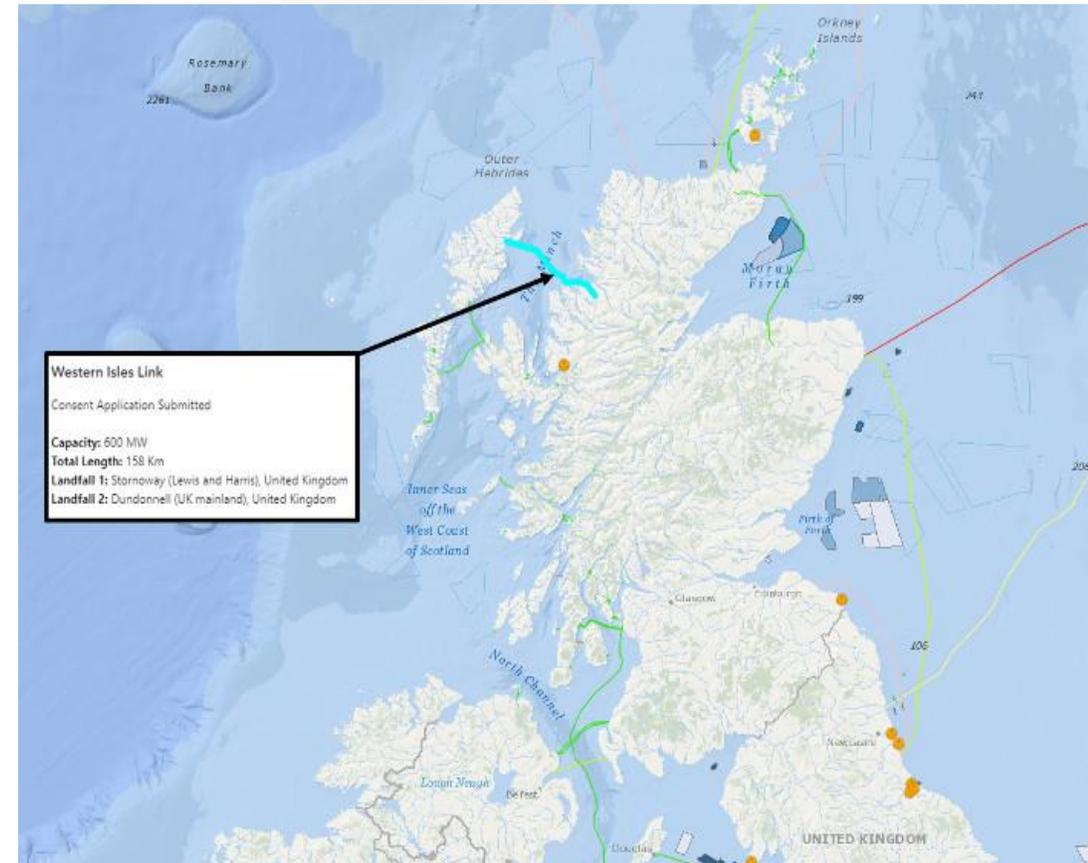
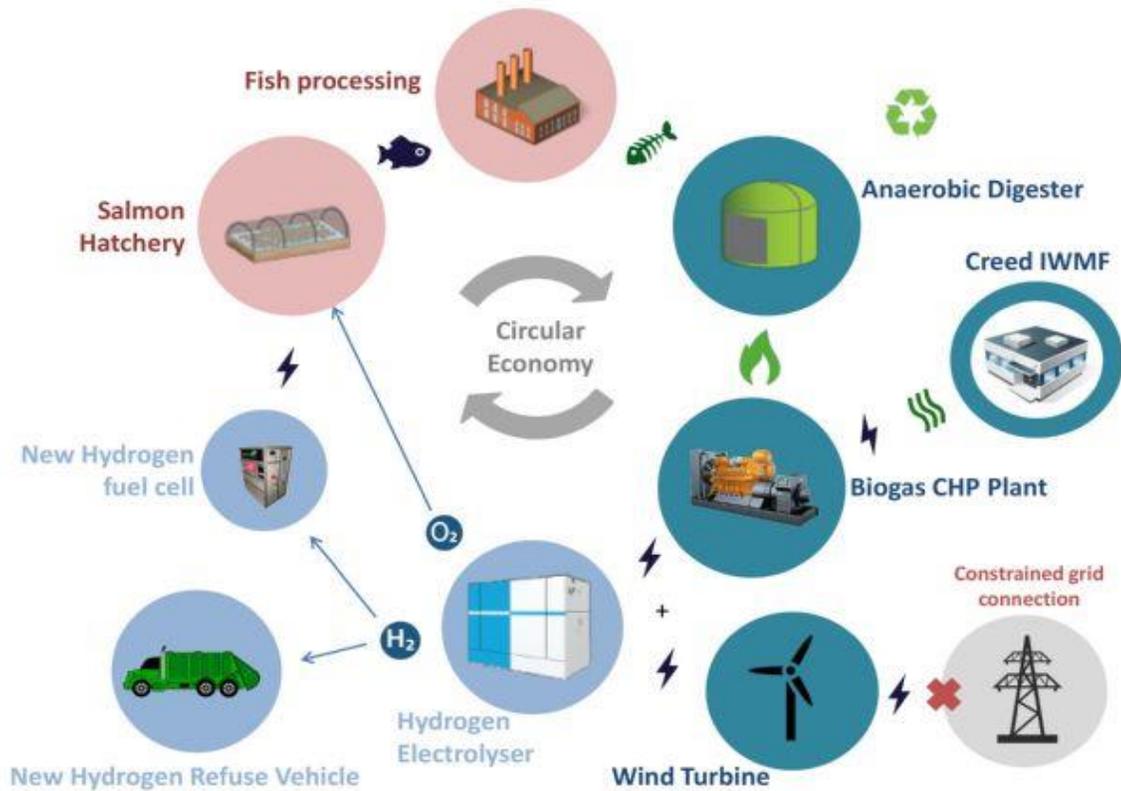


Best Practice Examples – SCOTLAND (Western Isles)

The Outer Hebrides, also known as the Western Isles, is an island chain off the west coast of mainland Scotland. The islands are geographically coextensive with Comhairle nan Eilean Siar, one of the 32 unitary council areas of Scotland.

The Outer Hebrides is home to some of the best renewable energy resources in the world. Current estimates project a realisable 6.5GW of renewable electricity, including a massive 4.8GW wave energy resource. There is currently 555 MW of contracted renewable generation in place in the islands, comprising a mixture of onshore wind and marine energy proposals, and including a nationally significant level of community owned generation. However, at the end of last year Ofgem (UK Energy Regulator) did not approve the much needed new subsea cable to connect to mainland, leaving Western Isles with excess energy to store and make use of.





The Vision and Successes

Various policy drivers have helped to shape Western Isles hydrogen strategy, including the Comhairle nan Eilean Siar. As the Comhairle continues to build on its hydrogen and wider energy strategies, a study has been commissioned, supported by Community Energy Scotland, to look at where additional hydrogen opportunities may lie and how they can be accessed. This work will run in parallel with the Comhairle's ground-breaking Hydrogen Project – Outer Hebrides Local Energy Hub (OHLEH).

Outer Hebrides Local Energy Hub (OHLEH) - is a partnership between the Comhairle, Scottish Salmon Company, Pure Energy Centre and Community Energy Scotland. The project aims to distribute renewable power, heat, and transport to the local community by using new and existing hydrogen-generation infrastructure to utilize excess renewable energy generation capacity at two key sites in the vicinity of Stornoway that are presently constrained by grid capacity issues. They generate green hydrogen and oxygen from fish farm waste at the Creed Recycling Centre in a true, circular economy model. They are also powering a Hydrogen Refuse Collection Vehicle, one of only five in Scotland, from the hydrogen produced by the OHLEH project. They also received The VIBES Partnership Scotland Award 2019 for a “a fantastic partnership project which will help both the environment and the local economy in the Western Isles”.



SWIFTH2 (Scottish Western Isles Ferry Transport using Hydrogen) - project aims to explore the viability of producing hydrogen through electrolysis powered by onshore wind on the Western Isles and to power two ferry routes. The constrained grid connection on these islands limits the deployment of renewable energy sources despite the excellent resources. Hydrogen production could act to balance the renewable energy generation on the islands, thus enabling further expansion and produce green fuel for the ferry transport that these communities are reliant on.

The Future/Conclusions

Despite the ongoing efforts of those involved in all renewable energy projects across the Western Isles, there are ongoing curtailment issues that have yet to be addressed when it comes to excess renewable energy.

It is clear, however, that there is significant commitment and enthusiasm from Comhairle nan Eilean Siar and the local community, as well as a number of public sector partners, for the development of further hydrogen development projects.

The local authority intends to help create the conditions required to facilitate the development of the infrastructure required for future integration of hydrogen, into the local economy, and beyond.



Best Practice Examples – SCOTLAND (Orkney)

Orkney is a sparsely populated archipelago (70 islands – 20 of which are inhabited). The islands are situated 16km north of the northernmost tip of mainland Scotland and have long since been at the forefront of energy innovation in Scotland.

The islands are recognised as being rich in energy resource but has some of the country's highest levels of fuel poverty. Energy production uptake has been extremely successful; to the point where energy generation now exceeds Orkney's needs (by 104%) and is greater than the capacity of the existing grid connection to mainland Scotland. Hydrogen was identified as a key potential future energy source and much work has been carried out to leverage this resource.



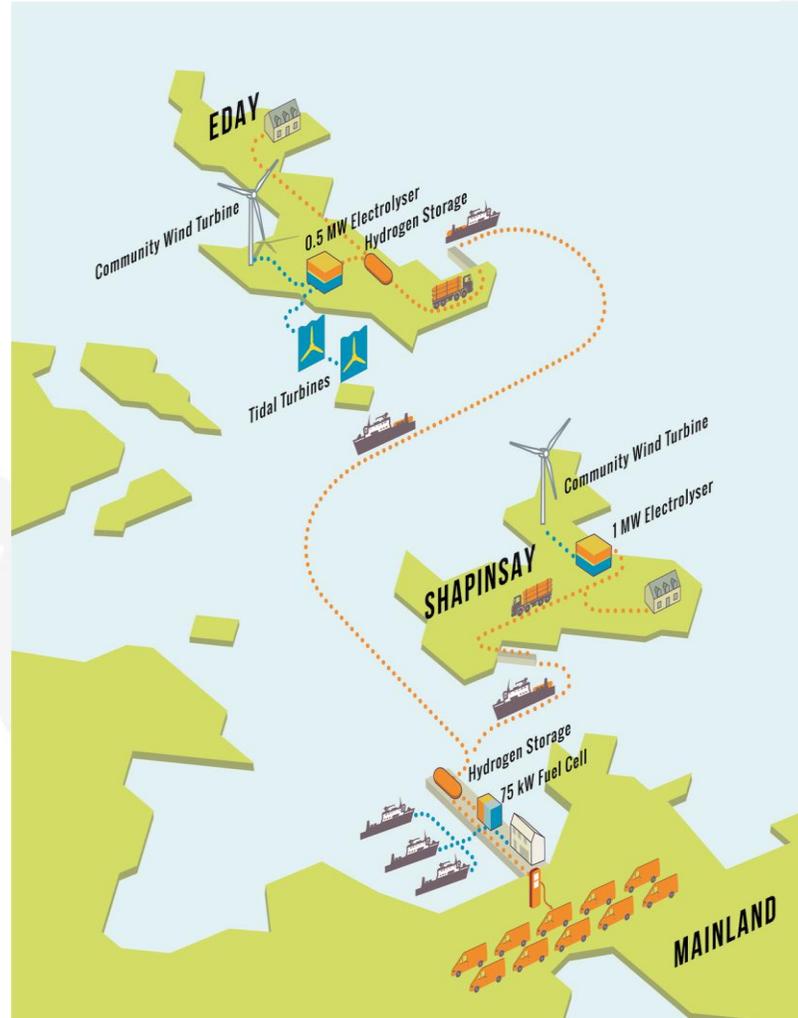
The Vision and Successes

Various policy drivers have helped to shape Orkney's hydrogen strategy, including Orkney Islands Council Plan. "A low-carbon renewable future, which is much talked about elsewhere, is coming early to Orkney," says ethnographer Laura Watts in her book *Energy at the End of the World: An Orkney Islands Saga*.



Orkney has been successful in carrying out a range of Hydrogen projects including:

Surf n Turf - Draws renewable electricity from tidal turbines and/or onshore wind turbine on Eday and transform is via electrolysis to hydrogen which is then stored; transferred to specially designed hydrogen storage trailers; and then shipped to Kirkwall, where a 75 kW fuel cell converts hydrogen back to electricity, which is used as auxiliary power for the ferries when docked in the harbour. Through Surf 'n' Turf, accredited hydrogen training courses are offered in conjunction with the local college.

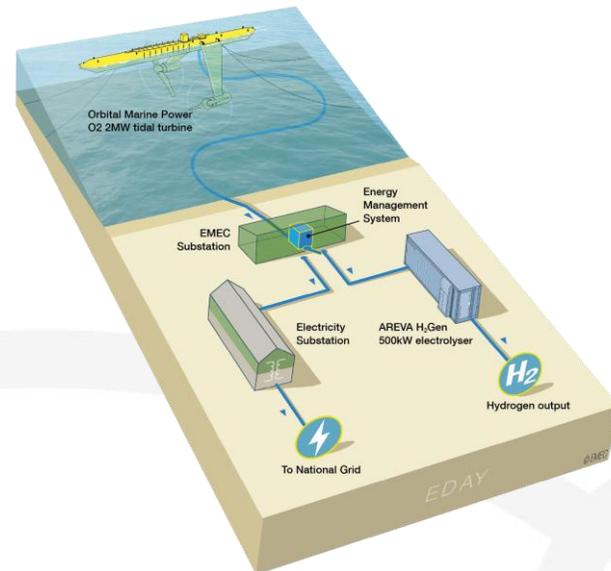


BIG HIT – BIG HIT is a 5 year, European-wide project aimed at overcoming local grid constraints. It build upon Surf n Turf achievements incorporating energy from Shapinsay's community wind turbine to produce hydrogen which is then shipped to Kirkwall in specially designed storage trailers. BIGHIT has allowed the construction of a hydrogen refuelling station in Kirkwall which powers a fleet of five electric council vans each fitted with a hydrogen fuel cell range extender. Additionally, a hydrogen-powered boiler will be installed at the Shapinsay Community School to provide zero carbon heat.

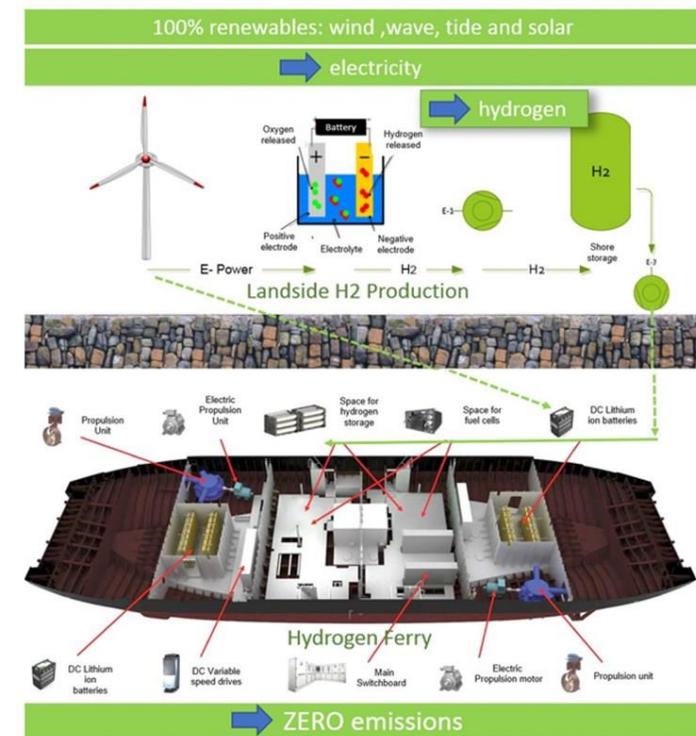
PITCHES (Powering Isolated Territories with Hydrogen Energy) - PITCHES examined the viability of using hydrogen to meet the energy needs of remote communities, such as Malawi. This project built on the experience gained in the BIGHIT project.



Integrated tidal energy and hydrogen production solution



ITEG (Integrating Tidal Energy into the European Grid) - ITEG will develop and validate an integrated tidal energy and hydrogen production solution for clean energy generation to be demonstrated in Orkney. Using excess power generated by Orbital's 2MW tidal turbine the Orbital O2 2MW (due to be deployed in 2020), the project will see an additional 0.5MW electrolyser and a smart onshore energy management system (EMS) installed on Eday which will enable EMEC to determine whether the tidal power generated at the EMEC's Fall of Warness test site is fed into the grid or into the electrolyser to produce hydrogen.



HySeas III - the final part of a three part research program that began in 2013 looking into the theory of hydrogen powered vessels (HySeas I), followed by a detailed technical and commercial study to design a hydrogen fuel cell powered vessel (HySeas II 2014-2015). HySeas III builds on the first two parts by aiming to demonstrate that fuel cells may be successfully integrated with a proven marine hybrid electric drive system (electric propulsion, control gear, batteries, etc), along with the associated hydrogen storage and bunkering arrangements. The project will do this by developing, constructing, testing and validating a full sized drive train on land. Should this test be successful, Scottish Transport have agreed to fund the building of a roll-on roll-off passenger ferry which will integrate the entire hydrogen/electric drive train which will be subject to extensive monitoring and testing.

HyDIME (Hydrogen Diesel Injection in a Marine Environment) - HyDIME is focussed on the use of hydrogen as a fuel in marine transport and will see the design and integration of a hydrogen/diesel dual fuel conversion system on a commercial ferry operating between Kirkwall and Shapinsay. The project will also gain the necessary marine licences and regulatory approvals for hydrogen to be used as a fuel in a marine environment which will have a significant impact on future hydrogen marine projects across the rest of the UK.



HySpirits - aims to investigate the development of a thermal fluid heater system to operate with hydrogen as the combustion fuel within the distilling process. This system will remove the need to use fossil fuels such as kerosene and liquid petroleum gas (LPG), for the process



HyFlyer - project aims to decarbonise medium range small passenger aircraft by demonstrating powertrain technology to replace conventional piston engines in propeller aircraft. The conventional powertrain in the aircraft will be replaced with electric motors, hydrogen fuel cells and gas storage



The Future:

The Orkney Islands are indeed a living laboratory for hydrogen developments and are at the forefront of developments in Scotland. They are testing hydrogen applications everywhere possible – road, land, sea, air – to find the best combinations for low carbon energy system.

There's no reason why the principles developed in Orkney could not be applied throughout the NPA area for communities to become more self-sufficient and energy secure.



Best Practice Examples – SCOTLAND (Shetland)

Background:

Shetland, is a subarctic archipelago in the Northern Isles of Scotland, situated in the Northern Atlantic, between Great Britain, the Faroe Islands and Norway. The islands lie some 80 km (50 mi) to the northeast of Orkney, 170 km (110 mi) from the Scottish mainland and 300 km (190 mi) west of Norway. They form part of the division between the Atlantic Ocean to the west and the North Sea to the east.



The remote and exposed Scottish islands have abundant wind power as well as other resources such as solar and marine energy. Similarly, to other fellow islands they can generate much more power that they can use themselves or the grid can take on. Thus, hydrogen capabilities are welcomed in order to limit curtailment and optimise both the generation and economic potential.



pure ENERGY CENTRE

10 YEARS
2006 - 2016

Celebrating our 10th anniversary, the Pure Energy[®] Centre is redefining the market with its **adaptive** and **flexible clean energy technologies** that can be used in conjunction with **conventional, renewable** and **smart energy** grids.

Pure Energy[®] Centre Achievements:

Year	Achievement
2006	Pure Energy [®] Centre established
2007	1 st renewable hydrogen training course in the world delivered.
2008	1 st community wind to hydrogen system in the world installed. 1 st road licensed H ₂ car in the UK.
2009	1 st high pressure H ₂ fuelling station installed in Scotland.
2010	1 st Scottish CHP FC developed. 1 st fuel cell training course in the world delivered.
2011	1 st solar training course delivered to Africa.
2012	1 st Micro Generation Accreditation achieved by Pure Energy [®] Centre.
2013	1 st wind to hydrogen system installed in Africa.
2014	1 st Hypothesis International Conference hosted by Pure Energy [®] Centre and held in Scotland. 1 st nitrogen system sold in Asia.
2015	1 st in roof solar system installed in Shetland. 1 st green hydrogen heating system delivered in the UK.
2016	1 st Scottish hydrogen dispenser developed and manufactured. 1 st hydrogen bus refuelling station in South America

www.pureenergycentre.com

The Vision and Successes:

The Pure Energy Centre (PEC) - focuses on the manufacture of energy storage systems and clean fuel production. Much of its work is ideally suited to supporting the development of island communities, being based on the development of renewables, hydrogen and combining these into off-grid energy solutions. PEC's central aim is to develop and employ projects centered on electrolyzers, storage, compressors, and complex hydrogen refuelling stations operating at 350 and 700 bar. The PEC also provides power-to-gas hydrogen solutions. In addition, the PEC design, integrate and install fuel cell systems of all types, shape and make. PEC's team has worked on stationary and transport installation and commissioning. The PEC is MCS (Microgeneration Certification Scheme) certified to develop renewable projects and has installed over 100 wind turbines and a large number of solar systems in Shetland and beyond.

The PEC is an expert company when it comes to producing green hydrogen from renewables and was the first entity in the world to have installed an off-grid wind to hydrogen system owned by a community. The PEC has developed several worlds-leading Training courses in renewable, fuel cell and hydrogen technologies and the company provide consultancy services in renewable, hydrogen technologies, oxygen, and nitrogen. Currently, the PEC is involved in the €9 million NWE GenComm hydrogen project, €2.5 million Hylantic AA hydrogen project and a €2.5 million Handiheat NPA project.



The Future/Conclusion:

Despite the ongoing efforts of those involved in all of Shetland's hydrogen energy projects, there are ongoing curtailment issues that have yet to be addressed when it comes to Shetland's excess green energy. At the end of last year Ofgem (UK Energy Regulator) did not approve the much-needed new subsea cable to connect to mainland, leaving Shetland with excess energy to store and make use of.

Shetland Island Council in conjunction with the North Yell Development Council, take inspiration from similar hydrogen schemes in Orkney and the Western Isles AND look to Yell to kick-start hydrogen economy. 4.5MW Garth wind farm on the island of Yell – which is run by the development council for the benefit of the community – could heat the Baltasound school in Unst five or six times over.

The constraint represents a loss of potential earnings for the community. Even though the wind farm is feasible even with the constraint, hydrogen is a promising alternative as a fuel for road vehicles and also as a marine fuel



- ✓ Clean Fuel Infrastructure
- ✓ Energy Storage Technologies
- ✓ Renewable Energy Solutions

