smallest
empowering the smallest communities renewably

Northern Periphery Programme 2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

"Promoting Unst Renewable Energy (PURE) Project"

1 - Project Aim

The Promoting Unst Renewable Energy or 'PURE' project as it is most commonly known started in 2001. The main aim of the project was to introduce sustainable renewable energy to Unst, in order to enhance its "Green Island" image and help it work towards energy sustainability.

Initially and as a firsts step towards the Island's Sustainability, a local industrial estate was selected to become a green estate. The Estate's offices were identified to be suitable for green energy as being near an empty field, whereby green technologies could be implemented.

The issue for this implementation was the lack of electrical grid connection, hence the need for an innovative solution for integrating green technologies on the island. As no renewables could be connected to the grid, the community decided to work a solution that allowed to store the renewable energy. The idea was simple. When there was renewable energy, this energy would power the estate. When there was excess renewable energy, the excess energy would be stored. When there was no or little renewable energy, then the stored energy would be used to supply the estate.

Therefore the main aim of the project was to provide a complete offgrid renewable energy solution for powering an estate. The proposed Renewable Energy solution was to deliver a reliable source of electrical and heating energy through the use of renewable and energy storage technologies. This led to the selection of storing wind power as the primary energy source into hydrogen, and from Hydrogen fuel cell technology to deliver an uninterrupted power supply. The combination of cutting edge renewable and hydrogen technology provided an accelerated learning environment for people to learn about the technologies. The project aims can be summarised as follows:

- Provide a Renewable Energy solution to the local Industrial Estate
- Provide a demonstration model for renewable energy packages that can be applied in a number of situations
- Provide an offgrid solution for other communities
- Use latest hydrogen technologies
- Enhance marketability of products & services powered from renewable energy
- Promoting the image of Unst as a "Green Island"
- Provide a focus for accumulating knowledge of renewable energy within the Shetland Islands
- "Kick-Start" a Renewable Energy based industry in Unst
- Provide learning opportunities for students
- Provide access to training and knowledge transfer.

3 - The PURE project and its potential impact on Communities Globally?

It is a fact that 40% of the world's population (over 2 billion) live in remote location & communities. It is also a fact that most of these populations do not have access to basic electrical power.

Global remote communities face major challenges on a daily basis, most of which are related to energy as follows:

- Remote communities constantly face energy insecurity when compared to their counterpart city inhabitants
- Communities pollute more per head of population as they are required to travel longer distances to access basic human needs
- Communities are currently the only ones that are really & mostly affected by global warming and climate change
- Many remote communities spend over 20% of their income on energy

Further to the aforementioned, one of the most important issues faced by communities is the non existence or weak electrical grid networks to supply them with power. Weak grid networks make the connection & development of renewable energy sources in rural areas almost impossible, hence adding to pressure to remote communities. In summary communities are left with:

- Weak grid infrastructure
- Lack of availability of grid connections
- High cost of new grid connections
- Issues associated with the intermittency of renewable energy sources
- Lack of investment in grid infrastructures

It is not surprising that many remote regions around the globe experiences the greatest incidence of fuel poverty and that many people moves to the city for better living experiences (in the UK fuel poverty is defined as a household spending more than 10% of its income to maintain a satisfactory living).

With the changing economic climate of oil and gas supply versus higher demand, it is now clear that fuel costs will continue to rise. In 2008 alone prices for crude oil have fluctuated between $70 to $147, making communities even poorer due to increase energy prices.

Sadly, the majority of communities around the globe are surrounded by the most abundant renewable energy resources in the world including wave, tidal, wind, hydro, solar, biomass and others. Harnessing these resources for electricity generation and transmission is in essence barred by the weak grid infrastructure. The economics and

logistics of energy generation & distribution as well as fuel supply including heat & cooling create a unique opportunity for the early deployment of hydrogen infrastructure in communities rather than the cities. These pre-commercial deployments will benefit from higher energy prices, hence making them affordable today and accelerating hydrogen uptake globally. In this context the Shetland Isles community, one of the most remote community in the UK, has developed a hydrogen project to tackle the ever unpredictable energy prices & to free itself from the dependence on hydrocarbons. This hydrogen project was named the PURE® project.

2 - Project Summary

Project title: The PURE Project

Lead organisation: Unst Partnership

Key words: Education, skill development, technology transfer, renewable energy, hydrogen, fuel cell, green transport, energy storage

Country: Shetland, United Kingdom

Town: Unst

Project website: www.pure.shetland.co.uk

Project time span: 2001 to 2011

Project budget: GBP £400k

Funding sources: Highlands & Islands Enterprise, European Regional Development Fund, Shetland Islands Council, Shetland Development Trust, Unst Partnership

The PURE project is a pioneering project on the windswept island of Unst, the most northerly island in the British Isles. Figure 1 illustrates the Island of Unst in perspective to the United Kingdom. The PURE project demonstrates how wind power and hydrogen technology can be combined to provide the energy needs for a remote rural industrial estate. It has been developed by the Unst Partnership Ltd., a community development agency established by the Unst Community Council to support local economic development and regeneration. The Unst Partnership saw the project as helping to address some of the principal needs of the community. In laying the foundations in Unst of an embryonic hydrogen economy, the PURE Project has created jobs, new business opportunities, and attracted new technical skills to the island.

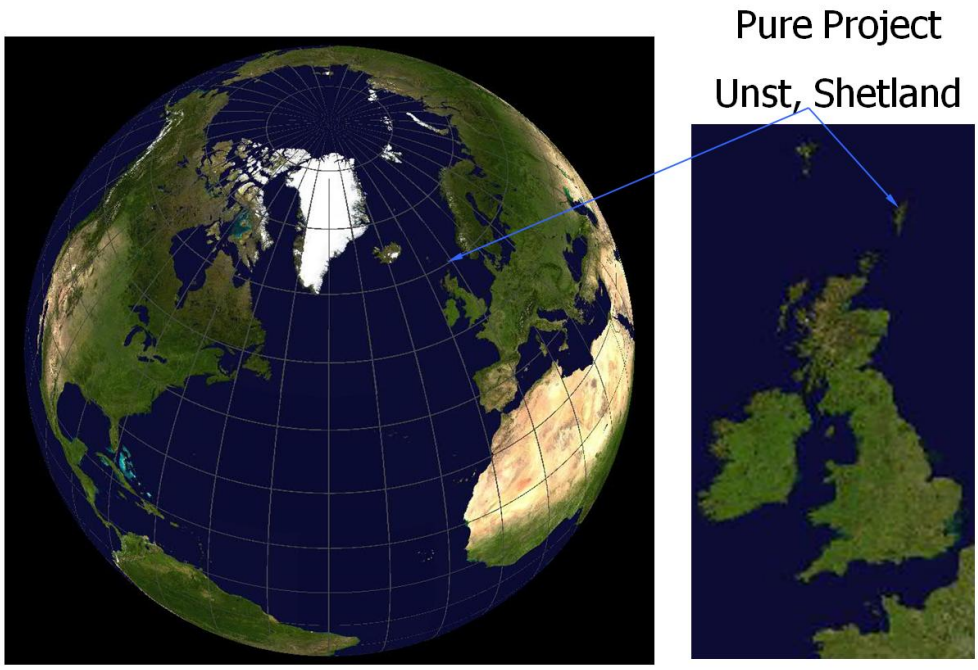


Figure 1. Shetland Islands

This is the first community owned renewable hydrogen energy project of its kind in the world, and represents an important milestone in the development of green energy systems at a community level. Figure 2 shows the PURE project at the launch event in 2005.

Figure 2: Pure Project Official opening day.

Although the wind resource in Shetland is among the best in Europe, its intermittent and unpredictable nature means that it requires a significant amount of load

management and storage in order to provide a dependable supply. Moreover, the limitations of the isolated Shetland electricity grid (Shetland is not connected to the United Kingdom electrical network), mean that the distribution company cannot accommodate any more firm connections from renewable supplies.

The potential for grid instability if more renewables are incorporated onto the Shetland grid, mean that for the foreseeable future, any renewable energy project must either be developed as an off-grid supply, or must incorporate a substantial amount of storage to provide assured predictable supply. In principle, hydrogen can provide such an energy storage medium for the surplus energy produced by the wind turbines. The hydrogen can then be used as and when required, either for conversion back to electricity via a fuel cell, or directly as fuel in much the same way as Liquid Petroleum Gas (LPG) or natural gas.

Whilst there are other electricity storage media (e.g. lead acid batteries) that potentially could be used to iron out electricity supply, hydrogen is the only one that is attracting massive amounts of public and private investment. The formal commitment by the US, Canada, the EU, Iceland, Japan and Australia to develop hydrogen economies, is already generating jobs, creating new businesses and supporting economic development in the areas prepared to embrace hydrogen technology trials and demonstration projects.

During the period of time the PURE Project has been in existence it has already created over 10 full time equivalent jobs on Unst, attracted around £400,000 of inward investment, transferred new high level technical skills to local graduates, and resulted in the start of new local business.

Being the most northerly island in the UK, Unst is effectively at the end of the supply chain for all externally produced commodities - specifically it has among the highest fuel costs in the country. A survey by Shetland Islands Council Social Services indicated that the average household income of Unst, at £16,860, is the lowest in Shetland. Moreover the recent energy balance study of Shetland's north isles, has identified the fact that an average Unst household spends over 15% of household income on fuel. (Fuel poverty is defined as anything over 10% of household income spent on fuel).

The high demand for fuel is compounded by the costs of heating during the severe winter weather, where wind chill penetrates even well insulated buildings. Hence the local and regional interest in the PURE Project which aims to produce on Unst an alternative to fossil fuel (namely hydrogen). This is done through electrolysing water with plentiful supplies of wind power, as shown on figure 3, the installed wind turbines. The successful implementation of this project have demonstrated that a viable alternative to fossil fuel, which produces zero carbon emissions, can be produced locally from a renewable energy source - even in such a remote rural community.

Figure 3: The two wind turbines that provide the primary power source for PURE

3 - The project

The PURE® (Promoting Unst Renewable Energy) project shown in Figure 4 is a pioneering hydrogen project on the windswept island of Unst, the most northerly island in the British Isles. The PURE® project shows how wind power and hydrogen technology can be combined to provide the energy needs for five (5) businesses. This is the first community owned renewable energy project of its kind in the world. It represents an important milestone in the development of green energy systems as well as hydrogen technologies. The PURE® Hydrogen system has been installed in a cubicle type container called the HyPod®. The HyPod® can be seen in figure 4.

Significant differences between the PURE® project and other hydrogen energy systems deployed around the world are the scale and the low budget within which it has developed. The PURE project has uniquely been developed with a comparatively small project budget of approximately £400,000 and thereafter the launch another £100,000, totalling £500,000. This budget included all the engineering, consultancy works surrounding the project, as well as the hardware.

Figure 4: Completed PURE Energy® system on Unst, Shetland

At present wind turbine technology offers the most cost effective method for generating green electrical energy. This technology was therefore selected to be deployed as the primary power source within the PURE® project system. The PURE Energy® system is unique in its design. The PURE® team designed the system so that any type of renewable resource can be connected to it. For example wave, tidal, solar, hydro or even the grid in case of green tariffs being used can be connected to the HyPod®.

The PURE® project consists of two 15kW wind turbines. It has a 3.55Nm^3 per hour high-pressure hydrogen electrolyser, high-pressure hydrogen storage system and a hydrogen dispensing facility. This facility is used to fill cylinders in a fuel cell/battery hybrid vehicle and other hydrogen applications. In the PURE® system hydrogen is used as an alternative to fossil fuels.

A back-up power supply has been installed and is based on a 5kW fuel cell and an inverter to supply the offices with electrical power when there is no wind. The hydrogen used by the fuel cell is produced from the electrolyser. The inverter was installed to convert the output power of the fuel cell from Direct Current (DC) into mains equivalent Alternating Current (AC).

A wind to heat system was designed and implemented to heat the five (5) business properties. It has been found that the best use of the wind power is to directly connect the wind power to the heating system warming up the buildings with green energy. The rational behind this is the direct correlation between high wind speeds and the need for increased heating energy. For instance when the wind speed increases, the buildings get colder. At the same time the more wind the more power the wind turbines generates. Hence most of the electrical power generated by the wind turbine is directed to heat up the buildings, provide a smooth temperature within the buildings.

Storage heater units have been installed in the buildings to store excess energy in the form of heat. Two types of storage heaters have been installed; The wet & dry types storage heaters. In the wet, standard radiators are used to heat up a building. In the dry system, bricks are used to heat up the buildings. The comparison between the two systems has shown that the wet heater provide lasting heating energy (4 days) while the dry system only provide a heat storage option of 12 hours. Though the wet system is better in heat storage terms, it is bulky, heavier and more expensive than its counterpart dry system.

A novel & intelligent electronic management system was specifically developed to maximise the efficiency of the system. This included a remote monitoring system shown in Figure 5.

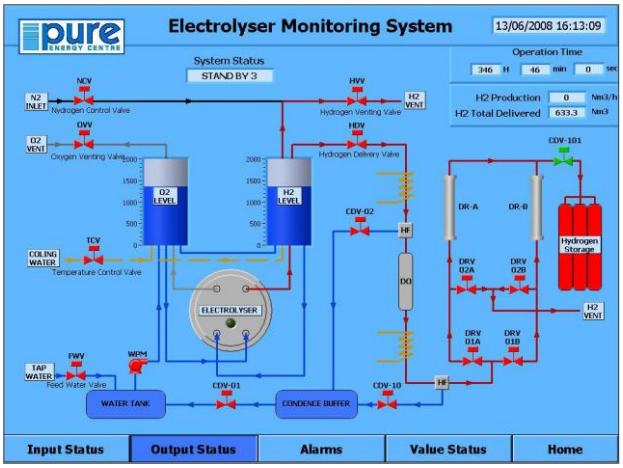
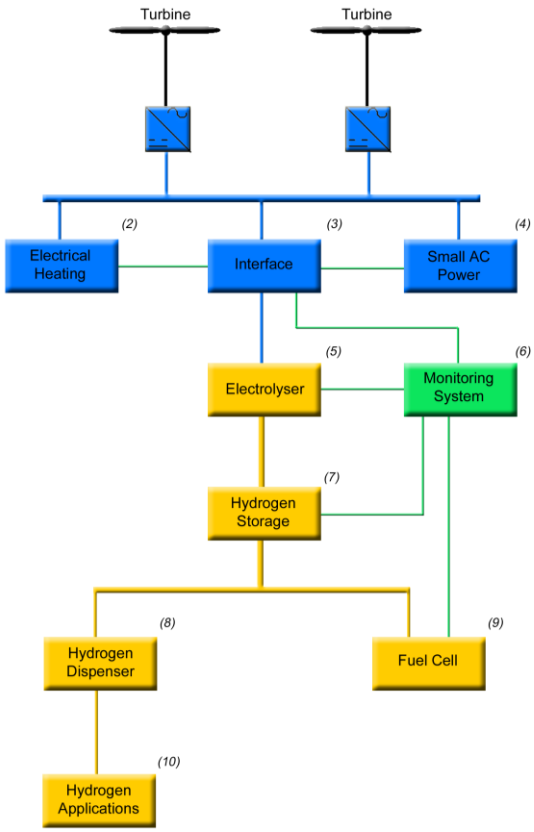


Figure 5: The PURE® energy remote monitoring system

A battery based electric vehicle was converted to run with a hydrogen fuel cell. This electric/fuel cell hybrid car is fully fuelled by the PURE® system, using hydrogen produced from the renewable source and the battery charged from the wind generation. This makes the electric car one of the only 100% carbon free vehicles on the British roads and the first fuel cell vehicle fully licensed to operate on UK roads. Figure 6 shows the fuel cell hybrid car with the Scottish Transport Minister Tavish Scott MSP, and Rural Affairs Minister Ross Finnie MSP, outside the Cabinet Office at Bute House in the Centre of Edinburgh (after driving from the Scottish Parliament in rush hour traffic. Minister Scott and Finnie are also shown with Sandy Macaulay one of the leaders of the PURE® project. Figure 7 illustrates the PURE project overview.

Figure 6: the PURE hydrogen® car, Minister Scott, Sandy Macaulay & Minister Finnie (from left to right)



1	Two Proven wind turbines
2	Electrical space heating system
3	Electronic System Control
4	AC Power conversion system
5	High pressure electrolysis
6	Data logging and monitoring
7	pressurised hydrogen storage
8	refuelling point for hydrogen car
9	PEM Fuel Cell
10	Hydrogen car, cooking, and on-demand power applications

Figure 7: Overview of PURE Project system

Whilst the direct impact of the PURE Project on reduction in carbon emissions is relatively small (c. 110 Mtons of CO2 per year), its real value is that it aims to provide a replicable model of:

- A community embedded energy scheme producing zero carbon emissions;

- A small-scale community run hydrogen production facility offering the opportunity to demonstrate and develop applications which use this locally produced fuel in a remote rural location which has zero carbon emissions.
- An off-grid facility for storing energy from an intermittent renewable source and re-using it in the form of electricity as and when required.
- An employment generating project which provides local residents with opportunities to gain new skills in the emerging hydrogen economy.
- A project which can demonstrate to the community the potential of renewable energy produced hydrogen in Shetland
- An embryonic hydrogen study centre that can attract some of the substantial investment to develop skills, jobs and businesses required to support a hydrogen economy. Figure 8 illustrates individuals receiving professional training.

Figure 8: International team of graduates receive hands-on training with the PURE System.

In summary, the PURE Project contains the following elements:

- Cavity wall insulation and other energy saving measures designed to improve energy efficiency at Hagdale industrial Estate by 30%;
- Two Proven wind turbines.
- Direct supply of wind power for all heating of industrial units;
- A high pressure electrolysis system for the production of pure hydrogen gas.
- Pure hydrogen storage and a hydrogen dispensing facility to fill hydride bottles for use in fuel cell vehicles and other hydrogen applications as an alternative to fossil fuels.
- Back-up supply of electricity to the industrial estate through 5 kW PEM fuel cell.
- Intelligent electronic management system to ensure optimised efficiency of interfaces between all elements of hybrid system, (including hydrogen fuel cell)
- Detailed monitoring and analysis of performance of the system to maximise learning opportunities and further developments
- An electric / hydrogen fuel cell hybrid car fuelled exclusively by the PURE system

The PURE project has generated considerable interest within other island communities in Shetland, Orkney, the Western Isles and Argyll, as well as rural communities in the UK and overseas. Although it may take some time for the capital costs of the plant to become cheap enough to attract a broad customer base for this kind of system, the scale of fossil fuel price increase over recent years and predictions of future supply shortages will make it viable much earlier. When the principal components of this kind of hybrid energy system have become sufficiently commercialised to produce from renewable energy, a financially attractive alternative to fossil fuels, it's market and its beneficiaries would be worldwide. Figure 9 shows a number of press cuttings amongst the 1000's published since its inception.

Figure 9. Press releases about the PURE project

The PURE project was officially opened by the then Deputy First Minister, Jim Wallace, on the 22nd May 2005. Figure 10 illustrates the Deputy First Minister official launch.

Figure 10. Deputy First Minister Jim Wallace Launching the PURE project

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