Stromness Renewable Energy Project

A study of community renewable energy
on behalf of
The Stromness Community Business Forum
and
Stromness Community Council
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Report OSE/2136

March 2004

Funding Organisation:

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Contents

SUMMARY 5

1 BACKGROUND TO THE REPORT 6

2 WIND ENERGY PROJECTS IN ORKNEY 7
  2.1 HISTORICAL CONTEXT 7
  2.2 CASE STUDY: BURRAY COMMUNITY WIND PROJECT 8
  2.3 FUTURE PROSPECTS FOR RENEWABLE ENERGY IN ORKNEY 9

3 THE STROMNESS RENEWABLE ENERGY PROJECT 10
  3.1 PROJECT DESIGN METHODOLOGY 12
  3.2 WIND ENERGY CONSTRUCTION AND OPERATIONAL IMPACTS 19
  3.3 WIND TURBINE AVAILABILITY 21
  3.4 WIND TURBINE SELECTION 23
  3.5 HYDRO ELECTRIC SYSTEM DESIGN METHODOLOGY 24
  3.7 HYDRO-ELECTRIC SCHEME SELECTION 28
  3.8 DEMONSTRATION SOLAR VENTILATION AND GROUND SOURCE HEATING SCHEME 30
  3.9 CASE STUDY: THE LIBRARY AT VISBY IN GOTLAND, SWEDEN 31

4 LOCAL OWNERSHIP OF RENEWABLE ENERGY 33
  4.1 CASE STUDY: BAYWIND ENERGY CO-OPERATIVE 33
  4.2 CASE STUDY: FOULA COMMUNITY ENERGY PROJECT 34
  4.3 THE STROMNESS PROJECT; SUMMARY OF COSTS 35
  4.4 THE STROMNESS PROJECT; ACHIEVING LOCAL OWNERSHIP 36
  4.5 THE STROMNESS PROJECT; ACHIEVING COMMUNITY GOVERNANCE 37

5 ACTION PLAN 39

6 CONCLUSIONS 40

7 REFERENCES AND INTERNET LINKS 41

REFERENCES 41

LINKS 41

APPENDIX 1: THE WIND TURBINES

APPENDIX 2: HYDRO ELECTRIC TECHNOLOGY

APPENDIX 3: THE GOTLAND RENEWABLE ENERGY SYSTEM

APPENDIX 4: COMMUNITY CONSULTATION
Summary

Renewable energy has become an important part of the Orkney economy, with local control seen as being vital to prevent over-exploitation of resources. This report is a study into the ownership of renewable energy by the Stromness community, and the future management of land around the Stromness Reservoir. Three themes are followed, with an examination of the most appropriate technology, local ownership, and community governance. Overviews and case studies of each theme are considered. A discussion on sharing revenue from the project is included to facilitate understanding of the concept of community governance.

A range of projects are discussed, including possible locations of wind turbines, a hydro electric generator supplied from Stromness Reservoir and solar heating of community buildings. The scale of each option is discussed, along with an appraisal of the likelihood that the project can be built as proposed. Potential environmental and planning impacts are discussed, with case studies and other development models included.

Various community ownership models are discussed, including grant-funded demonstration schemes, the establishment of a community fund, and the purchase of wind turbines and hydro electric generators. The report recommends that the Stromness community should establish a company to own the power generation equipment, and also recommends that this company should work in partnership with Stromness Community Council to establish a range of social and environmental initiatives; profit distribution should be negotiated between the community council, landowners, farmers and the development company.

Ownership of renewable energy equipment has risk, with the need to set aside revenue to cover maintenance costs, breakdowns and major component replacement. The correct size of wind and hydro electric turbine is important as the project must be large enough to provide a community revenue stream, while at the same time be of a manageable capital cost. Medium scale wind turbines are proposed for a site near Stromness Reservoir, along with a possible hydroelectric generator located next to the derelict mill on the north end of the town. A demonstration solar energy scheme is also proposed, however a location has not yet been identified.

The study has shown how a community can manage a renewable energy development, working in partnership with farmers and companies for the greater benefit of the wider community, and at the same time considering the long-term issues of sustainability and ownership of renewable energy.
1 Background to the report

The establishment of government support mechanisms has increased the use of renewable energy in the UK, allowing wind energy in particular to become cost effective (Boyle, G 1996). In April 2002 a new mechanism of renewable energy support was established; The Renewables Obligation is a requirement on electricity supply companies that will ensure that at least 10%, or 18% in Scotland, of electricity is produced from renewable resources by 2010. In 2003 the Scottish Executive indicated that this latter target may well be increased to ensure that 40% of our electricity is renewable. The electricity suppliers are required to meet these renewable targets. Should they fail to meet their obligations, an increasing scale of fines will be applied until the required target is achieved. There is therefore a strong demand for renewable energy projects throughout the UK.

Scotland has the greatest concentration of renewable resources in the UK, with island communities in particular having strong turbulence-free wind. For this reason wind energy projects are being considered for all parts of Orkney, Shetland and the Western Isles. Hydro electric schemes are less easily located. A good resource is required, i.e. high rainfall, along with a fast, free-flowing river or a large drop in elevation. Orkney has none of these requirements. There is however a redundant reservoir located in the hills above Stromness, allowing the consideration of a small scale hydro-electric generator. Solar heating has not been favoured in Scotland, due to the seasonal mismatch between resource availability and heating demand. Recent advances in technology can however allow the consideration of a combination of a solar-power heating and ventilation system for use in the summer months, and a ground-source heating system which uses stored solar energy for the winter months.

There are environmental issues to consider when developing renewable energy; visual impact, noise issues, and ecological impacts should all be considered. It is also recognised that there are difficulties in constructing and owning energy projects; delivery, craneage, roads, foundations and assembly are all problematic, particularly for island locations. Ownership of renewables by the community has risk, with the need to set aside revenue to cover breakdowns and major component replacement. For these reasons choosing the correct size of system is important; the project must be large enough to provide a community revenue stream, while at the same time have capital costs appropriate for investors within the community. Stromness Community Council and Stromness Community Business Forum initiated this study to control renewable energy development in the area, with funding from the Scottish Community and Householder Renewables Initiative.
2 Wind energy projects in Orkney

This report has been commissioned by the Stromness Community Business Forum and Stromness Community Council to investigate the potential for local ownership of a renewable energy scheme appropriate for the Stromness community. To this end, case histories of different wind energy projects in the islands are discussed. Wind energy is becoming a major industry in Scotland; over the last twenty years, the industry has progressed from research and development, to small wind farms in the north and in the borders, to the establishment of blade and wind turbine factories in Fife and Kintyre. The creation of the Renewables Obligation has resulted in strong demand for new renewable energy projects throughout Scotland. Although hydro, biomass and solar energy are all being considered, it is wind energy that is creating most interest, due to the relative low cost and minor environmental impacts of wind turbines

2.1 Historical context

Wind energy has become an important industry in Orkney. The first wind project in Scotland was undertaken by the North of Scotland Hydro Board, who erected an experimental 100 kW machine at Costa Head, Orkney, in the late 1950s. This lasted a couple of years before being damaged by turbulence; this site was too near the cliff edge.

In 1983, development of the Burgar Hill site began. The first machine was an experimental 250 kW turbine, followed two years later by the Howden 300 kW, a prototype machine that resulted in a small windfarm in the United States. In 1987, a 3 MW offshore prototype wind turbine was constructed, which operated successfully until the mid-1990s. All these wind turbines were demolished in 2000.

Commercial wind turbines arrived in Orkney in 2000. NEG Micon installed a 1.5 MW and a 2.0 MW turbine, and Nordex have installed a 1.3 MW machine on Burgar Hill, with energy traded under the older Scottish Renewable Order scheme. NEG Micon have now replaced the 2 MW machine with the larger NM92. The average wind speed on Burgar Hill is just over 10 m/s, the upper limit for class 1 turbines, making these machines the most productive of their size; the Nordex N60 produces 5 million units of electricity per annum. Parallel to the Burgar Hill development, three 900 kW turbines have also been installed on Stronsay. Under these schemes the landowners are offered a small percentage of generation revenue, with little or no community benefit. Although the projects have generally been successful, these have been developed by commercial organisations without community involvement.
2.2 Case Study: Burray Community Wind Project

Due to the long history of wind energy on Orkney, wind turbine projects are generally seen as an acceptable development. There are plans for another six possible clusters of wind turbines on mainland Orkney and the outer islands, however it is being felt that the fullest benefits are not being made available to the community. Landowners are offered a percentage of generation revenue, currently around 2 to 3%, and local companies have been awarded contracts from design to commissioning. However, all other profits from the projects have gone to organisations outwith the islands, leading to a desire to create a local community-owned wind development.

The Burray Community Wind Project was instigated within the Orkney Renewable Energy Forum, an organisation established by those involved in renewable energy projects in the islands. A member of the forum has a family farm on the island of Burray, and following discussions within the forum, it was felt that the companies who had built the existing projects on Orkney could equally design and develop a locally owned project. A dedicated company was established, and a project put forward for planning approval. Consent for a single 900 kW wind turbine was duly awarded in 2002, and a mechanism of community ownership established.

For the community to become directly involved in such a project, financial investment is required. To enable individuals to become involved, it is expected that an Industrial and Provident Society will be established. This society will have a share of the project, allowing those that live on Burray and South Ronaldsay the opportunity to invest. The projected annual income, after allowing for all construction work, is expected to be around £75,000 per annum for this single wind turbine. Construction is due to commence in the Spring of 2004.
2.3 **Future prospects for renewable energy in Orkney**

The pattern of land ownership on Orkney is different from that of Northern Scotland and the Western Isles. Typically, a farmer or landowner will directly own small areas of hilltop, arable fields or moorland, extending to around 4 to 5 km$^2$; crofting is generally not part of the Orkney economy. This type of landownership is suitable for small clusters of wind turbines, where typically 1 to 3 wind turbines rated around 1.5 MW can be installed on farmers land.

Although conventional projects are developer-owned, the high levels of revenue produced under the Renewable Order (Scotland) scheme is resulting in high annual incomes, along with a community fund based on project capacity. On a high wind site, the income for the landowner from a site with three wind turbines could approach £50,000 per annum.

![Gruf Hill Wind Energy Project](image)

**Figure 2 - Gruf Hill Wind Energy Project**

The success of the projects on Burgar Hill and Stronsay has demonstrated the viability of wind energy in the islands, and with consent awarded for new projects on Burgar Hill, Burray, Flotta and Sanday, wind projects will become an increasing part of the Orkney economy. It can be expected that each island will have a small wind energy project, either developer-driven or with community involvement. This increasing demand has pushed the existing grid infrastructure to the limit and it is expected that an upgrade of the cable linking Orkney to Scotland will be required before demand can be satisfied.

Discussions with Ofgem, the energy regulator, has suggested that an upgraded cable link to Scotland will be put forward in the near future, provided there is demand. The proposed change would be to upgrade to a 132 kV link, increasing renewable energy capacity to around 100 MW. There is demand for sites, and it can be expected that developments will continue to come forward. Controlling the scale of development is the responsibility of Orkney Islands Council, with community councils in a position to govern acceptability.
3 The Stromness Renewable Energy Project

The Stromness Community Business Forum and Stromness Community Council initiated this investigation into the potential for renewable energy in and around Stromness with the aim of providing local control and ownership of future developments. The use of Stromness Reservoir was considered at an early stage. As the reservoir is no longer used for water supply, it was recognised that the site could be acquired by the community, and provided annual inspection and maintenance of the dam continues, the land and resource can be considered for a wind or hydroelectric generation system.

The original scope of the study suggested that wind turbines could be installed at Garson Industrial Estate, with a local grid used to provide energy to nearby businesses. Assessment of the area indicated that there was no site available that was 500m or more from housing, with noise impact the main constraint. Assessment of the greater Stromness area has however identified three other locations that could be suitable for a wind energy development. An initial project has been designed around two wind turbines, each with a tower height of 45m and a blade diameter of 60m. The rated power level of this machine would be 1.3 MW. Another possibility that can be considered is the installation of a small hydro electric turbine supplied by water from the water reservoir. The water available from the reservoir, local streams and the surrounding hills is quite limited due to relatively low annual rainfall in Orkney, nevertheless it has been possible to design a preliminary hydro electric scheme rated at around 250 kW.

Mechanisms to provide direct benefits to the local community are being considered, including the use of solar heating systems for the town community buildings. Options available include solar-source ventilation systems and solar panels for water heating in the summer and underground heat pumps for winter heating. A pilot project based around the Community Centre is one possibility.

One proposal is that the Community Land Fund would be used to acquire the reservoir and the surrounding land, then the Community Council would establish the area as a local amenity. The wind turbines would be located on grazing land at the back of the site, with all the project’s infrastructure, including the civil and electrical engineering, designed and constructed by experienced Orkney companies.

It is proposed that the wind turbines and the hydro-electric generator would be funded through local investment into a development company that would own the project. Allowing for debt repayment, insurance, maintenance and other outgoings, it is proposed that the investors into the development should receive a rate of return limited to 10%. The additional profits produced by the project will be governed and distributed by Stromness Community Council. One strong possibility is that the Community Council would be in a position to combat fuel poverty by distributing additional profits as energy dividends.
Figure 3 – Possible layout of Stromness Project
3.1 Project design methodology

The Stromness Project can be considered to have three aspects; a wind energy development, a hydro-electric system and a combined solar / ground source heating demonstration scheme. The design methodology for each aspect is described below.

The wind energy development has been designed to avoid impact upon environmentally sensitive areas and has ensured that disturbance to communities is minimised. While an assessment of potential environmental impacts will be required, it may be possible to construct each development outwith the Environmental Impact Assessment regulations provided the planning department and the primary environmental agencies are consulted. This has important implications for the planning process.

1. Identify the route and capacity of the high voltage cables across the island. The Orkney Mainland 33 kV grid links Stromness and Kirkwall to an undersea cable at Scorradale. At Stromness there is a substation at the north end of the town, where an 11 kV system is established. There is an underground 11 kV cable linking the European Marine Energy Centre (EMEC) to the substation, routed around the back of the town, adjacent to Stromness Reservoir and The Loons. This cable has a rating of around 8MW, and has been designed to accommodate four prototype wave energy devices that are expected to be moored off Billia Croo in the near future. In general terms there is little available energy capacity on the Orkney grid, however advanced power control and a constrained connection agreement can be considered to enable the deployment of medium scale wind turbines. Following consultation with Scottish and Southern Energy, voltage restrictions may make it necessary to connect the wind turbines either at Stromness substation or at the EMEC centre at Billia Croo.

2. Identify all sensitive habitats and protected areas. The West Mainland of Orkney has an extensive SSSI and the Stromness Heaths and Coast Special Area of Conservation, designated for habitats and plant species. The methodology of this project has been to fully avoid designated areas, however it should be noted that these areas can be considered for development, provided it can be demonstrated that the sensitive areas are in no way affected by the proposed project. Rural settlement, nature reserves and other sensitive environments have also been avoided. It should be considered that Stromness is within a National Scenic Area, and there may be visual impact upon the Ring of Brodgar World Heritage Site. Existing land use is also important and consultation with landowners and tenant farmers has been conducted. While properly located wind
turbines have little environmental impact, attempts should be made to accommodate any concerns raised by landowners, farmers and environmental agencies.

Figure 4 – Environmental constraints

3. **Identify all inhabited and habitable properties around Stromness.** This study has attempted to identify habitable properties and has established exclusion zones around each property. There are two issues to consider to avoid blight from wind energy development; noise and shadow impact. Guidance on these issues is included in the Scottish Executive Planning Advice Notes 45 and 58 - to avoid noise nuisance, the sound power level from the turbine should be no more than 40 dB(A) during day time and 35 dB(A) in the evening at the nearest property. Most turbines have noise levels between 100 and 105 dB(A) at the nacelle and regardless of the energy produced all wind turbines require a minimum spacing of 500 to 600m before noise levels diminish to an acceptable level. To avoid shadow flicker impact a turbine should be positioned 10 rotor diameters from the nearest properties. For this development the Nordex N60 1.3MW wind turbines has been identified as the largest that can be positioned in the available land; shadow flicker clearance is 600m and the noise clearance is 500m.
4. **Constraints and visual impact.** Plotting all exclusions on a map of the area revealed areas that are far enough from properties, near to the overhead wires and with little risk of environmental damage. The appropriate areas were then considered, avoiding sites which adjoined Special Protected Areas; special powers are in place to protect species that can be affected by developments outwith these designated areas (SNH). Having identified the least sensitive area, the one remaining environmental issue to be considered is the visual impact of the development. This issue can be emotive and although wind turbines cannot be hidden, the visual impact of the development can be considered by using the services of a landscape architect or by the production of a series of photomontages. This issue has not been explored in any detail by this study, however figure 5 is an example of the visual impact of the proposed development, showing two 1.3 MW wind turbines of the correct size located at the least sensitive location, with figure 9 showing the local zone of visual impact.

5. **Identify alternative sites.** Alternative sites have been identified, should the chosen location be inappropriate, figure 7. The use of a smaller 60kW wind turbine can also be considered if there are grid connection restrictions, however note that the smaller wind turbines have similar sound levels to the Vestas and Nordex machines, and although the smaller blade diameters mean that the shadow impact exclusion zones can be reduced to 150m, the noise exclusion zones around properties should be maintained at 500m. Figure 6 is a comparison of alternative class 1 wind turbines that could be considered for deployment around Stromness; it should be noted that the project would need over twenty Vergnet GEV 15/60 wind turbines to take the place of one Nordex machine. Section 3.3 of the report is a discussion on the alternative models.

6. **Identification of the most appropriate site.** Detailed planning of the area has to be completed, including location of access tracks and the required substation, figure 8. Note that for hilltop locations access tracks should have their gradient limited to 1:10, and that the substation should be located as close as possible to the 11 kV underground cable. The project layout has the two wind turbines spaced 300m apart, with the substation located off the hill to ensure that any ancillary structures are not visible from the reservoir. The access track is a continuation of the farm track past Mayfield, however an alternative route is possible to the west of the site, provided the turbine transportation and erection crane can negotiate through Stromness and past two corners on the Outertown road.
Figure 5 – View of 1.3MW wind turbines from track to the south of Stromness Reservoir

Figure 6 – Comparison of alternative wind turbines
Figure 7 – Identification of alternative locations

500m noise and shadow impact exclusion zones established around each property.
Figure 8 – Detailed site plan for two 1.3MW wind turbines
Figure 9 – Local zone of visual impact for two 1.3MW wind turbines
3.2 Wind energy construction and operational impacts

All construction and engineering projects have the risk of problems during delivery and assembly and have risk of environmental impact from operations; recognition of these issues at an early stage can reduce or eliminate risks and potential difficulties. These issues require to be addressed when the project planning application is submitted.

Ferry Access

The most important construction issue for wind energy development on islands is the suitability of the harbour and ferries for delivery of components and cranes. By limiting the size of the turbine to 1.3 MW, the wind turbine parts are transportable from Stromness harbour, although it should be noted that transport from the pier to the site may be difficult due to tight turns off the A967 and at The Loons. Delivery is normally the responsibility of the turbine manufacturer and this issue must be fully discussed with the supplier at the time of order. A full and detailed access survey will be required if larger turbines are being considered.

Roads and foundations

The construction of the wind turbine will require the establishment of a well constructed access track and suitably designed foundations. Good quality crushed stone and concrete are required for the foundations, however much of the access track can be made from the material excavated during track manufacture. The Heddle Hill quarry is the normal source of suitable stone. The foundations and access track should be completed a minimum of one month in advance of the delivery of components.

Pollution risks

The construction activities during mobilisation and installation of the turbine represent the greatest risk of pollution. This may be through operational discharges or as the result of an unplanned or accidental event. Given the sensitivity of the islands, care should be taken to protect against the release of any material with the potential to leach into the soil or water courses; a reserve of oil absorbing material should be kept on site.

Noise impact

The noise generated by wind turbines is low, and is generated mainly by the turbine blades passing through the air as the hub rotates; there is also mechanical noise from the gearbox and generator, although this noise is largely absorbed by the turbine’s nacelle insulation cladding. Note that the Nordex and NEG Micon wind turbines have been in operation on Burgar Hill
for over three years and are not noticeably noisy. Noise is measured in decibels (dB) and is a measure of the sound pressure level, or size of pressure variations in the air; a decrease of 10 dB represents a halving of loudness. Environmental noise measurement is made in dB(A) which more fully represents sound levels as heard by the human ear. By ensuring a minimum of 500m separation from neighbouring properties the noise impact is not expected to be significant, and should meet planning guideline levels of 5dB(A) above background levels (DTI Noise Report ETSU 1996).

Ice build-up
One identifiable risk during operation is the possibility of ice build-up under certain conditions in winter. Experience from the Burgar Hill developments suggests that this occurs only rarely. Under these conditions the turbine will automatically shutdown, and will remain stopped until environmental conditions improve (BWEA 1998).

Potential disturbance to birds
By ensuring that the developments are outwith and do not adjoin designated areas it is expected that there is little risk of bird disturbance, however should the decision be made to proceed with the development, there should be consultation with the RSPB and SNH to ensure that the indicated areas have little risk of disturbance. If disturbance is a possibility, an alternative site should be chosen (Meek et al 1993). Note that the RSPB have concerns about high rotational speeds and the use of guyed and lattice towers, particularly in areas where there are large numbers of birds; if a lattice or guyed tower is used then there should be measures to increase the visibility of the wires, and roosting or perching on the tower should be prevented.

Potential radio communications interference
When a wind turbine is positioned near to a radar, radio, television, or microwave transmitter system, it may reflect some of the electromagnetic radiation in such a way that the reflected wave interferes with the original signal as it arrives at the receiver; this can cause the received signal to become distorted. The extent of any electromagnetic interference caused by a wind turbine, beyond positioning, depends mainly on the blade materials and the surface shape of the tower. Where reception is generally poor, there is the risk of television interference. This can however be remedied using recognised improvement techniques, including the installation of repeat transmitters and the use of digital television systems. Clearance is required from the Radio communications Agency, the CAA, the MOD and Kirkwall Airport before proceeding with any wind energy development (Defence and Civil Aviation Interests Working Group (2002)).
3.3 Wind turbine availability

A range of alternative models was considered. Medium scale wind turbines are no longer common, with the major manufacturers increasing scale to accommodate the offshore industry. The manufacturers of small wind turbines have begun to fill this gap, however there is not a large choice available. The following are the alternative wind turbines considered for the project, listed in increasing scale. Appended to the report are details on each model, including costs. The small wind turbines tend to be downwind design, where the blades are behind the tower and all the turbines apart from Vergnet have three blades.

**Vergnet GEV 15/60 and GEV MP**

The GEV 15/60 is a 60kW wind turbine developed by Vergnet, of Saran in France. This is a downwind design with a 15m diameter rotor and hub heights of 24, 30 or 40m. The tower is held in place with guy wires and the blades rotate at 92 rpm. Smaller models of the Vergnet wind turbines have been operating successfully in North Ronaldsay for over 10 years, and although there have been failures in that time, strong support from the manufacturer and good maintenance has resulted in reliable operation. The GEV MP is the latest model from Vergnet, and is a step towards a larger scale of wind turbine. This is a downwind design rated at 275 kW with a 55m high tower and blade diameters of 26 to 32m. The tower can be tubular or lattice and is held in place with guy wires. Rotational speed is 31 to 46 rpm. The main advantage of the Vergnet wind turbines is that they are relatively lightweight and can be erected without a crane, an important issue for islands.

**Enercon E30**

The Enercon E30 is one of the new generation wind turbines that do not use a gearbox; a specially constructed multipole generator is built into the wind turbine hub. Rotor speed is fully variable between 18 and 46 rpm, the rotor diameter is 30m and the tower height is 44m. The E30 has been specifically designed for remote and isolated sites, and areas with high average windspeeds; cut-out wind speed can be set at 34 ms⁻¹, 25% higher than most other wind turbines. With over 400 machines now in operation, it is one of the most successful wind turbines in the world. An important feature of the E30 is the adaptive power output designed for areas with a weak grid; should the voltage levels be seen to rise at times of low demand, the E30 automatically reduces the power output to reduce fluctuations. The grid power is created by a power converter, ensuring that phase angle between voltage and current remains constant. The E30 has been recommended for installation on Westray, Papa Westray and Rousay.
**Vestas V52**

Vestas has a range of machines available rated from 600 kW to 3 MW. The Vestas V52 is rated at 850 kW and is manufactured in Scotland. This machine is an upwind design, with a 52m diameter rotor, a tower height of 44m and a rotational speed varying between 14 and 31 rpm. Noise levels are low, and can be set at 100 dB(A) at a windspeed of 8 ms⁻¹. The V52 is of a similar scale to the three wind turbines installed on Stronsay in 2001, and a turbine of this scale is planned for construction on Burray this year. The smaller tower height should allow construction with a local crane. The V52 is an IEC class 1A turbine and can be recommended for sites where the annual mean windspeed reaches 10 ms⁻¹. The principal difference between the Vestas and Nordex turbines is the power control mechanism, with the V52 recommended in locations requiring good power quality.

**Nordex N60**

Nordex are a Danish / German company with a range of machines available rated from 900 kW to 2.5MW; the Nordex N60 is rated at 1.3 MW. This machine is an upwind design, with a 60m diameter rotor, a tower height of 45m and dual speed operation of 12 and 19 rpm. Noise levels are around 104 dB(A) at a windspeed of 8 ms⁻¹. There are almost 600 N60 wind turbines operating worldwide, with one operating successfully on Burgar Hill for over three years; at 5000 MWh energy production per annum the Orkney machine is the most productive of all the turbines installed by the company. The N60 is an IEC class 1A turbine.

<table>
<thead>
<tr>
<th>Wind turbine</th>
<th>Installed cost per kW</th>
<th>Classification</th>
<th>Construction</th>
<th>Tower construction</th>
<th>Guy wires</th>
<th>Sound levels</th>
<th>Maintenance issues</th>
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<tbody>
<tr>
<td>Vergnet GEV 15/60</td>
<td>£1,333</td>
<td>1</td>
<td>1; winch</td>
<td>Tubular</td>
<td>Yes</td>
<td>4</td>
<td>Good support and manufacturers warranty</td>
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<tr>
<td>Vergnet GEV MP</td>
<td>£800</td>
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<td>1; winch</td>
<td>Tubular</td>
<td>Yes</td>
<td>4</td>
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<tr>
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<td>1</td>
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<td>5 yr extended warranty</td>
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<td>3</td>
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*Table 1 – summary of alternative wind turbines*
3.4 Wind Turbine Selection

Each wind turbine has its own specific application. The Vergnet wind turbines have been developed specifically for locations with difficult access, however the two-blade guyed design is not considered as aesthetically pleasing as the three blade design. The Enercon E30 is a very robust class I turbine that has been developed for extreme environments; on site assembly is relatively easy, with a local crane able to lift the main turbine parts. This machine has been recommended for use in the northern isles, and can be recommended should a smaller turbine be favoured for the Stromness development. The Vestas V52 and the Nordex N60 have very similar installed costs per kW, with the heavier N60 requiring slightly larger foundations. This additional cost however is compensated for by the extra energy production. Given that there is a track record of operations in Orkney, with Stromness companies familiar with servicing requirements, a project utilising two Nordex N60s is recommended. However, it should be considered that a project of three Vestas V52 turbines will provide a greater economic benefit to the community, with the added security of a third machine to reduce any loss of energy production during servicing and maintenance. It should also be considered that grid quality issues may make the V52 more appropriate for this site.

<table>
<thead>
<tr>
<th>Wind turbine</th>
<th>Power rating (kW)</th>
<th>Capital Cost + construction and assembly (£)</th>
<th>Installed cost per kW</th>
<th>Annual Production (kWh), 9ms⁻¹ annual mean windspeed,</th>
<th>Avoided emissions 1T CO₂/MWh per annum</th>
<th>Payback (£0.05 kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vergnet GEV 15/60</td>
<td>60</td>
<td>70,000 + 10,000 to install</td>
<td>£1,333</td>
<td>240,000 (estimated)</td>
<td>240 T</td>
<td>6.7 years</td>
</tr>
<tr>
<td>Vergnet GEV MP</td>
<td>275</td>
<td>190,000 + 30,000 to install</td>
<td>£800</td>
<td>1,100,000</td>
<td>1,100 T</td>
<td>4 years</td>
</tr>
<tr>
<td>Enercon E30 300kW</td>
<td>300</td>
<td>225,000 + 70,000 to install</td>
<td>£960</td>
<td>1,200,000</td>
<td>1,200 T</td>
<td>4.8 years</td>
</tr>
<tr>
<td>Vestas V52 850kW</td>
<td>850</td>
<td>407,000 + 168,400 to install</td>
<td>£677</td>
<td>3,500,000</td>
<td>3,500 T</td>
<td>3.3 years</td>
</tr>
<tr>
<td>Nordex N60 1.3MW</td>
<td>1300</td>
<td>680,000 + 192,500 to install</td>
<td>£671</td>
<td>4,500,000</td>
<td>4,500 T</td>
<td>3.8 years</td>
</tr>
</tbody>
</table>

Table 2 – summary of costs, production and payback period

notes: 1. Grid connection is not included and could add a further £100,000+ to the project costs, irrespective of generator size.
2. Construction costs will be affected by the access route and length of track.
3. The mean annual windspeed is a conservative estimate based on the elevation and location of the site – Burgar Hill has a mean windspeed of 10.5 ms⁻¹.
4. Energy trading is based on £0.015 for the energy and £0.035 for ROCS.
3.5 Hydro electric system design methodology

An investigation was undertaken into the potential for hydro-electric generation. The fundamental limitations to the use of Stromness Reservoir are the quite restricted catchment area and the relatively low annual rainfall. Three alternatives were considered: 1. maximum head to give maximum power output over a limited period; 2. a reduced head combined with a pump storage lagoon at The Loons; 3. reinstatement of a 1940s military scheme at Mousland to increase the catchment area. Assessment of the resource and energy availability were calculated using formulae from a standard reference volume: Renewable Energy; Power for a Sustainable Future (Boyle et al. 1996).

### Energy Formulae:

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, $H$ (m)</td>
<td>difference between reservoir outlet and generator inlet</td>
</tr>
<tr>
<td>Water Velocity, $V_w$ (ms$^{-1}$)</td>
<td>$\sqrt{2gH}$, where $g = 9.8$ ms$^{-2}$</td>
</tr>
<tr>
<td>Pipe Area, $A$ (m$^2$)</td>
<td>$\pi r^2$</td>
</tr>
<tr>
<td>Flow Rate, $Q$ (m$^3$s$^{-1}$)</td>
<td>$AV_w$</td>
</tr>
<tr>
<td>Available Power, $P$ (kW)</td>
<td>$10QH$</td>
</tr>
<tr>
<td>Catchment area, ($m^2$)</td>
<td>600,000 m$^2$ (approx)</td>
</tr>
<tr>
<td>Rainfall, 50 year average</td>
<td>1100 mm</td>
</tr>
<tr>
<td>Annual volume of resource</td>
<td>660,000 m$^3$</td>
</tr>
</tbody>
</table>

### Option 1 Maximum power and restricted operations

The simplest scheme to give maximum power output is to locate a hydro-electric generator adjacent to the Stromness substation, with a penstock (supply pipe) routed directly from the outlet at the reservoir, across The Loons, then skirting the north end of the town, figure 10. This gives a maximum head of 60m. Using a constricted pipe of 150mm in diameter the water velocity, $V_w$ will be around 34 ms$^{-1}$, giving a flow rate $Q$ of around 0.5 m$^3$s$^{-1}$. The available power, $P$, will be a maximum of 350 kW at the substation, however in practice the flow rate will be reduced as the long length of penstock will reduce the effective head; power output will probably be around 250 kW. The restricted catchment area and the low rainfall gives a total annual resource of 660,000 m$^3$, equivalent to 1800 m$^3$ per day; at a flow rate of 0.5 m$^3$s$^{-1}$ the hydro electric turbine can only run for an average of around 1 hour per day to avoid lowering reservoir water levels. The actual operational hours would reflect seasonal rainfall patterns.
Option 2  Pumped storage system

One mechanism to increase production hours would be to establish a storage lagoon at The Loons and operate with a lower head, figure 11. Such a scheme would have a head of 30 m, a water velocity of 24 m s\(^{-1}\), a flow rate of 0.4 m\(^3\) s\(^{-1}\) and available power of 120 kW. By establishing a storage lagoon, the effective catchment area increases to include the Loons and the surrounding hills, an area of around 2 km\(^2\). This gives an average volume of 6000 m\(^3\) per day that can be run through the hydro-electric system, equivalent to four hours at 120 kW per hour. For this system to work the energy produced during the four hours of operation should be sold at a premium rate to coincide with peak demand, then water must be pumped back up to the reservoir over the rest of the day using off peak rates, or alternatively use spare production from the wind energy aspect of the development.

Option 3  Increased catchment area

The research into the project revealed that the restricted catchment area of the reservoir was identified during the second world war. At that time the Stromness Hotel was the Orkney and Shetland Military HQ, and the town supplied water to the Navy stationed in Scapa Flow. This increased demand led to investigations into ways of increasing the water available to the reservoir, leading to the construction of a dam across the Burn of Mousland and the installation of 2 km of pipework from a pumping station at the burn over to the reservoir, figure 12. This system did work initially, however the pipework was found to be inadequate for the pressures involved, and the pipework was dismantled. The dam remains in good condition and the trenches excavated for the pipe can still be identified. It may therefore be possible to install modern pipework and a new pumping station to divert the outlet of the Burn of Mousland, increasing the catchment area available to the reservoir to an area of around 4 km\(^2\). This would allow option 1, the conventional generation system, to operate for an average of six hours per day, provided water can be pumped up to the reservoir over the rest of the day.

Options 2 and 3 both entail extensive water engineering, and although there is some merit to both options it must be considered that the area between the burns of Mousland and Selta is very wet and boggy and some drainage work would be required to ensure that water flows at the maximum rate over the area, with potential environmental impact on a protected site. The establishment of a storage lagoon also has potential impact upon the integrity of the Loons; the potential impact of each of the options must be considered, explored below in section 3.6.
Figure 10 – Maximum head hydro electric

Figure 11 – Possible pump storage scheme at The Loons

Figure 12 – Location of dam and pipework trench at Mousland
3.6 Hydro electric system construction and operational impacts

The construction of hydro-electric systems can have serious environmental implications, with hydrological effects to water flow, groundwater, water supply and irrigation. There are also ecological effects to the land and its plants and animals to consider. For the Stromness project it is proposed that an existing reservoir be used, reducing environmental impacts in the catchment area, however care must be taken to consider the results of any changes to water flow, and any change to existing irrigation use. Existing water use must be considered and consultation with landowners is essential to ensure that detrimental impact upon farming practice is avoided.

Hydrological effects

A hydro-electric system is not a consumer of water, but rather involves mainly the diversion of water systems from natural routes. The Stromness Reservoir is no longer used for water supply, with water simply overtopping the dam then flowing down existing channels to The Loons. Although this area was drained in the 1960s, the drainage channels are generally clogged and water now appears to be pooling, re-creating the original boggy conditions. The outlet for The Loons is the stream that runs past Stairwaddy, becoming the mill stream that travels around the north of Stromness then entering the sea at the head of Hamnavoe. The Loons is an important area for vegetation and wading birds, and after consulting with RSPB, it is thought that this return to natural boggy and wet conditions should be encouraged.

Water usage

The installation of a long penstock across to the old mill at Stromness, figure 10, would divert some of the water now flowing into The Loons, however hydrological studies undertaken by RSPB have indicated that this water supply is only a minor source to the area, and in any event reflects the way water has been abstracted over the lifetime of the dam. Although the establishment of a storage lagoon, figure 11, at the Loons may encourage more bird species, water levels at the lagoon would alter on a daily basis, with silting and freezing strong possibilities. The diversion of the outlet of the Burn of Mousland, figure 12, should not have an impact on Mousland Farm, since the dam is near the cliff edge. It should be considered that not all water that falls on the catchment area ends up in the burn; agricultural use will take precedence. A reservoir will be created along part of the Burns of Mousland and Selta, with the likelihood that more of the area will return to wet and boggy conditions unless additional drainage is created.
Effects on vegetation and habitats
There are important habitats in all of the identified areas; Figure 4 indicates the location of the environmentally sensitive area west of the reservoir and the location of the two areas important for nature conservation at the reservoir and the Loons. The small field between the Stromness substation and the old mill to the north of Stromness contains orchids, iris and marsh marigold and should not be disturbed. Of the three hydro-electric options described above, the proposal for the turbine location at Stromness Substation creates the least impact, provided the tailrace can be routed under the A965 to avoid localised flooding.

Pollution risks
The water flows through hydro-electric systems, causing the turbine wheel to rotate at high speed, directly driving generators with no need for a gearbox. This reduces the possibilities of major oil pollution, nevertheless there are still some pollution risks from the oils, greases, coolants and other fluids present within the machinery. It is therefore important that the water outlet from the turbine system should not enter environmentally sensitive areas, further reducing the likelihood that a storage lagoon should be considered at the Loons.

Noise impact
The noise generated by hydro-electric turbines can be quite high at the turbine runner, however the turbine building can be designed and constructed to high soundproofing standards. By ensuring a minimum of 200m separation from neighbouring properties, and ensuring that sound levels outside the turbine buildings are limited to 50 dB(A), planning guideline levels of noise levels of 5 dB(A) above background levels should be achieved.

Potential disturbance to birds and fish
There are fish stocks in Stromness Reservoir. It is therefore important that water levels remain adequate, suggesting that any hydroelectric scheme should be designed to prevent fish from being drawn into the penstock, and to ensure that water levels are not extracted beyond an absolute minimum. Provided that wader habitats are preserved there is little risk of bird disturbance by any of the three schemes, however extensive consultation will be required.

3.7 Hydro-electric Scheme Selection
The viability of any hydroelectric scheme must consider the resource, environmental impact, potential energy output and the project economics. As detailed above, the available water resource is quite restricted and maximum power levels are relatively low, making a hydroelectric project less viable, when compared with a wind energy development.
From the simplest scheme, option 1, production levels will be an average of 250 kWh per day, or 91,000 kWh per annum. As the output can be switched on at periods of peak demand the energy has a higher value than that of wind energy systems; at say 7.5p per kWh, including ROCs payments of 3.5 pence, the total income from the scheme will be around £7,000 per annum, giving a payback period of around 28 years. Although hydro-electric schemes are long-lived, this payback period compares very poorly with the figures offered by any scale of wind turbine, table 2.

The construction of a storage lagoon at the Loons increases the available resource but at the expense of a lower head of water; 120 kW for four hours is 480 kWh per day, or 175,000 kWh per annum, giving an income of around £13,000 per annum and a probable payback period of around 15 years, dependant on the extent of civil engineering and the cost of the technology used for generation / pumping. Although the generator can be run in reverse to pump the water back to the reservoir, the cost of energy for pumping must also be considered; as the project wind turbine would have electricity worth 4.5p per kWh, it may be more appropriate to use off peak grid electricity.

With option 3 the further increase in resource catchment area could allow a hydroelectric system to run at 250 kW for an average of 6 hours per day, giving 1500 kWh per day, or 550,000 kWh per annum. At 7.5p per kWh the income available will increase to £40,000 per annum, giving a favourable payback period of around 6 years. As the pumping station is separate from the generation station there is also the cost of a water pump to consider, as well as that of the extensive pipework and the cost of pumping. Nevertheless this last option appears to be the most favourable from an economic perspective, provided the environmental concerns can be overcome.

It is felt that option 1 is not commercially viable unless the cost of the generator and penstock are grant-supported and discounted. Options 2 and 3 are possible however there may be unacceptable environmental impacts. The generation technology will depend upon the final choice of scheme; head and flow rate are used to decide the type of turbine rotor, with Pelton turbines used for the higher head option and Francis turbines for higher flow rates. At very low flow rates and low head applications, the crossflow design can be more appropriate. Examples are appended to the report. Further discussion and consultation is required on the appropriateness of the alternative schemes and a detailed appraisal of the environmental issues is required before a decision can be made on the final choice of scheme or technology.
3.8 Demonstration solar ventilation and ground source heating scheme

It is proposed that the use of renewable energy be demonstrated within one of the public buildings within Stromness. While there is a mismatch between heating demand and energy availability when considering solar energy, options could include solar-source ventilation systems and solar panels for water heating in the summer, combined with underground heat pumps for winter heating. Such schemes require a south-facing roof to maximise solar gain in the winter, along with sufficient land for 30m of heat extraction pipework. A pilot project based around the Community Centre was considered, figure 13.
The solar heating and ventilation system proposed for the Community Centre would involve the installation of large panels similar to Velux windows on the southern roof surface of the building, and the ground source heating will require some excavation work either in the adjacent children’s play park or in neighbouring land next to the Old Academy. As this work would take place with the town Conservation Area, all parts of the installation would have to be controlled by the planning process.

The costs of running the Community Centre is fully covered by Orkney Islands Council; any energy savings should be passed on to the users of the building but there would be an impact upon annual budgets. Moreover grant levels for the demonstration project would be limited to 50% of costs, with OIC responsible for on-going maintenance of the renewable energy system. For these reasons it may be more appropriate to consider buildings not owned by the local council. Possibilities include the Pier Arts Centre or Stromness Museum. Although these buildings do have south facing roofs to allow installation of solar heating systems, planning constraints may prevent the installation of large Velux-type windows. For this reason it may be more appropriate to consider the novel proposal of using the heat pump process to extract energy from the sea.

3.9 Case study: The Library at Visby in Gotland, Sweden

Gotland has the aim of producing enough energy from renewable sources to meet 100% of its needs by 2025. A variety of technology is being used to achieve this target, including wind, solar, biomass, biodiesel and hydrogen fuel cells. In 2001 a new library opened in Visby which incorporated a variety of novel energy systems, figure 14. Seawater is used for both heating and cooling systems, dependent on seasonal requirements. The heat pumps in the system are supplied by photovoltaic panels, with all aspects of the system controlled by an interactive climate-control system. This innovative system shows how modern renewable energy technologies can drastically reduce energy requirements of buildings.

Due to the high insulation levels and internal heat loads the heating demands of the building are extremely low. The building’s heating requirements can be met by the use of a heat pump connected to a seawater intake. A new type of heat pump that employs 4.5 kg of propane because of its better environmental performance has been installed. The heating system for the new building is also integrated with the heating system on the older campus buildings. This has enabled excess output from the heat pump to be distributed to adjacent older buildings.
The extent to which the library building integrates renewable energy systems, energy efficiency technologies and a building energy management system is unique for a public building of this size in the Baltic region. Innovative energy efficiency techniques have been used to achieve a target energy consumption of 100 kWh per m² per annum whilst achieving healthy indoor climate conditions. In the Orkney context, this target is equivalent to annual heating costs of £500 for a modern three bedroom house.
4 Local ownership of renewable energy

Full community ownership of renewable energy can only be achieved through ownership of the land, the equipment used to produce the electricity and management of the resource. Local and community ownership of renewables is being attempted throughout Scotland, mainly driven by the Scottish Community and Householder Renewables Initiative (SCHRI), with small-scale projects based on single wind turbines, or small run-of-river hydro-electric turbines. On a larger scale, an example of community ownership of windfarms is The Baywind Energy Co-operative, a company established to enable ownership of the Harlock Hill windfarm in Cumbria. In contrast to this successful model, the energy project on Foula is discussed to highlight the difficulties of community ownership. The remainder of this section explores ideas relevant to Stromness, and identifies mechanisms to allow businesses and the community to work in partnership.

4.1 Case study: Baywind Energy Co-operative

Baywind Energy Co-operative Ltd is an Industrial & Provident Society and was formed in 1996 on the lines of co-operative models pioneered in Scandinavia. This successful community ownership model has been slowly expanding over the last seven years and now has over 1300 shareholders and has part ownership of two windfarms. The first share offer in 1996/97 raised £1.2 million to buy two turbines at the Harlock Hill wind farm and in 1998/99 the second share offer raised a further £670,000 to buy one turbine at the Haverigg wind farm site, figure 15. Preference is shown for local investors, so that the community can share some of the economic benefits from their local wind farm; 43% of existing Baywind shareholders live either in Cumbria or Lancaster with a wider number from the Northwest Region.

![Figure 15 – Baywind Energy Co-operative](image)

A co-operative society operates much like a traditional limited company except that the voting rights are distributed equally amongst the members, regardless of the number of shares held.
Baywind has a minimum share holding of £300 and a maximum of £20,000. Since the formation of Baywind in 1996 members have received a competitive return on their investment; between 5.6% and 6.6% gross. Under the government's Enterprise Investment Scheme, most members can claim back 20% tax on their initial investment in the co-op thus increasing the return to between 7% and 8.2%. Further information can be obtained from the Baywind website, listed at the end of the report.

It should be noted that the rate of return offered by the Baywind Energy Co-operative is less than that possible on Orkney. This reflects the lower wind speeds in Cumbria, and the higher costs per kW due to the use of smaller machines. It should also be recognised that the Stromness project development costs can be reduced by allowing local companies to use their own expertise as an investment in the development.

### 4.2 Case study: Foula Community Energy Project

The island of Foula is situated 21km to the west of Mainland Shetland, and approximately 90 km to the north of Papa Westray. Due to this remote location this island has never been connected to the Shetland grid, but instead had a local electricity grid from a combined wind, hydro and diesel generation scheme commissioned in 1989 and managed by the Foula Community Co-operative from 1990 onwards. Although the scheme initially functioned quite well, the system became inadequate in reliability and output and by 1996 the scheme was in need of repair, figure 16. All installation costs were covered by grant assistance, with maintenance covered by internal billing from the householders on the island.

*Figure 16 – Corrosion impact on the Foula energy project*
The Foula project was inspected by Richard Gauld of Orkney Sustainable Energy Ltd, and Bryan Rendall of Bryan J. Rendall Electrical Ltd in 1997, completing a survey of all the generation equipment, the control systems and the island transformers. All parts of the system had evidence of corrosion and failure, with the wind turbine in particular suffering quite badly. All the components of the system have subsequently failed.

The Foula project was not managed correctly, with the Community Co-operative unable to fund operations, maintenance and parts replacement through internal billing. The west mainland of Orkney has similar environmental and weather conditions to that of Foula, requiring high management and maintenance standards to ensure maximum project lifetime.

4.3  The Stromness Project; summary of costs

Total costs can only be detailed once a final project has been identified. The scale and number of wind turbines has yet to be decided, as is the capacity of any hydroelectric scheme. The proposed demonstration solar heating scheme may be fully funded by SCHRI however a location has not yet been identified; this aspect of the project will require further study once a building has been determined.

Appendix 1 contains a spreadsheet showing comparative costs of the two most appropriate wind turbines, with three Vestas V52 showing a better return and overall profits than two Nordex N60s. Further expenditure will be required before the project can commence, with a full planning application necessary, including environmental impact assessment, visual impact assessment and an ecological survey. The cost of planning has been allowed for, the project management figure detailed in the appended spreadsheet, however there will be other costs that should be considered before construction can commence; the planning fee, likely to be around £5,000 and the grid connection feasibility study, likely to be around £4,500.

It should be considered that economic viability is controlled by energy trading. The power from the project will be sold for around £0.015 per unit. In addition to electricity production, the project will also produce renewable order certificates, ROCs. These are traded separately and market value depends on demand and availability. ROCs are presently of high value, however this could decrease as and when more renewable energy projects are commissioned.

Table 3 is a summary of the possible costs of the wind and hydro schemes, based on manufacturers quoted figures, along with identified planning and construction costs. These figures are indicative only, and should be revised once the project scale has been determined.
### Table 3 – summary of wind and hydroelectric system costs and returns

<table>
<thead>
<tr>
<th>Renewable Energy Technology</th>
<th>Power rating (kW)</th>
<th>Capital Cost + construction and assembly (£)</th>
<th>Annual Production (kWh), average wind</th>
<th>Income from energy trading; £0.045 for wind, £0.075 for hydro (£)</th>
<th>Expenditure; O&amp;M, rates, rent, insurance, reactive kW, reserve fund (£)</th>
<th>Projected annual profit and maximum rate of return, 20 year project lifetime.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind scheme; 2 x 1.3MW</td>
<td>2600</td>
<td>1,360,000 + 385,000 to install</td>
<td>9,000,000: 9 ms(^{-1})</td>
<td>400,000 per annum</td>
<td>100,000 per annum</td>
<td>£210,000 per annum; 12% return</td>
</tr>
<tr>
<td>Option 3 hydro scheme</td>
<td>250</td>
<td>225,000 + 100,000 to install</td>
<td>550,000 for max. catchment area</td>
<td>41,250 per annum</td>
<td>10,000 per annum</td>
<td>£15,000 per annum; 4.6% return</td>
</tr>
</tbody>
</table>

#### 4.4 The Stromness Project; achieving local ownership

The Baywind case study indicates that local ownership of renewable energy projects is possible, provided the management problems of Foula are avoided. Although the economic returns from wind energy projects can be very high, particularly under the Renewable Order (Scotland) mechanism, there is risk. Total project costs for the scale of development being proposed could be in the order of £1,800,000, and although the initial outlays may be reduced through assistance from SCHRI, it should be recognised that there is a cap on available grants, and that SCHRI is targeting householders and not-for-profit community groups.

**A local development company**

It is proposed that a local company be established to own the development, with members of the Stromness Community Business Forum invited to become shareholders of the development. The design, construction and management of the project should be undertaken by local firms, using organisations experienced with the construction of the wind energy projects already in operation in Orkney.

**Investment opportunities**

Renewable energy project costs occur at the initial stages of the development, with investment required at an early stage. One way of controlling the initial costs would be to consider developing on a sequential basis, using the revenue stream from an initial wind turbine to help fund expansion in a controlled way. It is also recommended that the project be as inclusive as possible, offering an investment opportunity to all of the Stromness community. A three-level ownership package is a possibility; bronze, silver and gold investment levels could be set at £500, £5000 and £50,000 respectively, with the gold investors underwriting the project.
Partnership with established companies

The project could also be managed more effectively by calling upon experienced wind energy owners and developers to work with the community. Strong control of the financial structure of the project is also required, and from the experience of Foula, it is felt that communities would benefit more if they worked in partnership with either a company established to manage the development, or in partnership with an organisation experienced in the implications of long term operations. Using an experienced operator will be less divisive and would enable the community to achieve maximum local benefits, at minimum risk.

4.5 The Stromness Project; achieving community governance

It is proposed that Stromness Community Council would provide community governance of the project, and should explore mechanisms to provide direct benefits across the Stromness community. Working in partnership with the development company established by the Stromness community, it is proposed that the Community Council will manage the community revenue from the development.

Resolving conflict and uncertainty

One possible way of resolving the conflicts and uncertainty of renewable energy development, along with avoiding risks and impact upon communities and the environment, is to have strong governance by the community involved, without having direct ownership. The Stromness Reservoir is an important local amenity, and Stromness Community Council should be responsible for management and planning of the site, and should control exploitation of the resource.

Community revenue

It is proposed that the project should have a capped rate of return, with the development company agreeing to an upper limit on profits that can be drawn from the project, possibly limited to 10%. Actual profits and project revenue depend on energy trading and will vary from year to year, with windy and wet years producing more electricity and thus more revenue. Table 3 indicates that the minimum rate of return achievable by the wind energy project is around 12%, giving a potential community fund of £35,000 per annum. The correlation between windy years and additional community income should lead to the establishment of a substantial community fund; 18% return and a fund of £140,000 per annum is achievable. It should also be noted that the hydro-electric scheme does not return sufficient profits to contribute any community revenue.
Energy dividends

One proposal could be to establish distribution of energy dividends to combat fuel poverty. This concept was initially proposed by Orkney Sustainable Energy to Orkney Housing Association as a mechanism of reducing the cost of electricity to OHA tenants, without requiring tenants to change electricity suppliers. This idea is still being explored and can equally be considered for the Stromness community. Other possibilities could include the establishment of a local environmental fund and the enhancement of the nature reserves around Stromness; it is for Stromness Community Council to decide what would be an appropriate use of the community revenue stream.

How would community governance work?

The community council should become a partner in the development and should be responsible for achieving planning consent for the most appropriate site; a sensitively designed project may not need planning under the Environmental Impact Regulations. Once consent is awarded the community should then continue to work in partnership with the development company, ensuring that the community achieves maximum benefit, while at the same time ensuring the project is managed in a strong and sensible manner.

Local control and environmental protection

Local control is essential and it is recommended that a representative should be elected from within the community, with the post funded from the project. This community representative should be involved at all stages of the development, and should be given the remit of community support and environmental protection. Should it be found that the project is having a detrimental effect upon the area of Stromness reservoir and the Loons then mitigation should be enforced by the community representative to ensure that any damage to the environment is remedied.

A renewable energy community

The establishment of a renewable energy scheme clearly identified with the Stromness community and owned by a local development company will have important marketing and tourism implications. In much the same way that Mackies, the dairy products company in Aberdeenshire, use a wind turbine symbol on their packaging to show that they produce their own green electricity, it is felt that a renewable energy logo could be produced for the Stromness community. This would demonstrate a commitment to sustainability and would highlight the environmental awareness of the Stromness community.
5 Action Plan

This study has proposed a renewable energy project for Stromness. Possible mechanisms of local ownership and community governance are described. It is recommended that a community revenue stream should be established, at a level appropriate for the Stromness community. Full consultation with the community should be considered to help resolve planning and environmental issues. The following action plan is recommended:

<table>
<thead>
<tr>
<th></th>
<th>Establish the level of support for the project within the Stromness community. Conduct full consultation through public meetings and ensure that all residents become aware of the development.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Identify a property appropriate for a demonstration renewable energy heating scheme. Possibilities include Stromness Community Centre, Stromness Museum or The Pier Art Centre. Approach the building owners to confirm that a demonstration project is desired and acceptable.</td>
</tr>
<tr>
<td>3</td>
<td>Stromness reservoir and the surrounding land should be acquired on behalf of the Stromness community. Confirm that Scottish Water intends to dispose of the site and ensure that the Community Land Fund is willing to support a community buy-out.</td>
</tr>
<tr>
<td>4</td>
<td>The Stromness community should establish a development company to proceed with a planning application. Confirm that the concept of community governance is acceptable and negotiate the level of revenue and benefits to be shared between the company, farmers, and the community.</td>
</tr>
<tr>
<td>5</td>
<td>If the decision is taken to proceed with one of the hydroelectric options then Stromness Community Council should decide on the appropriate scale of development. Discuss the project with the relevant landowners, RSPB and SNH and identify environmental constraints. Should the decision be made to proceed then use grants available from the Scottish Community and Householder Renewables Initiative to complete detailed design.</td>
</tr>
<tr>
<td>6</td>
<td>Stromness Community Council and Stromness Community Business Forum should discuss the project and agree upon an appropriate scale of wind energy development. Discussions with Scottish and Southern Energy and the European Marine Energy Centre are required to confirm grid capacity. Use grants available from SCHRI to initiate a grid connection feasibility study.</td>
</tr>
</tbody>
</table>
6 Conclusions

It is believed that the Stromness community would like to establish local control and ownership of a renewable energy project. This study has identified appropriate sites for a wind energy development and a possible hydro-electric scheme. The report has also discussed mechanisms to establish local ownership and community control of the developments. By identifying the most appropriate location for each aspect of the project, there should be minimal impact upon the environment. Various case studies have been considered, discussing the issues involved in local ownership and control of renewable energy systems.

The Scottish Executive has set an ambitious target that 40% of Scotland’s electricity should be supplied from renewable resources by 2020, with a mixture of on and offshore wind energy seen as being the most likely options. Locally owned renewable energy projects are feasible, can become a reality and can become an important Scottish industry. Renewable energy schemes must be properly designed to minimise impact upon communities, and at the same time should be environmentally sensitive, avoiding impacts upon habitats and ensuring that protected species are respected. Strong community governance is essential.

Renewable energy is becoming an important part of the economy of Scotland, however this will have a detrimental impact upon the environment and local communities unless fully controlled. Community governance is a possible way forward, encompassing mitigation of environmental impact, management of resources and the support of fragile communities. These issues all affect the quality of life in the remote and isolated parts of Scotland, and as such, must be considered when any renewable energy development is proposed.

This study has designed a commercially viable development for the Stromness community, with strong economic benefits and the project revenue retained within the community. It can be concluded that constructing the Stromness project will give a positive message on the importance of renewable energy to Orkney, at the same time allowing viable community control and providing new income for the islands.
7 References and internet links

References


Links


SNH site describing Special Protected Areas: [http://www.snh.org.uk/about/ab-pa06.htm](http://www.snh.org.uk/about/ab-pa06.htm)


Planning Advice Notes in pdf format: [http://www.scotland.gov.uk/about/Planning/advice.aspx](http://www.scotland.gov.uk/about/Planning/advice.aspx)

Community Energy Unit: [http://www.hie.co.uk/community-energy.html](http://www.hie.co.uk/community-energy.html)

The Scottish Community and Householder Renewables Initiative: [http://www.est.org.uk/schri/community/](http://www.est.org.uk/schri/community/)


Baywind energy co-operative: [http://www.baywind.co.uk/index.htm](http://www.baywind.co.uk/index.htm)

Enercon wind energy: [http://www.enercon.de/englisch/fs_start.html](http://www.enercon.de/englisch/fs_start.html)

Vestas wind energy: [http://www.vestas.com](http://www.vestas.com)

Nordex wind energy: [http://www.nordex-online.com](http://www.nordex-online.com)

NHT Engineering at Newmills Hydro: [http://www.newmillshydro.freeserve.co.uk/](http://www.newmillshydro.freeserve.co.uk/)

Nuaire solar powered ventilation and heating system: [http://www.nuaire.co.uk/sunwarm.shtml](http://www.nuaire.co.uk/sunwarm.shtml)

The library at Visby in Gotland: [http://www.gotland.se/imcms/servlet/GetDoc?meta_id=3917](http://www.gotland.se/imcms/servlet/GetDoc?meta_id=3917)
APPENDIX 1: THE WIND TURBINES
Comparision of costs; 12% rate of return from 4.5 pence per unit of electricity

<table>
<thead>
<tr>
<th>Wind turbine</th>
<th>Turbine cost</th>
<th>Engineering design</th>
<th>Civils</th>
<th>Electrical contracts</th>
<th>Project management</th>
<th>5 year warranty</th>
<th>Total wind turbine costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas 850kW</td>
<td>£407,000</td>
<td>£5,400</td>
<td>£65,000</td>
<td>£40,000</td>
<td>£18,000</td>
<td>£40,000</td>
<td>£575,400</td>
</tr>
<tr>
<td>Nordex 1300kW</td>
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<td>£7,500</td>
<td>£75,000</td>
<td>£50,000</td>
<td>£18,000</td>
<td>£42,000</td>
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<table>
<thead>
<tr>
<th>Site wind speed</th>
<th>kW rating</th>
<th>Units generated</th>
<th>Unit price</th>
<th>Annual Revenue (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>m/s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>850</td>
<td>3,200,000</td>
<td>0.045</td>
<td>£144,000.00</td>
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<tr>
<td>9</td>
<td>1300</td>
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<td>1300</td>
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Enter expected unit price: (£) £0.045
Enter expected grid connection fee (£) £50,000

<table>
<thead>
<tr>
<th>Annual expenditure</th>
<th>Vestas V52</th>
<th>Nordex N60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insurance</td>
<td>£8,000</td>
<td>£8,000</td>
</tr>
<tr>
<td>Grid connection</td>
<td>£5,000</td>
<td>£6,000</td>
</tr>
<tr>
<td>Telephone</td>
<td>£2,000</td>
<td>£2,000</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>£3,000</td>
<td>£3,000</td>
</tr>
<tr>
<td>Reactive power</td>
<td>£1,000</td>
<td>£1,500</td>
</tr>
<tr>
<td>Rates</td>
<td>£1,250</td>
<td>£1,500</td>
</tr>
<tr>
<td>Accountancy</td>
<td>£2,000</td>
<td>£2,000</td>
</tr>
<tr>
<td>Public insurance</td>
<td>£2,000</td>
<td>£2,000</td>
</tr>
<tr>
<td>Site rental 3%</td>
<td>£5,000</td>
<td>£7,500</td>
</tr>
<tr>
<td><strong>Total expenditure</strong></td>
<td><strong>£29,250</strong></td>
<td><strong>£33,500</strong></td>
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<table>
<thead>
<tr>
<th>Profit calculations</th>
<th>3 x Vestas V52</th>
<th>2 x Nordex N60</th>
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<tbody>
<tr>
<td>Project cost</td>
<td>£1,776,200</td>
<td>£1,795,000</td>
</tr>
<tr>
<td>Annual revenue (9m/s wind)</td>
<td>£432,000</td>
<td>£405,000</td>
</tr>
<tr>
<td>Annual expenditure</td>
<td>£87,750</td>
<td>£67,000</td>
</tr>
<tr>
<td>Reserve fund</td>
<td>£30,000</td>
<td>£30,000</td>
</tr>
<tr>
<td>Annual profit over 20 years</td>
<td>£225,440</td>
<td>£218,250</td>
</tr>
<tr>
<td>Rate of return (%)</td>
<td>12.69</td>
<td>12.16</td>
</tr>
<tr>
<td>Company profit (10% cap)</td>
<td>£177,620</td>
<td>£179,500</td>
</tr>
<tr>
<td>Community dividend</td>
<td>£47,820</td>
<td>£38,750</td>
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</table>
Comparision of costs; 18% rate of return from 5.5 pence per unit of electricity

<table>
<thead>
<tr>
<th>Wind turbine</th>
<th>Turbine cost</th>
<th>Engineering design</th>
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<td>Nordex 1300kW</td>
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<td>£42,000</td>
<td>£872,500</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Site wind speed m/s</th>
<th>kW rating</th>
<th>Units generated</th>
<th>Unit price</th>
<th>Annual Revenue (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>850</td>
<td>3,200,000</td>
<td>0.055</td>
<td>£176,000.00</td>
</tr>
<tr>
<td>9</td>
<td>1300</td>
<td>4,500,000</td>
<td>0.055</td>
<td>£247,500.00</td>
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<tr>
<td>10</td>
<td>850</td>
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<td>0.055</td>
<td>£203,500.00</td>
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<tr>
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<td>1300</td>
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<td>0.055</td>
<td>£275,000.00</td>
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Enter expected unit price (£) £0.055
Enter expected grid connection fee (£) £50,000

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<thead>
<tr>
<th>Annual expenditure</th>
<th>Vestas V52</th>
<th>Nordex N60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insurance</td>
<td>£8,000</td>
<td>£8,000</td>
</tr>
<tr>
<td>Grid connection</td>
<td>£5,000</td>
<td>£6,000</td>
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<td>£1,500</td>
</tr>
<tr>
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<td>£2,000</td>
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<td>Public insurance</td>
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<td>£2,000</td>
</tr>
<tr>
<td>Site rental 3%</td>
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<td><strong>£33,500</strong></td>
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<tr>
<td>Project cost</td>
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<td>£1,795,000</td>
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<tr>
<td>Annual revenue (9m/s wind)</td>
<td>£528,000</td>
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<td>£30,000</td>
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<td>£308,250</td>
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<td>Rate of return (%)</td>
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<td>17.17</td>
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</tr>
<tr>
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</tbody>
</table>
N60/1300 kW  N62/1300 kW
Long-term experience all over the world.

High-tech power plants for a range of wind conditions.

NORDEX
We’ve got the power.
The Nordex N60/1300 kW and the Nordex N62/1300 kW are two of our top-selling wind turbines. Both machines are equipped with stall regulation and produce a nominal output of 1.3 MW. With a rotor diameter of 60 and 62 metres respectively, they can be operated at wind speeds between 3 m/s and 25 m/s. The Nordex N60 has been optimized for regions with high winds (GL1) and the Nordex N62 is designed for low wind locations (GL2).

We supply the Nordex N60 and the Nordex N62 as 50 Hz and 60 Hz machines as a standard, in the hot climate version (HCV turbine) for desert regions and in the cold climate version (CCV turbine) for permafrost regions.

The Nordex N60 and Nordex N62 are supplied as a standard with the Nordex-Control automation software to control and visualise all relevant data. Our wind turbines are designed for a service life of at least 20 years. And the ISO 9001 certification stands for the tested quality of our products.
Reliability, Service, Environmental Sustainability: Nordex always offers that bit more.

The machines offer low-maintenance due to
- user-friendly rotor lock and easy checking and monitoring of the elastomer bearings in the drive train
- the controls at the bottom of the tower and the nacelle and wide-ranging remote query possibilities

They are reliable
- as more than 15 years of Nordex experience with wind energy have gone into their development
- as the N60 is certified in accordance with GL1 — i.e. for windy regions — and the N62 in accordance with GL2 — i.e. for low wind locations
- as they have a long product cycle time and are a mature series product
- as all components are of a guaranteed high quality due to our choice of certified and reputable sub-suppliers
- as the tubular steel tower is a rigid structure. The tower’s resonant frequency is not transported by the turbine. It is not possible for any resonance to occur between the tower’s resonant frequency and the exciter frequency of the system

They are environment-friendly due to
- the enclosed grease and oil-collecting pans
- the hydraulics in the tower head with all lines in the area of the oil pan — meaning that no oil can pollute the environment

They are noise friendly due to
- helical gearing of all gearwheels reduces the noise level within the gearbox
- vibration absorbing mounts

Across the globe the Nordex N60 and Nordex N62 rotate no matter whether they are located in areas with high winds or low winds.

The Nordex N60 and the Nordex N62 are supplied either in the hot climate version (HCV) for desert regions or in the cold climate version (CCV) for permafrost regions.
The N60 and N62: Two machines equipped with trendsetting technology.

**Rotor**
The rotor blades are made of high-quality glass fibre reinforced plastic (GRP). The blade tips are pivotable and can be swivelled 85 degrees relative to the main blade, in this position acting as aerodynamic brakes. Lightning receptors are integrated into the blade tips, diverting a lightning strike to the hub.

**Main shaft**
The main shaft is forged from high-quality tempered and quenched steel. The shaft is connected to the gearbox by a shrink fit coupling.

**Gearbox**
The gearbox is a three-stage design, with the first stage as a high torque planetary stage and the second and third stages as spur stages. The planetary gear makes the construction very compact, yet allowing for the high torque from the rotor to be transferred with a high gear ratio.

**Generator**
The generator is a water-cooled squirrel-cage asynchronous type. The generator is connected to the gearbox by a flexible coupling. The solid rubber mounting de-couples the generator from the nacelle frame and thus reduces the transfer of machine noises.

**Cooling and filtration**
Gearbox and generator of the N60 and N62 have a combined cooling system. Corresponding to the different temperature levels, first the gearbox oil and then the generator is cooled in the cooling circuit. The water/air cooler is placed in the upper part of the nacelle and is flown through by fresh air.

**Braking system**
The primary brake system is the aerodynamic blade tip brake. The secondary mechanical brake is a disc brake. Both systems are able to decelerate the wind turbine from any state in order to reach a safe status.

**Hydraulic system**
The hydraulic system provides the oil pressure for the operation of the blades, tips, yaw brakes, the rotor brake and the hood.

**Nacelle**
The nacelle consists of the cast main frame and the nacelle cover. The nacelle cover is made of high-quality glass fibre reinforced plastic (GRP). The nacelle roof is opened hydraulically.

**Yaw system**
The wind direction is continuously monitored by two wind vanes at hub height. When the wind direction changes the nacelle is yawed actively.

**Tower**
The Nordex N60 and Nordex N62 can be erected on a tubular or a lattice tower. The tubular tower takes the form of a conical solid wall steel tower. The lattice tower consists of a square angle iron construction.

**Controller**
The wind turbines have two anemometers each. One anemometer is used for controlling the turbine, the second anemometer is monitoring the first one. On a control screen placed at the switchboard all operational data can be monitored and checked and a number of functions, such as starting, stopping and yawing, can be controlled. In addition, the wind turbines are equipped with a remote monitoring system. The data and signal transfer only requires an ISDN-connection. The appropriate communication software and hardware can be installed on any PC on Windows NT and is provided by Nordex.

**Lightning protection**
The lightning and overvoltage protection of the wind turbine is based on the lightning protection zone concept and is according to IEC 61024 and DIN VDE 0185.
### Facts and Figures.

<table>
<thead>
<tr>
<th>N60/1300 kW</th>
<th>N62/1300 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotor</strong></td>
<td></td>
</tr>
<tr>
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<td>3</td>
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<tr>
<td>Rotor speed</td>
<td>12.8 / 19.2 rpm</td>
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<tr>
<td>Rotor diameter</td>
<td>60 m</td>
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<tr>
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<tr>
<td>Power regulation</td>
<td>Stall</td>
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<tr>
<td>Cut-in wind speed</td>
<td>c. 3-4 m/s</td>
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<tr>
<td>Cut-out wind speed</td>
<td>25 m/s</td>
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<td>Survival wind speed</td>
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<td>Brake</td>
<td>Pivotable blade tips</td>
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<tr>
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<td><strong>Blades</strong></td>
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<td>Blade length</td>
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<td>Material</td>
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<tr>
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<td>Oil quantity</td>
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<tr>
<td>Oil change</td>
<td>Annual check, change as required</td>
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<td><strong>Main shaft bearing</strong></td>
<td>Cylindrical roller bearing</td>
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<tr>
<td><strong>Generator</strong></td>
<td></td>
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<tr>
<td>Type</td>
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<td>Insulation class</td>
<td>IP 54</td>
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<tr>
<td>Weight</td>
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<tr>
<td><strong>Yaw system</strong></td>
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<td>Yaw bearing</td>
<td>Ball bearing</td>
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<tr>
<td>Brake</td>
<td>Disc brake</td>
</tr>
<tr>
<td>Yaw drive</td>
<td>Three asynchronous motors with built-in brakes</td>
</tr>
<tr>
<td>Speed</td>
<td>&lt; 0.6 0/s</td>
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<tr>
<td><strong>Control system</strong></td>
<td></td>
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<tr>
<td>Type</td>
<td>PLC, Remote Field Controller (RFC)</td>
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<tr>
<td>Grid connection</td>
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</tr>
<tr>
<td>Scope of monitoring</td>
<td>Remote monitoring of more than 300 different parameters, e.g. temperature sensors, hydraulic sensors, wind sensor set</td>
</tr>
<tr>
<td>Recording</td>
<td>Production data, event lists with filter function, long and short-term trends</td>
</tr>
<tr>
<td>Visualisation</td>
<td>Panel-PC in switchboard and remote monitoring software</td>
</tr>
<tr>
<td><strong>Brakes</strong></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>Two independent systems, fail safe, various brake sequences, softbraking function</td>
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<tr>
<td><strong>Aerodynamic</strong></td>
<td></td>
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<tr>
<td>Pivotable blade tips</td>
<td>Pivotable blade tips</td>
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<tr>
<td><strong>Mechanical</strong></td>
<td></td>
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<td>Hydraulic disc brake</td>
<td>Hydraulic disc brake</td>
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<td><strong>Tower</strong></td>
<td></td>
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<tr>
<td>Type</td>
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<tr>
<td>Hub heights</td>
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<tr>
<td>Hub heights</td>
<td>Tubular tower 60 m, Certificate GL 1, DIBt 3</td>
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<td>Hub heights</td>
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### Power Curve N60/1300 kW

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<td>5</td>
<td>73</td>
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<td>6</td>
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<tr>
<td>7</td>
<td>240</td>
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<tr>
<td>8</td>
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<td>9</td>
<td>536</td>
<td>0.424</td>
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<tr>
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Rounded values based on measurements of DEWI (April 1999) and aerodynamical calculations.

### Power Curve N62/1300 kW

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<tr>
<th>Wind speed [m/s]</th>
<th>Power [kW]</th>
<th>Cp</th>
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<td>25</td>
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</table>

Rounded values based on aerodynamical calculations of LM, Certification is under preparation.

As of 2/2002, subject to change.
The Nordex Group is one of the world’s leading suppliers of wind turbines. The principal focus is on units with a high capacity – above all in the megawatt range: the strongest growth segment in the sector.

**Our philosophy:**

One company – two brands – infinite application possibilities

Under the brand names Nordex and Südwind, we offer powerful wind turbines for almost all geographic regions across the globe. Onshore and offshore, for desert and permafrost areas.

We are represented with offices and subsidiaries in 19 countries worldwide.
## Sales Quotation

<table>
<thead>
<tr>
<th>Customer:</th>
<th>TBN</th>
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<tbody>
<tr>
<td>Project name:</td>
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<tr>
<td>Country:</td>
<td>UK</td>
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<tr>
<td>Site location:</td>
<td>Orkney Islands</td>
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<tr>
<td>Project size in MW:</td>
<td>1.3MW</td>
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<td>Turbine type offered:</td>
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### Scope of supply

<table>
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<tr>
<th>Scope of supply</th>
<th>Price per unit EURO</th>
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<tr>
<td>Nordex N60/1300kW (46m hub height) – Basis 1 turbine supply</td>
<td>1,180,000</td>
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<td>Nordex N60/1300kW (46m hub height) – Basis 3 turbine supply</td>
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<tr>
<td>5 Year Warranty/Service/Maintenance Agreement – per turbine</td>
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<td><strong>TOTAL</strong></td>
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### Prices

Prices quoted are exclusive of VAT and other taxes, import and other duties, etc. Prices are quoted based on the assumption that all site and environmental conditions are suitable for such a project and that all permitting, land use, access, grid and other connection requirements are satisfied.

### Price includes:

- Nacelle and blades
- Hoist for service and maintenance purposes, mounted inside the nacelle
- Tubular tower for the hub height indicated above
- Construction templates, foundation ring(s) and bolts
- Lightning protection system
- Transportation of WTGs to site (subject to accessibility)
- Installation, start-up and commissioning of the WTG's (including crane costs)
- Remote monitoring and control system
- Technical documentation
- Insurance for Nordex scope of supply
- Initial 500 hour service
- 5 year standard maintenance and service
- 5 year warranty

### Price excludes:

- Agreements and permits including land use, access, power purchase and grid connection agreements, planning, zoning and construction permits
- WTG layout and positioning, site specific certification
- Geotechnical and other site investigations
- Civil works including foundations, buildings, access roads and storage areas
- Electrical works including transformers, switchgear, cables and grid-connection
- Fixed telephone connection to the WTGs – ISDN type with dual connection
- Computer for monitoring and control system, SCADA system
- All other works and services not explicitly mentioned within this offer
# Sales Quotation

**Terms and Conditions**

## Terms of payment:
- **20%** of the contract price shall be paid, as a down-payment, on signature of the contract. The remaining 80% of the contract value is to be secured by a confirmed, irrevocable and transferable Letter of Credit.
- **60%** of the contract price shall be paid upon the shipment of the equipment from the Nordex works and upon presentation of normal transport documents. Payment shall be made on a pro-rata basis.
- **10%** of the contract price shall be paid upon the delivery of the equipment to site and upon presentation of documentation confirming delivery. Payment shall be made on a pro-rata basis.
- **5%** of the contract price shall be paid upon mechanical erection of the equipment and upon presentation of a certificate of mechanical erection. Payment shall be made on a pro-rata basis.
- **5%** of the contract price shall be paid upon the commissioning of equipment, in accordance with NORDEX standard commissioning procedures and upon presentation of commissioning documentation. Nordex reserve the right to invoice in accordance with local requirements as necessary.

## Terms of delivery:
- In accordance with CIP (INCOTERMS 2000).
- Delivery of foundation parts 5 months from receipt of down-payment and Letter of Credit.
- Delivery of WTGs and towers 6 months from receipt of down-payment and Letter of Credit.

## Equipment Warranties:
- The 5 year warranty on the WTGs that they shall be in accordance with the Nordex technical specifications and free from defects in material or workmanship. The warranty period shall commence on the date of commissioning of the WTGs, however in no event later than 3 months after delivery.

## Maintenance:
- Standard service and maintenance for an initial period of 5 years is included in the contract price. NORDEX is ready to carry out all aspects of service and maintenance under a separate service and maintenance contract for further periods. This contract can include scheduled service and maintenance, including parts, labour and consumables. Such a contract would be made on the basis of a fixed price per year. Unscheduled work can also be arranged on request.

## Language:
- Unless otherwise agreed, all technical documentation will be delivered in the English language.

## Other Comments:
- The wind turbine is certified according to the appropriate standard and it is presumed for the purposes of this quotation that the site specific wind and climatic data are within the criteria for this certification.
- All warranties are conditional upon Nordex being responsible for service and maintenance for the duration of the warranty period.
- In no event shall Nordex’s total contractual liability in respect of warranties or otherwise exceed the contract price.
- The above information is intended to serve as a brief outline of NORDEX terms and conditions, and its contents are not legally binding. The official NORDEX sales, warranty and O&M contracts define, in greater detail, all points outlined here and shall be the legally binding documents for approval and signature by both parties.

## Validity:
- This quotation will remain valid until 31.07.2004

Signatures: 

Nordex UK Ltd. 

Claus Poulsen  
General Manager

Date: 01 March 2004
V52-850 kW
Pitch regulated wind turbine with OptiTip® and OptiSpeed®
The efficient all-round turbine opens up new opportunities

The V52-850 kW turbine improves exploitation of wind resources. Vestas has done it again. Through intensive development of the V47-660 kW model, Vestas has succeeded in creating a new, highly efficient turbine that is ideal for all wind conditions.

The Vestas V52-850 kW turbine is a pitch-regulated turbine with a 52 metre diameter three bladed rotor. The speed of revolution of the rotor can vary from 14.0-31.4 rpm, allowing optimal energy capture at both high and modest wind speeds, while simultaneously ensuring the best possible power quality.

Vestas OptiSpeed®

The V52-850 kW turbine is fitted with OptiSpeed®, a system that enables the rotor to operate at variable speed (RPM) and hereby optimises the aerodynamic efficiency of the rotor. OptiSpeed® is a further development of the OptiSlip® system, which allowed the rotor speed to vary by as much as 10%. With OptiSpeed®, the rotor speed can now vary by up to approximately 60%.

OptiSpeed® is an efficient solution as the converter only converts the generator rotor energy, which accounts for a small part of the entire energy production of the turbine. The energy generated by the generator rotor is transformed back to the electrical grid by means of the converter.

The use of a converter eliminates the need to consume reactive power from the electrical grid. Nevertheless, it is possible to adjust the turbine to supply or consume reactive power, if appropriate.

In short: OptiSpeed® optimises energy production, especially in modest winds, making it easy to adapt the operation of the turbine to the parameters of the electricity grid.

Lower sound level

Sound levels are of crucial importance when deciding on the placement of wind turbines in populated inland areas – often at locations where wind speeds are low. Thanks to the low speed of revolution of the V52-850 kW turbine in modest wind speeds, Vestas has taken yet another important step towards fulfilling requirements for a wind power solution with a low sound level. The OptiSpeed® feature makes it possible to program the turbine sound levels before installation so the operation of the turbine is tailor made for the specific characteristics of the chosen location.

Optimal pitch with OptiTip®

As with all other Vestas turbines, the V52-850 kW model is equipped with microprocessor-controlled OptiTip® pitch regulation, which ensures continuous and optimal adjustment of the angles of the blades in relation to the prevailing wind. The OptiTip® and OptiSpeed® systems make it possible to optimise the solution to the often contradictory requirements for high output and low sound levels, depending on the location.

Lightning protection

Naturally, the V52-850 kW model is equipped with Vestas Lightning Protection, to protect the entire turbine from the tips of the blades to the foundation. The turbine has, of course, also been thoroughly tested and fully conforms with the applicable IEC standards.

Proven Performance

We spend many months testing and documenting the performance of the Vestas turbines. When we are finally satisfied, we run one last check by allowing an independent organisation to verify the results. This is standard practice at Vestas – a procedure we call Proven Performance. It is our guarantee that your Vestas turbine meets the very highest requirements for energy production, availability factor, power quality and sound levels.

* Vestas OptiSpeed® is not available in the USA and Canada.
The figure illustrates the relationship between wind and sound levels as well as wind and speeds of revolution for turbines equipped with OptiSpeed®. It clearly shows the sound level advantages of lower speeds of revolution because the turbine’s measured sound level at the lowest level is approximately 7 dB(A) lower at 4 m/s than at 8 m/s. For other sound levels, the advantage is up to 10 dB(A). It should also be noted that a decrease of 3 dB(A) is considered to decrease the sound level by half.
### Rotor
- Diameter: 52 m
- Area swept: 2,124 m²
- Speed of revolution: 26 o/min
- Operational interval: 14.0-31.4 o/min
- Number of blades: 3
- Power regulation: Pitch/OptiSpeed®
- Air brake: Feathered

### Tower
Hub height (approx.): 40 m, 44 m, 49 m, 55 m, 60 m, 65 m

### Operational data
- Cut-in wind speed: 4 m/s
- Nominal wind speed: 16 m/s
- Stop wind speed: 25 m/s

### Generator
- Type: Asynchronous with OptiSpeed®
- Nominal output: 850 kW
- Operational data: 50 Hz/60 Hz, 690 V

### Gearbox
- Type: 1 planet step/2-step parallel axle gears

### Control
Type: Microprocessor-based monitoring of all turbine functions as well as OptiSpeed® output regulation and OptiTip® pitch regulation of the blades.

### Weight (IEC IA/IEC IIA)

<table>
<thead>
<tr>
<th></th>
<th>40 m</th>
<th>44 m</th>
<th>49 m</th>
<th>55 m</th>
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<td>Tower</td>
<td>39 t/</td>
<td>44 t/</td>
<td>50 t/</td>
<td>57 t/</td>
<td>69 t/</td>
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<td>Rotor</td>
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<td>10 t</td>
<td>10 t</td>
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<td>10 t</td>
<td>10 t</td>
</tr>
<tr>
<td>Total</td>
<td>71 t/</td>
<td>76 t/</td>
<td>82 t/</td>
<td>89 t/</td>
<td>101 t/</td>
<td>109 t/</td>
</tr>
</tbody>
</table>

OptiSpeed® allows the speeds of revolution of both the rotor and the generator to vary by approximately 60%. This reduces fluctuations in the grid system as well as minimises the loads on the vital parts of the turbine.

The sound output level can be adjusted by varying the speed of revolution and the pitch angle of the turbine as illustrated in the figure below. In practice, this means that the sound level recorded at a distance of 300 m (hub height 49 m), for example, can be reduced from 45.0 to 40.8 dB(A).
Good, stable wind conditions are often found in unobstructed areas and close to the coast. However, there are many complex wind sites with high energy production potential. In developing the V52-850 kW turbine, Vestas has recognized the need to make better use of the wind in these more demanding areas.

Vestas OptiSpeed® and the pitch system reduce the disadvantages of the high and often unstable winds. Even at times with low wind, this versatile turbine will still achieve optimal output, as Vestas OptiSpeed® allows the speed of revolution to vary by as much as 60%.

In addition to this, the V52-850 kW model is designed to work with the weak grid conditions often found in remote locations.

Vestas is continuing to strive for excellence by taking firm steps towards full exploitation of the resources of the wind.

The V52-850 kW turbine is an all-round turbine that condenses Vestas’ extensive experience into a highly efficient turbine design. In short, the V52-850 kW model is efficient under all conditions.
Subsidiaries

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Fax: +86 10 65667335

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Fax +91 11 26327733
vrrb@gndel.global.net.in
Richard Gould
Orkney Sustainable Energy
6 North End Road
Stromness
Orkney Islands
KW16 3AG

Campbeltown, 26th February 2004

VESTAS QUOTATION NO. 053/02B

| PROJECT: Site Burray//Turbine Delivery and Erection |
| WTG Type: 1 off Vestas V52-850kW // Hub height; 44m |
| Project price: EURO 458,600 and GBP £102,200 |
| Exclusive all import duties and VAT |

The project consists of the following elements of which the highlighted are included in the project price:

1. Wind Turbine
2. Tower
3. Remote monitoring
4. Supervision and Erection
5. Crane
6. Transportation
7. Project Management (not included in above price)
8. Warranties
9. Commercial Terms – Capacity costs

Please find detailed description of the individual elements on the next pages.

Please note that this quotation is valid for acceptance within 4 months. Prices are based on delivery taking place within 2004.

The maximum delivery time from receipt of order with prepayment shall be 8 months. Subject to goods unsold.

Yours sincerely,

Mark Powell, Area Sales Manager
VESTAS – CELTIC WIND TECHNOLOGY LTD.

Registered office
DE Machrihanish
Campbeltown, Argyll PA28 6NU
UK-Scotland
Company Number SC216807

Postal Address
P.O. Box 9263
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PA28 6WA

Phone +44 1586 555000
Fax +44 1586 555111
E-mail v-celtic@vestas.com
Web www.vestas.com

Bank: Barclays Bank Plc
West George Street
Glasgow G2 2ND
Sort Code: 20-33-70
1. Wind Turbine

1 Vestas V52-850kW complete wind turbine, inclusive foundation cast-in section for foundation prepared by the client suitable for erection and ready for connection to the site electrical infrastructure, details of which shall be agreed.

We have included for basic safety equipment in the above price and this covers: 2 Safety harness, Emergency Descent Equipment, Emergency Lighting with Battery Back Up and 2 Fire Extinguishers (you will have to accept the ongoing maintenance of these last items). These can be removed from the price if preferred.

2. Tower

The quotation includes two section, steel, conical 44-meter towers, corrosion class C4 (outside) and C3 (inside) according to ISO 129-44. Due to the site proximity to the sea we would recommend that the offshore corrosion class is applied to the tower, the extra cost for this is GPB £2,300

The quotation is based upon towers and nacelles produced by Vestas in Campbeltown. The blades will come in from Vestas in Denmark and all the associated costs for this are included.

3. Remote monitoring

The quotation includes a wind farm control and monitoring system, the VESTAS REMOTE PANEL (VRP). There are other options possible for remote control, which we can happily quote for. However this option is most common for low numbers of turbines where the client wants to be able to see operational parameters remotely from the site.

Please note that communication cables are not included in the above. Communication cables can be purchased at a price of EURO €4.00 per metre if you should need them for some purpose, such as connecting up to a ‘met’ mast

4. Supervision and Erection

We have included for the provision of one qualified and experienced Vestas supervisor and team for the duration of the assembly and erection of the wind turbines and the auxiliary equipment as well as the test and commissioning of the same.
5. Crane

We have included for crane costs in this quotation.

Please note that the client holds the full responsibility for areas suitable for erection of turbines. We are happy to discuss our requirements in this respect to allow you to assess total project costs.

6. Transportation

The price for the transportation, freight and insurance from manufacturer to the site is included in the project price.

Please note that the client holds the full responsibility for proper accessibility to the site from the nearest public road to each turbine foundation on the site.

7. Project Management

Please note that all external assistance is excluded in this quotation.

We have not included for any of the following items: Micrositing/Site Management, Power Curve measurement, Noise measurements, GL Site specific approval, Foundation calculations etc. All such features can be quoted for as optional extras if required.

8. Warranties

A two-year warranty in accordance with the Vestas Celtic Wind Technology Ltd. ‘Warranty Certificate’ is included in the price of each turbine.

ALTERNATIVELY we can offer a five-year comprehensive warranty and maintenance package at a price of **GBP £8,000** per turbine per year for each of the five years. If you prefer these sums can be capitalised in the contract price. Please note that this price also includes consumables.
9. Commercial Terms

The following commercial terms are applicable to our quotation

Terms of Payment

30% of total Contract Price to be paid on order.

60% of total Contract Price to be paid against shipping documents.

10% of total Contract Price to be paid at issue of Taking Over Certificate.

or to be agreed upon.

Payment security for the total amount less prepayment must be provided in the form of a Irrevocable Letter of Credit.

Yours sincerely,

Mark Powell, Area Sales Manager
VESTAS - CELTIC WIND TECHNOLOGY Ltd.
Wind power for Antarctica

They keep turning even in a storm

Patents from East Frisia

Pot luck with performance curves
One of the most innovative and exciting wind projects has now been implemented with three ENERCON converters of type E-30 (300 kW).

Under the curious gaze of several penguins, ENERCON erected the first wind energy converters in Antarctica. The animals showed no fear as they came by one evening, examined the building work, and went on their way. The converters will work as part of a hybrid system together with a diesel generator in order to supply the Australian Mawson research station with electricity. The customer is the Australian Antarctic Division.

The converters must withstand extreme stresses, being exposed to temperatures as low as 40 degrees Celsius below zero and wind speeds of up to 250 km/h. These conditions called for specially modified towers, strong enough to withstand the special loads presented by air density and wind, and manufactured of special steel suitable for the very low temperatures. The nacelle itself is mostly fitted with standard components. Only the cast parts have been manufactured with some small modifications that adapt them to the low temperatures. A thermal supply was required for the electrical parts. The electrical boxes, for instance, were fitted with heaters. The rotor blades conform to ENERCON standards. Blade heaters are not necessary because of the extremely low air humidity.

Transport and erection were difficult tasks, as Bernd Rosner and Deerk Thos from the ENERCON erection team discovered on site. Bernd Rosner sent the WINDBLATT editors an e-mail describing his impressions and experiences:
“Transport here in Antarctica is quite difficult. For reasons of environmental protection, there are no roads. The tower sections, nacelle and hub were brought to the foundations on a sledge. It took ten days just to unload the ship.” The components began their journey by ship in Tasmania. Erection was also difficult, because a wind of between 15 and 25 m/s blows until the early hours of the afternoon, only easing later.

As for the temperature, the South Pole summer at that time was relatively merciful. The thermometer sometimes even climbed above freezing point. Daily life in the Australian station, writes Bernd Rosner, was not at all bad: “The food is very good. There is a hot house here, and other food is deep-frozen. We have a bar and a cinema, while the view of a unique natural panorama is almost too spectacular to describe.”

Further information is available at www.aad.gov.au
# Indicative Price for supply of Enercon E30 WEC for Orkney Sustainable Energy Ltd

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wind Energy Converter</strong></td>
<td>£ 225,000</td>
</tr>
<tr>
<td>One (1) ENERCON E30 / 300 kW – Wind Energy Converter, 44m hub height steel tower with 30m rotor diameter, Enercon lightening protection system, control and power cabinets, Scada PC and software, foundation drawings and section, erection, installation and commissioning personnel and equipment (not including crane hire or other civil works or transformer or switchgear).</td>
<td></td>
</tr>
<tr>
<td><strong>Warranty</strong></td>
<td></td>
</tr>
<tr>
<td>In the above-mentioned price for the WEC a two (2) year Full Warranty is included, as per Enercon Standard Contract Terms and Conditions - This comprises of quarterly service and maintenance including all necessary parts and materials to the manufacturers specifications.</td>
<td></td>
</tr>
<tr>
<td>An extension of this Full Warranty is possible if required:-</td>
<td></td>
</tr>
<tr>
<td>Years 3-7</td>
<td>£ 8,500</td>
</tr>
<tr>
<td>Years 8-12</td>
<td>£ 10,150</td>
</tr>
<tr>
<td><strong>Transportation - UK</strong></td>
<td></td>
</tr>
<tr>
<td>The exact transport price cannot be stipulated at this time, as it depends on the exact shipping date, route and the price charges of the transport companies. Price for transportation will be confirmed once a shipping date is stipulated.</td>
<td></td>
</tr>
<tr>
<td>Estimated transport cost per WEC</td>
<td>£ 24,500</td>
</tr>
<tr>
<td>For Information Only - UK Foundation</td>
<td></td>
</tr>
<tr>
<td>The exact foundation price cannot be stipulated at this time, an estimate for a typical Enercon design flat foundation for this turbine built by the customer or his contractors (subject to survey and appropriate soil conditions) per foundation.</td>
<td>£ 35,000</td>
</tr>
</tbody>
</table>

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Head office: Axiom House, Station Road, Stroud, Gloucestershire GL5 3AP
Globally ideal

The E-30 offers absolute freedom in terms of siting as well as unmatched flexibility as regards transport, assembly and maintenance as an ideal basis for combination with other regenerative sources of energy or storage systems.

Armed with the technology of large-scale plants, the E-30 can overcome the limits of conventional systems. The prefabricated components of the steel tower, nacelle and rotor unit can easily be transported in containers and erected on site using a modular assembly system and a standard crane without any difficulty. The ENERCON modular construction also means that the plant offers great ease of maintenance. The systematic arrangement of the components makes repair work or inspections much simpler. As a result most maintenance can be carried out directly on site - instead of back at the works, something which minimises operating costs. No matter where the converter is installed.

Technical Data
Data of the gearless E-30

Rated capacity: 300 kW
Rotor diameter: 30 m
Hub height: 44/50 m
(tubular steel tower, various bases)

Turbine concept: gearless, variable speed, variable blade pitch

Rotor with pitch control
Type: upwind rotor with active pitch control
Direction of rotation: clockwise
Number of blades: 3
Swept area: 707 m²
Blade material: fiberglass (reinforced epoxy)
Rotor speed: variable, 18–46 rpm
Tip speed: 28–72 m/s
Pitch control: three synchronised blade pitch systems with emergency supply

Generator with drive train
Hub: rigid
Main bearing: tapered roller bearings
Generator: direct-driven ENERCON ring generator

Grid feeding: ENERCON inverter

Braking system:
- 3 independent pitch control systems with emergency supply
- rotor brake
- rotor lock for service and maintenance

Yaw control: active through adjustment gears, load-dependent damping

Cut-in wind speed: 2.5 m/s
Cut-out wind speed: 28–34 m/s
Remote monitoring system: ENERCON SCADA
Sound power level: 99 dB (A) (predicted)
APPENDIX 2: HYDRO ELECTRIC TECHNOLOGY
Water power
(hydro, tidal and wave)
Products and services from Britain
The British Government's Sustainable Energy Programmes

This guide has been produced for the British Government's Sustainable Energy Programmes, which are managed by Future Energy Solutions.

The Department of Trade and Industry operates a Renewable Energy Programme under its Sustainable Energy Policy Unit (SEPU).

This programme is designed specifically to evaluate, develop and encourage the commercialisation of renewable energy technologies and other novel energy sources. One of the principal aims of the programme is to assist British industry to identify and evaluate business opportunities in international markets. The programme is very much a collaborative exercise, involving government, industry and the energy supply sector.

Its aims include:

■ The assessment and development of technology options
■ Ensuring the market is fully informed
■ The removal of inappropriate market barriers
■ Encouraging the development of internationally competitive industries.

The Technology Transfer and Export Promotion (TT&EP) Programme aims to create a strong and profitable position for UK industry in the renewable energy industry internationally. This programme disseminates information on UK research and development outcomes, and on UK renewable energy capabilities, both in the UK and overseas. It disseminates to UK companies information about overseas markets, assists in business introductions, and carries out international trade promotions.

The water power component of the Renewable Energy Programme has helped to establish water power in Britain through a programme of fundamental research and development, market enablement, resource assessment and work to address non-technical issues, such as environmental issues and planning.
Water power
(hydro, tidal and wave)
Products and services from Britain

September 2002

This guide has been produced as part of the British Department of Trade and Industry’s (DTI’s) Sustainable Energy Programmes.

Whilst every care has been taken in compiling the information for this guide, the DTI cannot be held responsible for any errors or omissions; nor does inclusion of any company in this guide constitute any form of approval or endorsement. The information on specific companies has been provided and approved by the companies themselves and therefore the views and judgements expressed in this publication do not necessarily reflect those of the DTI.
The worldwide drive to limit greenhouse gas emissions means that increasingly we are seeking to make better use of our renewable resources. Water power is an obvious choice as it flows freely and is truly renewable – it will never run out. It has been harnessed for over 2000 years in Britain. Traditionally, water from flowing rivers (and to a lesser extent the tides) has been used to turn mill wheels, but since the beginning of the twentieth century hydro power has been used to generate electricity. Modern hydro power equipment ranges from small dynamos (used to supply power at remote locations) to large multi-gigawatt installations that supply power to the electricity grid. Worldwide, hydro power now accounts for 6.5% of all energy consumption. As the new tidal flow and wave energy technologies come on line, this is set to grow further.

Using water power has important environmental benefits. It displaces fossil fuels, and therefore avoids the environmental damage caused by the production of fossil fuels and the emission of carbon dioxide and other gases (that come from using fossil fuels). It also has important socio-economic benefits. It is frequently deployed in rural locations where the skilled employment it creates and the revenue it produces help to stimulate the economy. With the advent of modern tidal and wave energy, the ports that are used to service the installations should enjoy the same economic stimulation. Hydro energy has been competitive with other forms of generation for a long time, hence it is the most widespread of all the renewable electricity technologies. As the fuel is free, using hydro power can help the balance of payments at a national level when it displaces imported fossil fuel.

Britain has a long history of using water power. As a result, British companies are among the world’s leading providers of products and services in the field - both for the domestic market and in response to worldwide demand.

This Guide

This guide provides an overview of Britain’s capabilities in water power, together with brief details of the activities of key British water companies active in overseas markets. Each company’s entry contains information about its main projects and experience, together with its contact details. The key capabilities of each company are listed at the start of each entry. For ease of reference, these are also summarised in the capabilities table starting on page 6.

Please contact companies directly or, for more general enquiries, make use of the expertise available within the relevant trade associations, details of which are given on page 5.
The technologies

Hydro power
Conventionally, hydro power is produced when the kinetic energy of flowing water from a reservoir, in a river or in a tidal current, is converted into electricity by a turbine connected to an electricity generator. In this guide, the definition is widened to include the generation of electricity by conversion of kinetic energy in waves. For conventional hydro power, the amount of power generated depends on the rate of flow and the volume of water available to drive the turbine. For wave energy, it depends on the height, length, frequency and speed of the waves. Hydro power schemes are designed to offer power generation with high levels of availability over a long operating life. Civil engineering works (weirs, channels) can last for many years with suitable maintenance and the mechanical and electrical lifetime of a hydro power plant can be up to 50 years.

■ Large-scale hydro
Large-scale is typically taken to mean more than 20 MW of grid-connected generating capacity and is usually associated with a dam and a storage reservoir. The largest schemes are well over 1000 MW in size and can take years to construct. However, most large-scale schemes were developed prior to 1990 and the potential for identifying new large-scale schemes is now more limited, not only because there are fewer commercially attractive sites still available, but also because of environmental constraints.

■ Pumped storage
Pumped storage schemes are large hydro schemes that are designed with a storage reservoir that is larger than justified by the natural flow of water into it. At times when electricity demand is high, water is released from the reservoir to drive the generators in order to send power to the grid. At times when electricity demand is low, the generators draw electricity from the grid and become motors, which are then used to drive the turbines in reverse. They then pump water back into the reservoir. Pumped storage schemes play a major role in many countries in smoothing out imbalances between supply and demand, and providing rapid response capabilities that help stabilise the grid.

■ Small-scale hydro
Schemes of less than 20MW now offer a greater opportunity for providing a reliable, flexible and cost-competitive power source with minimal environmental impacts. Although these small-scale schemes currently contribute only about 3% (21GW) to the total hydro power capacity, they are making an increasing contribution towards new renewable energy installations in many regions of the world, especially in rural or remote regions where other conventional sources of power are less readily available. Small-scale schemes can be associated with a dam and storage reservoir or can be located in a moving stream (“run of river”).

Small-scale hydro power generation is a well-established technology. It is characterised by relatively high initial capital outlay but these high initial costs are offset by the long lifetime of the scheme, its high reliability and availability, low running costs and the absence of fuel costs. Capital costs can often be reduced by making use of existing engineering structures or by refurbishing existing plant and equipment. The cost of generating power from small-scale hydro schemes depends on the characteristics of the site and in particular the height of the hydraulic head (the vertical distance from the reservoir or river to the turbine). Economic viability decreases as the head decreases. Where the grid supplied by a scheme is isolated from the main national or regional grid, hydro plant can be run in conjunction with another form of generation, typically diesel. See the text on hybrid systems below.

■ Micro hydro
In certain locations, even very small hydro schemes can be developed to provide an economic source of power. Micro hydro plant are typically a few hundred watts up to a few hundred kilowatts. They are generally “run-of river” schemes, frequently utilising water wheels that were previously used to drive water mills. Micro hydro has a particular role to play, from recovery of energy from water pipelines to providing electricity in remote locations that are not connected to the national grid. It is increasingly used in less developed parts of the world, where the provision of electricity is seen as a major factor in improving living standards.

■ Hybrid systems
Micro and small-scale hydro power are very suitable for incorporation into hybrid systems. They offer flexibility, because they can provide power even when there is little water in the river or reservoir during dry periods. Hydro diesel combinations are common, but more recent developments include hydro photovoltaic units, a hybrid option which offers power generation from 100% renewable sources.
**Tidal power**

Tidal power can use either conventional or new technology to extract energy from a tidal stream. It is usually deployed in areas where there is a high tidal range.

Typically a barrage with turbines is built across an estuary or a bay. As the tide ebbs and rises, it creates a height differential between the inner and outer walls of the barrage. Water can then flow through the turbines and drive generators. Some tidal barrages operate on both the rising and falling tide, but others, particularly estuarine barrages, are designed to operate purely on the falling tide.

It is also possible to make use of the tidal flow that occurs between headlands and islands or in and out of estuaries. This is known as tidal stream. It is this application that is the focus of much research and development and new products for this purpose are now being commercialised. These “in-flow” tidal turbines can be arranged singly or in arrays, allowing a range of power outputs to be produced.

**Wave power**

The power of the waves is readily visible on nearly every ocean shore in the world. There has been much research to harness the power of these waves and various machines have now been developed. These fall broadly into three categories:

- Machines which channel waves into constricted chambers. As the waves flow in and out of the chamber, they force air in and out of the chamber. These air flows are in turn channelled through a specialised turbine, which is used to drive a generator. This type of machine is principally designed for use on or near the shore, or for incorporation into breakwaters. Commercially, this kind of machine is the most advanced and is particularly advantageous when incorporated into coastal protection.

- Fixed or semi-fixed machines which utilise the pressure differential in the water that occurs at a submerged point as the wave passes over that point. The pressure differential is used by a variety of means to cause a fluid to flow in a circuit, which is then used to drive a turbine and generator.

- Machines which utilise their buoyancy to cause movement in a part of the device as it moves up and down in the wave. The movement is used either directly or indirectly to drive a generator.

The UK water power industry offers high-quality products and services for a range of applications. It is based on a tradition of excellence, from design and engineering through to insurance, and backed by proven expertise in developing innovative hydro power projects. From micro hydro run-of-river systems to multi-megawatt installations with large storage reservoirs, UK companies are ideally placed to provide a comprehensive range of services and solutions in all aspects of the use of water as an energy resource.

Many UK companies draw their expertise from practical experience of the expanding domestic market, which at the small and micro scale is now growing rapidly, while others have been active in different parts of the world for many years. British-manufactured hydro-turbines of many sizes from micro to large are operating in many locations around the world. These products demonstrate state-of-the-art technology and generate electricity at low cost, with high efficiency and high overall productivity. British companies are also expert at the restoration and refurbishment of existing hydro power schemes and can, in addition, offer expertise in providing appropriate hydro technology to support the development of indigenous industries.

More recently, UK companies have been at the forefront of new initiatives to develop tidal and wave power systems, the first of which are now being installed off our coasts and the coasts of North America. These technologies are aided by the UK’s enviable expertise in offshore engineering in some of the most difficult marine conditions in the world.
UK companies have unrivalled experience in key areas of the hydro power industry - in development services and installation, as well as manufacture. They can provide high-quality products and services to customers, wherever they may be around the world.

UK companies offer expertise and experience in the following broad categories:

■ Site investigation, water/wave/tidal flow analysis and energy yield calculation
Accurate surveys of conditions and estimation of the hydro power regime at any given site is necessary to determine project economics and to ensure that designs and equipment are matched to site conditions.

■ Research and technology
Materials sciences, integration of generation into grids, development of civil engineering structures for both on and offshore and offshore scour protection are just some of the critical areas where the UK has world-class capabilities.

■ Design and manufacturing
UK companies produce a range of equipment and components for hydro power projects, especially advanced turbines, generators, and computerised control equipment. Bespoke designs services (for example as required by many hybrid systems) are also provided. British companies are very active in the area of micro and small-scale hydro power as well as tidal and wave energy.

■ Project development
Specialist firms can take part in all aspects of the development of a range of hydro power projects, as consultants or in joint ventures with local project partners. This may include feasibility and resource studies, Environmental Impact Assessments, site investigation, transportation, site design and equipment specification, procurement, construction logistics, construction management, staff training, grid connection and integration.

■ Construction and operation
British developers can build, operate and maintain hydro power plant under a variety of different contract types. Their unrivalled experience in the North Sea oil industry means that UK companies are already the leaders in the field of offshore installation, which is particularly pertinent for wave and tidal power.

■ Restoration and refurbishment
A number of British hydro power companies are experts in the restoration and refurbishment of existing hydro power plant. Many older plant can benefit from a complete refurbishment at the same site, thus ensuring a new lease of life and, usually, a greater power output. This refurbishment often needs specialist fabrication skills to renovate the existing plant and equipment, especially where the original manufacturer is no longer in business.

■ Engineering services
British engineering companies are active worldwide on a very wide range of construction contracts and can offer skills and expertise to provide engineering services reliably and cost-effectively.

■ Financial and legal services
The pioneering role that the UK played in development of hydro power and the privatisation of the Electricity Industry means that there is a great wealth of experience in providing legal and financial frameworks for projects, for a great many different situations.

■ Training
British companies provide training services to ensure that hydro plant and equipment are constructed and maintained to high standards.

In the UK, grid-connected small-scale hydro power was until recently supported through the Non-Fossil Fuel Obligation, a system that awarded long-term contracts to renewables generators through a highly competitive process. This has now been replaced by the Renewables Obligation, which requires Electricity Suppliers to source an increasing percentage of their power from renewables generators, creating even greater potential for renewables. It is anticipated that by 2010, the UK will get 10% of its electricity from renewables. This is a major spur to hydro power. It is therefore no surprise that British businesses are now involved in the development of projects on all continents. Having competed successfully in their domestic market, they are now using this experience to expand their activities to assist customers worldwide.
PB Power has a long track record in the planning, conception, design, engineering and construction of hydroelectric projects covering, since 1929, a wide range of conventional plant and a number of important pumped storage projects worldwide.

As well as developing new schemes, PB Power is today also a key international player in the growing market for the rehabilitation of existing hydro power plant. This encompasses the initial condition and performance assessments and study of the scope for uprating, followed later by the management and supervision of the implementation of projects.

Other services we provide include:
- Project technical and economic evaluations
- Project risk analysis
- Scheme design
- Equipment selection
- Bid documentation and evaluation
- Environmental services
- Owner’s engineering services during and following the development phase
- Lender’s engineering services during and following the construction phase
- Automation and remote control
- Station and river chain optimisation
- Asset valuations
- Project purchase due diligence
- Project sale documentation and process management

Projects
We have an international client base which includes lenders, developers, governments, utilities, contractors and international funding agencies. A selection of our recent assignments includes:
- Three small hydro schemes in Indonesia comprising 6 generating sets with a total installed capacity of 5MW.
- Tis Abay II on the Blue Nile, Ethiopia (2 x 36MW, 53.5m).
- Detailed design of the 4 x 250MW Upper Cisokan pumped storage scheme, Indonesia.
- Developer’s Engineer for a new IPP development for Bujagali, Uganda (5 x 50MW, 20m).
- Refurbishment and uprating of the hydroelectric plant at both the Kariba South and Kariba North power stations (total capacity of 1350MW) on the Zambezi River, Zimbabwe and Zambia.
- Lender’s Engineer for the Caliraya Botocan and Kalayaan (CBK) pumped storage scheme, Philippines.
- Kapichira (2 x 32MW, 55m) on the Shire river, Malawi.
- Asset valuation of Snowy Mountains Hydroelectric Corporation, Australia, comprising 7 powerhouses with a total capacity of 3756MW.
Gilbert Gilkes and Gordon Ltd

Gilbert Gilkes and Gordon is a world leader in the field of small hydro. It has been producing hydro power turbines for nearly 150 years and a continuous programme of technology development ensures that the right solutions are always available to customers. The company manufactures turbines rated at up to 15MW – and offers the client all the expertise and equipment needed to deliver complete hydro power projects. With offices in the UK, USA and Japan, and contracts completed in more than 80 countries, Gilbert Gilkes & Gordon can offer its services anywhere in the world.

Operational experience
With an unrivalled wealth of expertise in the field of small-scale hydro power, Gilkes is able to offer a comprehensive range of services.

Water turbines. Gilkes offers a wide range of its own carefully designed and cost-efficient products. There are three types of machine in the manufacturing programme:
- Pelton – this impulse turbine has been developed over a number of years and is supplied for operation on applications with heads up to 750m.
- Turgo Impulse – this range of impulse turbines is generally applicable to medium-head hydro power projects. Originally designed and patented by Gilkes in 1919, the turbine is successfully operating in over 60 countries.
- Francis – this reaction turbine is designed for a wide range of heads.

Project development. Gilkes offers a bespoke service for the full range of projects – from small to medium-sized schemes, stand-alone schemes or those feeding power into distribution networks. The company can manage a complete project from early feasibility studies, detailed design, through manufacture, construction and installation.

After-sales customer care. All Gilkes contracts can be offered with a full inspection and maintenance service to ensure long, reliable and trouble-free operation. The company also offers refurbishment services to both Gilkes’ and other manufacturers’ equipment.

Projects
To date Gilkes has supplied about 4000 units to more than 80 countries. The company’s projects include the following examples:
- Gilkes supplied three turbines for two run-of-river hydro power schemes owned by the Provincial Electricity Authority of Thailand. The Nam San facility incorporates two 3MW Twin Jet Turgo Impulse turbine generating sets, operating on an 85m net head. The Nam Man station has one 5MW Twin Jet Turgo Impulse turbine generating set, operating on a net head of 119m.
- At the Alaska Light and Power Company’s Lower Salmon Hydro Project in the USA, a Gilkes Turgo Turbine generates 5.9MW of electricity from a head of 300m.
- In South Africa, a 6MW hydro power scheme was installed for the Transkei Electricity Supply Corporation.
- At the Carolina scheme in Sri Lanka, a power output of 2.5MW is obtained from three Twin Jet Turgo turbines, operating on a head of 88m.
- A hydro power project built for the Government of Nagaland in India, has three Pelton turbines each capable of generating 8.5MW of electricity from a head of 750m.

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APPENDIX 3: THE GOTLAND RENEWABLE ENERGY SYSTEM
Renewable energy on Gotland is taking off...

The Swedish island of Gotland has already many interesting and innovative renewable energy projects and there are now plans in place for many more. Perhaps this is not surprising when you consider that the Baltic island of Gotland has the most sun hours in Sweden, good access to biofuels and also one of the best wind resources in Europe.

These natural assets combined with the municipality’s focus on strategic environmental planning have lead to the realisation of many initiatives that have contributed to making Gotland one of Europe’s foremost actors in the field of renewable energy.

Windpower installations are being built both on and offshore. The sea is used for both heating and cooling. Nearly half the island is covered in bio-mass sources. Large parts of the medieval world heritage town of Visby are heated with district heating based on renewable energy, and local people are also getting involved. In a local school and community centre a unique educational experiment is taking place that aims to raise environmental awareness by demonstrating the use of solar power and wind energy.

As well as all this the Municipality of Gotland has entered a renewable energy partnership with the European Commission with the aim that by 2025 the island will produce enough energy from renewable sources to meet 100% of its needs.

So as you can see, when it comes to renewable energy, the island of Gotland is about to Take-off!

What has been achieved?
Results so far...

- An energy plan has been produced outlining development to 2005. In this plan the target is 40% from sustainable energy sources by 2005. A plan for 100% for renewables by 2025 is now underway.
- 95% of the Island’s district heating plant is supplied by renewable energy.
- 20% of the Island’s electricity comes from renewables.
- Bio-climatic, sustainable buildings are being built.
- Widespread energy saving measures are being implemented.
- Heating systems are being converted to biomass and solar energy.
- Bio-diesel is replacing fossil fuels in municipal fleets.
- The use of fuel-cells as part of a solar-hydrogen transport system is being developed for Visby.

"Society shall be organised in such a way that the need for transport energy supply be minimised."
"Buildings shall be designed in such a way that the need for energy supply for heat and light be minimised."

Water will be the only emission from fuel-cell driven buses in Visby!

A new project with hydrogen fuelled buses is under development on Gotland. The project is called USHER (Urban integrated Solar Hydrogen Economy Realisation project). It will develop a sustainable transport system to reduce emissions and help protect the world heritage city of Visby. The project is unique in that the hydrogen used to fuel the buses will be produced on the island. With the help of 2500 square meters of solar cells the hydrogen needed to fuel the buses will be produced by electrolysing water. Water is also the only exhaust emission that the buses will produce and thus the circle is made complete.

The project is being supported by the European Commission the Swedish National Energy Authority and private companies. The buses are expected to be in operation in Visby by 2004.

"Gotlandic renewable energy shall be developed until it suffices for all the necessary functions of society."

"The Gotlandic renewable energy shall suffice for all necessary operations of tools, machinery and production processes."

"Green Rooms” in Gråbo – a living experiment in environmental education.

These rooms act as calm oases for story telling and experimentation, and at the same time provide educational possibilities together with a hands-on demonstration of renewable energy technologies.

In the Gråbo building there are six “Green Rooms” with:
• Solar collectors and accumulator tanks for providing warm water
• Solar cells and small-scale wind turbines that generate electricity
• Meteorological stations for recording the weather conditions
• Water streams and pools for fish and other nature studies
• Areas for growing plants and vegetables

Gråbohouse is a building in a housing area of Visby which contains a school, a library and a community centre. When the building was being renovated the municipality and the local community decided to create new “Green Rooms” for use in connection with innovative environmental education techniques that are unique for Sweden.
Clean energy at a distance – bio-fuelled district heating in Visby

Visby’s buildings and medieval ruins are mainly built of Gotlandic limestone. Limestone is sensitive to airborne pollution, and especially from the burning of fossil fuels. This is one of the reasons that Visby’s district heating system is so well developed. The use of fossil fuels in the district heating system is gradually being phased out and today 95% of the energy supply is from renewable sources. Over 40% of Gotland is covered in forest so the availability of biomass is good. The district heating station in the picture uses bark, wood chips, sawmill residues and forestry waste.

"Fossil fuels shall be replaced with renewable energy."

“The Gotlandic renewable energy shall suffice for all household needs.”

Bockstigen - Sweden’s first offshore wind farm

Gotland’s position in the middle of the Baltic sea provides the island with an endless energy source - the wind. In order to ensure that windpower is developed in a rational and democratic manner, and with consideration for the islands natural and cultural heritage, the municipality has produced plans for windpower developments both on and offshore. Today the island has nearly 200 wind turbines and around 2000 households own shares in co-operatively owned wind turbines. As the sites that are suitable for wind turbines on land are limited larger wind farms are being built at sea. Sweden’s first offshore wind farm, Bockstigen 2.5 MW was built outside Gotland’s coast in 1996 with support from the European Commission’s Thermie R&D programme. In the coming year a larger offshore project - Klasorden 42MW is being planned. This project aims to demonstrate the increased efficiency and the economies of scale of larger wind turbines and is being supported by the European Commission and the Swedish National Energy Authority.

The Campaign for Take-Off forms an integral part of the European Community Strategy and Action Plan for Renewable Energy Sources by 2010. It is designed to act as a catalyst for the development of key renewable energy sectors.

For more information about Gotland’s role in the Campaign for Take-Off please contact: Bertil Klintbom, Head of Buildings and Infrastructure projects, Gotlands Kommun, 61281 Visby. Tel. 0046 498-269287 Mob. 0046 708-865020.

Visit our website at www.gotland.se/cto