and Ultra-Peripheral Regions Specificity", European Union, THERMIE, 1997)

For more Information Contact:

Organisation: AREAM

Address: Madeira Technopolo
P-9000 Funchal
Madeira
Portugal

Tel.: +351 91 723300
Fax: +351 91 720033
E-mail : aream@madinfo.pt

Internet address:

Pellworm (Germany)

General Information:

Population: 1000

Area (km2): 37

The island is located in the Nordsee in the Schleswig-Holsteinisches Wattenmeer National Park.

Renewable Energy Installations:

In the beginning of 1997 a considerable amount of electricity and heat was still imported from the mainland. But on average the existing wind power and PV plants covered app. 55% of electricity needs. At the end of 1997 renewable energy sources contributed to app. 160% of the electricity consumption (e.g. there was export to the mainland).

The share of renewable energy sources of total electricity needs have risen significantly at the end of 1997, when a new wind plant with a capacity of 4.8 MW was completed and connected to the grid.

In the end of 1997 the renewable energy installations on Pellworm included:

1. A 4.8 MW wind plant consisting of 8 AN Bonus turbines. The total investment for the wind farm was 12.5 million DM.
2. A 730 kW PV/wind power plant. The PV plant was originally 300 kW, but 30 kW was added in 1997. There are four wind turbines at the plant: 3 x 30 kW HSW 30 turbines and 1 x 300 kW Enercon 33 turbine.
3. Other 700 kW of wind power.
4. A few heating pumps and solar collectors, which are used for heating, making an insignificant contribution.

Renewable Energy Plan:

The Future Energies Forum e.V. (Bonn) elaborated, together with SCHLESWAG (Rendsburg) - the regional energy utility on the island of Pellworm - and the Verein Ökologisch Wirtschaften! e.V. (Pellworm) (Association for ecological management), a local development plan to tap renewable energy. The plan from 1997 have the title "Energy Supply on the Basis of Renewable Energy Sources Using the Example of the North Sea Island Pellworm. A Local Development Plan"

Main Objective:

The overall objectives for the Pellworm's renewable energy plan is a CO2-free island.

Specific Objectives:

1. Wind Power. A further extension of the already installed 5.8 MW is possible, but it is limited at present time by bottlenecks in output through the sea cables.
2. PV. SCHLESWAG intends to further increase the capacity of the PV plants by drawing on new technological developments.
3. Solar Thermal Energy. Increased use is to be made in two ways for water heating. On the one hand, it is considered advisable to have a solar outdoor pool heating for the municipal swimming pool. Either SCHLEWAG or the community of Pellworm will be the investor on an economically efficient basis. On the other hand, Ôkologisch Wirtschaften! e.V., togehter with the local heating trade, is setting up a purchasing pool for standardised solar collectors (4 m2 collector area, 300 l storage capacity) to hot water heating. The link with summer tourism and corresponding hot water consumption offers good preconditions. Some interested parties have already been found.
4. Demand Side Management. A field study in DSM has been proposed in order to ascertain both the requirements for islands systems with a high proportion of wind power use and the corresponding, supply-oriented demand structures. The field study is designed to supply consumers with heat from wind power and heat pump systems and use local storage facilities, e.g. of boilers or freezers will be included in the calculations. When the winds are up, priority will be given by means of ring control to appliances and heat pumps of this kind. The heat pumps would run solely on electricity from the wind power plants and could thus assume the role of traditional heating systems, above all existing off-peak electricity systems. Then, a scientific measurement program will evaluate the experiences from a system of this kind. If successful, there are plants to extend the heat pump systems on Pellworm.
5. Rapeseed Oil Back-up System. If the field study proves viable, another field study should be undertaken with a battery rapeseed oil back-up system. A back-up system of this kind would do away with the need for electricity from the mainland since it could supply electricity for general applications when the wind drops. The system was designed for a progressive demand structure and could make do with a peak capacity of app. 700 kW. The battery would handle the short-term fluctuations and the rapeseed oil-based co-generation power plant any drops in wind spanning several hours. Investment in a system of this kind would amount to around DM 2.5. million. The costs for the stores electricity would amount to app. 50-70 Pf/kWh.
6. Biomass. Great hopes for future energy supply have been placed in the use of biomass energy. Biomass can provide heating form the new housing are in Tammensiel by means of the existing district heating system, for the community centre including the energy unit for the

swimming pool and the Mother-Child Convalescene home. Biomass could cover around 87% of their energy needs. A system with an extension capacity of 500 kW firing performance would seem to be appropriate when coupled with additional, existing fossil fuel-fired peak load system of 1.5 MW. The land required to grow biofuels would be 77 hectares. One problem are the high costs and the need to subsidise the system. The project partners are trying to limit the need for subsidies to around 70% by various means. The reason for this high costs is the cultivation of biomass required on Pellworm for heating purposes since no residual materials are available.

7. Transport. What appears to of interest on Pellworm is the introduction of motor vehicles run on electricity for island traffic. On the one hand, electrotransporteres could be used to deliver supplies and passenger vehicles could be used form the transport of people. Another idea to offer rental service to tourists who leave their cars on the mainland. The rented vehicles would be recharged from wind or solar energy in line with demand-side management. Several supply units could be installed.
8. Energy Savings. Electricity savings in the field of heating and electricity will not be neglected despite a clear commitment to renewable energy technologies. they are the necessary precondition for a viable concept and offer the highest savings potential of up to 54% and 35% respectively. Targeted training schemes and awareness campaigns by the energy suppliers and the Ökologish Virtschaften! e.V. could contribute towards tapping this potential. The development plan contains the suitable tools in order to provide information on this subject, in co-operation with an energy consultant, to the inhabitants and tourists on Pellworm in an existing SCHLESWAG information center.
9. Information Dissemination. The results of the development plan are to be disseminated via various channels on the national and international levels and their extension to other islands discussed. What is suggested in an national or international conference on energy supply systems based on renewable energies on islands. Furthermore, the results are also to be made known on the Internet and an own homepage and by technical presentations.

If the project proposals are implemented, this would have various effects:

- It would bring Pellworm closer to the goal of a CO2-free island
- It he would mean the development of state-of-the-art technology
- It would lead to more local employment opportunities.

For more Information Contact:

Organisation: Future Energies Forum

Address: Godesberger Alle 90
D-53175 Bonn
Germany

Tel.: +49 228 9 59 55 0
Fax: +49 228 9 59 55 50

E-mail :
Internet address:

Rathlin Island (Northern Ireland)

General Information:

Population: 120

Area (km2): 17

Rathlin Island is located app. 10 km north of the north coast in Northern Ireland.

General Energy Information:

Rathlin Island has been regarded by Northern Ireland Electricity (NIE) and the government as too small and isolated to be connected economically to mains electricity supplies, despite a long campaign by the local people and parliamentarians, for a service to be provided.

On the other islands around Ireland electricity had long been centrally generated from diesel sets, but that was not done on Rathlin whose households hitherto relied on private generators. An undersea cable link had been investigated but the island is separated from the mainland by the Rathlin Sound, and in 1987-1988 during trials NIE lost two of five current meters, which had been anchored to the seabed. Cabling could also had a negative impact on fishing.

In the end Rathlin had to await both the development of suitable wind-power technology and the European Community

Renewable Energy Installations

The system in operation on Rathlin is a German development, by SMA Regelsysteme. On Rathlin's highest point, the 134 m Kilpatric, now stand three wind generators, which generate 33 kW each at rated wind speed of 10 m/s. The turbines generated 70-80% of the island's total electricity usage (1994)

Given that the system is closed, without links to outside the island, back-up diesel generators with a total capacity of 250 kW, which can run independently or in parallel with the wind turbines, were provided to produce power when the wind conditions are unfavourable. Also, there is 75 kWh of battery storage charged by the turbines forming another system back-up, which is also used as a quick start-up to avoid unnecessarily frequent starting of the diesel sets. The overall consumer maximum load is app. 57 kW, so there is room within the installed system for expansion.

The system can be controlled remotely by NIE in Coleraine or SMA from their base in Germany, but two islanders manage the day-to-day running of the company Rathlin Energy.

The UK£ 1.2 million system came into operation on October 1992. There was a connection fee of £1,300 per household but 55% of the system's total cost was paid by the VALOREN scheme, with NIE and DED meeting the balance.

For more Information Contact:

Organisation: Northern Ireland Electric (NIE)

Address:

Tel.: +44 1232 661100
Fax:
E-mail : nie@globalgateway.com
Internet address: http://www.nie.co.uk/

Scottish Islands

There are approx. 90 inhabited Scottish islands ranging in population size from 2 - 23,000 and in area size from 0.1 - 2,171 km2.

The following has been concluded about the Scottish islands and renewable energy:

- renewable energy technologies are being used on a small scale
- potential exist for increased energy generation from renewable energy sources, but the industry is still in its infancy and misconceptions abound
- renewables have particular significance for Scottish Islands which, by their very nature, are the ideal location for development. There are hundreds of miles of coastline, heavy swell, string tides, and lots of wind. Average energy consumption on the islands is also higher than in most of the UK due to high winds, low average temperatures and short winter days. Most fuel, however, is imported in one form or another and this makes energy an expensive proposition for anyone concerned. A degree of energy independence would therefore be desirable and would lead to more freedom for the islands.

For more Information Contact:

Organisation: European Islands Energy and Environment Network (ISLENET)
Attn. John Crawford
Address: Sandwick Road
Stornoway HS1 2BW
UK

Tel.: +44 1851 703773
Fax: +44 1851 705349
E-mail : jcrawford@w-isles.gov.uk
Internet address:

Other Islands in the North Atlantic Ocean with Renewable Energy

Island	Population	Area (km2)	Energy	Renewable Energy
Benbecula (Western Isles, Scotland, UK)	1,771	82.20		A hybrid system consisting of a 60 kW wind turbine together with a 160 kW diesel generator forms a stand alone system used in a community school.
Eigg (Lochaber District, Scotland)	70	29.70		A 10 kW wind turbine is installed at a Primary school. The 10 kW wind turbine is supplying all the electrical needs of the school and many requirements of the schoolhouse.
Froea (Norway)	N.A.	N.A.		A hybrid wind/diesel system consisting of a 55 kW wind turbine, a 52 kW diesel generator, a short-terms battery storage bank, and a separate converter and control unit was assembled on the island of Froea in January 1995. The system is connected to an autonomous grid with 15 consumers. The total fuel savings was estimated to be 54% of the corresponding consumption when running the diesel generator set only.
St. Mary (Isles of Scilly, South-west England, UK)	N.A.	6	There is a 2 MW diesel power plant. The island is connected to the mainland electricity grid.	In October 1987 a 100 kW wind turbine was connected to the grid.
Lyklingholmen (Norway)	N.A.	N.A.		A stand-alone hybrid system consisting of a 3 kW wind turbine, 64 W PV panels, a battery bank, and a 3 kW diesel generator supplies electricity to a single household and a small workshop. The system started operating in 1993 and the electricity production from the renewable energy production is about 4,000 kWh/year. The renewables provide approx. 97% of the households emergy.
North Ronaldsay (Orkney Islands,	90	7.80		Since 1988 a 10 kW wind turbines has been used to provide space heating in a remote rural homestead.

Scotland, UK)				Space heating account for over 50% of the island's energy consumption. The turbine provides power to hearing elements in a 110 litre primary water tank in the house.
Vikna (Norway)	N.A.	N.A.		The first Norwegian wind farm is located at Vikna, a group of islands at a latitude of 65 degrees north. The wind farm, consist of five Vestas turbines with a total installed capacity of 2.2 MW. The wind turbines are connected to a 22 kV distribution system. The wind farm is delivered to the power company Nord-Trondelag Electrisitetsverk (NTE). The energy produced is delivered to the company's grid system for local supply.

South Atlantic Ocean

Ascension Island (UK)
Falkland Island (UK)
Fernando de Noronha (Brazil)
Ilha Grande (Brazil)
Mel Island (Brazil)
St. Helena (UK)

MAP

Ascension Island (UK)

General Information:

Population: 1,500

Area (km2): 82

The island is located approx. 1,000 miles west of Africa (Angola).

Ascension Island Wind Farm

General Information:

The first wind farm in the U.S. Department of Defence is located on the British owned Ascension Island. There are no civilians on the island, which is home to an U.S. Air Force satellite-tracking station.

The 1 MW wind farm consists of four Micon 250 kW turbines and supplements electricity generated by diesel fuel. The turbines operate in a wind-speed range of 9-56 mph and the average wind speed on Ascension is 17.5 mph. No special modifications has been made on the turbines expect for a non-corrosive paint to withstand the salt air.

Some other of the projects main characteristics are as follows:

- hybrid system
- grid connected
- maintenance is divided between personnel on the air bases and contractor in USA
- monitoring, service and repairs is the responsibility of the contractor in USA

The project cost was just over US$ 3 million and the pay back for the wind farm is 8-9 years.

Achievements:

After four days of operation the farm had produced more than 38,000 kWh, saving more than 3,100 gallons of fuel. After the first month and a half, the total power produced was 351,000 kWh. The farm is expected to produce almost 4 million kWh of electricity pear year and save 300,000 of JP-8.

The wind farm has supplied 20-25% of the air station's electrical demand load.

Project Duration and/or State of Advancement:

The project ended in the fall of 1995

For more Information Contact:

Organisation: INEEL

Address: P.O. Box 1625
MS-3790
Idaho Falls
USA

Tel.:
Fax: +1 208 526 2818
E-mail :
Internet address:

Falkland Islands (UK)

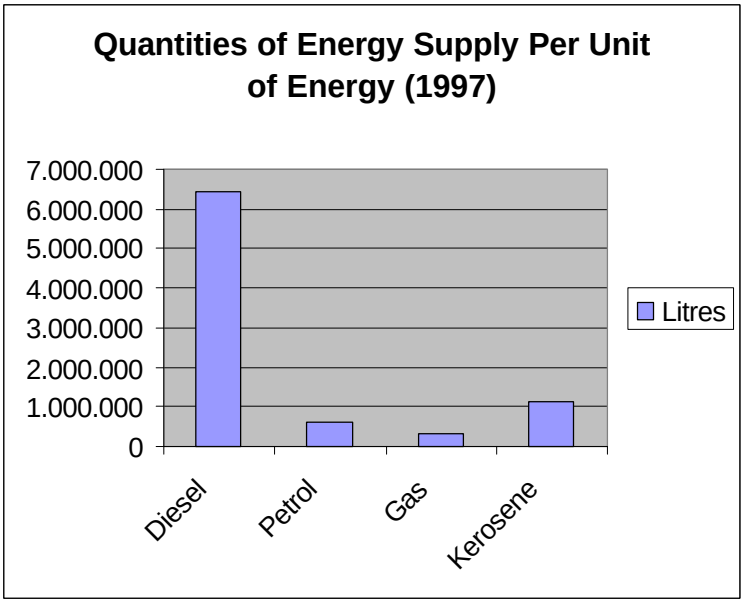
General Information:

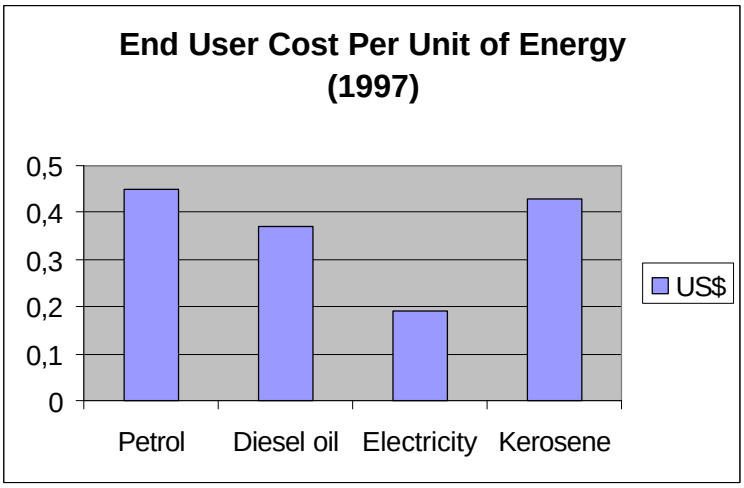
Population: 2,564

Area (km2): 12,173

Energy Supply:

Nearly 100% of the energy supply comes from fossil fuels.





Background for Energy Plan:

The revised energy policy plan was approved by the Falkland Islands Government in November 1997. This energy plan was drawn up against the background of:

- electricity production island-wide relying entirely on imported fossil fuels
- in respect of renewable energy technology, a seemingly high initial transient capital cost resulting in longer terms savings
- the rapid transition from peat to fuel oils and liquefied petroleum gas for heating and cooking purposes
- an international desire to reduce atmospheric levels of carbon dioxide and other pollutants associated with the combustion of fossil fules
- in the Falkland Islands, the attendant disadvantages of continued reliance on imported fuels are; increasing cost to the national economy, economic risk arising from oil price sensitivity and currency valuation changes and outflow of foreign exchange.

The Objectives of the Energy Plan:

The objectives of the Falkland Islands Government energy policy is:

1. to reduce reliance upon imported fuels for production of electricity throughout the Falkland Islands
2. to reduce consumer operating costs through energy conservation and good energy house keeping
3. to reduce production of carbon dioxide and other polluting emissions associated with the consumption of fossil fuels

In the energy plan it is not specified what degree of self-sufficiency with renewable energy is expected to realistic within few years and the transport sector is not included.

The Strategy of the Energy Plan:

1. investigate the viability of supplementing the Stanley electrical power system through wind power as a renewable energy source
2. provide encouragement remote residents to conserve fuel oil through use of renewable energy technology
3. promote energy conservation measures in the public sector and recommend that attempts are made to reduce annual energy expenditure through good energy management and use of low energy equipment
4. ensure appropriate energy saving measures are considered for incorporation into all new building projects
5. promote energy conservation measures in the private sector through issue of advice and information
6. evaluate a grant assistance programme for insulation of domestic and commercial premises and the supply of low energy equipment

Project Title: Rural Energy Grant Scheme (Small Farms)

Objective:

To increase the availability of 24 hour electricity in the remote farms whilst at the same time reducing the consumption of fossil fuels.

General Information:

The principle of the scheme is to enable small farms to store wind generated electricity in a large battery and make it available as mains electricity through the use of an inverter. The existing diesel generator may be used to provide electricity and charge the battery in calm periods.

Grant assistance is restricted to equipment that has been approved by Falkland Island Development Corporation (FIDC). The turbines most used are Proven 2.5 kW, but also Proven 600 W and Bergey 10 kW are represented.

The organisation of the project is as follows:

- The Falkland Island government and EU are financing the project together with the farms. In phase 1 which is costs for battery, inverter, installation, etc. the farms pay 50% and in phase 2 which is cost for turbine, tower, installation, etc. the farms pay 30%.
- After a minimum of five years ownership is private
- Maintenance by suppliers

Applications are stand alone or mini girds.

Achievements:

Status of Rural Energy Grant Scheme by 1st of December 1997:

Systems implemented	app.17
Systems on order	app. 6
Systems planned	app. 13
Farms expressed interest	app. 17

Project Duration and/or State of Advancement:

The installation was started in 1995 and is expected to be on going.

For more Information Contact:

Organisation: Falkland Island Development Corporation
Energy Advisor Tim Cotter
Address: Stanley
Falkland Islands

Tel.: + 500 22711
Fax: + 500 27210
E-mail :
Internet address:

Fernando de Noronha (Brazil)

General Information:

Population: 2,300

Area (km2): app. 30

The island is located app. 500 from the coast in the Northeast part of Brazil.

Energy Supply:

Until 1992 the electricity on the island was exclusively produced by a diesel fuelled thermal power plant. Although the diesel plant is still essential, that of power is expensive and involves environmental risks.

The electric system of the island today is a centralised hybrid mini grid and consist of a thermal power plant with a total installed capacity of 2,070 kVA and 75kW wind turbine.

The diesel power plant consist of:

1. A set CGA generators. Three generators of 400 kVA each. Diesel engines with speed governor regulators.
2. A set CGB generators. Two generators of 375 kVA each. Diesel engines without speed governor regulators.

The wind turbine is connected to the grid through a 112.kVA transformer. No dump lead is needed in the hybrid system because of the low wind power penetration.

It is mainly generator set CGB that has caused high frequency fluctuations on the grid. Not having any speed governor regulation, it has constantly been regulated manually by the staff personnel. Even the set CGA with automatic speed governor control regulation, has in long periods been regulated more or less manually by the staff personnel because of old habits.

Wind Generation on the Island Fernando do Noronha

Objective:

The objective was to install a Danish wind turbine in order to encourage the use of wind energy in Brazil in general and furthermore to demonstrate and pave the way for Danish technology on the emerging Brazilian wind energy market.

General Information:

In June 1992 the first grid connected wind turbine (75kW) in Brazil and the first commercially operating large-scale wind turbine in Latin America was installed on the island Fernando do Noronha. Because the turbine was exceptional in the area it was subject to a lot of attention, not only from the electricity companies and other involved in the energy business, but also from politicians, visitors and the press in general.

The project was carried out as a co-operation between the Danish NGO Folkecenter for Renewable Energy, the Brazilian wind energy Eolica and the electricity company of the state of Pernambuco (CELPE).

The reason for CELPE's decision to install the wind turbine on Fernando do Noronha was that the island has status as a national protected area, known as an unspoiled ecological paradise in Brazil. The main economic activity is tourism, but the government controls the flux of tourists in order not to jeopardise the fauna and flora of the island. The control of tourism is also associated with the limited power supply on the island. The installation of a wind turbine in such a place would send a clear signal: "pure energy for a pure island".

The total project cost was US$ 250,000 and was financed as follows:

CELPE	50%
Danish Ministry of Energy	30%
Folkecenter	20%

Achievements:

Despite some technical problems due to the weak electric gird on the island resulting in lower energy production than estimated the project has been an success (the wind turbine itself has not caused technical problems). In the period from 1992-1995 the accumulated energy produced was 152,926 kWh.

However, the adaptation to a small and weak grid has in the future to be given special attention. When connected to a normal grid, no special problems should be expected in Brazil and there will be access to what is expected to be an extensive wind energy program in a country, where people have no prior experience with wind generated electricity.

At the present CELPE is considering the installation of further 2 wind turbines on the island, raising the wind energy penetration to app. 40%.

For more Information Contact:

Organisation: Folkecenter For Renewable Energy

Address: P.O. Box 208
DK-7760 Hurup Thy
Denmark

Tel.: +45 9795 6600
Fax: +45 9795 6565
E-mail : fcenergy@inet.uni-c.dk
Internet address: http://www.gaia.org/los/folkecentre/

Ilha Grande (Brazil)

General Information:

Population: 6,030

Area (km2): 190

Ilha Grande is located app. 70 km. south of Rio de Janeiro.

Energy Information:

Electricity generation on the islands is delivered from:

- a 13.8 kW cable on the mainland
- diesel generators
- three PV systems on the island.

Only one village is connected to the mainland grid via the electricity cable. A number of isolated beaches accounting for 30% of the island current power consumption, depends on expensive and unreliable diesel generators.

The three PV systems is installed in three different beaches by FURNAS, the regional utility, with support from the federal government through the Ministry of Mines and Energy. The low installed capacity meets only partially the needs of schools, public toilets and public lightning. The operation and maintenance of the PV systems will be transferred to the municipality of Angra dos Reis very soon.

Electricity Production by Source in 1997:

Source	Generated Electricity	Percentage of Total Generated Production
Cable on Mainland	144 MWh	70.4%
Diesel	60 MWh	29.3%
PV	0.45 MWh	0.3%

As can be seen from the table only app. 0.3% of the electricity production is generated from local renewable energy sources. But if it is taken into consideration that app. 40% of the electricity from the mainland is from hydropower then renewable energy sources contributed to app. 32% of the electricity production on Ilha Grande in 1997.

Electrical Energy Consumption in 1997:

Households	119 MWh
Small Hotels	35 MWh
School	3 MWh
Other	47 MWh
Total	204 MWh

Renewable Energy Plan:

Today there is not an overall renewable energy plan for the island, but as can be seen below there is a *project proposal* for such a plan.

A Renewable Energy Strategy for Ilha Grande

Objective:

Design of an overall strategy for the development of renewable energy use throughout Ilha Grande, including pilot projects, with support from the Danish experience with the Renewable Energy Island (REI) initiative, and eventually an exchange of information with similar projects in developing countries.

General Information:

The targets and activities of the first year 1998-1999 is as follows:

- monitoring an evaluation of the results obtained of the three PV installations on the island
- general review/update of the socio-economic and energy data of the island
- study of the Danish experience with the REI initiative
- review and updated of a project proposal for a mini hydro power station from 1992/1993
- elaboration and discussion with the local government of a renewable energy strategy for Ilha Grande, including the identification of additional pilot projects (solar, small hydro, and energy efficiency technologies)
- support the municipality of Angra dos Reis in assuming an active energy planning role at Ilha Grande - assessment of the needs in training and institutional building
- identification of pedagogical material on renewables to be used at the schools in the beaches of the island

Project Duration and/or State of Advancement:

Project start is proposed to be in 1998 and ends year 2000.

For more Information Contact:

Organisation: Laboratorio Interdisciplinar de Meio Ambiente (LIMA)
Attn. Emilio Lèbre La Rovere
Address: C.P. 68565
Rio de Janeiro
CEP 21945-970
Brazil
Tel.: +55 21 560 89 95
Fax: +55 21 290 75 33
E-mail :
Internet address:

Mel Island (Brazil)

General Information:

Population: 2,000

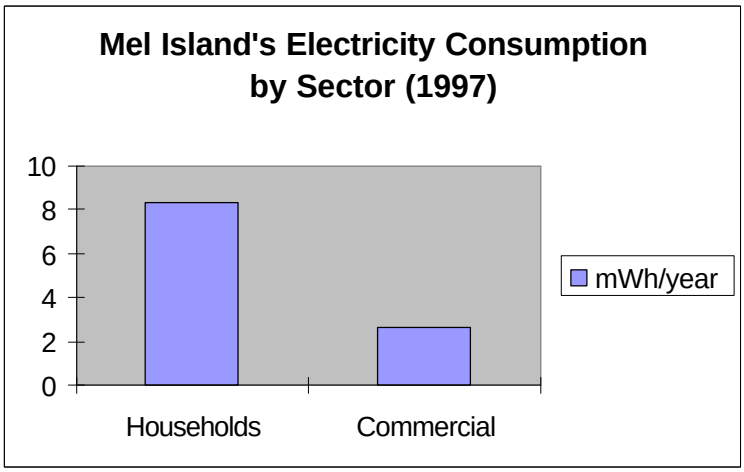
Area (km2): 27

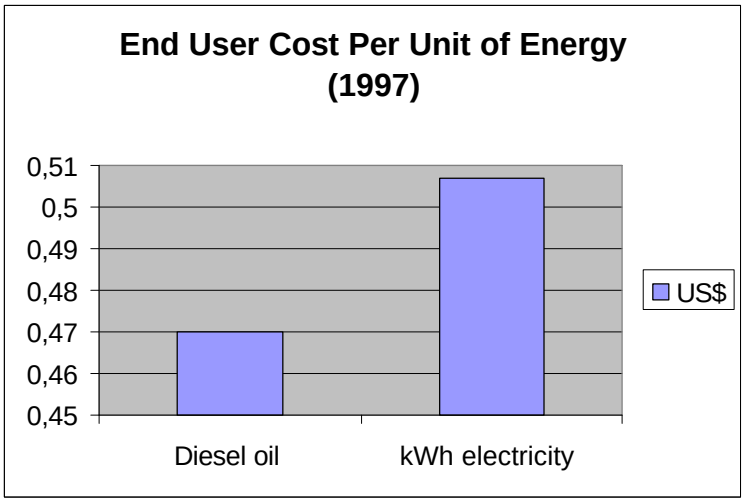
Energy Supply:

- the electricity on the island is generated 100% from diesel
- the island is not connected to the mainland
- there is no overall energy efficiency plan

- there is not an overall renewable energy plan for the island

Energy Demand:





Project:

General Information:

There have been installed 200 solar water heaters and replaced 2000 uneconomic lamps with more economic ones. As a result it is expected to achieve a reduction in demand of 150 kW out of about 810 kW installed. The project is an isolated effort on the island.

Organisation of the project:

- the state government have financed the project
- the government owns the project
- a private firm are responsible for operation and maintenance

Project Duration and/or State of Advancement:

The project started in October 1996.

For more Information Contact:

Organisation: Companhia Paranaense de Energia - COPEL

Address: Rua carlos de Carvalho
608 - 11 Andar
Curitiba Paraná
Brazil

Tel.:
Fax:
E-mail : pizzato@mail.copel.br
Internet address:

St. Helena (U.K.)

General Information:

Population: 5,644

Area (km2): 121

Energy Supply:

Electrical power for St. Helena is supplied by five diesel engine generators in a single power station in Rupert's Bay. Details are as follows:

1 x 1,000 kW
2 x 151 kW
1 x 340 kW
1 x 230 kW

End user cost per unit of energy:

Diesel oil: 0.32 US$
KWh electricity: 0.23 US$

The island is not connected to the mainland.

There is not an overall renewable and energy efficiency plan for the island.

Generation and Load Management Package. Wind Turbine Generator Component.

Objective:

The project is part of a package of measures to safeguard existing diesel generated suppliers, improve system efficiency and incorporate an element of wind powered energy generators. It represents an approach to an energy strategy, which also includes electricity demand forecasting for the forseable future.

General Information:

Over the last years a number of proposals for development projects in the energy sector have been considered and the relative merits of various alternatives discussed. On the generation side of the sector a proposal has been considered for wind turbine generation.

A feasibility study of wind turbine power generation was carried out in 1994. From the data reviewed as part of the study together with wind capture calculations and budget calculations it was concluded that two wind turbines delivering a maximum 80 kW each were technically appropriate and economically and financially viable. Below is a detailed description of the project's prehistory.

St. Helena has an indigenous wind regime of almost constant force and magnitude which is well suited for wind powered generation. Interest in wind powered generation originates from 1978 when Electrical Research Association set up an anemometer at a site on Woody Ridge. Weekly recordings were made from this site for another on Deadwood plain for approximately ten years.

The suitability of the Deadwood Plain site for wind generation was noted but as the technology was felt to be still in it's infancy there was a recommendation to defer investment in generation plant until a track record was established elsewhere and there could be reliability of the equipment.

More wind data was gathered at the Deadwood site culminating in a report in 1994 recommending the installation of two 80 kW Lagerway units. The report was issued together with a supporting document which review a range of available equipment to compare costs and energy capture. Both documents referenced the previous out on the wind characteristics at Deadwood Plain and a study into the optimum location for the siting of wind turbines.

The study based the energy capture on wind data recorded at Deadwood Plain between December 1991 and November 1992. The data was presented in the form of a time series of hourly mean wind speeds at four measurement heights. The mean wind speed at 30.4 meters height for the year was 10.26 m/s, which was scaled be a factor to produce a mean of 9.6. m/s to

correspond with the predicted long term mean. The scaled data set was then used to evaluate each of five short listed turbines by predicting a wind speed at hub height to be used in energy capture assessment.

The study was based on the Deadwood Plain site, which was considered the most suitable and if another site were to be eventually selected the energy capture calculations will need to be revisited as slightly lower wind speeds are to be expected. The input hourly wind speed values were converted into energy using the manufacture's published power curves with extension of the published characteristics applied as necessary.

A limiting factor in the potential for wind powered generation input to the supply system results from the minimum load requirements of the existing diesel generators and the maximum step increase in the demand they can accept . This maximum step increase can be equated in this instance to all wind powered generation shutting down at rated input. Two approaches to this limitation were evaluated as part of the study. The first assumed a generation limit of 25% of the capacity of the diesel generator usually running during the overnight low-load period which was felt to be the maximum step increase which could be accommodated. This equated to a maximum wind generation limit of 125kW. The second alternative was to set the limit to a fraction of electrical demand at the time of production. The justification to this strategy would be that for periods of higher demand, more diesel generation is running and a greater step increase in net demand can be met without endangering system stability.

For the second alternative the study created a typical year of electrical demand based on representative hourly data and equated over that year to the availability of wind generated power with a demand dependant generation limit of 25%.

It was concluded that twin Lagerway 80kW units would represent a preferred package for the St Helena situation. With the typical daily electrical demand used the twin Lagerway have a maximum potential to generate some 1.3 MWh per year.

A recent project on Ascension Island for the US base has shown that wind turbines can successfully be installed in a situation not dissimilar to St Helena and contribute to the electricity demand for the island. The potential intrusion level in the Ascension case is rather greater considered prudent for the St Helena project and there have to be some operational adjustments to cater for the fluctuation potential of the new capacity.

Some of the main characteristics of the project are as follows:

- the wind turbines will be grid connected
- the project will be financed with aid from the British government
- St. Helena owns the turbines
- the Energy Division and project managers are in charge for operation and maintenance

Project Duration and/or State of Advancement:

The project will start in April 1998.

For more Information Contact:

Organisation: St. Helena Government
Public Works and Services department
Energy Division
Address:

Tel.: +290 2300
Fax: +290 2323
E-mail :
Internet address:

Baltic Sea

Aeroe (Denmark)
Bornholm (Denmark)
Gotland (Sweden)
Hiiumaa (Estonia)
Laesoe (Denmark)
Moen (Denmark)
Samsoe (Denmark)

MAP

Aeroe (Denmark)

General Information:

Population: 7,600

Area (km2): 90.45

Energy Consumption:

The electricity plus heating consumption was 184,000 MWh in 1996.

Renewable Energy Installations:

In 1996 app. 15% of the total energy production was from renewable energy sources (excluding the transport sector).

Below are in some detail specified the existing renewable energy installations on Aeroe.

Wind Turbines:

The total installed wind capacity on the island was 2,054 kW in 1996. The total number of wind turbines is 22 and they have the following characteristics:

No.	Capacity
16	55 kW
1	75 kW
1	99kW
3	200kW
1	400 kW

As can be seen from the table below wind energy contributed to 12% of the total electricity production on the island:

Total Electricity Production	Total Wind Electricity Production	Wind Electricity Production in Percentage
41,028 MWh	5,000 MWh	12%

(Source: "Ærø som vedvarende energi-ø. Forprojekt", 1997)

Areoeskoebing District Heating Plant:

The objective of the district heating plant was to develop a multi-source energy system so that the town of Areoeskoebing could supply itself with district heating and electricity on a co-operative basis by using renewable energy sources.

The plant supplies heat and electricity to 517 consumers and consists of:

- a 1600 kW straw burning boiler
- a 325 kW electrically driven heat pump
- a 140 kW diesel generator
- two 200 kW and one 75 kW wind turbines
- 1000 km2 solar panels (low temperature)
- heat accumulation tanks

The heat pump and the solar panels are not in operation. The diesel generator is used to provide electricity when the turbines are not in operation or during periods of peak electricity tariffs to produce electricity for sale to the community.

The following energy sources was used in the district plant in 1996:

Source	Total Quantity
Straw	2,910 tons
Diesel	429 tons

The annual energy production in 1996 was 12,600 kWh and renewable energy sources contribute on average basis with 75-80% of the heat production.

In 1998 and in 1999 a new solar installation is taken in operation - 4,500 m2 high temperature solar collectors.

Marstal District Heating Plant:

This is the largest solar heating power plant in the world. It was finished in November 1996. The plant supplies heat to 1,257 consumers and consist of:

- 8,000 km2 solar panels
- 2,100 m3 water tanks
- to small diesel generators used in case of emergency
- oil tanks
- oil burning boiler

13% of the annual heating production is from the solar panels and the remaining is from diesel oil.

Renewable Energy Plan:

Areoe has an extensive renewable energy plan from 1997. This plan was supported financially from the Danish Ministry for Environment and Energy. Areoe was among the pre-selected participants for becoming the official Danish REI.

Objective:

The objective is that 100% of the island's electricity and heating supply should come from renewable energy sources within a minimum period of 10 years. The objective for the transport sector is not precisely specified.

General Information:

The renewable energy plan include the following renewable energy technologies:

- Wind turbines
- PV
- Biomass for heating
- Biomass for gas production
- Solar heating

The project will be financed with funds from privates, the Danish government and the EU. Ownership is a mixture of private, public, co-operative and leasing. Operation and maintenance will be a mixture of individuals, contracts with private firms and co-operatives. There will also be some information activities.

For more Information Contact:

Organisation: VE-OE Organisation Aeroe

Address: c/o G Karsten Landro
Raadhuset, Vestergade 32
5960 Marsatl
Denmark
Tel.: +45 62 53 11 23
Fax: +45 62 53 11 27
E-mail :
Internet address:

Organisation: Aeroe Energi- og Miljoekontor

Address: Vestergade 64
5970 Aeroeskoebing
Denmark

Tel.: +45 62 52 15 37
Fax: +45 62 52 27 31
E-mail :
Internet address:

Bornholm (Denmark)

General Information:

Population: 45,000

Area (km2): 587

The island is located south of the Swedish coast. There is no bridge link.

Energy Information:

In the table below are for selected years specified how much of total energy demand has been covered from renewable energy sources:

Year	Percentage of Total Energy Demand From Renewable Energy Sources
1982	5%
1993	18%
1997	20%

At present the majority of the island's electricity comes from a local utility and via an under-sea cable, which links Bornholm to the electricity supply network in nearby Sweden. The total electricity production for the main electricity grid was 249,458 MWh in 1997.

The electricity production, by renewable energy sources for 1997 is specified in the table below:

Source	Production	Percentage of Total Production
Wind	16,914 MWh	6.8%
Woodcips	1,240 MWh	0.5%
Biogas	172 MWh	0.07%
Renewables Total	18,326 MWh	7.3%

Renewable Energy Installations:

Wind Turbines:

There are 62 wind turbines on the islands, with a total generating capacity of 8,535 MW and an annual production of 16,914 MWh in 1997:

The electricity company "Oestkraft" owns 25 x 225 kW turbines with an total capacity of 5.625 MW and an annual production of 11,592 kWh in 1997.

There are 37 privately owned turbines with a total installed capacity of 2.910 MW and an annual production of 5,322 MWh in 1997. Typically these are private companies formed by a small co-operative of just 50-60 households.

Biogas:

There are two 55 kW biogas installations on two farms and they produced 172 MWh of electricity in 1997.

District Heating:

Today app. 20% of all households in Bornholm are users in a district heating system, and this is obtained over only 8 years.

The following four district heating system is implemented:

1. A demonstration project from 1986 in the town of Lobbaek with app. 400 inhabitants. Surplus straw, are used as fuel.
2. A demonstration project from 1986 in the town of Klemensker with app. 700 inhabitants. Surplus straw, are used as fuel.
3. In the town of Nexo with app. 3,600 inhabitants there is a 10 MW straw-fired district heating plant, which has being supplying district heating since 1989. This project is described in details below.
4. In the city of Ronne with app. 15,000 inhabitants there is a 6.2 MW heating plant that has been in operation since 1991. Fuel is solid waste, coal and woodchips. This project is described in details below.

Four projects have been prepared, but not yet established:

1. The town of Ostermarie with 600 inhabitants. Straw as fuel.
2. The town of Aakirkeby with 2,000 inhabitants. Combined heat and power production with biogas as fuel, and straw/wood chips as fuel for heating.
3. In the town of Hasle with 1,700 inhabitants. Combined heat and power productoion with biogas and straw as fuel.
4. In the town of Snogebaek with 400 inhabitants. Combined heat and power production with biogas as fuel.

The basic advantages by the establishing of district heating has been:

- better air pollution control
- lesser dependence on one type of fuel
- more convenience at consumer level

Solar Heating:

Over the last years the County Energy Unit in Bornholm has accomplished several solar heat campaigns, in co-operation with the local plumbing offering:

- computer-calculations from individual dwellings
- contact to local plumbers
- guidance regarding applications for Satee grant

The results was in 1994:

- 175 small-scale solar heat units
- 1 major 220 m2 solar heat system for heating a folk high school established in 1989
- growing interest for new solar heat units, both in private households and in public institutions

In the municipal administration there is an important awareness of careful adaptation of solar panels to preserved buildings and quarters.

Renewable Energy Plan:

For more than 10 years Bornholm has given high priority to renewable energy and energy savings.

The reason for this involvement is:

- pursuing a local political goal "Bornholm - a green island"
- high oil prices in Denmark, due to energy taxes
- high potential of local renewable energy sources
- new possible funding from European Union and the Danish Energy Agency
- local waste problems solved
- local environment improved
- local employment improved

The means used has been:

- analysis and research: Local Energy Resource Mapping (1981), Energy Balances (1983, 1987 and 1994), heat planning (1985), energy planning (1986), and integrated energy and environmental planning (1991)
- demonstrations plants
- pilot projects
- information and consulting
- campaigns
- proper local organisation: Regional Energy Board (1986-) and Administrative County Energy Unit (1986-)

The potential for further development in renewable energy and energy savings is still large. Realistic goals for app. the next ten years are:

- energy savings can lower the total consumption by 10%
- renewable energy sources can cover app. 1/3 of total energy consumption

BOFA's Waste Heating Plant in Ronne

General Information:

BOFA, short for the Municipal Waste Handling of Bornholm, was founded in 1996, when the five municipalities of Bornholm joined forces in order to handle the waste problems of the island. This happened at a time when the existing waste treatment system faced problems with meeting the growing demands from the authorities.

The old system of waste treatment was based on two outdated incinerator plants and a number of official and unofficial dumps where unsorted waste was placed and occasionally burnt. The National Agency for Environmental Protection closed down the incinerator plants as they no longer were capable of meeting the new demands, leaving BOFA to face a new challenge. At first, BOFA considered aiming at depositing, and the new possibilities for the establishment of one single official dumping site were considered. In the meantime, the municipality of Roenne decided to establish district heating, and thus the possibility of establishing a waste fired heating plant emerged.

The initial cost of the plant was app. 75 million DDK.

Technical Information:

The furnace has a capacity of 5.2 MW. Adding the capacity of the waste burner, 1 MW, the total capacity of the plant is 6.2 MW, which is equivalent of the basic consumption in Roenne.

The amount of waste for incineration is estimated at 18,000 T/year. Due to tourism the amount is expected to vary somewhat from summer to winter.

The furnace is planned to incinerate 2.5 T of material per hour at a caloric value of 2,200 kacl per kg. In the after-incineration of waste oil is placed with a capacity of 100 kg per hour. A 1300 metres long transmision pipe conducts the heat to a heat exchanger station from where the heat is transferred to the heat supply system of Roenne.

The plant is fitted with a dry flue gas purifying system. The flue gas is lead to a n absorber where the gas is mixed with absorbant lime. The flue gas is purified in a bag filter in which process dust and absorbing material cum reaction product are segregated. After this, clean gas passes through a ventilator and is discharged through the chimney, which is 70 metres high. The lime is stored in a 60 m3 silo.

In the incinerator plant 575 kg of cinders and ashes are produced every hour. The residues from the smoke purifying system consist of reaction products

(50 kg/hour) and dust from the bag filters. These residues are deposited separately in a special store.

Project Duration and/or State of Advancement:

The plant was decided in October 1988, and in November 1988 the construction was begun, and in January 1991 the plant was operational.

The Straw-fired Heating Plant in Nexo

General Information:

The straw-fired heating plant in Nexoe is the latest straw-fired district heating plant on Bornholm.

An amount of 8 - 10,000 tons of straw is delivered at the plant every year by the straw suppliers' union of Bornholm. Each bale weigh app. 500 kg.

A truck places the straw in the store house, after which an automatic crane delivers the bales to the straw divider, in which the bales is torn to pieces prior entering the straw furnace. The storage capacity is 300 tons, which equals four days of maximum heat production.

The boiler system consists of two %MW straw furnaces and one 9 MW oil furnace for periods of maximum strain. In order to equalise the heat consumption, an 800 m3 heat accumulation tank is connected to the system. The smoke is purified in bag filters, and the ashes are lead to containetrs in closed wet-ashes systems for subsequent distribution to the straw suppliers' field.

The district heating network consists of app. 22,000 metres of pre-insulated steel pipes with diametres from 32 to 300 mm. The service pipes are pre-insulated plastic tubes with diametres from 25 to 40 mm. Once fully developed, the system will compromise some 1,625 service pipes.

The total initial expenditure was app. 14.2 million DDK.

Achievements:

In 1989/1990, the district heating plant delivered an amount of 88 TJ. On completion in 1999, the system is expected to reach a heat production of 141 TJ.

In the summer of 1991, some 1050 out of a possible number of 1,500 was affiliated to the heating plant.

The strain on the environment changes in accordance with the change over from individual oil heating to district heating. The consequences are as follows:

SO2	- 0,7 T/year
NOX	+ 4 T/year
CO2	- 10,380 T/year
PaH	+ 27 kg/year
Cd	- 270/year
Particles	+ 3,5 T/year

Project Duration and/or State of Advancement:

The laying of the district heating pipes and the construction of the plant commenced in the spring of 1988. In September 1989 the first consumers began using the heat from the plant.

For More Information Contact:

Organisation: County of Bornholm

Address: Ullasvej 23
Postboks 160
3700 Rønne
Denmark
Tel.: +45 56 95 60 00
Fax: +45 56 95 73 97
E-mail :
Internet address:

Gotland (Sweden)

General Information:

Population: 58,000

Area (km2): 3,100

The island is located in the middle of the Baltic Sea.

Energy Information:

Gotland has an isolated power grid connected to mainland Sweden by a high voltage DC cable. The cable can only transmit power from the mainland to the island.

A majority of the energy consumed on the island is produced on the mainland and imported. The dependency on fossil fuels and main land produced electricity is high.

After about ten years of the introduction on renewable energy sources today app. 10% of the total electricity supply is from renewable energy in the form of wind turbines.

Renewable Energy Installations:

Wind Power:

Gotland is the municipality in Sweden with the biggest number of wind turbines. The development in this area has been extensive in the last 5-6 years. There is today about 100 wind turbines on Gotland, with a total installed capacity of app. 40 MW. In 1995 the total production was 48,500 MWh.

So far the development of wind power has taken place in the south-western part of the island. This is mainly due to a number of factors such as:

- a good public support to the concept of wind power
- the frameworks under which a wide ownership has been created
- the mobilisation of local groups and entrepreneurs to utilise the current interest in wind power

In the small town of Näs, where most part of Gotlands turbines are installed (app. 32 MW), the introduction of renewable energy has not only increased the possibilities of economic survival in the form of sales of energy, leasing of land, construction of jobs etc., but has also attracted a great number of visitors to the area.

Today's 32 MW capacity at Näs could be double within a few years and there are plans for groups of several 1.5 MW turbines in other areas of Gotland as well as a series of off-shore wind farms of 30-50 MW around the island's coastline.

Hydro Power:

There is a small hydro-power plant.

Electric Cars:

There have been built several home made electric cars on Gotland. In the summer 1997 led the car hiring company Hertz as a demonstration project one of their cars be electrical driven.

There are six electrical supply units on the islands

Rapeseed Cars:

Since the summer of 1996 had two of the municipals forest department cars been driven by rape-seed oil. Other departments in the municipality has also been introduced to these cars.

There are three rape-seed oil supply units on the islands.

Renewable Energy Plan:

In the strategic development plan for Gotland - Vision Gotland 2010 - adopted by the municipal council in 1994 a number of strategic areas for the development of the island are outlined. One major area is the environment. It is stated that the development of Gotland should be undertaken in a manner that considers the development aspects, thus safeguarding a sustainable development of the island.

An overall objective for the development plan is that Gotland should be eco-municipality, which means that they want to create a development within the frame of a sustainable society.

One major field of an environmental friendly development is the introduction of renewable energy sources. This is done with a two-fold aim:

- increase the share of domestically produced and environmentally friendly sources of energy in the energy system
- to provide the necessary energy to develop areas such as tourism and high-tech industry at a competitive cost

An Energy Agency was created to take initiatives and implement measures regarding energy plans, energy savings, renewable energy and co-operation with other islands.

The Energy Agency is co-operating with the following organisations:

- the municipality on the island
- the Energy Agencies on the Orkney Islands (UK) and Bornholm (Denmark)
- ISLENET

For more Information Contact:

Organisation: Gotland Energy Agency
Gotlands Kommun
Address: St. Hansgaten
S-62 181
Visby
Sweden

Tel.: +46 498 269014
Fax: +46 498 203520
E-mail :
Internet address:

Hiiumaa (Estonia)

General Information:

Population: 11,800

Area (km2): 1,000

Hiiumaa is situated in the eastern part of the Baltic Sea around 25 kilometres away from the Estonian mainland.

Energy Information:

Electricity Production in 1997, by Source:

Source	Electricity Production	Percentage of Total Electricity Production
Fossil	41,280 MWh	96%
Wind	1,720 MWh	4%

Estimated energy used for heating in 1997 was 280 TJ and app. 80% was from fossil fuels and 20% from wood.

In the electric grid the energy losses is about 20% and in the central heating system losses is about 50%. Local initiatives have started to reduce these losses.

Environmental and Renewable Energy Plans:

Hiiumaa is part of the West-Estonian Archipelago Biosphere Reserve and has been member of the UNESCO World Network of Biosphere Reserves since 1990. Under preparation is a national target programme to develop the island as a model region of sustainable development. A draft law will be finished in 1998.

According to the Hiiumaa Development Concept from 1993 the following development objectives was set out:

- to preserve and develop the island as a self supporting viable development unit
- to establish an integrated approach to the planning of different levels by using ecological, social and economical criteria simultaneously
- to revise the principles of land and resources exploiting and suggest operational general cross- sector frameworks to the sustainable use of the nature

Hiiumaa participates in European Islands Energy and Environment Network (ISLENET).

The objective of the PHARE/ECOS-OUVERTURE Programme Round 2 project "Energy E.S.T.O.N.I.A - Energy Efficient Stategies and Technologies of Northern Island Authorities" is to:

- carry out the general energy plan
- to create demonstrate projects on energy savings in buildings
- installation of a unit with a view to be the further establishment of a local advisory agency for energy and environmental management
- create a wind atlas
- evaluate the island's potential to use biomass

Hiiumaa participates in this project with the following islands: Saaremaa, Gotland, Bornholm, Aaland, Shetland and Orkney.

In co-operation with Gotland Energy Agency there is identified a project to evaluate and explain possible areas on Hiiumaa's coastal zone for establishment of off-shore wind farms. Environmental impacts of off-shore wind energy will be assessed in this project.

Discussions about the idea to develop Hiiumaa as further Renewable Energy Island (REI) have started. The 10-15 REI subprogram will be included in the National Biosphere Reserve Target Program as a key objective in regard to obtaining the status of a model region of sustainable development.

Demonstration Wind Turbine Tahkuna

Objective:

To establish on Hiiumaa the first demonstration wind turbine in Estonia.

General Information:

In 1997 a 150 kW Genvin wind turbine was installed.

The project was initiated and hold by Biosphere Reserve's Hiiumaa Centre (recipient institution) and the partner was the Danish firm Genvin.

The project was financed by the Danish Environmental Agency, Estonian Ministry of Environment and Estonian Environmental Foundation.

Achievements:

The generated electricity in the period 19/9 1997 to the 20/1 1998 was 83,155 Mwh.

Project Duration and/or State of Advancement:

The project started in 1994 and the was finished in September 1997.

For more Information Contact:

Organisation:	West-Estonian Archipelago Biosphere Reserve's Hiiumaa Centre Attn. Ruben Post
Address:	Vabrikuväljak 1 Kärdla Hiiumaa EE3200 Estonia
Tel.:	+372 46 962 60
Fax:	+372 46 962 69
E-mail :	ruuben@bka.hiiumaa.ee
Internet address:	http://www.hiiumaa.ee/~bka/eng.html

Laesoe (Denmark)

General Information:

Population: 2,400

Area (km2): 114

Energy Information:

In 1997 renewable energy constituted app. 20% of the island's total energy consumption (apart from the transport sector), primarily from the district heating plant at Byrum, using wood chips. The district heating plant was commissioned in 1993-1994 and has 168 consumers and supplies over 90% of the towns heating demand.

There are only a few wind turbines on Laesoe and local wind power do not contribute to electricity generation. The island is connected to the Danish mainland electricity grid by under water sea cable.

Energy Consumption by Source, in 1997:

Source	Energy Consumption
Heating	30%
Electrical Devices	6%
Fishing Vessels	40%
Agriculture	3%
Transport	11%
Ferries	10%

Renewable Energy Plan:

Laesoe was part of the Danish competition in 1997 of becoming the official REI and has therefore an extensive renewable energy plan.

The objectives where that 95-100% of the heat consumption, 100% of the electricity consumption and at least 13% of the transport energy should be transformed into renewable energy within a 4 year period.

Today the renewable energy plan will not be implemented in its original form.

For more Information Contact:

Organisation: Laesoe Municipality

Address: Doktorvejen 2
9940 Laesoe
Denmark

Tel.: +45 98491300
Fax: +45 98491406
E-mail :
Internet address:

Moen (Denmark)

General Information:

Population: 11,425

Area (km2): 217.3

The island is linked by bridge to Zealand mainland and the island Faltser.

Energy Information:

In 1997 renewable energy constituted app. 25% of the island's total energy consumption without the transport sector. The renewable energy comes mainly from:

- wind turbines, which supplies app. 15% of the islands electricity consumption
- the 6.3 MW straw heating plant at Stege
- individual systems using biomass for heating

App. 30% of the heat consumption is from renewables.

Renewable Energy Plan:

Moen participated in the competition of becoming the official Danish REI in 1997 so there is an extensive renewable energy plan.

The objective was that 50% of the island's electricity consumption, 75% of the heating consumption and 10% of the transport consumption was covered by renewables within a 10 year period.

The only part of the plan that probably will be implemented is regarding wind power. Moen has made a restrictive wind turbine plan which means that most of the replacement possibilities are in roughness group 3 - i.e. relatively weak energy placements. The municipality has estimated that the maximum total wind exploration within the frames of the plan will correspond to about 1/3 of the electricity consumption. That leaves room for a doubling of the present production.

For more Information Contact:

Organisation: Moen Kommune

Address: Storegade 56
4780 Stege
Denmark

Tel.: +45 55 81 55 55
Fax: +45 55 81 14 86
E-mail :
Internet address:

Samsoe (Denmark)

General Information:

Population: 4,400

Area (km2): 114

Samsoe is located between the Danish mainland and the biggest island where the Danish capital is located.

Energy Information:

Today there are some exploitation of renewables on the island mainly as wind turbine and at the straw heating plant at the town Tranebjerg. About 12% of the energy consumption is today covered by renewables (apart from the transport sector) which corresponds exactly to the national average. About 5% of the electricity consumption and about 15% of the heat consumption is covered by renewables.

Renewable Energy Plan:

Samsoe is the official Danish REI and there is a very extensive renewable energy plan (English versions of this plan can be obtained from the organisation mentioned below).

Objective:

The objective is that 100% of the consumption of electricity and heat is converted to renewables within a 10 year period. With regard to the transport sector it is estimated that a 20% reduction/change can be obtained compared to the present fossil fuel energy consumption.

Renewable Resources and their Proposed use:

Samsoe has potentially good wind resources due to its location, and there is a large interest in private turbines. The islands is exempted from the planning of wind turbines - which almost all parts of Denmark has to consider - from landscape reasons as only about 1/6 of the area is not pointed out as special areas in the regional plan, which limits the present prospects. The county declared that if Samsoe did become the official REI it would be prepared to consider a change of the regional plan. Besides it is possible to place turbines at sea at low water.

Locally there are good biomass resources of which the largest unexploited potential comes from straw or manure. The local wood resources for energy is today almost fully exploited in stoves etc. There is for example plenty of straw on the islands whereas the present wood resources are not sufficient to fulfil the objective - with the chosen technologies - and therefore must be increased or subsidiary released from the present individual use where conversion to for instance district heating is a possibility.

The project focus on a marked conversion to district heating (new project from scratch) in a number of even small villages based on the present biomass resources and supplemented by exploitation of surplus heat from the two large enterprises on Samsoe, and the ferries, combined with large heat pumps. With the proposed idea about 65% of the future heat supplies will be connected to district heating. There will also be electricity production from the suggested biogas plants while electricity production from straw/wood is not proposed.

The remaining individual supplies are expected converted into primarily a combination of solar heating and heat pumps. There is also a basis for 4-5 biogas farm plants besides the use of manure in the district heating plants, just as the possibilities for excess heating from neighbours will be exploited.

On Samsoe today all waste which is not recycled is deposited on the island - including waste that could be incinerated. It might also be possible to use

waste wood for energy purposes. Landfill gas is a part of the district heating schedule of the project.
It has been emphasised that the suggested collective supply system is flexible with regard to future change of goals.

Savings:

It is estimated that it will be possible to reach heat savings of 20% and electricity savings of 25% by target specific actions during the project period. A need for extra electricity for heat pumps must be added to this, however.

Transport Sector:

Samsoe has carried out a very thorough mapping of the transport situation on the island. There is little work commuting to the mainland. About 1/3 of the transport energy consumption comes from the ferries, and the driving per resident car is probably relatively small which makes this transport need suited for electricity.

The project points to a large number of possible saving activities, and with regard to renewables the project has chosen solely to point to the possible conversion to electric cars and busses based on wind turbine electricity.

Local Involvement:

Samsoe Energy Company has been formed to forward the REI project. The company - which consist of Samsoe trade and industry council, Samsoe farmers' association and Samsoe municipality - has been responsible for the project proposal in co-operation with the utility ARKE and the consultancy company PlanEnergy. A citizens meeting has been held during the pre-project phase.

Organisation:

Samsoe Energy Company will be in charge of the co-ordination and the ongoing conceptual work in close co-operation with ARKE. ARKE - which has organised and financed the establishment and the working of the present straw heating plant at Tranebjerg - will if wanted organised and differentiate this model of organisation and financing so that it can be adjusted to offer competitive renewable heat supplies to all consumers, also for individual installation. ARKE will also be able to organise and finance savings initiatives. It is furthermore expected that private wholesale societies will be formed to buy renewable plants, services etc.

Samsoe Environmental and Energy Association has recently been established in order to forward the idea of REI among the island's inhabitants. Samsoe has established a local energy and environmental office, which is the practical co-ordinator for the REI.

Aarhus county has expressed the will to give Samsoe high priority in connection with favourable loans for energy and environmental installations from the county's release fund.

Tourism - other Exchange:

Samsoe has a very large tourism with 400,000 yearly bed-nights. There is one high school with about 450 students and about 50 guest teachers per year, 2 continuation schools and a considerable exchange a camp school.

The Project's Association with other Local Green Initiatives, etc.:

As part of its tourist policy Samsoe wants the island connected with a general consciousness of the environment, and activities which will further a unity concept of the island are supported (the "Unity Samsoe" project).

As part of the REI project plans have been made to establish a new wing - the energy house - to the local school with 3-6 new class rooms which will be a renewables experimentarium for the school's pupils and those from the camp school.

A centre of ecological farming and renewables already exists on Samsoe which will be visited by tourists and especially by farmers. The centre is selected as official test centre by a Danish agriculture council.

Besides this a number of communication ideas is part of the renewable energy plan.

For more Information Contact:

Organisation: Samsoe Energi- og Miljoekontor

Address: Langgade 24
8305 Samsoe

Tel.: +45 86592322
Fax: +45 86592311
E-mail : energikontoret@image.dk
Internet address:

The Mediterranean

Agios Efstratios (Greece)
Greek Islands
Kythnos (Greece)
Lemnos (Greece)
Sîpan (Croatia)

Agios Efstratios (Greece)

General Information:

Population: 250-300

Area (km2): approx. 50

The island of Agios Efstratios is situated in the middle of the North Aegean Sea app. 18 n.mi. south of the island Limnos. The only settlement and port of the island Agios Efstratios has a population of just 250.

Energy Information:

Currently most of the energy needs is covered by the existing diesel station.

The energy consumption is mostly electricity consumption for households, because there are no industrial activities. Total electricity consumption in 1995 was 481 MWh.

The peak power demand is approx. 240 kW during summer and during winter the load is as low as 40 kW.

Installation of a 100 kW Wind Turbine

Objective:

The objective of the European Union THERMIE project is:

- demonstration
- research on different optimising strategies

General Information:

The project is an isolated wind power effort although Center for Renewable Energy Sources (CRES) aim is to make Agios Efstratios an island where different renewable energy scenarios will be applied.

The system will be operating autonomously, but it can also feed the existing electricity grid.

The degree of self-sufficiency with renewable energy is expected to approx. 30% when the turbine is installed.

Organisation of the Project:

Financing	European Community (THERMIE) and the local municipality
Ownership	Municipality of Agios Efstratios
Operation and Maintenance	CRES in co-operation with private enterprise

Project Duration and/or State of Advancement:

The project is in the commissioning phase.

For more Information Contact:

Organisation: Center for Renewable Energy Sources

Address: 19th klm. Marathonas Ave
GR - 190 09 Pikermi
Greece

Tel.: +30 1 6039900
Fax: +30 1 6039905
E-mail :
Internet address:

Greek Islands

Regarding energy on the Greek islands the following conclusions can be made:

- There is still no island in Greece where the penetration of renewable energy sources is very high. But there are plans for such pilot actions as the Danish REI "Samsoe"
- Most of the Greek islands are still not interconnected to the mainland electricity grid. In most of the cases electrical energy is currently supplied by autonomous diesel power stations. The cost per kWh of these diesel stations is usually very high and therefore the integration of renewable energy sources is in most cases an economically feasible solution.
- The main renewable energy sources currently exploited in the Greek islands is wind, PV and active solar
- There is a lot of potential regarding wind and sun in the Greek islands
- In most of these small island there is not any worth mentioning industrial activity. Therefore, the main electricity consumption comes from households

For more Information Contact:

Organisation: Center for Renewable Energy Sources (CRES)
Attn. Mr. Panos Ladakakos
Address: 19th km Marathnos Av.
GR-109 09 Pikermi
Greece

Tel.: +30 1 6039900

Fax: +30 1 6039905
E-mail :
Internet address:

Kythnos (Greece)

General Information:

Population: 1,600

Area (km2): 100

The island of Kythnos lies in the Norts Agean Sea approx. 80 km south east from Athens.

Energy Information:

Energy Supply:

Electricity on the island is supplied from a hybrid diesel/wind/PV system. It consists of the following:

- a 200 KVA diesel generator
- 100 kW PV station
- 5 x 33 kW MAN wind turbines
- batteries and inverter of 100 kW rated capacity

Most of the electricity comes from the diesel station. In 1997 less than 10% was from the wind turbines and the PV system.

The annual mean wind speed is 7 m/s at 30 m height.

Energy Demand:

Most of the island's energy consumption is electricity for households since there are no important industries. In 1995 the total electricity consumption was 3,672 MWh.

Renewable Energy Plan:

There is a renewable energy plan for the island. The transport sector is not included. The objective is the maximum exploitation of renewable energy sources primarily in the electricity sector.

Installation of a 500 kW Wind Turbine and a 500 kW

Diesel Generator

Objective:

The objective of the European Union THERMIE project is the extension of the existing hybrid diesel/wind/PV system with:

- 1 x 500 kW VESTAS V39 wind turbine
- 1 x 500 kW diesel generator

General Information:

The project is part of the overall renewable energy strategy for the island. The turbine and diesel generator will be grid connected.

Organisation of the project:

Financing	European Union (THERMIE) and PPC
Owner	Public Power Corporation (PPC)

Achievements:

Expected results will be maximum wind and PV penetration - over 30% of electricity supply is expected to be from renewable energy sources.

Project Duration and/or State of Advancement:

The wind turbine and diesel generator will be installed in 1998.

For more Information Contact:

Organisation: Public Power Corporation (PPC)
Department of Alternative Energy Forms
Address:

Tel.: +30 1 3636240
Fax:
E-mail :
Internet address:

Lemnos (Greece)

General Information:

Population: 14,923

Area (km2): 475.61

The island of Lemnos is situated in the middle of the North Aegean, midway between Mt Athos and Asia Minor.

Energy Information:

The power system of the island consists of an autonomous diesel power system and two wind parks installed at Vigla and Vounaros sites.

Installed Electricity Capacity by Source, in 1995:

Source	Installed Capacity	Percentage of Installed Capacity
Diesel	13.250 MW	92.1%
Wind	1.140 MW	7.9%

(Source: "Development and Implementation of an Advanced Control System for the Optimal Operation and Management of Medium-Sized Power Systems With Large Penetration From Renewable Energy Sources", 1996)

The wind park at Vigla site consists of 7 x 100 kW Windmatic 19S turbines and the wind park at Vounaros site consists of 8 x 55 kW Windmatic 15S turbines.

Development and Implementation of an Advanced Control System for the Optimal Operation and Management of Medium-Sized Power Systems with a Large Penetration from Renewable Power Sources

Objective:

The islands of the European Union (EU) represent a large potential for the installation of wind and PV plants due to their wind and solar resources and the high cost of electricity production in the isolated networks.

However, in order to achieve a high level of integration of renewable energy plants, while maintaining a security in the grid, an advanced control system must be available to help the power operators on site.

The objective of this EU JOULE II project is: the development and implementation of an advanced control system for the optimal operation and management of medium size power systems with a large penetration from renewable energy sources.

General Information:

The partners of the project are ARMINES (France), the National Technical University of Athens (Greece), AMBER S.A. (Greece), DRAL (UK), and INESC (Portugal). The Public Power Corporation of Greece has also actively co-operated in the project.

The development of an advance tool design to assist the operators of diesel power stations in systems with high wind penetration, was proved to be a necessity according to the results and the conclusions of the analysis performed in previous EU projects like the "European Wind Power Integration Study" and the "Wind Power Integration into Diesel Grids - Development of an Assessment tool".

During these studies it became clear that, since the uncertainty of the produced wind power is much higher than that of the demand load, a high running reserve is necessary in order to obtain a relatively high level of system security. However, in this case the expected fuel savings due the integration of the wind power is reduced considerably.

In small power systems, where the maximum demand does not exceed 1 MW, the existing diesel generators are small units, with a short stating point. Therefore the main point of interest for these cases is the automation of the system, eventually, the co-operation of the controls of the diesel units and the wind turbines.

On the contrary, for medium size power systems (maximum demand up to 30 MW) the starting point of the diesel units is in the scale of 10 up to 30 min or even more, so that the optimal dispatching largely depends on the judgement made by the operator. It is evident that the necessity of such a control system, that assist the operator to make up its decisions, is higher when there is also a high penetration of wind power or power from any other uncontrolled renewable energy source.

The power system of the Greek island of Lemnos, which presents a maximum demand of almost 7 MW a minimum about 2 MW (1993) and where there are already installed wind turbine generators of app. 1.2 MW, was selected with the above mentioned criteria, as a typical medium size diesel-wind power system for the study.

An advance control system to assist the operators has been developed by the partners and enables to maximise the integration of wind power while ensuring the stability of the power system through the operation of security rules.

The system has been installed in January 1995 on the island of Lemnos, where two wind farms are installed. (These wind farms was in June 1995 under reparation due to serve damages caused by heavy storms in the island in Spring 1995).

The control system has been designed so that it could take easily into account the introduction of additional wind farms of PV plants in the island. The modularity of the control system also enables its adaptation to other islands that present similar features with the island of Lemnos, i.e. medium sized isolated power systems.

The control system runs on a PC computer. The main features of the control system are the following:

- Dispatching module (to optimise the scheduling of the various diesel units)
- Security assessment module (to assess the security of the power system)
- Load forecasting module (to produce forecasts for the power demand)
- Wind power forecasting module (to produce forecasts for the future, i.e. two or three hours)

An important aspect is related to the development of a specific wind power forecasting module to improve the scheduling of the diesel units in the next two or three hours. This horizon was chose based on the characteristics of the management of the diesels on the island of Lemnos.

For more Information Contact:

For a copy of the report contact

Organisation: Office for Official Publications of the European Union (EUR-UP)

Address:

Tel.:
Fax:
E-mail :
Internet address:

Sîpan (Croatia)

General Information:

Population: 350-400

Area (km2): 17.5

Sîpan is located in the south Adriatic cost of Croatia approx. 15 km west from Dubrovnik.

Energy Information:

Energy Supply:

The are no precise data. Approx. half of the total energy supply is from fossil fuels such as diesel, petrol and gas. The another half is from non-fossil fuels such as biomass and hydropower produced electricity from the mainland electricity grid.

Energy Demand:

There are no precise data. There is no industry on the island, but there is a hotel with a capacity of 100 person. It is opened 4 months a year. In the transport sector energy is used for small agricultural machines, fishing boats and ship lines.

Renewable Energy Plan:

There is not an overall renewable energy plan for the island.

COE Center for Renewable Energies - Frajga/Sîpan

Objective:

The objective is the design and promotion of small solar and wind systems for isolated agriculture based islands and/or coastal family communities/farms/villages.

General Information:

Zeleni Mir is a NGO who works on the protection of the sea and the coast, especially taking care of the protection of sensitive island biosystems. Among other things is has started the Center for Renewable Energies on the island of Sîpan which is an example of utilisation of renewable energies in small and isolated islands.

They primarily use equipment made in Croatia, but they also test imported products.

Technologies used is as follows:

- PV systems
- Wind power
- Solar cookers (solar reflectors and collectors)

The different installations are stand alone systems.

Educational and informational efforts in the project:

- workshops for schools
- practical use of solar irrigation for farmers

- test
- solar cooker production
- PV design and installation

Organisation on the project:

Financing	From all sources: equipment producer, private, local and state government
Ownership	Co-operative and private
Operation and Maintenance	Co-operative and private

Achievements:

Actual results are good. During wartime in the region 91-93 the island was disconnected from the grid and they had a lot of practical work and success with promotion of renewable energy.

The overall expected results of the project is a net of energy self

Project Duration and/or State of Advancement:

The project started in 1990 in will continue until the year 2000.

For more Information Contact:

Organisation: Zeleni Mir

Address: Frana Bulica 6
20 000
Hrvatska
Croatia
Tel.: +385 20 412 496
Fax: +385 20 413 745
E-mail :
Internet address:

The Indian Ocean

Mauritius
Reunion (France)
Seychelles

MAP

Mauritius

General Information:

Population: 1,127,068

Area (km2): 1,860

Mauritius is located east of Madagascar.

Electricity Information:

The whole island is electrified and there is app. 276,000 customers connected to the network.

Installed Electricity Capacity in 1997 by Source:

Source	Capacity	Percentage of Total Capacity
Diesel	173 MW	47.4%
Gas Turbines	80 MW	21.9%
Bagasse-Coal	52 MW	14.2%
Hydro	60 MW	16.5%

Electricity Production in 1996, by Source:

Source	Electricity Production	Percentage of Total Electricity Production
Thermic Power Stations	920 GWh	80%
Renewables	230 GWh	20%

Renewable Energy Sources:

Since Mauritius' hydro potential is almost exhausted, the scope for renewable energy is limited to bagassse, solar energy for weater heating, and wind energy.

Wind Power:

Mauritius has a good wind regime. A wind energy resource assessment program was carried out from 1983 to 1985 under the auspices of UNDP. The Mauritius Meteorological Services collected wind data from 10 sites and edited a wind atlas of the island. A number of locations on the northern, eastern and southern coast, were found to have a good potential for electricity generation. Especially the southern coast line offers excellent sites with average yearly wind speeds of about 8 m/s above ground level.

The Government of Mauritius in collaboration with the Central Electricity Board (CEB) intends to encourage the development of wind power in

Mauritius. Government policy is to substitute as far as possible imported oil for wind power development is now considered as a priority. In June 1997 there was deadline for interested parties regarding installation of a wind farm with the capacity of 10-30 MW.

Solar Water Heating:

Mauritius has favorable conditions for utilising solar water heaters. The tropical sun shines evenly all year around, and the technology is available. The conditions are best in the coastal regions, where small collectors will do the job; in the central plateau area around Curepipe lager-sized units heater is necessary during wintertime. The pay-back time for investment in a solar water heater is reported to be attractive. Solar water heater have the extra benefit of facilitating water storage because tap water is often restricted to a certain periods of the day in Mauritius.

In 1994 there was approx. 10,000 solar water heaters installed on the island, but the potential market is estimated to exceed this number by 5 to 10. Some 12 manufactures and 3 importers of solar water heaters operated in Mauritius in 1994.

Bargasse:

The most plentiful indigenous source of energy is bagasse, the by-product of sugar cane processing. In 1994, sugarcane production amounted to 5.8 million tons, yielding approx. 1.7 million tons of bagasse. The bagasse is almost entirely used by sugar factories for process heat and power generation, with excess power sold to the gird.

In 1992, excess was 85 GWh generated from 265,000 tons of bagasse. This left 1.44 million tons of bagasse for internal consumption by the factories. Based on the energy contend that bagasse "commands" as a substitute for coal in power generation, the primary energy equivalent of the power sales was 42,400 tons of oil (about 6% of total primary energy requirements), while the factories' own bagasse use made up for about 229,000 tons of oil.

The potential availability of bagasse for power generation and other purposes is inexorably linked to the future of the sugar industry in Mauritius.

Hydro Power:

Mauritius' hydroelectric has largely been developed, and the remaining hydro resources are confined to water supply and irrigation. While the installed capacity is 60 MW, output has been uneven. Over the years, hydro generation has varied between 64 GWh in 1984 and 147 GWh in 1989. Until 1994 the average output has been 104 GWh. In 1994 the medium-to-long term prospects was that hydro generation would contribute at most 130 GWh a year.

For More Information Contact:

Organisation: Central Electricity Board (CEB)

Address: Royal Road
Curepipe
Mauritius

Tel.:
Fax:
E-mail :
Internet address:

Reunion (France)

General Information:

Population: 600,000

Area (km2): 2,512

Reunion is located between Madagascar and Mauritius.

Energy Information:

Over half of the island's agricultural land is devoted to sugar-cane production. Producing 2 millions tons of sugar cane per year, Reunion has app. 640,000 tons of bagasse, the equivalent of 120,000 tons of heavy fuel oil.

Commissioned in 1992, the Bois-Rouge bagasse-coal power plant is the leader of this new system. In 1996, it experienced an very good year, processing twice as much as sugarcane as in 1995. In the co-generation power plant generated 312 GWh made available to the Electrcite de France network. A power plant of the same model was commissioned in Gol in 1995. Bagasse alone covered 18.3% of the electricity requirements in 1996.

With hydropower renewable energy sources provide more that 63% of the electricity consumed on the island in 1996.

For More Information Contact:

Organisation: ADEME Reunion

Address: 97 rue de la Republique
97400 Saint - Denis
Reunion

Tel.:
Fax: +262 21 12 60
E-mail :
Internet address:

Seychelles

General Information:

Population: 72,000

Area (km2): 450

The Seychelles is located north east of Madagascar. There are over 115 islands of which 35 are inhabited.

Energy Information:

Almost 100% of Seychelles energy consumption are from petroleum products. Renewables contribute between 3-5% of total energy consmption.

Most of the islands have their own diesel power producing facilities.

Total energy consumption on the islands was 120 GWh in 1996.

Renewable Energy Plan:

The Seychelles have an renewable energy plan and the objective is the reduction in the dependence on imported oil. Among other things are government buildings fitted with solar water heaters.

PV for Marine Park Rangers

Objective:

The projects consist of the installation of PV and solar water heaters in the only six houses on the island of Curuse. The island lies approx. 30 miles from the main island Mahe. The project is part of an awareness campaign to promote renewable energy.

General Information:

Each system will provide enough power to supply:

- four lights
- one radio
- one refrigerator

Organisation of the project:

Financing	Financed by the Italian Trust Fund
Ownership	Public
Operation and Maintenance	Public: The Energy Affairs Bureau and the Divisions of

Environment

Project Duration and/or State of Advancement:

The project started in the end of 1997.

For more Information Contact:

Organisation: Seychelles Bureau of Standards
Energy Affairs Bureau
Address: P.O. Box 953
Mahe
Seychelles

Tel.: +248 375 151
Fax: +248 375 333
E-mail :
Internet address:

Annexes

Terms of Reference
Main Internet Databases Used
Cover Letter and Questionnaire Used
References

Annex 1: Terms of Reference (in Danish)

FEU, august 1997

KORTLÆGNING AF INTERNATIONALE
VE-Ø-INITIATIVER

1. BAGGRUND

Regeringens har i Energi 21 besluttet at der skal etableres en dansk VE-ø, der skal være selvforsynende med energi fra vedvarende energikilder i løbet af en kortere årrække, også indenfor transportsektoren.

Demonstrationseffekten vil være betydelig og programmet vil derfor kunne få stor positiv effekt på udbredelsen af vedvarende energi. Samtidig vil programmet være et godt internationalt udstillingsvindue for dansk VE-udstyr.

Energimiljørådet, der er oprettet for at rådgive regering og folketing om gennemførelsen af Energi 21, har tilkendegivet særlig interesse for initiativet, og har nedsat en ad-hoc gruppe til at følge det.

Energimiljørådet lægger navnlig vægt på VE-øen's mulighed for at synliggøre og konkretisere hvordan fremtidens energisystem kan se ud, og for at udvikle og demonstrere løsningsmodeller, der kan finde anvendelse over hele landet. Energimiljørådet finder endvidere, at initiativet, der på en gang omfatter alle elementer af en bæredygtig energiudvikling og samtidig på grund af sin afgrænsning et overskueligt, kan være en god basis for et internationalt samarbejde omfattende f.eks. erfaringsudveksling, information og fælles udviklingsprogrammer.

Med henblik på at forberede et sådant internationalt samarbejde har Energimiljørådet besluttet at iværksætte en kortlægning af lignende initiativer i andre lande.

Energimiljørådet vil blandt andet anvende kortlægningen og informationen i denne som inspirationskilde for det danske VE-ø-initiativ og ligeledes til at afdække mulighederne for samarbejde og erfaringsudveksling på internationalt plan.

2. FORMÅL

Udarbejdelse af en faktuel og systematisk oversigt vedrørende VE-ø-initiativer på nordisk, europæisk og globalt plan.

Kortlægningen vil mere præcist blandt andet indeholde:

- Beskrivelse af øernes størrelse
- Beskrivelse af initiativet:

  a) Indsatsområder
  b) Teknologier
  c) Organisationsformer
  d) Finansiering
  e) Om initiativet omfatter undervisning eller information
  f) Tidshorisont
  g) Forventet resultat

3. RESULTAT

Resultatet er en rapport, som i omfang forventes at være mellem 50-100 sider alt afhængig af mængden af den tilgængelige information. Yderligere vil der på baggrund af indsamlingen af information blive etableret en materialesamling vedrørende VE-ø-initiativer på internationalt plan.

4. AKTIVITETER

Følgende grove aktivitetsfaser kan identificeres:

a) Afgrænsning, definition og operationalisering af VE-ø-begrebet
b) Specifikation af hvilke information der skal indsamles
c) Informationsforespørgsel til relevante aktører
d) Bearbejdning af indsamlede information
e) Udgivelse af rapport

5. INPUTS

Følgende danske aktører vil i forskellige faser og i varierende omfang bidrage til færdiggørelse af rapporten:

1) Energistyrelsen

Energistyrelsen bidrager med foreliggende viden om danske, nordiske og europæiske VE-ø-initiativer (primært om Middelhavet og Østersøregionen).

2) Forum for Energi og Udvikling (FEU)

FEU er ansvarlig for følgende aktiviteter i forbindelse med kortlægningen:

- Indsamling af information om VE-ø-initiativer på globalt plan. Følgende geografiske regioner, stater eller områder vil blive kortlagt: a) Stillehavet,

b) Sydøstasien, c) Indiske Ocean (herunder Mauritius), d) Vestafrika (herunder Kap Verde Øerne), e) Brasilien (Fernando de Noronha), f) Middelhavet, g) Nordamerika (herunder Hawaii), h) Østasien (herunder Japan) og i) Nord Atlanten (Grønland, Færøerne og Island) og j) Caribien.

- Sammenskrivning af indhentet materiale om VE-ø-initiativer på dansk, nordisk, europæisk og globalt plan.
- Trykning af rapporten

3) Organisationen for Vedvarende Energi (OVE)

OVE virker som konsulent for FEU primært i forbindelse med FEUs indsamling af information om VE-ø-initiativer på globalt plan.

Her ud over anvendes eksterne internationale konsulenter i forbindelse med FEUs indsamling om VE-ø-initiativer på globalt plan.

6. METODE

Følgende informationskanaler vil blandt andet blive kontaktet eller anvendt i FEUs kortlægning af globale VE-ø-initaitiver:

1) Multilaterale organisationer:

- Det Internationale Energi Agentur (IEA)
- Verdensbanken (WB)
- United Nations Development Program (UNDP)
- Europæiske Union (EU)

2) Nationale energiagenturer

3) Internationale kontakter

4) International Network for Sustainable Energy (INFORSE)

Via dette internationale netværk kontaktes relevante organisationer blandt andet via forespørgsler og annoncer i INFORSE's nyhedsbrev "Sustainable Energy News" (SEN).

5) Internettet

Der laves en målrettet søgning på eksterne energi- og miljødatabaser lokaliseret ved forskellige NGOer, nationale styrelser og regionale og internationale organisationer.

6) Forskningsbiblioteker

Her undersøges blandt andet bibliotekerne på Risø, Center for Udviklingsforskning og Danmarks Tekniske Universitet.

7. ORGANISATION

Projektet ledes af en styregruppe bestående af Energimiljørådets ad-hoc-gruppe og Energistyrelsen. Styregruppen mødes månedligt.

FEU etablere en intern projektgruppe, der referer til styregruppen via løbende udsendelser og månedlige møder. Hovedparten af arbejdet i FEUs regi vil blive udført af Cand. Scient. Pol. Thomas Lynge Jensen, der tidligere har udført ligende kortlægningsopgaver for FEU.

8. TIDSPLAN

Arbejdet påbegyndes ultimo 1997. Rapporten udgives senest 1 april 1998.

Annex 2: Main Internet Databases Used

Name	Description	Internet Address
CADDET	Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) collects, analyses and disseminates information on demonstration projects in energy efficient and renewable energy technologies. Working within the framework of the International Energy Agency (IEA), CADDET's objective is to provide impartial information about proven technologies to help accelerate their adoption in the market place. CADDET functions as two separate operations; CADDET Energy Efficiency and its sister organisation, CADDET Renewable Energy .	Energy Efficiency: www.caddet-ee.org Renewable Energy: www.caddet.co.uk
CORDIS	The Community Research and Development Information Service (CORDIS) provides information on a vast range of research, development and innovation activities undertaken on a European level in the EU.	http://apollo.cordis.lu/cordis/EN_PROJl_search.html
DOE Reports Bibliographic Database	The Department of Energy Reports Bibliographic Database contains citations for the US Department of Energy (DOE) sponsored scientific and technical reports covering the period of January 1, 1994 to present.	http://apollo.osti.gov/waisgate/eren.html
EREN	Energy Efficiency and Renewable Energy Network (EREN)	http://www.eren.doe.gov/menus/search1.html
RSVP	The Renewables for Sustainable Village Power (RSVP) Web site provides information to assist in the implementation of renewable energy solutions for rural electrification programs in developing countries.	http://www.rsvp.nrel.gov/rsvp/database/search.html
SOLSTICE	Solstice is the Internet information service of the Center for Renewable Energy and Sustainable Technology (CREST)	http://solstice.crest.org/index.shtml

Annex 3: Cover Letter and Questionnaire Used

Dear Sir/Madam

Re: Review of Renewable Energy Islands (REIs):

In its action plan for energy – Energy 21 – the Danish government has decided that a Danish island as a demonstration project should become self sufficient from renewable energy sources, including transportation, within the 5-10 years. The Renewable Energy Island (REI) will be selected this year among 5 candidates. Is can be expected to have a population of 5.000 – 7.000 inhabitants.

The Danish REI would be a good starting point for global co-operation among similar initiatives to exchange experience and information and to plan and implement collaboration programmes.

To look further into this matter, it has been decided to elaborate a report with an overview of REI-initiatives around the world. It is furthermore considered to organise an international REI-conference in Denmark, most likely during 1998. The objective of the report and the conference is prepare for future global co-operation and networking among REIs.

As a first step, the Government's Advisory Council on Energy and Environment has asked the Forum for Energy and Development (FED), to carry out a review of renewable energy initiatives in islands around the world.

Through this letter we kindly request you to inform us whether your are involved in or know of actual or planned renewable energy projects on smaller islands. To this end, we would be very pleased if you would fill out the enclosed questionnaire and return it to us via letter or fax before... If not all the requested information is easily available to you, just fill in as much information as you can. If you can inform us of more than one project we would be grateful if you would copy the questionnaire and make one for each initiative.

The final report will be available in English in April 1998. In return for your co-operation we will be happy to forward you a complementary copy.

Please forward your reply to Mr. Thomas Lynge Jensen, who is responsible for the review.

Thank you very much.

Yours sincerely,

René Karottki
Secretary General, Forum for Energy and Development

QUESTIONNAIRE

GENERAL INFORMATION ABOUT THE ISLAND

1. Name of the island: _____

2. Questions regarding presence of an overall renewable energy and energy efficiency strategy on your island:

a) Is there an overall renewable energy and energy efficiency strategy for your island? No ☐

Yes ☐

If no please go to question 3

b) If yes, please specify briefly _____
_____
_____
_____
_____

c) If yes, is the transport sector included in the strategy? No ☐

Yes ☐

d) If yes, what degree of self-sufficiency with renewable energy is expected to be realistic within few years? (expressed in percent) _____

3. Island population size: _____

4. Size of island (e.g. in km^2): _____

5. The island's energy consumption pattern (e.g. how much of the total energy consumption that is used by different sectors, such as households, industry, transport etc. - expressed in the units MWH or GJ per year):
_____
_____
_____
_____
_____

6. The Island's energy supply pattern:

a) How much of total energy supply comes from different kinds of fossil and non-fossil fuels? (expressed in the units MWH or GJ per year)

_____
_____
_____
_____
_____
_____
_____

b) Is the island connected to the mainland or other islands via electric grids or other grids?

No ☐

Yes ☐

7. Are there great energy loses in your energy system? If yes, is there any energy efficiency initiatives? (please specify briefly):

_____
_____
_____
_____
_____
_____

8. End user cost per unit of energy (in US$):

- Diesel oil: _____
- KWH electricity: _____
- LPG pr. Kg: _____

SPECIFIC INFORMATION ABOUT THE RENEWABLE

ISLAND PROJECT

9. Project name if applicable:

_____

10. Name, address, phone, fax, e-mail etc. of implementing organization (e.g. utility, municipality, government, NGO etc.):

_____
_____
_____

_____
_____
_____

11. Is the project an isolated effort or part of an overall renewable energy and energy efficiency strategy for the whole island?

_____
_____
_____
_____
_____
_____

12. Technology used (e.g. photovoltaics, wind power, biomass etc.):

_____
_____
_____
_____
_____

13. Application of the produced energy (e.g. grid connected, mini grid, stand alone (water pump, light etc.) etc.):

_____
_____
_____
_____

14. Does the project include any kind of educational and informational effort? If yes, please specify briefly:

_____
_____
_____
_____
_____

15. Organization of the project:

a) How is the energy activities financed? (e.g. private, public (local or state government), foreign aid etc.)

_____
_____
_____

b) Ownership (e.g. private, public, cooperative, leasing etc.):

_____
_____
_____

c) Operation and maintenance (e.g. individual, contract with a private firm, cooperative etc.)

_____
_____
_____

16. Project start

_____

17. Project termination if applicable

_____

18. Please give a short description of the background and the actual or expected results of the project:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Annex 4: References

Boopsingh, Trevor M. et al: "Caribbean Energy Sector. Review and Perspectives", Caribbean Dialouge, vol. 1, no. 1, July/August 1994

"Cabo Verde Regional Studies", Project SOLARGIS, INESC, Portugal, 1996

"Cape Clear Renewable Energy Trail. Feasibility Study", Sean McCarthy, Hyperion Energy Systems, October 1997

"Caribbean Conference and Exhibition on Renewable Energies. Abstracts", Gouadeloupe, 1-3 December 1997

Conway, James M. and Wade, Herbert A: "Photovoltaic Electrification in Rural Tuvalu", 1994

"Country Profiles. Renewable Energy and Energy Efficiency in Latin America and the Caribbean", U.S. Export Council for Renewable Energy, 1995

Danish Ministry of Environment and Energy, "Energy 21. The Danish Government's Action Plan for Energy 1996", 1996, Copenhagen

"Danish Wind Power in Brazil. Part 2. Experience with Danish 75 kW Wind Turbine - the First Modern Turbine in Brazil", by Niels Rich and Troels Kildemoes Møller, Folkecenter for Renewable Energy, Denmark, 1996

"Development and Implementation of an Advanced Control System for the Optimal Operation and Management of Medium-sized Power Systems with Large Penetration From Renewable Energy Sources", Europen Commission, JOULE II, Wind Energy, 1996

"Energy Supply on the Basis of Renewable Energy Sources Using the Example of the North Sea island Pellworm - a Local Development Plan", Forum für Zukunftsenergien, EU, DG XVII, ALTENER, 1997

"Environment and Development. A Pacific Island Perspective", Asian Development Bank, Manila, 1992

"European Energy Network for Peripheral Islands", EU, DG XVII, January 1994

"Fair Isle Renewable Energy Project", National Trust for Scotland, 1995

Hansen, Jens Carsten et al.: "Wind Energy in Island Grids Experiences from Cape Verde", Sub-Regional Wind Energy Workshop, Forum Secretariat, Suva, Fiji, 23-27 June 1997

"Hawaii Renewable Strategy Report 1995", State of Hawaii, Department of Business, Economic Development, and Tourism, Energy Division, 1995

"Hawaii Renewable Energy Data Report 1995", Pacific International Center for High Technology Research (PICHTR), 1997

Headly, Oliver: "Renewable Energy Technologies in the Caribbean", Solar Energy, vol. 59, no. 1-3, pp. 1-9, 1997

Hopkins, William: "The High Penetration Wind/Diesel Wind Farm of La Desirade - the Increased Capacity of a Proven System to 500 kW wWithin the Cyclone Belt", VERGNET S.A., 1996

Johansson, Ulf: "Impact of Renewable Energy on Tourism in Sweden", ETSU Conference, Stratford on Avon, 11 September 1996

"The Islay Energy Study", ETSU, May 1996

ISLENET Newsletter

Liebenthal, A., Mathur, S., and Wade. H.: "Solar Energy. Lessons from the Pacific Island Experience", World Bank Technical Paper Number 244, Energy Series, 1994

"Mauritius Energy Sector Review", ESMAP, World Bank, 1994

Mendes, J.M. Melim: "Renewable Energies in Madeira", European Seminar on Renewable Energy Islands, 29-30 April 1998, Samsø, Denmark,

"Pacific-Danish Environmental Education and Action Program - Feasibility Study Phase 1", COWI-RISØ, January 1998

Persaud, Bishnodat: "Alternative Energy Sources for Small Island Developing States", prepared for Global Conference on the Sustainable development of Small Islands Developing States, 1994

"Photovoltaic Solar Energy Best Practice Stories", EU, DG XVII, THERMIE, 1997

"Country Profiles. Renewable Energy and Energy Efficiency in Latin America and the Caribbean", U.S. Export Council for Renewable Energy, 1995

"Promotion of Energy Efficient Technologies matching with Islands and Ultra-Peripheral Regions Specificities", EU, DG XVII, THERMIE, 1997

"Relatório Anual de 1996", Electricidade dos Azores (EDA), 1996

"Renewable Energy Plan of the Canary Islands. Objectives and Actuation Strategies", Gobierno de Canarias, Consejeria de Industria y Comercio, Direccion General de Industria y Energia, 1996

Royle, Stephen et al.: "Renwable Energy in Northern Ireland", Geography, no. 344, vol. 79, pp. 232-245

Smith, Birgitta Godhavn & Crawford, John: "Renewable Energy - The Way Ahead for Scottish Islands?", Islander Magazine, Issue 2, July 1996

"Strategies for Management of the Environment in Tuvalu", Environment Office, Ministry of Natural Resources and Energy Office, Ministry of Finance, Economic Planning, Commerce and Industries, GEF Scoping Workshop, Nadi, Fiji, 1-3 August 1995

"Sustainable Energy Planning for 27 Small Danish Islands", Aeroe Energi- og Miljoekontor, 1997

"Tools for Renewable Energy Management in Island Regions", ISLENET, October 1996

"Waide, Paul: "Toward Energy Independence in Western Samoa: An Integrated Energy Study", Greenpeace International, 1995

Wardrop, Nick: "PV Power in the Forum Island Countries", prepared for the Pacific Region Photovoltaic Applications Workshop, 1994

Wind Power Monthly

Wind Energy Weekly