

“The Creed Waste Treatment Plant And The H2SEED Project”

**From community household waste to green
transport**

1 - Project Aims

The CREED waste treatment plant and H2SEED project have been designed to address three main problems; (a) reduce waste landfill; (b) reduce costly imported hydrocarbon based fuel; and (c) to provide a solution to a grid lock problem, where renewables cannot be connected to the weak electrical grid network. To solve the first issue, the Comhairle Nan Eilean Siar (Cnes) also known as the Western Isles Council in the Outer Hebrides aimed to develop a collection of community waste system and convert it into energy via a biogas plant. To solve the second problem, the Cnes decided to use state-of-the-art hydrogen technologies to dramatically reduce the isles dependence on imported fuel, hydrogen being the new fuel. To solve the third challenge, the Cnes aimed to develop a solution that can store excess renewable energy generation and use this excess in a set of applications such as cooking, heating, and others. The overarching aim was to equip the Outer Hebrides with knowledge, competences and technologies that will increase the penetration of renewable, provide a green alternative for imported fuel, create new job and business opportunities and enhance educational prospects.

In summary, the CREED and H2SEED projects have been set up to support the accelerated development of green transport, increase the penetration of renewable and reduce the level of landfills in the Outer Hebrides. The main goals were to first build a system that can make use of the community waste, then create an embryonic Hydrogen Transport Project and finally a hydrogen grid balancing system that can increase the level of renewable onto the electrical network. All of these goals were aimed at becoming of international, national, regional and local significance, thereby helping to place the Outer Hebrides at the centre of the global drive to create a low landfill waste region, low carbon community and a unique self sufficient economy.

2 - Project Summary

Project title: The H2SEED Project

Lead organisation: Comhairle Nan Eilean Siar (Cnes) or the Western Isles Council (Public sector), Stornoway Trust

Key words: Renewable Energy, biogas, skill development, technology transfer, green hydrogen, hydrogen vehicle green transport, energy storage

Country: Scotland, United Kingdom

Town: Stornoway, Outer Hebrides

Project website: <http://www.cne-siar.gov.uk/renewable/h2seed.asp>,
www.hydrogenhebrides.com

Project time span: 2006 to 2010

Project budget: GBP 700k

Funding sources: Comhairle Nan Eilean Siar (Cnes), Scottish Government

In common with other Scottish island groups, the Outer Hebrides have some of the highest fuel costs and the highest prevalence of Fuel Poverty in the UK. Over 97% of the energy consumed by the islands' 26,500 inhabitants is imported, while the average energy cost is over 13% higher than the UK average. With the changing economic climate of energy supply it is anticipated that imported fuel costs will continue to rise. Unfortunately, only one 33 kV line connects the islands to the UK National Grid. This inhibits severely the capacity to export power to the Grid and causes a significant instability and a lack of reliability of electrical supply. The economics and logistics of fuel supply in the Outer Hebrides create a unique opportunity for the early deployment of hydrogen infrastructure for demonstrating the pre-commercial hydrogen economy.

In parallel with their reliance on imported fuel, the Outer Hebrides have one of the richest renewable resources in the world, which if harnessed to produce hydrogen, offer a viable alternative to traditional fuel supply. In 2006 the Scottish Executive commissioned an assessment of the extent to which wave and tidal stream energy could contribute towards the national energy mix without significant effects on the environment. The study concluded that the Scottish wave power resource that could be extracted without undue environmental impact was between 525 and 1800 MW of installed capacity. Around 50% of this national total is predicted to be located off the Outer Hebrides. Additionally, the islands are also home to the best wind power resource in Europe; with an annual mean offshore wind power density in excess on 1200 W/m².

In this context, Cnes has developed an Outer Hebrides Economic Strategy that aims to [1]:

- Grow and develop the creative industries sector in the Outer Hebrides.
- Assist the creation and growth of creative industry businesses.
- Encourage creative individuals and businesses to locate to the islands.
- Promote the Outer Hebrides as a creative place at a national and international level.
- Increase the number of employment opportunities in the sector.

To this end, Cnes has constructed the Creed Waste Treatment Plant and has extended this worldwide structure to incorporate hydrogen technologies. The hydrogen project is called the H2SEED project.

The Creed Waste Treatment Plant is a unique project that takes community household daily waste and from it produces a gas, called biogas. From this biogas, it is easy to generate electrical power. Unfortunately, as the Outer Hebrides electrical grid infrastructure is weak, the Creed plant cannot be connected to the grid.

Therefore the Cnes decided to innovate by not connecting the Creed plant to the grid, but to store the green energy produced from the plant as hydrogen. This hydrogen would then be used to fuel a set of vehicles. Figure 1 shows the CREED plant as installed in the Western Isles.



Figure 1: The CREED Plant almost finalised

The innovative Creed and H2SEED projects are a leading global example of the infrastructure solutions required to respond to the inevitable long term decentralisation of energy generation, which will be created as global oil reserves decline and security of supply reduces. Cnes has supported this development by investing £450k and the Cnes has attracted £250k of funding from the Scottish Executive Renewable Hydrogen and Fuel Cell Scheme and £21k from the Stornoway Trust.

The H2SEED project in conjunction with the Creed Waste Treatment Plant provide a world-class hydrogen infrastructure and a unique process to utilise house waste to turn it into clean fuel for vehicles through hydrogen technologies.

The H2SEED project itself is an international example of a low carbon, sustainable and high energy efficiency facility for refuelling cars. Built to future hydrogen standards of “iconic” design, with a very low environmental footprint and low energy life cycle costs, the objective is for the facility to encourage exemplar work and research into low carbon energy systems.

3 - The project

The H2SEED project has been developed by the Cnes. It is the world first hydrogen infrastructure project to harness H₂ produced from biogas derived from municipal waste. It is also the first project of its type and size delivered in the Outer Hebrides community covering the whole value chain of H₂ technologies: H₂ production from biogas plant, H₂ storage, H₂ filling station and H₂ use in both stationary and transport applications.

H2SEED provides an innovative solution to the problem of not being able to export electricity onto the grid on an island a community set up. It also provides an innovative solution for use of the electricity generated by a biogas engine from the Creed Waste Treatment Plant, which otherwise would have been dumped. Furthermore, it is the starting point for the creation of both a lower landfill needs, hence a cleaner island, and to the conversion of the island to hydrogen fuel and infrastructure.

At present, the annual biogas production from the Creed Waste Management Plant accounts for 1,382,400 Nm³/year, with a methane content around 60%. Figure 2 shows a schematic diagram of the plant.

The biogas from the Creed is used to feed an engine producing electricity and heat. The plant is not authorised to export electricity to the grid due to technical constraints forcing the engine to operate at partial load. Operating at partial load, the engine temperature is reduced and the sulphur contained in the biogas corrodes the engine reducing considerably its lifetime.

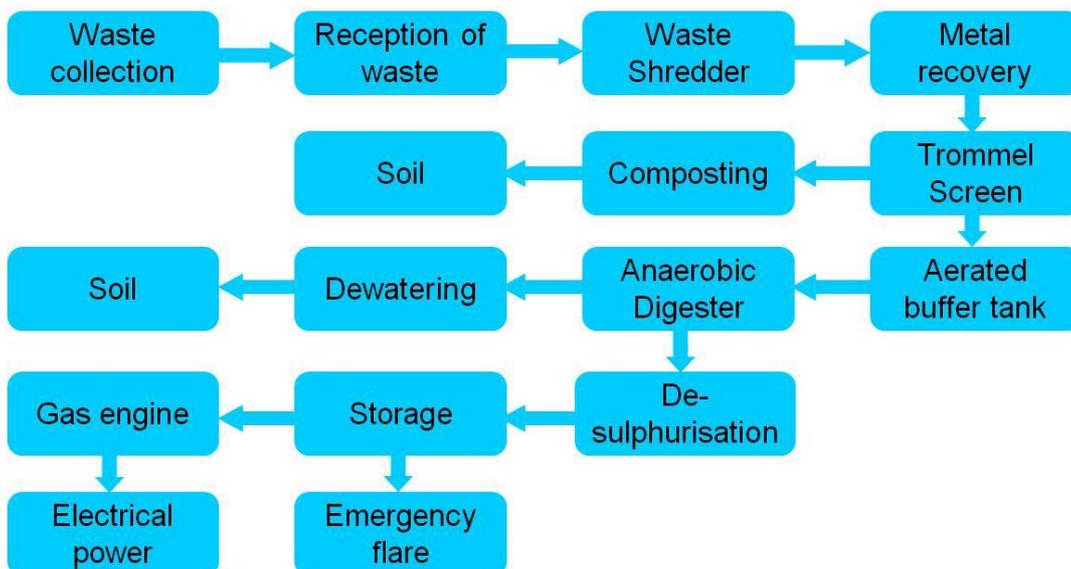


Figure 2. Schematic diagram of the CREED plant

With the present biogas production, the engine could operate for 8 hours per day from Monday to Friday at a partial load close to 80%. With these 8 hours of operation the match between the Waste Treatment Plant requirements and electricity production from the engine is maximised, providing, during this time, the 100% of the Waste Plant electric requirements and 40% excess. The heat produced by the engine could also be used for heating requirements of the plant, accounting for around 30% of total heating needs. The excess of electric energy generated accounts to around 700 kWh per day. Since this electricity cannot be exported to the grid, the innovative nature of this project consists of installing an electrolyser that will absorb this surplus. Figure 3 illustrates the Anaerobic digester partially built.



Figure 3. CREED biogas digester being built

Several different technologies for hydrogen generation were considered to use the excess energy, including the use of a natural gas reformer and a biogas purifier.

The selected option was an electrolyser. The electrolyser is a 5 Nm³/hour system (or 5000 litres of hydrogen per hour), working at 100% of its capacity. The system was designed to allow for an increase production capacity when the Waste Plant is

expanded. The H₂ produced is compressed to 430 bars and stored in a high pressure compressed tank. The storage capacity of the tank is around 700 Nm³ of hydrogen. Figure 4 provides a schematic diagram of the hydrogen system in picture format, while figure 5 illustrates the system as installed.

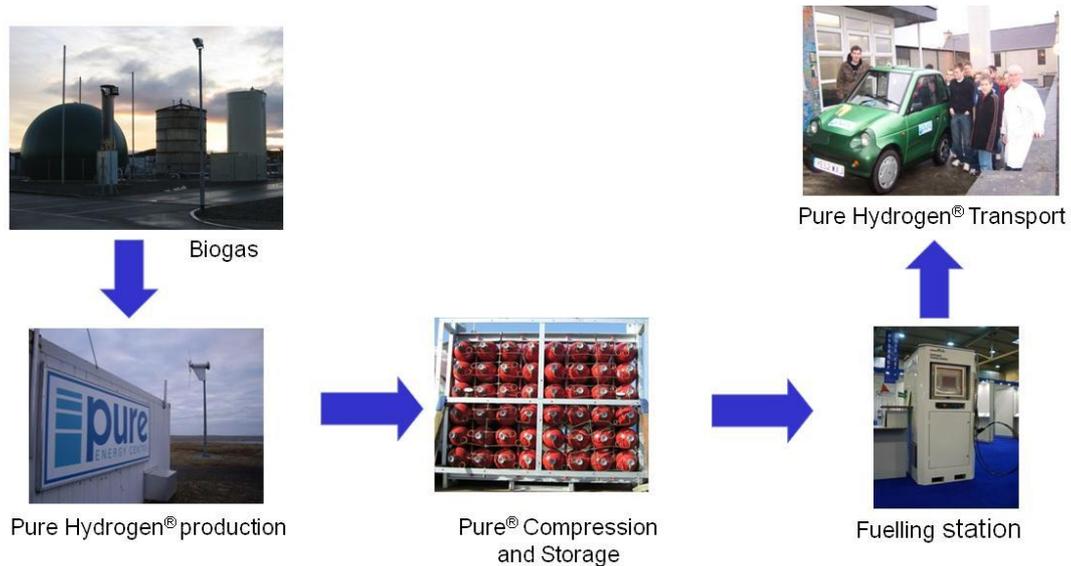


Figure 4: The H₂SEED Schematic diagram



Figure 5: The H₂SEED system as installed

The initial main application selected for the use of stored hydrogen fuel is transport. The rationale behind this is simple. The Cnes needed to demonstrate to the local community that the installed Creed and H₂SEED systems were both operational. The obvious choice was a high visibility application, which is a vehicle operating with hydrogen. In order to further capitalise on the hydrogen system, the Royal Mail provided a hydrogen vehicle, as shown below. The aim was to collect and distribute mail all over the island with green fuel, hence lowering the carbon footprint of the islanders and at the same time the carbon footprint of the Royal Mail. Figure 6 illustrates the Royal Mail Van being filled.



Figure 6. Filling the Royal Mail Van from the H2SEED hydrogen facility

The H2SEED and CREED projects have benefited substantially the Outer Hebrides communities. Below provides a number of these community benefits:

- Increase the lifetime of the biogas engine currently installed in the Creed Waste Treatment Plant.
- Produce a new, renewable, autochthonous and clean fuel (H₂) that will be used in vehicles.
- Reduce the need for importing fuel.
- Attracted a major fleet owner, the Royal Mail, to supply one of its vehicles for distributing mail, hence providing the community with a potential customer for the fuel being produced locally.
- Allowed the community to see that energy storage technologies can be used today.
- Allowed the community to start developing plans for the installation of renewable infrastructure, without the need for the grid. The H2SEED has indirectly unlocked the electrical grid.
- Creation of an embryonic hydrogen infrastructure in the islands that could grow in the near future with other renewable energy sources, such as wind energy.
- Raise public awareness, especially owing to the high visibility of the H₂ public vehicle fleet.
- Provide training in state-of-the-art H₂ technologies and the establishment of a specialist skills base in the Outer Hebrides (the islands suffer from a high rate brain drain as people pursue better education and job opportunities, whilst at the same time the islands' secondary school educational attainment is double the UK average).
- Creation of an attractive (innovative, environmentally friendly, dynamic) image of the islands that could be beneficial in terms of tourism, attraction of industry / investments, promotion of the islands as a potential "HY-COM" community.

The H2SEED project has had a unique media coverage and has put the Western Isles communities at the forefront of the renewable and hydrogen agenda. Some of the project outcomes were discussed at the National Hydrogen Association (NHA) conference and exhibition, the largest hydrogen conference in the world in the USA. The project has had a strong televised media coverage including BBC broadcasting, web based articles and many newspaper articles. The Western Isles communities understand that hydrogen is key to demonstrate the innovativeness of the islanders and local community groups are already drafting plans to develop further the concept. Leader of Comhairle nan Eilean Siar, Cllr Angus Campbell, said: "I am delighted that the Outer Hebrides is pioneering the demonstration of hydrogen technology. The Islands have the potential to be a centre for green energy if the available resources can be harnessed effectively and hydrogen is one way of achieving this. The outcomes of the trial are nationally significant and will form the basis for future developments in this revolutionary energy carrier."

Reference:

[1] Creative Industries Strategy 06-09