BURÐARDYGG EL ORKA

Sustainable energy in the Faroe Islands

- the role of hydropower

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Contents

Executive summary

The BEO research project is an independent analysis of the need to make electricity production in the Faroe Islands more sustainable and focuses in particular on the role of hydropower.

Background information is provided by factual descriptions of small-scale hydro plant structure, pumped storage systems and a range of energy sources, including both fossil fuels and renewables. Energy efficiency options and global environmental concerns are outlined, followed by an overview of the position of hydropower in the Faroe Islands and in a sample number of European countries. The Renewable Energy Islands (REI) initiative is also mentioned and mini-case studies are presented as examples of good practice.

A review of the environmental, economic and socio/political impacts of hydro development, both in general and in the specific context of the Faroe Islands, reveals both positive and negative aspects.

The current dominance of oil in the production of electricity in the Faroe Islands is examined and the advantages of renewables, as viable alternatives, are stressed.

The thorny issues of what to do regarding the Kyoto Protocol and electricity company privatisation are raised. Suggested strategies for a more sustainable energy future include energy efficiency measures and an expansion of renewables, particularly hydropower, to reduce the current high level of thermal production.

The dangers to the natural environment and to the self-sufficiency of Faroese society of continuing to rely on oil are outlined. A balanced viewpoint regarding hydropower development is called for in order to ensure that the Faroe Islands continue as a vibrant and progressive society, where 21st century needs can be met without offering an impoverished legacy to future generations.

The recommendations of this report are to reverse the current percentage of electricity produced by oil and by hydropower by doubling the present hydropower capacity, introducing urgent energy efficiency initiatives and giving support to all renewable energy sources.

1 INTRODUCTION

The BEO research project was set up in January 2005, with support from the Ministry of the Interior, to explore how electricity production in the Faroe Islands can be made more sustainable. The emphasis of the report is on hydropower - its current use and its potential for future development.

The primary aims of the report are to:

- assess the environmental impacts of hydropower, while giving due regard to economic, social and political considerations;
- examine hydropower in the context of the alternative energy sources available within the Faroe Islands;
- focus on current issues and future strategies for sustainability;
- gain insight from observing hydropower production & operations abroad, as well as new equipment and technological advances.

The report is organised in two parts:

- Part 1 gives background information consisting of definitions, descriptions, facts and figures. This information appears as a series of short items grouped under 10 headings;
- Part 2 is in four sections, followed by Conclusions and Recommendations. Each of these sections relates to the stated aims of the project.

The intention of this report is to present an independent overview of energy-related topics with a view to stimulating interest in, and debate about, the important future role of hydropower in the Faroe Islands.

2 BACKGROUND INFORMATION

2.1 Components of a hydro plant

2.1.1 Definition of hydropower

Hydropower is a mature technology which relies on the energy of falling water. Hydropower plants are defined by size/scale as either large or small hydro. The cut off point between large and small hydro varies. In some countries such as USA, Canada, China etc., small hydro is installed capacity of up to 30MW but the consensus within Europe is 10MW. Small hydro is further subdivided into mini hydro and micro hydro which produce enough power for small communities or individual houses.

Large hydro	> 10MW
Small hydro	10MW - 1MW
Mini hydro	1MW - 100kW
Micro hydro	< 100kW

Although there are many significant differences between small and large-scale hydro, the basic principles are the same. Water falling under the force of gravity turns the blades of a turbine connected to a generator to produce electricity.

The energy potential of a hydroelectric scheme is proportional to the product of the flow (volume and speed of the water) and the head (vertical distance the water drops). The greater the amount of water and the higher the head, the greater the energy potential.

The head is classified in 3 groups:

Low head	2 - 30m
Medium head	30 - 100m
High head	> 100m

The gross head is a constant but the flow varies over the year. In run-of- river schemes the turbine generates electricity when there is sufficient water in the river. When the river dries up and the flow falls below a pre-determined amount - the minimum technical flow of the turbine equipping the plant - the turbine stops and generation ceases.

As this is generally not cost-effective, in larger schemes the construction of a dam enables water to be stored in a reservoir. This extends the opportunities for generation and tunnels can be bored through the rock in order to collect water from a larger catchment area.

Since the availability of an adequate water supply is the number one criterion for any hydropower development, careful measurements and hydrological studies are needed to provide essential data on rainfall, stream flow, drainage basins, catchment areas, evapotranspiration and surface geology, etc. In addition, infrastructure and equipment has to be provided, which is described below in its most basic form.

2.1.2 Intake

A water intake is normally a concrete structure built at the entrance to the pressure pipe (penstock). It serves to ensure a controlled flow of water both in quality and quantity down to the turbines. It enables the turbines to function efficiently by minimising turbulence (vorticity). It also prevents any flowing debris entering the penstock by means of a trash rack placed at the entrance to the intake.

2.1.3 Penstock

The purpose of the penstock is to convey water from the intake to the powerhouse. There is a variety of sizes and materials that can be used, ranging from flexible and relatively small diameter PVC penstock, to steel, ductile-iron pipes or pre-stressed or steel-reinforced concrete with an interior steel jacket. Fibre-glass penstock can also be used and this, although expensive, eliminates turbulence and is very long-lasting. The penstock can be above ground and designed with or without expansion joints. It is usually built in straight lines and attached to the hillside by means of concrete anchor blocks. Alternatively, it can be buried to reduce visual impact on the environment.

2.1.4 Powerhouse

This building protects the turbines and the electro-mechanical equipment that convert the energy of water into electricity. In larger schemes the powerhouse is often underground. It is important that it is located at the lowest point in relation to the intake in order to achieve the maximum possible head.

2.1.5 Turbines

Selection criteria for turbines depend on many factors including the head, the flow-regime, the geomorphology of the terrain, environmental requirements and the cost and efficiency of the turbines. Modern turbines have been developed with an efficiency of over 90% with help from computer software. Turbines are classified in two groups; reaction turbines and impulse turbines.

For reaction turbines the water pressure applies a force on the face of the runner blades which decreases as it proceeds through the turbine. The turbine casing has to be strong to withstand the operating pressure. It is possible for the turbine to be below the tailrace, thus utilising the full head.

For impulse turbines the water pressure is converted into kinetic energy before entering the runner. This is in the form of a high-speed jet that strikes the buckets mounted on the periphery of the runner. After striking the buckets, the water falls into the tail water with little remaining energy. These turbines have to be above the level of the tailrace.

Kaplan turbines (reaction type) are frequently chosen for low-head schemes and Pelton turbines (impulse type) for very high-head schemes. However within each group the turbines are suitable for a range of heads, as follows:

Reaction turbines:	*Head*
Francis	10-350m
Kaplan/Propeller	2-40m
Impulse turbines:	
Pelton	50-1300m
Cross-flow	3-250m
Turgo	50-250m

2.1.6 Generators

Generators transform kinetic energy into electrical energy and can be synchronous or asynchronous. Synchronous generators are used in power systems where the output of the generator represents a substantial proportion of the power system load. Asynchronous generators are used in large grids where their output is only a small proportion of the power system load. They are less efficient but they are less complex to manufacture and therefore cheaper.

2.1.7 Tailrace

This takes the spent water, which has passed through the turbines, away from the power house and channels it back into the river or straight into the sea.

2.1.8 Catchment area tunnels

Where conditions are suitable, several rivers and streams can be harnessed and channelled into the reservoir through tunnels cut in the mountains. This enlarges the catchment area, increases the flow and the potential energy. Sophisticated boring equipment is now available for rent or sale. Many firms offer a complete service, providing both equipment and expertise. There is also scope for local participation, where appropriate. Iceland got its first TBM this year but one was used in the Faroe Islands for the Eiði project 20 years ago.

2.1.9 Dams & reservoirs

According to ICOLD (International Committee of Large Dams) a dam is considered small when its height, measured from its foundation level to the crest, does not exceed 15m, the crest length is less than 500m and the stored water is less than one million cubic metres. (By contrast, the dam being built at the Three Gorges Hydro Project in China has a height of 185m, a width of 2km and a reservoir capacity of 39 billion cubic metres).

Whatever the size of dam required, the type of dam depends on the geological and topographical conditions of the site. Many dams in small or mini hydro schemes are of the gravity type. Gravity dams are built where there is hard rock and where materials for concrete i.e. aggregate, stone and sand are easily accessible.

Buttress dams are suitable where the rock is capable of bearing pressures of 2-3MPa. Buttress dams require between a half and two-thirds of the concrete required for a gravity section, hence making them more economical for dams over 14m.

Rockfill dams can be built where the foundation is unreliable for sustaining the pressure necessary for any form of concrete dam. They are embankment dams used in wider valleys, where suitable rock and an adequate amount of clay are available in the vicinity. Modern rockfill dams may use synthetic geomembrane on the upstream face as an alternative to a clay core, in order to stop water infiltration and provide water-tightness.

The size and shape of reservoir that forms behind the dam varies according to the terrain and to the size of catchment area and volume of water available. Every hydro development is different and, at each site, the potential reservoir area has to be surveyed and excavated to achieve the optimal size and depth.

This ensures that the required volume of water can be accommodated without causing environmental impact by flooding an unnecessarily large area of land. The excavation of the reservoir produces valuable quarry resources that may be used off- or onsite, without any negative visual impact.

2.2 Pumped storage

Electricity is not a commodity that can be stored but has to be produced to meet demand. However, water can be stored and converted to electricity when needed. A pumped storage system consists of two reservoirs, located at different elevations. When needed, water is released from the upper reservoir. It drops down through the penstock to the turbines and is used to generate electricity. Then, instead of the water being released to the tailrace and back to the river or into the sea, it is released into the lower reservoir. At times of low demand, water is pumped from the lower to the higher reservoir to be used again. The efficiency rate is in the 70% to 85% range.

In terms of the quantity of electricity produced, there is a no net gain since as much or more power is needed to pump the water to the top reservoir than is produced when it is released for generation. However the value of the pumped storage lies in the fact that it enables electricity to be produced as and when it is needed, whether for peak demand, for stabilising the network grid or during periods of low rainfall. If wind turbines are utilised for pumping, it enables them to operate during low demand periods when they would normally have to be switched off. There is over 90GW of pumped storage in operation world wide. It is the most widespread renewable energy-storage system in use in power networks.

Two examples of large-scale pumped storage plants are Dinorwig, which is located in the Snowdonia National Park in North Wales, UK and the KWO plant at Grimsel Pass in the Swiss Alps, an area of high scenic value. Both of these use nuclear power to pump the water back to the upper reservoir for re-use at periods of high demand when the electricity can be sold at high rates.

There is a demonstration project under way on the island of El Hierro, Canary Islands, which includes a wind-pumped hydropower station with the target of covering 75% of the island's electricity demand and achieving 30% direct wind penetration into the grid. It is due to be operational in 2008. The system overcomes the usual problems of intermittency and power fluctuations caused by the random character of the wind resource and, thanks to the potential energy storage (pumped water) and the controllable power output of hydro turbines, can establish a stable grid in terms of frequency and voltage.

El Hierro, declared a Biosphere Reserve by UNESCO, has an area of $276km^2$, a population of approx. 10,000 inhabitants and is not connected to a continental electricity grid. Currently, its electricity demand is met by a conventional thermal power station (diesel) but El Hierro intends to become a 100% Renewable Energy Island (REI) and is implementing an energy savings programme, electricity production by 100% renewable energy sources (including solar thermal and PV) programme and a transport programme (bio fuels).

2.2.1 Seawater pumped storage

In recent years, it has become possible to have a pumped storage system which uses seawater. The advantage of this type of pumped storage is that no lower reservoir is needed as the sea effectively becomes the lower reservoir. Currently, the only seawater pumped storage plant in the world is located on the island of Okinawa, Japan. It was built in 1999 as a demonstration project and has been under test for 5 years. Japan was motivated to build this plant since demand for electricity is rising steadily and peak power demand is rising sharply.

In the Okinawa plant, the upper reservoir was excavated at an elevation of 150m and is approximately 600m from the shoreline. In order to guard against any seepage of seawater into the ground, the reservoir has a complex lining structure composed of a drainage layer of gravel, covered by a layer of cushioning material and topped with an ethylene propylene diene monomer (EPDM) rubber sheet, specially tested for water-tightness. New technology FRP penstocks are used since they do not corrode from seawater and marine organisms do not adhere to these pipes, as they do to coated steel pipes.

Environmental conservation is of high importance as this is an area of high biodiversity and high frequency of species and sub-species not found anywhere else in the world. Mitigating measures were put into effect to protect 16 species of rare animals, including some endangered or Red Data book listed ones, 14 species of indigenous plants and a bank of reef-building coral located near the outlet.

2.2.2 Hydrogen

Hydrogen as an energy carrier and fuel cells as a conversion technology can be used as a way of storing energy. However, the reality of implementing hydrogen storage is determined by its efficiency and that depends on the type of fuel cell and the electrolyte used. After re-conversion of hydrogen to electricity, only 25% or less of the original energy becomes available to consumers. Although there are many positive reasons why hydrogen would be an effective approach to storing solar and wind energy, the use of hydrogen is currently very expensive and is best when reserved for smaller usages rather than large amounts of energy storage.

2.3 Fossil fuels

Fossil fuels are non-renewable energy sources so supplies are being depleted and will eventually run out. Fossil fuels release energy through burning and this process releases emissions of carbon dioxide and other gases into the atmosphere.

2.3.1 Coal

Around 40% of the world's electricity is produced from coal and is double the amount of electricity generated from any other fuel source. However, the greenhouse gas emissions which result from the burning of coal are significantly greater than for other energy sources. Also, the fuel efficiency of traditional power stations is low and the combustion process produces large quantities of solid wastes, including fly ash which contains toxic metals. For countries with large coal reserves and an established mining industry, there has traditionally been high dependence on coal-fired power stations.

Developing countries, including China and India with 2/5th of world population, are adding coal-fired capacity at a fast rate. In recent years concern about climate change has prompted frantic research into "clean coal technologies" such as Integrated Gasification Combined Cycle (IGCC) and Circulating Fluid Bed combustion (CFBC). IGCC makes the best environmental use of coal but high capital costs have limited its up-take. CFBC is more widespread and utilises a range of low-grade fuels, waste and biomass to increase fuel efficiency and reduce emissions.

2.3.2 Oil

In most countries, oil has become too expensive to use for generating electricity and is generally reserved for transportation and the petrochemical industry. Like any fossil fuel, resources are finite and dwindling stocks elsewhere put the focus on the vast supplies in the Middle East. However, it is estimated that by using Enhanced Oil Recovery (EOR) techniques, some 300 billion barrels of previously inaccessible crude oil from known reservoirs could be tapped. In terms of emissions, diesel produces fewer greenhouse gases than coal but almost twice those produced by gas. Crude oil produces more emissions per litre than diesel but contains more energy so less oil is used and the end result is similar.

2.3.3 Liquefied Natural Gas (LNG)

Liquefied natural gas is stored and transported in liquid form rather than as a gas. To condense natural gas into a liquid, it must be cooled to approx. -162˚C at atmospheric pressure. When it condenses, it takes up less than 1/600th of the volume it did when it was gas. It can be transported by super tanker and, before being used as a fuel, must be heated and turned back into a gas. Supplies of natural gas are plentiful and it has recently become popular for producing electricity, especially in combined cycle gas turbines.

2.3.4 Combined Cycle Gas

Since the 1980s, gas has gained popularity for generating electricity by combining with steam-turbines. A gas turbine on its own has low fuel efficiency, because its exhaust gases emerge at over 500˚C, carrying away a lot of energy. But this hot gas can be used to raise steam for a steam turbine, to generate more electricity from the original fuel. Combining gas turbine and steam turbine in the same unit can produce a fuel efficiency of more than 60%. A Combined Cycle Gas Turbine (CCGT) may be designed solely to generate electricity or cogenerate both electricity and heat in the form of steam or hot water. This raises the overall fuel efficiency to more than 80% and reduces both costs and pollution significantly.

2.3.5 Uranium

Around 16% of the world's electricity is produced in nuclear power stations using uranium (Fast Breeder reactors utilise plutonium). In a nuclear power reactor the heat released by nuclear fission is used exactly like that from burning coal or oil, to raise steam to turn a turbine-generator. Advocates of nuclear power often refer to it as a clean technology as, unlike other fossil fuel generation, it does not produce greenhouse gases. However, it produces accumulations of high and medium-level radioactive waste and routinely discharges low-level concentrations into the atmosphere and the sea. Many plants were built in the 1950s and are now due to be decommissioned. Failure to find an acceptable way to manage and dispose of nuclear waste is a major cause of concern, as are issues of safety (melt-down, terrorism, etc), reliability and cost.

2.4 Renewables

Hydropower contributes 20% of the world's power generation. It also provides over 90% of the world's total electricity from renewable sources. As well as hydropower there are a number of other renewable sources for making electricity. These include:

2.4.1 Biomass

This technology involves the combustion of organic matter such as energy crops (crops grown specifically for the purpose of generating electricity), agricultural and forestry wastes, landfill gas and municipal wastes. The biomass fuel can be burned in a combustor to produce steam for a turbine or it can be converted into combustible gas to be burned in a gas turbine. Since some or all of the carbon dioxide (CO_2) emitted during combustion was recently sequestered from the atmosphere it is simply recycled and in terms of the effect on global warming, biomass combustion is CO_2 neutral. However, some of the CO_2 released during incineration of municipal waste is derived from fossil fuels such as plastics, so account has to be taken of these emissions.

2.4.2 Geothermal

Geothermal energy is energy derived from the natural heat of the earth. The earth's surface temperature varies widely, and geothermal energy is usable for a wide range of temperatures. Since the earth's crust is continuously emitting heat towards its surface at a rate of 40 million megawatts, geothermal is in principle an inexhaustible energy source, with the centre of the earth having cooled down by only about 2% over the earth's lifetime of about 4 billion years. There are no problems of intermittency in the utilisation of geothermal energy sources for direct heat applications or for electricity generation.

2.4.3 Solar power

Solar power harnesses energy directly from the sun. It is an intermittent source since it is interrupted by night and by cloud cover. Electrical energy is obtained from photovoltaic (PV) cells that convert sunlight. Thermal energy is harnessed from the sun by a variety of devices which transfer it to a medium such as air or water. Confusingly, both PV panels and solar thermal panels are often referred to as "solar panels".

2.4.3.1 Photovoltaics

This technology makes use of sunlight falling on a thin solar or PV cell to produce voltage between connectors attached to different layers of the cell. A PV panel consists of many individual cells interconnected into a single electrical circuit and the more cells, the more electricity produced for a given brightness of light. PV panels can be used on roofs and facades of buildings to produce Direct Current electricity. Some people are calling for architects to include them in house design as standard. While the operational phase causes few impacts, there will be some emissions at the production, construction and decommissioning stage. The price of photovoltaic modules has dropped rapidly in recent years and efficiency rates are rising.

2.4.3.2 Solar thermal

The major applications of solar thermal energy at present are for heating swimming pools, for heating water for domestic use, and space heating of buildings. For these purposes, the general practice is to use flat-plate solar energy or evacuated tube collectors with a fixed orientation.

2.4.4 Wind power

Wind turbines can convert wind power into electrical energy. The amount of energy that can be produced is dependent on the wind speed. Wind power can become unavailable at times of low wind speeds and also at times of very high wind speed and can fluctuate over short timescales intra-day and intra-hourly. Due to this intermittency, if wind energy is going to be integrated into electricity grids on a large scale, then different management strategies will be needed than were used in the past in order to avoid compromising system stability. Wind is the fastest growing of the renewable technologies with Germany, Spain and Denmark accounting for more than 75% of wind energy generation in Europe. The fast pace of recent development has seen rapid changes in the size and design of wind turbines.

2.4.5 Wave power

There are currently over 30 different types of wave power research projects being undertaken on a worldwide basis. All are in the research and development (R&D) phase but several have produced a prototype device, which is undergoing tests. The wave devices vary widely in design from the Wave Dragon being developed in Denmark to the Pelamis (Sea-snake) system and the Salter Duck, both developed in Scotland. Included among those under test is the Wavegen Limpet, a large concrete structure, with an oscillating water column (OWC) device built into the face of a cliff, utilising an air chamber in order to capture wave energy. One installation has been set up on the island of Islay, off the west coast of Scotland and a second installation, using tunnels rather than a concrete structure, is planned in co-operation with the Faroese electricity company, via the newly formed company, SeWave.

2.4.6 Tidal power

Tidal energy devices seek to harness potential energy generated by the rising and falling of the tides. Tidal barrages are the simplest of tidal energy devices. The barrage comprises a series of gates which are open during the flood tide and closed at high water. Water is then allowed to flow out from the barrage during the ebb tides across a series of turbines which generate electricity. There are many examples of this technology including the 13m high 240MW tidal barrage built on the Rance River, near St Malo in northern France which began operations in 1967 and the 20MW experimental scheme built in 1984 at Annapolis Royal in Nova Scotia. Barrages are expensive to build but are cheap to operate as there are no fuel costs and the main structure requires little maintenance, although there can be problems with silting behind the barrage.

2.4.7 Tidal stream power

Tidal streams are generated by the horizontal movement of seawater. These currents are most noticeable in constricted channels or fjords and can reach a velocity of 8-10 knots in the Faroe Islands. There are a wide range of devices, similar in some ways to wind turbines, which are trying to harness the kinetic energy in tidal streams but all are in the R&D stage. Devices are classified according to whether they harness power by using a turbine that rotates around a horizontal or a vertical axis.

2.5 Electricity transmission

2.5.1 Off-grid

If a power station is built to serve the needs of a particular industrial site or small community close-by, then the electricity produced is transmitted directly to the customer and this is referred to as off-grid transmission. One topical example of off-grid hydro supply is the underwater power station on the River Thames that is being constructed for UK Queen Elizabeth to supply power for Windsor Castle. Experts believe off-grid electricity options will grow in popularity in future years.

2.5.2 Grid network

Traditionally, electricity has been produced in remote power stations and transmitted to consumers in towns and cities often long distances away. This is achieved by constructing a network or grid of transmission cables, some of which are overhead lines, some buried underground, to link up all the different power stations and communities. In order not to have unacceptable losses from travelling long distances, the electricity is transmitted at high voltage and then at the end of each transmission line, it passes through a sequence of transformers which decrease its voltage for distribution to customers.

2.5.3 System operations

If the system is to remain in stable operation, the amount of electricity being generated must match the amount being used at any given moment, within very stringent limits. Any deviation outside these limits may damage equipment, so to avoid such damage the system must include protective devices to isolate the deviation, usually causing that part of the system to shut down, i.e. a power failure or black-out.

The load on the system is the amount of electricity being used and as it increases or decreases generators are added to the system or are shut down. Normally, the least flexible generators, such as big nuclear or coal-fired stations, operate continuously to meet the minimum or 'base load' on the system. When the load increases above the base load, generators that are smaller and more flexible can be progressively added to the system. This is known as 'load following'.

2.6 Energy Efficiency

2.6.1 Smart meters

Automatic Meter Reading (AMR) is spreading rapidly across Europe and Canada. So called 'smart meters' have already been installed in parts of Norway, Sweden and Finland. Denmark is in the process of implementing AMR in Jutland, in a project that will be completed by 2007.

The smart meters can send and receive information automatically to the electricity company's central data system, thus giving an up-to-date picture about individual users' electricity consumption and allowing the company to issue bills that are based on actual rather than estimated consumption. This not only gives the benefit of instant availability of information for the company and a better service to the customer, it has other more significant advantages. It can provide an opportunity for the supplier to influence changes in consumer behaviour.

In countries such as Britain, where there are different tariffs at different times of day, consumers quickly learn it is cheaper for them to reduce their consumption during peak periods. For domestic customers this could mean using the washing machine or dishwasher at off-peak times or even choosing to lower their heating at peak periods.

This reduction in peak demand in turn results in massive savings for electricity suppliers, who otherwise have to buy in high-price electricity or make large investments to increase capacity in order to match surges of demand at peak times or risk system failure and black-outs.

Smart meters can also assist with outage detection and restoration and can become a key component in the electricity company's efforts to address black-outs and storm-related outages.

2.6.2 Green Accounts

The Green Accounts Act was passed in Denmark in 1995 because of public concern regarding environmental issues in the 1980s and 1990s. Each year, some 1,200 companies are required by law to submit green accounts, which include environmental data about their production processes and environmental policy regarding energy, waste and transportation issues. Some 200 companies have also chosen to submit voluntary accounts.

The objective of green accounting is firstly to facilitate the public's access to information about the environmental performance of polluting companies and secondly, to motivate reporting companies to evaluate their operations and products in order to improve their resource efficiency.

Companies are discovering that if they consume fewer resources and utilise these more effectively, then they can minimise costs and increase profits. In addition to using the accounts as a management tool to evaluate processes and increase profit margins, they are motivated to make improvements to enhance their environmental profile in the eyes of their customers, including other businesses.

2.6.3 Combined Heat and Power (CHP)

Combined heat and power involves making use of heat that would otherwise be wasted in the process of producing electricity in thermal power stations. The energy efficiency of fuels such as diesel, coal or gas can be improved by harnessing the heat that escapes into the atmosphere or in water from the cooling systems. By means of heat converters, this by-product heat can be used for District Heating purposes.

In Denmark, the success of CHP development is attributed to government policy resolve and significant subsidy and grant provision.

2.7 Global Environmental concerns

2.7.1 Acid rain

Worldwide concern about the environment culminated at the UN Conference on the Human Environment in Stockholm in June 1972, at which more than 150 national governments endorsed an action plan to address environmental problems of every kind. By the 1980s vast tracts of forest in Germany, Scandinavia, northeast USA and elsewhere were visibly deteriorating as trees withered and died due to 'acid rain' emissions of sulphur and nitrogen oxides from industry, power stations and motor vehicles.

2.7.2 GHGs & climate change

In the early 1990s, concern about the 'greenhouse effect' caused by emissions of carbon dioxide and other gases from burning fossil fuels prompted governments around the world to nominate a group of more than 300 top scientists to assess the issue and recommend policy responses. In 1992, the Intergovernmental Panel on Climate Change (IPCC) published its First Assessment Report. It indicated that greenhouse gas emissions (GHGs) would have to be substantially reduced to avoid potentially serious disturbance of the global climate.

2.7.3 Rio Conference 1992

Those with fossil fuel interests, namely the major oil companies, coal companies and natural gas companies, disputed the scientific basis of linking fossil fuels with climate change and opposed the call to reduce emissions. They took part in the negotiations at the UN Conference on Environment and Development in Rio de Janeiro in 1992. A Framework Convention on Climate Change was agreed, which commits governments to a continuing process of international negotiations to develop agreed global policies to tackle climate change. However, due to the strength of the oil/gas & coal lobby, no specific targets or quantified commitments were agreed at the Rio Conference.

2.7.4 Kyoto Protocol

In December 1997 the Conference held in Kyoto, Japan agreed the text of what is now called the Kyoto Protocol. It stipulates explicit and quantitative targets for countries to reduce greenhouse gas emissions by the period 2008 to 2012, in comparison with 1990 levels. The Kyoto Protocol sets legally binding emissions objectives and allows national commitments to be met through joint efforts such as emissions trading (via emission credits otherwise known as green certificates, emission reduction units, renewable obligation certificates, etc.) and other mechanisms to reduce the cost of compliance e.g. Joint Implementation (JI) and the Clean Development Mechanism (CDM).

Strict monitoring, accounting and recording systems are required. National assigned amounts incorporate emissions of six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) from the energy sector, industrial processes, solvents, agriculture and waste. Trading may be limited to certain types of emission sources i.e. certain greenhouse gas sources that can be monitored accurately. Emissions baselines for JI and CDM projects aim to quantify "what would have happened" in terms of greenhouse gas emissions in the absence of those projects. Actual emissions from JI or CDM projects are measured against baseline emissions, and, if lower, can generate emission credits.

2.8 The Faroe Islands

2.8.1 Description of the islands

The Faroe Islands have an isolated location in the North Atlantic Ocean (latitude 62˚N and 7˚W), midway between Scotland, Iceland and Norway. There are 18 islands covering a total land area of 1,400km^2. As of May 2006, when the sub-sea Norðoyggjar tunnel is completed, 6 of the islands (Borðoy, Viðoy, Kunoy, Eysturoy, Streymoy and Vágar) will be joined to form a mainland area. Suðuroy, in the far south, is one of the larger islands but is the most remote from the mainland group. The population of the Faroe Islands currently stands at 48,000.

Politically, the country is a self-governing state within the Kingdom of Denmark but, unlike Denmark, it is not a member of the EU.

The Faroes have abundant water resources and the numerous rivers or waterfalls flow rapidly from the mountains virtually straight down to the sea, dropping several hundred metres in the process. The topography, climate and geographical location of the Faroes all contribute to providing ideal conditions for hydropower production.

2.8.2 Topography

The Faroe Islands have a high-relief landscape with high, steep cliffs and glacial valleys. The islands extend from north-west to south-east with highlands of 400-600 metres above sea level in the south rising to almost 900m in the north and north-east.

2.8.3 Climate

The Islands have a maritime climate with mild winters and cool summers. They have an isolated location, far from any large landmass and are greatly influenced by the warm Gulf Stream and by frequent cyclones from the south and west. There are significant differences in annual rainfall in different parts of the islands with the far south and west receiving less than 1,000mm whereas the mountainous northern and eastern areas receive more than 3,000mm. Most rain falls in the autumn and winter months.

2.8.4 Geographical advantage

Since they are a group of islands, the Faroes have total control over their rivers. This differs from many landlocked countries in other parts of the world, where rivers rise in the mountains of one country but flow to the sea through others. In these countries ownership of the rivers, and the water and energy potential they contain, is a matter that necessitates cross border agreements in order to avoid one country placing dams and restricting the rivers from flowing into neighbouring countries.

2.8.5 Electricity

There are two grid networks in the Faroe Islands. Suðuroy has its own separate grid. The main grid serves most of the remaining islands but five of the small, remote islands have no connection by cable i.e. Fugloy, Hestur, Mykines, Skúvoy and Stóra Dímun.

In 1985 annual energy demand in the Faroes was 180GWh. This increased until 1989, declined until 1995 and then grew rapidly to over 250GWh in 2004.

The average daily pattern of demand varies from about 18MW to 35MW during the day. Peak demand is between 30-35MW from 9am to 10pm with the sharpest peak before & around midday.

The price charged for electricity is DKK1.11 per unit for domestic customers but less for industry. The exact price per unit that industrial customers pay depends on their electricity consumption, with the most intensive-energy users paying less per unit. At present, there is only one tariff used as there are no off-peak or night-time rates.

2.8.6 Hydropower

There are 4 operational hydropower schemes in the Faroes: Botnur (Suðuroy), Strond (Norðoyggjar), Vestmanna (Streymoy) and Eiði (Eysturoy).

Botnur is a small scheme with a 1MW Pelton and a 2MW Francis turbine. It is the only hydropower plant in Suðuroy and the first one ever built in the Faroes. It was built by the municipality of Vágur and the village people were directly involved. It is located in an isolated spot above the sea cliffs and is reached by a single track road from Vágur. The Botnur station was taken into use on 18 July 1921, a new turbine was added in 1965 to increase the power output, the influx was extended in 2002 and the original concrete penstocks were replaced by new steel ones. It is an unmanned station and is operated by remote control from the power station at Heimaru Oyrar.

Strond is located about 4km north of Klaksvík and is the only operational power station in Norðoyggjar. It has a single penstock carrying water from a small reservoir at 220m down to the turbine house right on the shore, which houses one 1.4MW Francis turbine. The turbine house is one of a cluster of buildings and houses that are painted in the traditional green and yellow colours and were originally built to accommodate the electricity company workers. A thermal plant also operates in the same complex. In 2002, the inflow of water to the power plant was extended and water was brought from Svartidalur.

There is an obsolete power station on the island of Kunoy in Norðoyggjar. It operated from 12 March 1952 until 1977 when the Faroese electricity company, SEV, offered to buy it and supply the community with network electricity. SEV intend to make it into a museum. SEV bought the hydro plant and shut it down on the very same day.

Vestmanna consists of 3 schemes with 3 reservoirs and 3 powerhouses. The first plant was built in 1954 at Fossá and later extended by blasting a tunnel to collect water from the river Dalá. In 1961 a reservoir was created at Mýrarnar at a height of 349m and from there water falls 240m through a tunnel and penstock to the Mýrarnar power station after which the water collects in the lower reservoir and then falls a further 107m through a tunnel and penstock to the powerhouse at Heygar power station. Both Mýrarnar and Heygar power stations are unmanned but the Fossá station is the control centre for the whole mainland area. Fossá station has 2 turbines, a 2.1 Pelton turbine and a 4.2 Francis. Mýrarnar has a 2.4MW Francis turbine and Heygar has a 4.9 Francis turbine.

Eiði consists of 3 projects named Eiði 1, 2 and 3. To date only Eiði 1 and 3 have been undertaken. Eiði 1, completed in 1987, consisted of building a turbine house south of Brimnes, 2 barrages on Eiði Lake, 10km of tunnel north to Dal and south to Svínáir and 39 intakes to channel water from the rivers to the tunnel. Two Francis turbines were installed with a capacity of 6.7MW each.

Eiði 3, delayed 10 years due to the recession, finally started in 1997 and completed in 2000, was an extension project to harness water from the hillsides along Funningsfjørður and was further extended south to Vesturdalur. The average annual production from both Eiði 1 and Eiði 3 amounts to 40GWh.

The Eiði 2 project is a proposal to extend the tunnel from Norðskáli to Selatrað. Licences were applied for in 2001.

Statistics for 2004, show that the majority (89.6%) of hydroelectricity is produced in Eiði (42.8%) and Vestmanna (46.8%). Strond produces 4.6% and Botnur 5.8%.

As of 2004, hydro represented approximately 34% of the electricity produced in the Faroes. Hydro was the main source for electricity production until 1976 when thermal power (diesel/crude oil) overtook it and has remained the dominant source ever since.

In 2004 the approximate relative percentages were: 60% thermal, 34% water and 6% wind i.e. 60% non-renewable fossil fuels versus 40% renewables.

NB: Calculated on the basis of fuel and maintenance only, the cost of producing 1 kWh by hydro is DKK0.05 and by diesel DKK0.40.

2.8.7 Thermal power

The pattern of thermal production has changed over the past years with crude oil becoming more dominant and the amount of diesel greatly reduced. In 1988 approx.12,000 tons of diesel were used as opposed to 21,000 tons of crude oil but by 2004 the position changed to approx. 2,000 tons diesel versus 29,000 tons of crude.

There are 11 thermal power stations in the Faroes, including 2 in Suðuroy, 1 at Sund near Tórshavn and 1 at Strond, near Klaksvík. The power station at Strond is the only one in the Faroes where thermal and hydropower are located in the same complex. The power station at Sund is the largest.

In recent years the thermal capacity has been expanded and in 2003 a new power plant was set up in Vágur. In 2001 and 2003 the Sund power station got 2 new 8.1MW engines, ancillary equipment and 2 new chimneys. These engines replaced the oldest ones which dated from 1974. Crude oil is being used more as it is cheaper and more efficient energy wise but the engines require more maintenance.

2.8.8 Wind power

The first wind turbine was set up by SEV in Neshagi. It has a capacity of 0.5MW. In 2003 a private company, Sp/F Røkt, set up the first windfarm in Vestmanna. This comprised 3 Vestas wind turbines with a combined capacity of 2MW. In 2005, SEV commissioned its own windfarm in Neshagi using 3 turbines of the same size and design from the same manufacturer as Sp/F Røkt.

2.8.9 Faroese Electricity Company (SEV)

Its name derives from the initial letters of the 3 islands - Streymoy, Eysturoy, Vágar as it was originally set up in 1946 to provide power for this area. However in 1963 it took over the responsibility of providing power supply for the whole country.

SEV, as the national electricity company, is jointly owned by all the municipalities in proportion to their population. It is run by a 70-strong Board of Representatives drawn from all municipalities, an elected Board of Directors (7 men), a Managing Director, and two Departmental Managers.

SEV generates power by diesel/crude oil, water and wind. Until recently, it was the sole electricity generating company in the Faroes but in 2003 Sp/F Røkt set up a windfarm in Vestmanna and was granted a 10-year licence to produce wind power for the network.

SEV is in complete charge of the electricity net, all transmission infrastructure & facilities and ancillary services. It owns all the thermal and hydro plants plus 4 windmills in Neshagi, Eysturoy.

It is the sole power distributor providing meters to all houses/business & other establishments and is in charge of all marketing publicity, billing and other customer services within the Faroe Islands. It currently has sole rights to water and rivers in the Faroes for hydropower production and this lasts until 2013.

In 2003, SEV and a UK company Wavegen (now owned by Voith Siemens) formed a limited company called SeWave to investigate the possibility of building an experimental wave power plant in tunnels in the sheer cliff. This co-operative venture has received support from the oil companies, Agip, Eni and BP. No environmental impact assessment has been mentioned in this case.

In terms of future plans for hydro development, surveys have been conducted to identify the best sites and a Summary of Extension Plans report was produced in 2000. A feasibility study was carried out in 2003, with support from the oil company, BP, regarding a wind-powered pumped storage facility near Vestmanna.

2.8.10 Environmental Protection Authority

There are local committees which make decisions regarding any proposed activity or development in the outfield environment within their area, including applications for hydro projects. The developer may appeal against the decision of the local committee and his appeal will be dealt with by the national Environmental Protection Authority. This body, which is appointed by the govt for 6 yrs at a time, has complete and final decision-making authority.

Academic organisations, including the Food & Environmental Agency, are the competent bodies to give advice on environmental matters and to carry out research in connection with Environmental Impact Assessments (EIAs). There is no set time scale for this work and the research may take several years.

2.8.11 FNU - environmental interest group

This is a small and fragmented interest group based in Tórshavn. It is strongly opposed to hydro development and was initially formed on 12 March 1980 in order to protest against the hydropower development in Eiði. It does not oppose other renewables or thermal power.

2.8.12 Environmental research

Environmental statistics are not comprehensive but are being added to year by year. There is no systematic mapping of wilderness areas, but geochemical studies of peat bogs have been undertaken to establish levels of atmospheric mercury and they have been studied in connection with palaeoecological research into the impact of human settlement. Various soil surveys and measuring & mapping of landslides have been carried out by the Faroese Geological Survey.

There is no complete data on the riparian value of Faroese rivers but there has been a scientific study of fish in fresh water lakes in the eastern part of the country (Toftavatn, Klubbatjørn and Skúvadalur) and research on environmental pollutants in the coastal zone, mainly in south Streymoy.

In 2003, a project was carried out by the Food & Environmental Agency to set a framework for the recording of environmental statistics using a set of indicators to assist in analysing progress towards sustainable development.

The Faroes are a small country, not a part of the EU but attempting to implement parallel measures. They are not party to the Kyoto Protocol. Statistical data of weather patterns has been collected over a number of years but not long enough to make any firm assessment regarding climate change as, for that to be attempted, comprehensive data is required over several 30-year periods.

A topographical atlas has been produced that gives information on the physical environment, as well as cultural and commercial details about a cross section of areas and settlements within the Faroe Islands.

A study has been carried out on water quality and growth in the Funningsfjørður in connection with the Eiði hydroelectric development. Preliminary results, published in October 2005, proved inconclusive but suggested that the development has had no significant impact. Data was requested over an extended time period and final results are due to be published in 2006.

2.9 Sample countries & projects

2.9.1 Norway (99% hydro)

Norway covers an area of 324,300km^2 and has a population of 4.6 million. Its topography and climate are ideally suited to the production of hydroelectricity. More than 99% of electricity production is by hydro. The installed capacity of hydro plants is about 28,000MW and the country also has 1,330MW of pumped storage in operation with a further 56MW under construction.

Two new major hydro plants are currently under construction and licences have been granted for the development of a further 859MW of hydro capacity, consisting mainly of small hydro projects. At present there are around 450 small hydro plants in operation with an installed capacity of approx. 1,000MW.

The cost of producing 1kWh of electricity is about NOK0.10 by hydro plants and between NOK0.25 and 0.35 by other types of power plants such as wind power. The electricity price is approx. NOK0.28 for households, 0.26 for the service sector, 0.23 for manufacturing and 0.11 for energy-intensive manufacturing and paper products.

The Ministry of Industry & Energy is the national energy and power authority and there are approx. 25 regional authorities. The electricity sector is de-regulated but many of the electricity companies are owned by the municipalities. The state-owned generation utilities and the central transmission grid are separated to ensure all users of the central grid are treated on equal terms. The central grid is a natural monopoly. Statnett SF operates the main grid and owns almost all the connections with other countries. Norway is connected by cable to Sweden, Finland, Russia, Denmark, Netherlands and Germany and interconnection to the British Transmission System by DC cables is also planned. Norway has traded power with the other Nordic countries for many years.

The main purpose of interconnection is the exchange of power between high demand periods and low demand periods. Thermal power plants dominate the systems in these countries. The Norwegian hydropower system, with high heads and storage capacities, can reduce the dependence on thermal power plants for peak power, which is costly and causes pollution. In dry years, when Norway's total production capacity drops to 90TWh in comparison with 145TWh in wet years, electricity can be imported so Norwegian thermal back-up is not required.

2.9.2 Switzerland (56% hydro)

Switzerland has an area of 41,285km^2 and a population of 7.4 million. As of 2003, the sources of electricity production were:

Hydro - 56%
Nuclear - 39%
Others - 5%

In Switzerland 80% of all power plants are under public ownership in terms of capital stock. Private owners have 12% and foreign owners about 6%. Switzerland is interconnected with the grid systems of several countries in Europe including Germany France Italy and Austria so electricity can be imported and exported.

The gross theoretical hydropower potential of Switzerland is about 100,000GWh/year and the technically feasible potential is estimated as almost half the gross figure. So far 86.6% of the technically feasible potential has been developed. An extension project at the Grimsel underground hydro plant is now underway and several other modernization and uprating projects are in progress including the 12MW Hagneck run-of-river hydro plant, which has been in operation for 100 years and will be uprated to 18MW.

There are approx. 1,050 small, mini and micro hydro plants in operation with a total capacity of 900MW. A new draft law has been prepared organising the opening of the Swiss electricity market. The draft law contains promotion regulations for hydropower and other renewable energy sources. A labelling and certification system for green electricity, including hydropower, has been established.

Switzerland has had a legal framework for environmental impact assessment since 1985 and has a strict system of environmental compatibility examinations for all hydro projects larger than 3MW. When a new scheme is planned, information hearings are held to communicate with local people and information is given in official publications and newsletters.

2.9.3 UK (2% hydro)

Britain covers an area of 243,300km^2 and has a population of 60 million. The main sources of national electricity production in 2003 were:

Coal - 39%
Gas - 33%
Nuclear - 24%
Renewables - 3%
Oil - 1%

There is 157MW of hydro capacity in operation in England and Wales of which the majority, i.e. 140MW, is in Wales. The total installed hydro capacity in Scotland is 1,206MW of which 70MW is at 41 small plants. Most of this was built in the 1950s.

Deregulation and privatisation saw an explosion of power producers in England and Wales but only 2 companies in Scotland i.e. Scottish Power and Scottish & Southern Energy. These two companies cover the full range of electricity provision. They operate generation, transmission, distribution and supply businesses. Many hydro plant refurbishment or extension projects have been completed or are in progress. As well as large hydro projects, the construction of the 3.5MW Kingairloch hydro scheme is almost complete. In Britain there are 4 pumped storage plants in operation, two in Scotland and two in North Wales, with a total capacity of 2,788MW.

In order to reach the Kyoto emissions targets, the British Government is now trying to increase the size of the renewables industry and has introduced the Renewables Obligation as the main support mechanism along with additional support in the form of capital grants and funds for research and development.

2.9.4 Iceland (83% hydro)

Iceland covers an area of 103,000km^2 and has a population of 294,000. As of 2003 the main sources of electricity were:

Oil - 0.1%
Hydro - 83%
Geothermal energy – 16.9%

Less than 1% of national electricity production is derived from imported fuels.

There are 10 hydro plants with capacity greater than 10MW, three large hydro projects are planned and one 690MW scheme is under construction at Kárahnjúkar in Eastern Iceland. It will be fully operational in 2007 and is being built to provide power for an aluminium smelter in Reyðarfjörður, on the east coast.

Iceland has a clear procedure regarding environmental impact assessments (EIAs). By law, the developer must produce an EIA. All EIAs are presented to the Planning Agency for approval. Appeals against the Agency's rulings are made to the Minister of Environment. The public are directly involved via consultations with the community council, public presentations, and opportunities for the public to comment on an EIA report and to appeal EIA rulings.

In spite of the fact that the heating and electricity market is already sustainable, government policy calls for the further utilisation of the country's hydro and geothermal resources. It is also committed to increase the use of sustainable domestic power resources in the transportation sector through continued R&D on hydrogen and fuel cells.

2.9.5 Renewable Islands Project

A Renewable Energy Island (REI) is an island that will become 100% self-sufficient from renewable energy sources, including transport. In 1997, Samsø was selected as the official Danish REI. This stimulated interest in renewable energy on islands and since then two global conferences have been held and a review of data from all the participating islands has been compiled and published, with funding from the Danish Council for Sustainable Energy.

Islands from many different parts of the world are taking part. Over 40% of them are located in the North Atlantic Ocean, including the Faroe Islands.

In nearly all the islands around the world the potential for renewable energy has not yet been tapped. For the majority, expensive and environmentally problematic fossil fuels are still the only energy sources utilised. This is largely due to lack of knowledge and awareness, which this Renewable Islands Project intends to rectify by facilitating global co-operation and networking among REIs.

Wind power is by far the most utilised renewable energy resource for energy production but all the islands, which produce more than 25% of their electricity by wind power, are connected by sea cable to another electricity grid.

Of the participating islands, those with the highest utilisation of renewable energy for electricity production are mainly using hydropower.

On a global scale, islands are relatively small, in terms of size, population, energy consumption, emission of greenhouse gases, etc. However, they are important for the promotion of renewable energy worldwide because they:

- can act as a showcase to demonstrate renewable energy in action;
- can make the shift to renewable energy which would be unrealistic in a big country;
- have a generally positive attitude towards renewables;
- rarely have fossil fuel resources of their own, so no vested interests;
- are concerned about global warming;
- are often the first victims of climate change brought about by fossil fuel consumption in industrialised countries;
- have a strong interest in finding sustainable ways of satisfying energy needs.

2.9.6 Utsira

On the island of Utsira, off the west coast of Norway, an experimental project was set up in 2004 to store wind power as chemical energy in the form of hydrogen. There are two 600kW wind turbines and when it is windy, electrolysers produce hydrogen for storage, and when it is calm, a hydrogen engine and a fuel cell convert the hydrogen back to electricity. The 240 inhabitants on the island receive all their electricity from renewable sources in a closed system. The stored hydrogen ensures that sufficient renewable power can be generated at any time, even when consumption is high and wind activity is minimal. The hydrogen is produced from water and the electricity from one of the turbines by means of an electrolyser.

2.9.7 Nólsoy experimental project

It has been suggested that the island of Nólsoy should take part in a West Nordic Council-funded experimental project similar to the Utsira one described above. The project is especially intended for remote areas with few inhabitants. Information is currently being collected about suitable locations in the Faroe Islands, Iceland and Greenland regarding population, wind measurement, agriculture, etc. A final decision will be made about which islands take part in the project once this information is to hand.

2.10 Examples of good practice

2.10.1 Karun 3, Iran

The 2,000MW Karun-3 project, completed in 2005, provides a good example of employing local capabilities in all aspects of engineering and project management. Social and environmental aspects were also handled well.

Rather than award one large contract to a foreign firm, the developer, Iran Water & Power, broke the work into many smaller contracts that were awarded to Iranian companies with sub-contracts to international firms. The Iranian companies performed a variety of work on the project including constructing the dam, power tunnels & cavern for the underground power plant, excavating diversion tunnels, and building access roads.

Feasibility studies showed 77 villages with a population of 10,000 people, mainly farmers or shepherds, would be affected by the project. Over the past 5 years, research was conducted by a group of social scientists, economists, agricultural experts and archaeologists from Tehran University. About half the affected people preferred to stay near their homelands, and they received new land provided by the government. The rest opted to move to nearby cities and towns, and they received money for their lands and for the cost of relocation.

An agricultural survey showed that using water from the dam to irrigate the existing forests around Karun-3, could increase the volume of forests from 1,350,500m^3 to 2,801,580m^3. In addition, irrigation could almost double the total herbages of grazing land, which would then support 40,000 more sheep.

2.10.2 Kali Gandaki A, Nepal

The 144MW Kali Gandaki-A hydro project in Western Nepal was commissioned in 2002 and is owned by the Nepal Electricity Authority (NEA). As well as an Environmental Impact Assessment (EIA), an Acquisition, Compensation and Rehabilitation Plan (ACRP) and a Mitigation Management Plan (MMP) were prepared. The social mitigation programme ensured that proper measures were taken to assess and compensate people affected by the hydro project.

Government-issued regulations were used to rate families affected by the project. 263 households were rated as severely project-affected families, losing their house, more than 60% of their income or more than 50% of their land. 1,205 households were rated as project-affected families, losing part of their land.

To determine compensation, each of the affected settlements formed advisory committees consisting of local community leaders and representatives of the affected families. These committees conducted a community consensus valuation of land and these values were presented to landowners for discussion and approval at public meetings. NEA set compensation rates above government minimums and compensation was also given for standing crops damaged during construction.

Skills-training and employment were provided for at least one member of the severely project-affected families. The income generated by this was about 10 times greater than income foregone from lost agriculture production. In addition, a micro-enterprise fund was set up to provide money for project-affected and severely project-affected families to support local income-generating activities, such as pig, goat or vegetable farming.

NEA committed 1% of net project revenues to electrification of villages surrounding the project. The programme, initiated in 1997, continues to expand, and data last collected in 2003, shows that a total of 3,000 households in 11 villages have benefited.

3 THE IMPACTS OF HYDROPOWER

Hydro is a clean, renewable energy source for making electricity but building a hydropower plant necessarily has some effects on the local community and on the natural environment. These impacts may be both positive and negative.

3.1 Impacts on the natural environment

3.1.1 Construction phase

Roads, tunnels and infrastructure have to be constructed, which cause physical and visual impact on the landscape. As with any large engineering project, the disruption in the construction phase will include churned ground, mud, vehicle emissions, noise and congestion as heavy, earth-moving and tunnel boring equipment move over the land, cars go to and fro and encampments are set up for workers.

Depending on the sensitivity of the site, in terms of its biodiversity and conservation value, this construction will have inevitable impacts. However, careful site selection, good working practices and mitigating measures adopted as a result of conducting a thorough Environmental Impact Assessment (EIA) will help to minimise the disruption and ensure restoration measures after the project is completed.

3.1.2 Visual impacts

The visual impacts of hydro plants tend to be proportional to their size. Large hydro schemes have large dams, powerhouses and other infrastructure which, in bare and open terrain, may look out of place and spoil the natural beauty of the environment. However, many of the visual impacts associated with hydro stations in the past are no longer a problem as the availability of sophisticated tunnel boring machines (TBM) mean many modern power plants are largely built underground and water is channelled to the underground turbine halls via concealed penstocks or tunnels.

Smaller schemes can use good design and colours to blend in with the landscape to minimise the visual impact. Penstocks can be buried rather than being visible on the hillside; buildings can be in traditional local style. If visual impact is of high priority for the local community, this fact should be made clear during the public meetings held at the planning stage so acceptable solutions can be found.

3.1.3 Aquatic ecosystems

Alterations in the river flow have an impact on the aquatic ecosystems. Also, the quality of water in terms of dissolved oxygen levels may be affected. Of all potential impacts, those on fish populations are generally taken to be the most important. The greatest of these is on migratory species, because the hydropower scheme can create or increase obstruction to their migration. Similarly hydro schemes can also present a barrier to the downward migration of smolt and non-migratory fish. These impacts can be mitigated by the use of fish passes, lifts and ladders to allow the upward migration of fish and the installation of grids or screens across water intakes and tailraces to prevent the entry of fish into the turbines.

3.1.4 Habitats

Hydro plants can cause disturbance to vegetation, birds and wildlife and can cause changes to, and loss of, habitat. This is particularly apparent if a large dam is built and the resultant flooded area for reservoir results in the destruction of heathland, forestry or agricultural land. Areas of high biodiversity, possibly with rare or endangered species, will require special measures to protect the habitats.

3.1.5 Transmission lines

Hydro, like all other power plants, needs a transmission system of pylons and transformers stretching across the countryside. These also have a physical and visual impact on the landscape and present a hazard for birds. However, pylons are not new and people in general have accepted them over the years as part of the price to be paid for the advantage and convenience of having electricity at the flick of a switch. Also, it must be said that cables can be buried where the impact is unacceptable.

3.1.6 Environmental Impact Assessment (EIA)

The above environmental impacts must not be dismissed as unimportant. It is crucial that professional EIAs are conducted and mitigation measures are implemented to ensure that disturbance is minimised and that precious and irreplaceable species are not displaced or threatened.

3.2 Environmental benefits

3.2.1 Research and designations

It is interesting that, quite often, rare or previously uncatalogued flora and fauna are only discovered because an EIA is conducted, so in that respect the development is beneficial. Also, the research is of intrinsic value and adds to the body of scientific knowledge but it would not have been done had the developer not paid for the EIA. In addition, if the plant is in a high conservation area, it may be decided that the area around the plant should be designated as a national park or a site of special scientific interest (SSSI) in order to preserve it and restrict further development.

So it can be argued that the park owes its existence to the development since it seems it is only when the natural environment is perceived to be under threat, that its true value is appreciated and action is taken. However, it is also recognised that hydropower is an intrinsically clean technology and many countries of the world demonstrate that hydropower plants and national parks can co-exist very well. (E.g. Snowdonia National Park, North Wales houses the Dinorwig and the Ffestiniog Pumped Storage Schemes).

3.2.2 Irrigation and flood control

Another positive aspect is that the water used by hydro plants to make electricity is not lost. In most countries, once it has passed through the turbines it is channelled through the tailrace and back to the river rather than straight into the sea. So this water is available for use for many purposes including irrigation, thus improving land for agriculture. Similarly, hydropower dams can be used for flood control in countries where this is an annual problem. In this way, some very damaging impacts on the environment are avoided.

3.2.3 Slowing down global warming

The overwhelming benefit of hydropower is its effect on the global environment. By replacing fossil-fuelled electricity generation, particularly in coal-fired power stations, it reduces atmospheric pollution and the resulting acidification of rain, soil and aquatic systems. Hydropower emits very few greenhouse gases in comparison with fossil fuel power stations and thus it has a very significant, positive impact on the natural environment since it contributes to slowing down global warming.

3.2.4 No dangerous waste products

Unlike nuclear power, hydropower generation does not result in accumulations of spent uranium fuel containing radioactive waste and plutonium. Nor does it produce other solid radioactive waste which requires permanent storage as a means of 'disposal'. To date, no country has solved the problem of finding a safe depository for permanent storage of waste but, in spite of this, the nuclear industry has recently started to claim that it should be considered alongside renewable energy sources since it does not produce greenhouse gases.

However, its utilisation of plutonium in the fast breeder reactors and its legacy of radioactive waste in gas, liquid and solid form presents an enormous threat to the natural environment, without even starting to factor in the possibility of a Chernobyl, 3 Mile Island or Twin Towers scenario. By comparison, hydropower, with water as its fuel and water as its waste product, deserves high recognition for its benign and beneficial impact on the natural environment.

3.3 Economic considerations

3.3.1 Capital costs

In commercial and economic terms, the greatest obstacle facing hydropower is the high capital cost of development, relative to other options. A hydro plant cannot be purchased ready-made; it has to be tailor-made to make best use of the water resources and topography available at the chosen site. It requires extensive planning and the input of skilled personnel and consultants with a high degree of knowledge and experience. Depending on its size and scale, the construction costs and the cost of equipment and machinery are also considerable.

However, once the hydro plant is built, it becomes a very attractive option since equipment reliability is very high and maintenance requirements are very low. Hydro plants are typically extremely robust and long-lasting, far out-performing competing power plant options both in terms of durability and generating costs since no fuel has to be purchased.

With annual operation and maintenance costs on average less than 1% of development costs, hydropower is the long-term economic preference. However, when only a short-term analysis is made, the reverse is usually true.

3.3.2 Financial solutions

Hydro projects that reduce emissions may be eligible for financial support under a variety of schemes. These include the Kyoto Protocol's Clean Development Mechanism (CDM) and many country-specific programmes that provide opportunities for a hydro developer to get paid for producing emissions-free power. Various international financial packages are available to reduce the difficulties of high start-up costs and the World Bank continues to play a big role, especially in developing countries.

In countries which have deregulated their electricity systems, an innovative scheme known as BOT (Build, Operate and Transfer) offers a solution to the high capital costs and takes account of the longevity of hydropower plants. Under the BOT arrangement, an international company or consortium not only agrees to build a hydropower station in a given country but to remain as its owners and operators, running the station and selling the electricity output to the country concerned until the station has made sufficient money to buy them out and take over the ownership and operation of the plant, perhaps some 20 years after start-up.

A variation on this scheme, called BOO (Build-Own-Operate) is being investigated by the Icelandic national power company, Landsvirkjun. It has signed a preliminary contract with Albania's government for a 30-year concession for the Bratile hydro plant south-east of Tirana, to be started no sooner than 2007.

3.3.3 Economic benefits

In spite of the daunting cost of developing new hydro schemes, there are many positive economic impacts connected to hydropower. These relate mainly to the creation of jobs, both in the construction phase and afterwards. Depending on the nature of the construction contract, work may be undertaken by domestic or international engineering companies. However, even if the main contractor is from abroad, there will still be sub-contracts and administrative roles that are fulfilled by national and local companies.

After start-up, employment opportunities will continue as a range of skilled electrical, electronic and engineering posts will be created on a permanent basis. All of these jobs create wealth and, by means of the multiplier effect, inject money into the local economy.

In addition, because hydro can produce electricity cheaply and with low greenhouse gas emissions, it is therefore very attractive to industry. Some hydro plants are built with a specific industrial customer in mind, as is the case with the Kárahnjúkar plant under construction in Eastern Iceland which will supply electricity to the aluminium smelter at Reyðarfjörður. Industry brings economic benefits to the community and large industry usually gives rise to satellite companies, which in turn create more jobs and wealth for the society.

3.4 Socio-political impacts

Many of the environmental and economic impacts of hydropower already discussed above are of concern to local communities. Also of concern, especially where the community is dependent on tourism, are visual impacts including the loss of waterfalls and cultural aspects such as damage to, or loss of, heritage buildings or archaeological remains.

3.4.1 Adverse media coverage

When dams are built, creating large reservoirs of water, the land that is flooded is often agricultural or grazing land, the loss of which has an immediate impact on the livelihood of people in rural farming communities. In the case of some large schemes, the area of flooded land is so great that entire villages are submerged and the population has to be relocated. This is the aspect of hydropower that receives the most attention and schemes such as the Three Gorges in China and the Narmada Valley development in India find themselves in the glare of worldwide publicity. The aim of the adverse publicity is to discredit the use of hydropower. However, in the developing world the death rate from respiratory disease, due to dirty energy sources, is very high and hydropower can help to alleviate this.

3.4.2 Compensation

All over the world, people are understandably angry when it is their house that is threatened by bulldozers when a new highway is built or their block of flats that is demolished to make way for an upmarket waterfront development. However, in general, provided there is advance consultation and sufficiently generous compensation and relocation, the changes are accepted. This is exactly the same for large hydropower developments. When planning permission is sought for a development, publicity materials must be circulated and public meetings held. In this way all aspects of the impacts on the community can be foreseen, alterations made where possible and fair compensation and relocation arrangements worked out well in advance.

3.4.3 The importance of communication

When the developers are international companies, the local or national government of the country concerned must facilitate the communication process and take charge of the administration of agreed arrangements. There are good examples of cases where this is achieved but they do not hit the headlines.

In the Kali Gandaki-A project in Nepal, the developers took care to involve the community in advance and gave them proper compensation for their losses. They also offered training, jobs, financial help for self-employment and an electric power supply. This is the acceptable way forward.

It is very difficult to condone big development that uproots and dislocates whole communities and completely changes their traditional way of life without offering a progressive alternative. However, it is unfair to blame the technology of hydropower for administrative failures in a highly emotive situation.

3.4.4 Protecting fragile communities

On the plus side, the jobs created by a hydro development have additional benefits for vulnerable rural communities since they can also help to arrest a decline in the population. Too often, the limited employment opportunities in rural areas are accompanied by rural-urban drift as young families leave in search of a better life. Once this happens, it is not long before schools close, services are cut back and the community stagnates and eventually dies.

Since hydropower developments often attract other industry, it can be a political decision by the government of a country to support development that will assist otherwise threatened communities. This fits very well if it is government policy to promote decentralisation and to avoid all commerce and industry being concentrated in urban areas or in the capital city.

3.4.5 Recreation and tourism

Reservoirs can be used for recreational purposes, for instance fishing or boating, and the roads and pathways around the hydro plant provide access to the countryside. This can be attractive for walkers and can also boost tourism.

It must be noted that in very sensitive and biodiverse areas it would not be desirable to attract masses of people. However, if mass tourism is already a problem then channelling people along set paths is preferable to having them trample the entire hillside.

When development surveys discover archaeological remains, they may be able to be preserved and become a focus of visitor interest. This happened at the Cordinanes scheme in the Picos de Europa Mountains in northern Spain, where a burial place was found when digging the foundation of the powerhouse.

3.4.6 Environmental interpretation

There is also an opportunity for interpretation of the natural environment so visitors may gain knowledge since it is through knowledge that people adopt a more responsible and caring attitude towards the countryside. Environmental research, done as part of an EIA, can be interpreted for the general public and for visitors. This can be posted on a website or can be displayed in Tourist Information Centres.

Hydropower plants in many countries have set up their own visitor centres so tourists can better understand how hydroelectricity is produced, what its value is and what engineering challenges had to be overcome during the construction of the plant. In addition to this, the visitor centres stress the value of the natural environment and it is clear that they could be an ideal venue for environmental interpretation.

4 THE IMPACT OF HYDROPOWER IN THE FAROE ISLANDS

4.1 Environmental impacts

4.1.1 Vegetation

In the Faroe Islands vegetation patterns change depending on altitude and 3 distinct vegetation zones have been identified - a temperate zone (up to 200 metres above sea level), a sub-alpine zone (200-400 masl) and an alpine zone (over 400 masl). Hydro schemes in the Faroes are located in the sub-alpine zone in areas of grass- or heathland. Impacts may also be felt in the temperate zone since penstocks descend to power houses built almost at sea level in order to benefit from the maximum possible head.

Biodiversity has to be measured at the individual sites to determine conservation value but vegetation includes a variety of herbiferous and vascular plants, lichens and mosses. There is a possibility of sphagnum mosses found in true blanket bog areas, which are rare in global terms and could merit World Heritage status. Over the years, natural vegetation has been greatly affected by the unrestricted grazing of sheep.

4.1.2 Wildlife and birds

Wildlife is limited (hares, rats or mice) but the moorland bird population is of high environmental value and it is necessary to ensure the nesting grounds of migrating birds such as oystercatchers, curlew, snipe, etc., are not unduly disturbed. Artic skua and merlin may be present and perhaps red- and black-throated divers on the peatland pools.

Some disruption during construction of a hydropower plant is inevitable but loss of habitat and long term impacts are relatively slight. Sea birds, nesting on the sheer cliffs, are not affected by hydro development.

4.1.3 Constructing the hydropower plants

Additional environmental impacts during the construction phase can be compared to the building of mountain roads and road tunnels. However, once the construction is complete and site reparations made, lasting visual and physical damage is much less than for quarries which leave a permanent scar on the landscape.

In the case of the Botnur power station, built in 1921, materials were brought in by sea and carried or winched up the hillside. Strond power station was built a few kilometres outside Klaksvík in 1931 and a winching arrangement was used to transfer materials from road level to the mountainside. In the 1980s when the Strond scheme was extended to channel water from Svartidalur, a helicopter was used to deliver materials.

The hydro plants built in the Vestmanna area in the 1950s and 60s had a greater impact on the environment since the scale of operations was larger. Access roads were built and a series of tunnels drilled & blasted through the mountains to maximise the water catchment area. Winches were still utilised but earth moving equipment and vehicles were also in use.

For the Eiði hydro projects, the first of which started in 1984, tunnel boring machines (TBM) were used for the first time in the Faroes. The rock that was needed to build the dam was taken from a quarry that disappeared underwater once the reservoir was flooded. In addition, the sloping outside walls of the dam were grass-covered to blend in with the landscape and avoid any negative visual impact.

4.1.4 Rivers & fjords

In many countries, the loss of a spectacular waterfall is seen not so much as a negative environmental impact but one which impinges on tourism. In the Faroe Islands, myriads of small streams and rivers flow down the steep hillsides and drain into the sea so, after heavy rain, the hills seem to be a mass of waterfalls, which quickly disappear when the rain stops.

In terms of drainage, prevention of blow-back of water during storms and landslides due to water-logged land, harnessing some of the rivers can be seen as an advantage. Aquatic ecosystems are at risk when rivers are channelled through tunnels and penstocks into hydro turbines but fish populations are not high and measures to protect them, if necessary, are taken according to the circumstances of the individual site.

Of highest concern, since the Faroese economy is almost totally dependent on sea fishing and related activities, is any impact a hydro scheme may have on the fjords and sounds. Consequently, after the construction of the Eiði 3 project, which harnessed approx. 40% of the rivers running into the Funningsfjørður, a research study was conducted to assess the impact of the reduction of river water on the water quality and ecosystems in the fjord and along the shoreline. The concern centres on whether the water in the fjord is exchanged sufficiently to purify wastes and neutralise the impact of human settlement and fish farming at the bottom end of the fjord.

The findings of the study will determine whether or not a licence will be granted for the third phase of the project i.e. Eiði 2 to proceed. The application for a licence was submitted in 2001. Preliminary results of the research suggest little or no impact on either water quality or on plankton etc. but further comparison studies will be carried out and final results published in 2006.

4.1.5 EIAs and designations

In global terms, the impact on natural habitats and ecology made by the existing hydro schemes in the Faroes would doubtless be classified as of low significance, in keeping with the relatively small-scale of the developments. However, the natural environment of the Faroe Islands is a precious resource and it is important that a full Environmental Impact Assessment (EIA) is undertaken for any new development. The assessment outlines counter-measures to reduce negative impacts on biodiversity and habitats. If it is felt that further protection is needed, then part or all of a chosen site can be designated as a conservation area or national park. The island of Vágar was designated as a special conservation area as a result of a proposal for a hydroelectric scheme at Lake Fjallavatn.

4.2 Economic impacts

In economic terms, the impacts of hydropower in the Faroes are generally positive. 34% of electricity produced in the country is by hydropower which reduces the burden of importing oil. The annual cost of purchasing oil has risen from DKK23m in 1997 to DKK53m in 2003 and costs are still rising.

4.2.1 Botnur, Strond and Vestmanna

The hydroelectric plant at Botnur has been running for 84 years, the one at Strond for 74 years and those at Vestmanna for 51 years (Fossá), 44 years (Mýrarnar) and 42 years (Heljareyga). Their construction costs have long ago been paid off and they have been producing cheap and reliable electricity ever since. Over the years various extensions, alterations and improvements have been made which have required some further investment. However, these upgrades resulted in increased flow, improved penstocks or bigger turbines which translated into significant increases in kWhs of electricity generated and thereby a return on the investment. These hydro plants represent financial assets for the electricity company and for the municipalities.

4.2.2 Eiði 1&3

When it comes to the Eiði project, the financial and economic situation is a little different since delays caused broken contracts and increased costs. Following the oil-shocks of 1973-4, which caused an exponential rise in the cost of oil, resulting in power cuts and enforced energy-saving measures, everyone was in agreement that increased hydro capacity was urgently needed.

Professional engineering surveys were undertaken and priorities decided. Following a refusal to build a hydropower station at Lake Fjallavatn in Vágar, it was decided to go ahead with the Eiði project and this was planned in several stages. A licence was granted in 1982 and, after much debate, Eiði 1 finally went ahead in 1984 and was finished in 1987.

The second stage, Eiði 3, was delayed a further 10 years due to the economic recession in the late 80s and 90s. It was started in 1997, following the signing of a new contract with the construction company, and was completed, on target and within budget, in 2000. Eiði 2 has not been started as the results of the Funningsfjørður environmental study have not yet been finalised.

4.2.3 Faroese rivers & waterfalls - worth gold

Capital costs were in excess of what was expected and budgeted for, but not because the inherent cost of the project was underestimated. There was some delay before getting the required licences but it was the unforeseen delay due to the recession that caused the original contract, signed in 1979, to be declared invalid and resulted in an inevitable increase in the costs.

SEV continues to advocate the economic benefits of hydro development and in 2000 went on record with the statement: "The water flowing in the Faroese rivers and waterfalls is worth gold". However since then, no further hydro development has taken place and instead there is increased dependence on oil, which will, without doubt, prove very costly in the long run.

4.3 Socio-political impacts

The dams and reservoirs of Faroese hydro schemes are relatively small-scale and have never resulted in the displacement of people or flooded any villages. However, they did submerge grass- and heathland for which the farmer/owners received compensation.

In the Faroes, hydropower plants have no role in irrigation or in flood control. However, the hydro schemes have resulted in agreements with the local municipalities regarding drinking water from the reservoirs.

To date, no Faroese hydro scheme has been built to attract or facilitate the operations of large industry but the Mýrarnar & Heljareyga development did have a specific customer in mind. In 1956, when the NATO headquarters indicated that they would require considerable power, this gave the impetus for the work to start.

4.3.1 Assisting vulnerable communities

It appears none of the Faroese hydro schemes was planned with the express purpose of preserving fragile communities. Both Vestmanna and Eiði are vulnerable, being dependent on fishing and tourism, but no attempt has been made to use the hydro development to boost the local economy. The schemes have resulted in only one job in each location and the electricity company, SEV, although registered in Vestmanna, operates from headquarters in Tórshavn.

With the opening of the airport tunnel in 2002, Vestmanna lost the valuable ferry trade and became a virtual cul-de-sac. The fact that it is well-established as a tourism centre, offering boat trips to the spectacular bird cliffs, means that it continues to attract summer visitors. However, now it has the first windfarm, in addition to 3 hydro plants, Vestmanna has, in essence, become a national centre for renewable energy production. It should be possible to exploit this fact, both for employment and tourism purposes.

4.3.2 Tourism potential

Hydro plants lend themselves very well to being tourist attractions, especially in scenic locations such as Vestmanna and Eiði. It is worth noting that in Ferðaráð Føroya's Ferðavinnuøkisætlan, published in 1994, the hydro plants at Botnur, Strond, Vestmanna and Eiði are all listed as the number one tourist attraction in their local area, under the miscellaneous category, alongside churches, museums and other places of interest. There is no mention made of any of the thermal stations.

Different countries link hydroelectricity with tourism in different ways, some concentrate on the recreational potential of reservoirs, some accentuate the access to mountain trails, some, like

Switzerland, transport visitors by cable car over hydro reservoirs to mountain top restaurants and offer multi-lingual guided tours of hydro plants deep in mountain tunnels.

The possibilities are endless and need not be expensive. Tours, film, website information, interpretive displays are all possibilities. Costly visitor centres are not required as existing buildings such as restaurants & cafes can be used and interpretation of the natural environment can be done alongside interpretation of hydro development.

4.3.3 National Centre for Renewable Energy

Since Vestmanna is a natural centre for renewable energy, perhaps interpretation of all the hydro and wind facilities around the country could be placed there with the result of stimulating people to visit the other facilities at a later date. Domestic tourism is just as important as international tourism and Faroese people would be very interested to see and learn more about renewables in their own country. The fact that the Faroe Islands is taking part in the Renewable Energy Islands Project could also be publicised and would perhaps link in with other Agenda 21 initiatives to promote sustainability.

When discussing the socio-political impacts of hydro development, it is clear that if the opportunities presented by the development are used creatively, they can bring many advantages to remote rural communities and can help to stem the tide of unemployment and depopulation.

5 HYDROPOWER IN THE CONTEXT OF ALTERNATIVE ENERGY SOURCES

At present, 60% of the electricity produced in the Faroe Islands is by oil (diesel & crude) in thermal stations, 34% is by hydro and approx. 6% by wind. In order to decide if this is the best fuel mix, it is important to consider the advantages and disadvantages of each of the three sources of power and to explore whether there are any possible alternatives.

5.1 Crude oil/diesel

5.1.1 Advantages

Oil can be stored and reserve stocks of up to 6 months supply held (provided safety precautions are in place to minimise the risks of explosion & fire). Planning permission to build thermal stations is not difficult to obtain. Conditions may be set but these stations do not attract environmental objections. Oil engines do not have to be custom-made but can be purchased off-the-shelf, quickly and easily. Oil is convenient for use on outer islands, which do not have access to an electricity grid.

5.1.2 Disadvantages

The use of oil for electricity production results in emissions of $C0^2$ and other greenhouse gases which contribute to global warming and climate change. Oil is expensive, has to be imported and incurs transportation costs. It is a fossil fuel and non-renewable, so at some point global supplies will run out. Prices and supply are both volatile and dependent on the geo-political situation.

Diesel/crude oil engines are expensive to run and need replacing after about 25 years. The electricity produced costs on average DKK0.40 in comparison with DKK0.05 for hydropower, calculated on the basis of fuel and maintenance costs. In recent years most of the thermal power stations in the Faroes have switched from diesel to crude oil as it is cheaper and contains more energy but it is also dirtier so the engines are expensive to maintain.

Oil is not a flexible source of power, is not able to start up easily and the electricity production is not energy-efficient. Thermal stations require chimneys of some 35m in height and, in addition, discharge large volumes of water at temperatures of 20-30°C from the cooling plant directly into the fjord.

5.2 Other fossil fuels

An examination of other energy sources reveals that the Faroes, like most small island groups, has a limited choice. Nuclear is clearly not an option and coal and gas, like oil, are polluting fossil-fuels which would also have to be imported. Coal produces even more pollution than oil. Liquefied Natural Gas (LNG) produces approximately half the quantity of greenhouse gas emissions as coal and in combined cycle gas turbines (CCGT) reaches high fuel efficiency, thus reducing emissions. LNG is preferable to oil but the investment costs of replacing oil power stations with CCGT stations would be high.

5.3 New Renewables

Of the renewable technologies, biomass (apart from waste for District Heating) is not feasible due to an unfavourable climate and limited land available for growing special crops. Photovoltaics have potential on a domestic scale. Tidal power cannot be harnessed since the Faroes have tidal currents rather than tides in the conventional sense and tidal stream power research is in its infancy. Wave power is still in the research and development (R&D) phase. So that leaves the established renewables - wind power and hydropower.

5.4 Wind power

5.4.1 Advantages

Wind power is a clean, renewable source of energy that does not incur fuel costs. In the past decade or so, wind has dropped its alternative energy status and has developed into a more reliable technology. Wind turbines have become quieter, more sophisticated, easier to install and extremely fashionable. Wind turbines are purchased ready-made and can be set up relatively quickly so there is not a long lead-in time before producing electricity.

The capital investment needed to start a windfarm is less than other options and obtaining planning permission is not difficult. Six wind turbines have been installed in the Faroes in recent years without attracting opposition on environmental or social grounds (as is a major problem in Scotland). Wind power can be used to facilitate pumped storage. Winds in the Faroes are usually more favourable during the day than at night and so the wind power produced follows people's daily pattern with regard to peak demand. Also, more wind can be used for generation in winter, which is when electricity is most needed.

5.4.2 Disadvantages

5.4.2.1 Obsolescence & maintenance

Wind turbines have a relatively short operational lifetime. Technological advances are so rapid that a model can become obsolete in 10-15 years. Maintenance requirements may necessitate large crane capacity and external technical support.

5.4.2.2 Location of windfarms

There are usually many restrictions on the location of wind turbines. They can not be sited near airports, military establishments, communications masts, populated areas, etc. It is also essential to choose the right hillside location, where wind conditions are favourable and turbulence is reduced. Poorly sited windfarms can result in many problems, including serious reductions in efficiency.

5.4.2.3 Environmental impacts

Windfarms have an impact on the environment and produce some disturbance during the construction phase as access roads have to be built. They function best if sited in open areas on hillsides but there may be some loss of habitat as a sizeable windfarm takes up a large area of land.

Windfarms also present a hazard for birds, especially migrating birds. Noise, flicker-effect and visual impact can be minimised if the wind turbines are well sited. The incidence of ice throw or of accidents from rotor blades shearing off is relatively low.

5.4.2.4 Impact on the grid

Wind is an intermittent source. Wind forecasting helps but it is difficult to predict wind patterns more than 36 hours in advance. If there is little or no wind, the turbines operate at reduced capacity or stop and if the wind speed is too great, again the wind turbines stop generating.

The wind turbines installed in the Faroes can operate with wind speeds between 4.5m/sec - 25m/sec. However, the wind frequently comes in gusts and even if the basic wind speed is appropriate for power generation, the sudden turbulence and resultant voltage variations can cause problems for the transmission network.

The modern wind turbines used by Sp/F Røkt and SEV minimise this impact but nevertheless the Faroese grid is very small and steps have to be taken to ensure system stability is not compromised. In addition, the Faroese transmission net is now up to full capacity for wind power, so there is no possibility of new windfarms being established.

5.5 Hydropower

5.5.1 Advantages

Hydropower is a clean, renewable source of energy that does not incur fuel costs. It is a flexible energy source and is not only useful as a base load but can be ready in seconds to deliver power for peak demand. As well as fast response, it also has a black-start capability as hydro plants do not need grid electricity to start. Hydropower plants have a life span of around 80 years and have low maintenance costs.

Hydropower keeps the grid stable by providing balancing power and ancillary services which are needed due to the intermittency of wind power. Hydro can work co-operatively with wind turbines to provide pumped storage. Reservoirs provide storage of water for electricity production and for supplementary municipal drinking water supply. Hydropower is a long-established energy technology and there is sufficient available unexploited potential in the Faroes to be able to double the current hydro production capacity.

5.5.2 Disadvantages

Hydropower schemes require costly infrastructure that has to be built to suit the individual site so capital costs are high and lead-in times are long. The schemes have a local impact on the natural environment and attract opposition because of this. Detailed environmental impact assessment has to be done and many conditions met before licences are issued.

5.6 The best choice of energy sources

When selecting the best fuel mix, it is important not to be totally dependent on just one source but to diversify and utilise all available appropriate sources to create the basis for sustainability. All energy sources have advantages and disadvantages, none is perfect, but it seems very clear that thermal power is not the best choice for the Faroe Islands, especially not in its current role as the major source of power.

At present, thermal power accounts for 60% of electricity production. If the Faroe Islands do intend to commit themselves to the Kyoto Protocol and agree to limit emissions of CO^2 and other greenhouse gases, clear measures are needed to reduce this dependence on oil. For reasons of cost and lack of security of supply, it is also urgently necessary to minimise its usage.

Wind power is a very attractive option to replace thermal power. It currently accounts for 6% of the electricity produced in the Faroes and is providing a valuable source of clean, renewable energy. Unfortunately, wind power development has already reached the maximum that the Faroese grid can allow, so there is no possibility of expansion.

Nevertheless, there is a very important and exciting role for wind power and that is to facilitate pumped storage. Entrenched preferences for one renewable over another should not lead developers into opposing camps. It is necessary to work co-operatively to reduce the need for fossil-fuel technologies and pumped hydro storage is one important way of achieving this.

However, in order to achieve a significant and direct reduction in thermal output, it is urgently necessary to increase hydropower production from a mere one-third of the total. Hydropower is stable, clean and renewable and, once the difficulties attached to building a new plant have been overcome, it comes closer than any other option to being the perfect source of power, at least at the present time.

In order to redress the imbalance of the current fuel mix, sufficient new hydro development should be undertaken to drastically reduce the reliance on diesel and crude oil and to restrict thermal power to providing back-up and for use on the outer islands.

6 CURRENT ISSUES AND FUTURE SRATEGIES FOR SUSTAINABILITY

6.1 From water to oil

For almost twenty years the country has been in a state of limbo, waiting and hoping for a better future, just over the horizon. Now a cross-road has been reached and some urgent choices need to be made in order to find the best way forward.

In the past there was a clear vision. That vision was to be as self-reliant as possible and to develop power from the most abundant source, nature-given water. There was a clear memory of the oil shocks of the 1970s and a realisation that diesel was strictly an interim measure until all the technically feasible hydropower development was completed and self-sufficiency was reached.

Then some unforeseen things happened, first the birth of an environmental movement opposed to hydro development, then the recession during the 90s. This brought a freeze both on energy use and new hydro development. Meanwhile, in the rest of Europe the electricity companies started to deregulate and many were privatised. In 1997, the Kyoto Conference achieved tangible progress by setting explicit and quantitative targets for signatory countries to reduce greenhouse gas emissions.

Then, at the turn of the millennium, the Faroese recession ended with the promise of a miracle. The nation was on target to find oil. With its own supply of oil, everything was possible. Oil could even finance hydropower development and the Faroes could follow in the footsteps of Norway towards 99% capacity. The Eiði 3 extension was finished and licences sought for the Eiði 2 extension but then nothing more happened - no new hydropower and no gushing oil wells.

Meanwhile, as the Faroese economy picked up, demand for electricity grew and the only way to satisfy it, apart from some limited wind power development, was to buy more and more diesel engines (crude oil) and buy more and more oil at higher and higher prices, resulting in more and more pollution.

Clearly, this is not a sustainable situation. So as 2006 approaches, what are the issues and what is the way forward?

6.2 Faroes and the Kyoto Protocol

Firstly, there is the unresolved question of whether the Faroe Islands should commit themselves to Kyoto Protocol targets. If the Government decides to do so, it effectively agrees to reduce pollution levels and must take steps to put this into action.

The Kyoto Protocol allows national commitments to be met through joint efforts, such as emissions trading, joint implementation (JI) and the clean development mechanism (CDM). In addition to the monitoring and recording necessary for compliance, domestic action is needed in terms of energy taxation measures and major energy policy decisions.

As regards electricity, the Government must agree to actively support and promote the development of renewables by setting a clear policy and timescale regarding applications for licences and rights of appeal, by guaranteeing that decisions, once made, will be binding and will not be reversed quickly after they are made, by facilitating loans and creating a stable framework for long-term investment, by encouraging R&D and by supporting, publicising, and introducing energy efficiency measures in all spheres.

Whether or not the Government actually signs an agreement at this stage is entirely its decision, but it is clearly time to start moving in this direction and to implement the changes that are needed to ensure a more sustainable future.

6.3 Off-shore exploration

There is also the issue of Faroese off-shore exploration and the effects that it might have on the country's future energy policy and economy. However, this can be virtually discounted from the present discussion. If reserves of gas were found in the Faroese sector, there might be a decision taken to replace oil-fired electricity production by combined-cycle gas which is less polluting and much more energy efficient.

Alternatively, any gas or oil found could be sold and the proceeds used to fund the development of renewable energy in order to make the Faroes into a 100% Renewable Energy Island (REI). In any case, there would doubtless be no difficulty in putting an unexpected bonanza to good use, but it is prudent not to rely on this eventuality.

6.4 Electricity company privatisation

Next is the looming issue of privatisation. In 1963, when SEV took responsibility to provide electricity for the entire country on an equal basis and for the same price, this was hailed as the realisation of a dream. A democratic structure was set up with proportional representation from every municipality. Now there is the threat that this may be dismantled. Privatisation of public companies has already become a reality in the Faroes, following the publication of the Caragata report in 1999, in order to gain money for the Treasury.

In theory, privatisation introduces competition which leads to more efficient management and reduced electricity prices for customers. However, some would argue it tends to have the effect of introducing a short-term mentality with emphasis on rapid financial returns and a consequent freeze on all long-term investment. In any case, if competition does bring prices down, then consumers become less conscious of the need for energy savings and tend to use electricity more wastefully. When more than half the electricity in the Faroes is produced in oil-fired stations, this has the effect of worsening the environmental impact, increasing the greenhouse gases and speeding up climate change.

For European countries which deregulated or privatised their electricity companies during the 1990s, the main advantage gained is to be able to buy and sell electricity across national borders. This gives the possibility of financial gain as off-peak electricity can be bought cheaply but high rates can be charged for peak supply and it also gives additional security by being part of a larger transmission network.

Countries using inflexible energy sources such as coal, oil, nuclear or intermittent sources such as wind power can benefit from the flexibility and stability of hydropower and hydro-producing countries are able to buy power during years of low rainfall.

Privatisation would not give this advantage in the Faroe Islands since the electricity transmission network is an isolated system. It would be very useful for the Faroe Islands if they could gain access to a larger grid as this would enable more wind power development, but due to their geographical position, there is currently no feasible, economically viable way of being linked to another grid.

6.4.1 Introducing competition

Of course, it is possible to introduce competition without dismantling the entire system and new generating companies could start up, as has been proved already by the Sp/F Røkt windfarm. It is not possible at the moment to introduce competition to build hydropower plants since in 1963 SEV was granted sole title to the country's water rights for electricity production for the next 50 years. If there are several generating companies competing to produce electricity, this has an effect on planning, finance, system operations and management. Separate cost centres have to be set up, strict rules have to be laid down and procedures adhered to in order to avoid disputes between the parties.

The transmission network is clearly a natural monopoly as any attempt to allow more than one company to run it would be disastrous. In addition, since the Faroe Islands do not cover vast distances or supply vast numbers of customers, it must be questioned why the electricity company should be divided into smaller units. A lot of time, effort and expense would have to be devoted to the enforced reorganisation and to sorting out the inevitable difficulties that would arise.

In some Scandinavian countries, the municipalities have formed their own electricity companies. This might be adopted as a model since the Faroese municipalities are already share holders but if this resulted in outlying communities being left to bear the full and actual costs of receiving power, then the Faroes would be taking a step back from the socially inclusive and egalitarian policy it created in the past.

So many variables make it difficult for the electricity company to continue to operate a sensible, long-term strategy if questions of future ownership and operational conditions are left hanging. This matter has to be decided and firm guarantees given so that the focus of activity can be on the real priorities of changing the fuel mix.

6.4.2 The need for better communication

SEV has a democratic framework and if greater openness is required, conditions can be set to achieve this. It is in the company's interests to explain what measures are being taken to ultimately achieve a better service for customers and to try to guarantee that the lights stay on and that interrupted supply (brown-outs) and power failure (black-outs) are not a frequent occurrence in future years. This can not be done unless the country is in charge of its own means of supply and unless the electricity company is allowed to go ahead to create the renewable capacity it knows is freely available.

Communication is all important; the issues need to be aired and the public kept abreast of plans and strategies. In spite of the Competition Council calling for price cuts, the general public is not necessarily motivated solely by short-term monetary gain. To many people and industry, the continuation of a reliable and renewable supply of power is top priority.

6.5 National Energy Policy

A preliminary energy strategy report has been prepared to set the framework for future legislation covering the generation, transmission and sale of electricity. It covers the fundamental interaction between energy, the environment and economy of the country, maps out the current situation and looks to finding solutions for the future. A working committee drawn from industry, supervised by the Ministry of Industry and supported by various experts and interest group representatives, is currently preparing the draft of the future energy policy that will be debated in parliament and be enacted into law, perhaps by the end of next year or soon afterwards.

The situation is becoming urgent. Unlike Norway and Iceland, the Faroe Islands do not have control of their own means of providing power for their people but they do have this possibility within their grasp, if the right decisions are made. Global climatic conditions are growing increasingly erratic. Reports of devastating and unprecedented natural disasters have been in the news throughout 2005. This not only makes decisions about reducing the emissions that contribute to climate change more urgently needed, it also causes disruption of the very supplies of fossil-fuels that contribute to the problem.

The severe hurricane season in the Gulf of Mexico resulted in the production of liquefied natural gas (LNG) being badly disrupted. As reported in the British press (The Independent, 22 October 2005), consignments of LNG destined for Europe have been diverted to the USA because they are closer and are willing to pay more for it. The battle has started to gain control of resources; the big players are determined and ruthless so what chance will there be for a little country such as the Faroes to get a fair share!

6.6 Strategies for sustainability

6.6.1 Energy efficiency

To move towards creating a sustainable energy future for the Faroe Islands, two consistent strategies are needed; energy efficiency and the expansion of renewable energy (to replace thermal production). The widest possible energy efficiency measures should be put in place and price incentives and publicity should be used to influence customer behaviour.

6.6.1.1 Smart meters and publicity

Smart meters can regulate peak demand and narrow the gap between demand fluctuations to achieve a degree of energy efficiency. SEV has already started a project to replace electricity meters so that customers can get computerised information about their own bills. If SEV also set different tariffs for low and high demand periods, then customers become motivated to make cost-saving efforts. As customers start to use electricity at night or early morning instead of at mid-day, this results in a change in patterns of consumption. This, in turn, causes a levelling-off of peak demand and reduces the burden of providing back-up capacity.

Even without price incentives, some changes in behaviour can be achieved simply by keeping the public informed and by explaining the importance of the issue. It is not enough that SEV managers and Government ministers know the urgency of the situation if they do not find ways to communicate this to the rest of the country. SEV's educational programme and its energy counselling service for households and industry are moves in the right direction but have not received the sort of government and media support that would make up-take attractive and fashionable, rather than just worthy.

If banks and building societies can publicise savings accounts and mortgages so effectively with the media assisting by conducting interviews and TV debates and turning them into virtual news stories, why can this not be done with electricity matters! SEV does not have to be privatised to employ the publicity techniques used in private industry.

6.6.1.2 Green accounts

A green accounting or similar scheme could be established for business and industry to publish details of their environmental policy regarding energy use, waste disposal and transportation. With regard to energy, this would encourage companies to evaluate their manufacturing or operational methods, their heating and cooling systems and general use of electricity within the workplace. This would motivate them to utilise their resources better in order to eliminate any unnecessary waste and to bring about energy efficiency improvements which would save them money. SEV could lead the way by scrutinising its own systems and use of resources and publishing these for public information. A league table of companies could be set up with a prize and award ceremony for the most energy-efficient company.

6.6.1.3 District heating/combined heat & power (CHP)

In addition, measures are needed to make more efficient use of the energy sources available. A district heating scheme is in place in Hoyvík based on the burning of biomass in the form of municipal waste from the refuse company, KOB. A similar scheme in Leirvík is used by industry to dry fish heads for export. Suggestions have been made to utilise the excess heat produced at the Sund power station to provide district heating.

Oil-fired stations only have a fuel-efficiency of around 40% so a great deal of energy is lost in the form of heat from the chimneys and from the hot water discharged into the sea from the cooling system. By investing in a heat exchanger, this by-product heat can be harnessed and used for district heating. This would greatly improve the efficiency of the electricity production cycle and would contribute to the reduction of greenhouse gas emissions as the houses in the district housing scheme would not be burning diesel in their own boilers. Since the by-product heat contains a lot more energy than that produced in normal domestic boilers, this is an additional benefit.

Electricity production using fossil fuels is not sustainable and should be phased out. However, as an interim measure, while more renewable capacity is provided, it is a useful option to link it to district heating in order to increase energy efficiency and to reduce overall emissions. There is the danger, of course, that firm contracts to supply district heating could lead SEV into the position of having to purchase more oil-fired capacity to ensure uninterrupted supply. This is only acceptable provided it does not reduce investment funds available for renewable energy development and provided no one forgets that this is a temporary solution to reduce the harmful impacts of the present system.

6.6.2 Renewable energy

Making oil-fired production more efficient and less polluting may be sensible, but it does not address the real issue of being in control of the means of electricity production. For this, only renewable energy has the answer. Developing renewable energy means expanding hydropower production since wind power is already up to the maximum capacity that the transmission network can tolerate. Hydropower is the best solution for the Faroes since it is a reliable and efficient source and is freely available. In past times people could go and cut peat to provide for their family but now they do not have this right; they are dependent on the government and on the electricity company. Faroese people have never hesitated to use the freely available resources of the land, sea and bird cliffs for fuel and food. Using the energy of the water in the rivers will enable them once again to be self-sufficient, independent of external fuel supplies and in control of making the future more sustainable.

6.6.2.1 Expansion of hydropower

Several studies have been made by professional consultants, including the Norwegian firm Norconsult, regarding possible hydropower expansion in five main areas of the Faroes and these plans have been studied by the national engineering company, Landsbyggifelagið. A report entitled, 'Summary of Extension Plans' was published in February 2000. These extension plans cover a range of possible projects, including Eiði 2, and estimated costs per kWh have been calculated.

By undertaking these projects, it would be possible to more than double the current hydropower capacity. Along with the currently available wind power, this would bring renewables capacity to around 66MW. This could significantly reduce the need for thermal production. The hydropower projects range in size but are all relatively small-scale in global terms, with the smallest ones tending to be the most expensive per kWh. There will be some inevitable impact on the local environment and local communities but environmental impact assessments, mitigating measures, goodwill and cooperation can ensure acceptable solutions.

6.6.2.2 Community involvement

It is important that the Extension Plans should be made public and a clear agenda and timetable set for hydro development. Literature should be produced and information given in newspapers and on the company website. SEV's website has recently been set up as a first step to the electricity company having a more open and transparent organisation and it lends itself perfectly to being used to convey relevant material about hydropower expansion.

In addition, a series of public meetings should be held, as experience in other countries shows that the projects most likely to succeed are the ones that have public involvement from the start. Communities that are consulted and whose views and interests are given full consideration are much more likely to accept and support hydropower development. This is particularly true if the public meetings begin with a very clear presentation of the reasons why hydropower development is so urgently needed and what the dangers are to the community and to the country as a whole of continuing to depend on oil.

It is much easier for a community to accept disturbance to and alteration of their local environment if they know it is for the greater good and that in future it will also benefit their children and grandchildren. Of course there will always be a minority of people in opposition but it is essential that the majority of people understand and accept the necessity for the development so it can go ahead.

6.6.2.3 Urgent action and balanced judgement

As well as starting the public debate, the electricity company also has to establish its priorities and timescale for the projects. It has to commission surveys and environmental impact assessments and apply for licences. It also has to arrange finance, make contracts, undertake a lot of strategic planning and preparation and get work set in motion with a degree of urgency. With all this technical, financial and administrative work to do, it is tempting for the company to say there is no time to spare for entering into a big public relations exercise, but unless this is done and done successfully, the progress of the whole development may be jeopardised.

Of course, it is true that time is running out as hydropower projects cannot be completed overnight. However, efficient methods, set timescales, 24-hour shifts and a great deal of determination and dedication will ensure results. In addition, a sense of perspective and balanced judgement is called for from the communities involved and from all Faroese citizens. If a sub-sea road tunnel can be completed in 3 years without attracting any environmental protest in spite of the fact that its only purpose is to facilitate the movement of traffic, which is after all a source of environmental pollution, then surely a project to secure renewable energy supplies can be equally expedited.

6.6.2.4 Publicity campaign

SEV is a company of long-standing and may well have a cumbersome structure and rigid working practices, but it has to rise to a new challenge. It has to adopt a modern approach and use marketing techniques to 'sell' its product and its service to the customers just like shops and banks and other companies do. People do not buy unless they are convinced of the value of the product. (Sometimes they buy because they are frightened of the consequences of not buying e.g. smoke alarms, health products, child-safety equipment, etc.). It is up to SEV to show people the value of hydro development and to convince them of the consequences to the nation of not supporting it.

SEV has a network of representatives in local areas who are in an ideal position to disseminate information, lead public meetings, discussion groups, etc. There is no need to wait for parliament to start discussing the issues next year. SEV could start a regular energy column in one of the national newspapers, produce literature, put meaningful information on its website and set up an energy chat line. It could enlist the help of TV and radio to bring energy issues to the public attention and keep them in the headlines so an informed public can guide their MPs to make the right decisions. MPs in all countries tend only to see as far ahead as the next general election but there is no place for short-term thinking here; there is no margin of error. If the wrong decisions are made, the country will pay the price.

6.6.2.5 Pumped storage

As well as implementing the hydro projects that are already mapped out in the Summary of Extension Plans report, another look should be taken at the Feasibility Study for a Wind Energy and Pumped Storage Development near Vestmanna. The consultants were asked to carry out the study within the limited framework of existing hydro operations at Mýrarnar and Heljareyga and were not allowed to disrupt patterns of water use from the 2 reservoirs. Since the hydro installation systems were tailor-made for the site, it is no wonder that it was concluded there was no viable role for wind turbines and pumped storage.

However, with a different perspective and revised terms of reference, this project could be made to work and would prove an invaluable asset. With annual oil costs around DKK50m and rising year on year, this project would justify the investment and would achieve several simultaneous advantages. It would reduce the need for oil-fired generation and therefore reduce oil costs and greenhouse gas emissions as well as increasing the renewable energy capacity and making the Faroes a little more self-sufficient and independent in terms of satisfying energy demand.

In addition to the Vestmanna project, there may well be other opportunities to use pumped storage and utilise wind power. If there are no natural lakes at appropriate elevations, man-made reservoirs can be built or alternatively, sea-water pumped storage might be investigated like the plant in Okinawa, Japan which eliminates the need for a lower reservoir and avoids flooding an additional area of land. The cost of financing these projects would be high but for every kWh of hydropower produced, there is a corresponding reduction in the amount of oil-based production needed, resulting in the economic and environmental benefits mentioned above.

6.6.2.6 Community projects

The main strategy to reach sustainability within electricity production is to double the present percentage of hydro capacity within at most the next 15 years. However, there is no harm in private individuals or community groups taking their own steps towards self-sufficiency by means of photovoltaic panels, small off-grid windmills and perhaps by building or resurrecting mini-scale projects, such as the hydro plant in Kunoy. Mini-scale projects do not produce enormous hydropower generation and are proportionally more expensive than larger projects. However, mini-turbines and components have become more developed in recent years and mass production has helped to bring prices down. The experience of community-owned-and-managed schemes in North Wales, UK and in parts of northern Canada, suggest that in order to be successful such projects usually need to be developer-led.

6.7 Sustainable development

Sustainability has 3 dimensions - environmental, economic and social. It is clear that oil is unsustainable. It is polluting the environment with CO^2 and other greenhouse gases, it is causing a financial burden from annual fuel-costs and future insecurity of supply poses an enormous threat to the way of life of the people of this island community. Hydropower, on the other hand, is a clean source of energy with a relatively low impact on the local environment. It is an economic asset in the long-term (also in the short-term as it removes the need for oil-fired generation) and it provides society with a virtually everlasting energy source over which they have complete control.

In 1987, Bruntland defined sustainability as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In the Faroes the present population is enjoying a wonderful legacy built and paid for in the past. If hydropower development is halted in the 21st century on the pretext that it is too difficult or too expensive and that it is easier and more convenient just to go on using oil, what sort of legacy will the next generation inherit! It is worth noting that, as a result of the industrial revolution currently taking place, it is projected that China will be using 100 million barrels of oil a day by 2025. The total world oil production today stands at 84 million barrels per day and is not expected to increase much more.

6.8 Oil back to water

The world is aware of the impending fuel crisis. Frantic efforts are being made in many countries to find renewable energy sources and to find technological solutions to improve fuel efficiency before it is too late. Vast sums are being spent on research and development. All possible renewables are being examined and, in particular, energy storage solutions such as hydrogen technologies are being developed as fast as possible. Neighbouring countries such as Iceland, Denmark and Shetland are involved in this and Iceland has already adopted hydrogen-operated buses but electricity storage solutions may take several decades to come on the market. The Faroe Islands are currently taking part in a tentative effort to develop wave power via the new company SeWave. However the results of most of the research and experimental trials can not be expected immediately. Wind power was developed many years ago but it is only within the last decade or so that it has become a main-stream technology and even then there are certain problems to be overcome.

It is to be hoped that viable alternatives will become available and people in the Faroe Islands will never suffer serious disruption of electricity supply. However, it is not wise just to sit and wait, especially as there is a readily available renewable source at hand, namely water. Hydropower is not an experimental technology straight out of the research laboratory. It is tried and tested and the people of the Faroes have been taking advantage of it ever since the first pioneers established the station in Botnur some 84 years ago. They were motivated to create electricity from hydropower to bring Faroes into the light; maybe the citizens of today will be equally motivated to prevent the Faroes being plunged again into darkness.

To quote Walt Patterson: “As society becomes ever more dependent on electricity, a power failure becomes like turning off a life support system”. In 1921, they still had peat and coal for heating and cooking as well as cod liver oil for their lamps but they did not wait until these fossil fuels ran out before they decided to develop hydropower. 84 years later it is not necessary to use the last drop of oil before expanding hydropower. As Professor Paul Steven from Dundee University's Centre for Energy, said, in his lecture to Oljutingið on 30 March 2005: “The Stone Age did not end because they ran out of stone”.

7 CONCLUSIONS

The Faroe Islands face a stark choice - to continue down the oil road or to switch to water. If they choose oil, the road ahead may be very slippery. However, there are obstacles along the other path too. Hydro development offers the chance to stop the pollution of the environment caused by thermal production; it offers freedom from dependence on foreign supplies of oil and gives the Faroe Islands a chance to regain control of their own future. The natural resources exist and there is plenty of untapped hydro potential. The knowledge, expertise and modern equipment to build extra plants all exist, even finances can be obtained but there is one major road block, namely environmental opposition.

One of the key environmental issues that renewables have to overcome is the imbalance between their readily apparent local impacts (loss of rivers) and their less apparent global benefits (reduction of greenhouse gas & acid gas emissions that would be produced by oil-fired generation). Ironically, the roadblock for hydro development has been erected by those trying to safeguard the local environment, the very same people who might be expected to be concerned about global pollution.

Sustainability implies a balance between, on the one hand, economic and social development and, on the other hand, preservation of the natural environment. The key word is balance. It is clear that promoting only one of these at the expense of the others, is not a sustainable situation. For example, few people want to see a world where profit and greed are the only driving forces.

Economic and social sustainability both imply development, change, progress whereas sustainability of the natural environment is taken to mean preserving, protecting, keeping everything in its natural state, as it was in the past, with no alteration allowed. Herein lies the conflict.

There is no doubt about the beauty, the special, unique qualities of the Faroese natural environment or about its ability to refresh the mind and soul but perhaps too much concentration on preserving it in an untouched state overlooks the needs of society. St Kilda has a natural, unspoiled environment. It has World Heritage Status for both its natural and cultural heritage but it exists now only as a museum, an interesting destination for conservationists and discriminating tourists as the island people have all gone; the last 36 remaining inhabitants left on 29 August, 1930.

The Faroes are a living community - a dynamic, modern society with 21st century needs, not least of which is the need for electricity. If concern for the environment takes precedence over the people, then this society may no longer be sustainable. There is a need for a balanced perspective, a willingness to reconcile differences and to work more co-operatively to find the best solutions.

In the same way, it is crucial to find a better balance in the use of the three available sources of power - diesel, wind and hydropower. Wind power can maintain its current position, although with increased emphasis on pumped storage projects and perhaps on hydrogen projects like the one in Utsira. However, diesel and hydro need to change places with each other in terms of dominance to let hydropower be increased to over 60% and diesel reduced to below 34%. The goal should be for wind power and hydropower to satisfy electricity demand in normal circumstances. There is no harm in having a lot of extra diesel capacity for back-up, just so long as it is not used.

Hydropower development needs to be actively promoted and facilitated. It should be treated equally and on a level playing field with the other energy sources. In terms of financial considerations, like-for-like comparisons should be made and costs calculated over an average hydro lifespan of 80 years rather than a short-term analysis. Global emissions costs should be quantified so diesel is penalised and hydro and wind rewarded. There should be objective, clear and fair rules governing the establishment and operation of all power stations and the regulatory authorities should apply the rules in similar ways. Hydropower developments are frequently delayed so that in-depth research can be carried out but this requirement does not apply to thermal power stations. For example, there has never been any scientific analysis of the impact on the marine environment of vast quantities of hot water being discharged into the fjord by the Sund power station.

A green light needs to be given to new hydro development. The full scope of hydro projects needs to be outlined and a clear long-term time-table drawn up in order to achieve the necessary doubling of hydro capacity within the next 15 years. The right framework has to be established so the public debate can start. Targeted, powerful, thought-provoking publicity materials need to be prepared and disseminated through all available media to outline the issues and present the choices. TV and radio can be used to set the tone of serious debate, co-operative working and intelligent decision-making.

At the same time energy efficiency measures should be introduced urgently and discussion about the topic included in the public debate. Meanwhile, the electricity company could review its own activities to see if there are any changes to be made that would result in an improved utilisation of water resources. Other companies and industries could be encouraged to do an evaluation of their use of resources and could find ways to cut their costs as well as saving precious electricity.

To conclude, the path to a more sustainable energy future is not static. It must be continuously reassessed. Hydropower may not be perfect, but it is the most sustainable of the present options. At some time in the future a better source of renewable energy may become available. If so, it will be considerably easier to drain the reservoirs and let the rivers go back to their courses than to refill all the oil wells, which at the moment are being emptied at record speed.

8 RECOMMENDATIONS

To make electricity production in the Faroe Islands more sustainable, take action to reach 70% generation by renewables by the year 2020.

To achieve this:

- build at least 30MW additional hydropower capacity;
- utilise wind power for electricity generation and for pumped storage;
- implement energy efficiency measures;
- encourage all forms of renewable energy.

Glossary of abbreviations

ACRP	Acquisition, Compensation and Rehabilitation Plan
AMR	Automatic Meter Reading
BOO	Build, Own and Operate
BOT	Build, Operate, Transfer
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CFBC	Circulating Fluid Bed Combustion
CHP	Combined Heat and Power
EIA	Environmental Impact Assessment
EOR	Enhanced Oil Recovery
FNU	Føroya Náttúru- og Umhvørvisverndarfelag
GHG	Greenhouse Gas
ICOLD	International Committee of Large Dams
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
LNG	Liquefied Natural Gas
masl	metres above sea level
MMP	Mitigation Management Plan
NATO	North Atlantic Treaty Organisation
OWC	Oscillating Water Column
PV	Photovoltaic
R&D	Research & Development
REI	Renewable Energy Island
SSSI	Site of Special Scientific Interest
TBM	Tunnel Boring Machine
UNESCO	United Nations Educational Scientific and Cultural Organisation

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