Item: 8

Development and Infrastructure Committee: 4 June 2019.

Draft Orkney Hydrogen Strategy.

Report by Executive Director of Development and Infrastructure.

1. Purpose of Report

To consider a consultation draft Orkney Hydrogen Strategy.

2. Recommendations

The Committee is invited to note:

2.1.

That, in October 2016, the Council approved the Orkney Hydrogen Economic Strategy, a Council document produced for the purpose of aiding an application for a specific fund, and as such is considered to be unsuitable to direct further development of hydrogen in Orkney.

2.2.

That, in February 2017, the Council agreed to facilitate the consultation process for the draft Orkney Sustainable Energy Strategy 2017 to 2025 on behalf of the Orkney community, with the final document published in September 2017 and endorsed by the Orkney Partnership.

2.3.

The proposal that a new Orkney Hydrogen Strategy, to be owned and developed by the wider Orkney community, with the Council facilitating the consultation process, be prepared to supersede the Orkney Hydrogen Economic Strategy.

2.4.

The draft Orkney Hydrogen Strategy, attached as Appendix 1 to this report, which will sit within and support the strategic aims of the Orkney Sustainable Energy Strategy 2017 to 2025.

It is recommended:

2.5.

That the draft Orkney Hydrogen Strategy, referred to at paragraph 2.4 above, be approved for consultation.

2.6.

That the Executive Director Development and Infrastructure should submit a report, to the meeting of the Committee to be held on 10 September 2019, detailing the outcome of the consultation exercise, referred to at paragraph 2.5 above, and presenting a final version of the Orkney Hydrogen Strategy for adoption in so far as it relates to the remit of the Council.

3. Background

3.1.

The Council has participated in an increasing number of hydrogen projects since the original Surf ‘n’ Turf project initiated in spring 2016.

3.2.

In October 2016, the Council approved the Orkney Hydrogen Economic Strategy for the purpose of aiding a funding application for the BIG HIT project. It was never formally published in final form and to an extent it has served its purpose but is considered to be unsuitable to direct further development of hydrogen in Orkney.

3.3.

In February 2017, the Council agreed to facilitate the consultation process for the draft Orkney Sustainable Energy Strategy 2017 to 2025 on behalf of the Orkney community. The final document was published in September 2017 and endorsed by the Orkney Partnership.

3.4.

It is proposed that the Council should take the same role in development of the new Orkney Hydrogen Strategy, attached as Appendix 1 to this report, which would supersede the 2016 Orkney Hydrogen Economic Strategy. The new Strategy will also sit within and support the strategic aims of the Orkney Sustainable Energy Strategy 2017 to 2025.

4. Orkney Hydrogen Strategy

4.1.

The Orkney Hydrogen Strategy is intended to have the ownership of the Orkney community and must support stakeholders from Orkney’s local industries and the wider community as a whole but will also deliver on significant national priorities and outcomes. It is proposed that the Orkney Energy Strategy Stakeholder Group should continue to oversee the formulation and communication of the strategy’s action plan and guide appropriate community ownership and governance considerations.

4.2.

The Orkney Hydrogen Strategy can provide the link between different hydrogen projects established or planned and will provide focus to project selection and streamline the project application process.

4.3.

The Orkney Hydrogen Strategy will contribute to the Council's efforts to addressing the Climate Change Emergency, with a particular opportunity to address transportation and heating energy vectors through time.

4.4.

In order to ensure that the Stakeholder Group has the necessary support, appropriate officers will provide co-ordination and expert advice to the Group. In addition, Orkney Renewable Energy Forum represents a local community of expertise and mechanisms to retain collaborative and constructive dialogue with the group should be conducted through the Orkney Hydrogen Network, a working group of Orkney Renewable Energy Forum.

5. Consultation

5.1.

It is proposed to carry out public consultation on the draft Orkney Hydrogen Strategy during a six to eight week period from July to August 2019.

5.2.

This will be advertised in the local media, on the Council website and through social media. Copies of the draft Orkney Hydrogen Strategy will be available at Customer Services (Kirkwall) and the Warehouse Building in Stromness. Partners and stakeholder groups will be contacted seeking their input.

5.3.

Following consultation, a final version of the Orkney Hydrogen Strategy will be presented to Council for adoption in so far as it relates to the remit of the Council. Approval for adoption may also be sought through the Orkney Partnership.

6. Equalities Impact

An Equality Impact Assessment has been undertaken and is attached as Appendix 2 to this report.

7. Links to Council Plan

7.1.

The proposals in this report support and contribute to improved outcomes for communities as outlined in the Council Plan strategic priority of Enterprising Communities.

7.2.

The proposals in this report relate directly to Priority 4.1 Develop Orkney as a Low Carbon Energy Systems Innovation Hub, including LNG Distribution, Hydrogen production and usage across all modes of transport and Academic Innovation Centre projects.

8. Links to Local Outcomes Improvement Plan

The proposals in this report support and contribute to improved outcomes for communities as outlined in the Local Outcomes Improvement Plan priorities of Strong Communities and A Vibrant Economy.

9. Financial Implications

There are no direct financial implications associated with the publication of this draft strategy for consultation. The provision of any investment or support costs for infrastructure or officer time associated with future projects will be assessed on a case by case basis.

10. Legal Implications

There are no legal implications arising from the recommendations of this report.

11. Contact Officers

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12. Appendices

Appendix 1: Draft Orkney Hydrogen Strategy.

Appendix 2: Equality Impact Assessment.

ORKNEY

Our hydrogen future

ORKNEY HYDROGEN STRATEGY:

The Hydrogen Islands 2019-2025

CONTENTS

EXECUTIVE SUMMARY

In 2009 the community in Orkney published the *Sustainable Orkney Energy Strategy* which sought to define three overarching aims to bring a strategic direction to its energy ambitions. These three aims sought to:

- ensure Orkney uses energy as efficiently as possible, and has a secure and affordable energy supply to meet its future needs;
- add value to Orkney's renewable energy resources, for the benefit of the local economy and local communities, whilst minimising damage to the environment and;
- to reduce Orkney's carbon footprint.

In 2017, the community in Orkney updated the 2009 document and published the *Orkney Sustainable Energy Strategy.* The three themes identified in 2009 helped develop the following vision statement in the 2017 document.

Orkney: a secure, sustainable low carbon island economy driven uniquely by innovation and collaboration, enabling the community to achieve ambitious carbon reduction targets, address fuel poverty and provide energy systems solutions to the world.

In order to realise the vision statement from 2017, the *Orkney Sustainable Energy Strategy 2017-2025* set out an activity framework of five key thematic pillars to deliver its strategic outcomes. Hydrogen spans all five strategic action thematic pillars as set out in the *Sustainable Orkney Energy Strategy 2017-2025*:

1. Maximising local value and efficiency (from local resources);
2. Smart, Low Carbon Transport and Heat;
3. A secure transition to renewable and carbon energy systems;
4. Smart, Supportive Infrastructure Investment;
5. Influencing and developing policy and access to energy markets.

This *Orkney Hydrogen Strategy: The Hydrogen Islands* seeks to identify how hydrogen can best be applied to Orkney in developing local energy systems to maintain the early mover advantage, fulfil wider strategic goals set by the governments in Scotland and United Kingdom and how solutions developed in Orkney can be applied to other communities facing energy challenges of their own as we transition to a low carbon society. This strategy seeks to encourage a wide range of hydrogen end-users to aid development of the associated economy and create conditions conducive to adopting hydrogen technologies while investment opportunities are available.

As Orkney has been demonstrating with the hydrogen projects already active on the islands, there is significant opportunity to aim towards developing a local hydrogen economy to increase economic vibrancy and promote sustainability. Development of an appropriately scaled hydrogen economy shall fulfil the goals applied in the *Orkney Sustainable Energy Strategy* to create a positive and lasting impact on the local community, private enterprise, industry and the public sector by developing a set of hydrogen specific strategic development themes. These five hydrogen development themes are:

1. **Innovative local energy systems & hydrogen economies**
2. **Renewably produced low carbon hydrogen**
3. **Energy security, system flexibility & self-sufficiency**

4. **Just transition**
5. **Promoting innovative research & development using a collaborative approach**

FOREWORD

INTRODUCTION

In 2017 the energy community in Orkney published the updated *Sustainable Orkney Energy Strategy 2017-2025*. Orkney recognised the importance of "A secure, sustainable low carbon island economy driven uniquely by innovation and collaboration, enabling the community to achieve ambitious carbon reduction targets, address fuel poverty and provide energy systems solutions to the world" (SOES, 2017).

The importance of rural communities was identified by the Scottish Government in *The future of energy in Scotland: Scottish energy strategy* (2018) which outlines an aspiration to develop affordable, clean and secure energy system in which hydrogen technologies can provide significant advantages for rural communities. The challenge for hydrogen lies in the absence of ubiquity of such local energy systems in practice. This scarcity of off the shelf solutions creates a challenge in developing the policy environment required for integration of hydrogen into any energy system.

This strategy is designed to represent the interests of the wider energy community in Orkney which has taken the views of a wide range of stakeholders into account. This collaborative approach has been a significant factor in Orkney's success in hydrogen to date and is necessary to identify the relevant applications for hydrogen as the hydrogen economy in Orkney evolves in the future. Defining our intentions now will help Orkney retain its early mover advantage and keep the region open to further hydrogen developments as we see the demand for hydrogen increase across our community and into the broader energy landscape of Scotland, the UK and beyond.

Many international governments are increasing support for hydrogen programmes to further technologies to address global warming, energy security, system balancing and mobility. Through increasing hydrogen activity in the Orkney region, Scotland and the UK have the potential to position themselves at the leading edge of energy innovation. Orkney's experiences will help shape how other isolated communities can address their own energy needs as we transition into a low carbon society to address the state of climate emergency as declared by both the Scottish and UK parliaments.

With continued concerted effort from the variety of community members, as well as with wider stakeholders, collaborators and suppliers, it is possible for Orkney to invent a low carbon future that meets the demands of all users without such significant reliance on costly and polluting fossil fuels. Innovation needs to continue to be fostered to allow mass uptake of low carbon technologies into every household with a view to reducing wide reaching issues such as fuel poverty, climate change and more sustainable tourism that particularly affect the future prosperity of rural regions.

While hydrogen cannot act alone as a panacea to our impending requirement to decarbonise, there is potential for Orkney to define its own solution to the paradigm shift required around how communities, countries and nations approach energy production, consumption and supply. In doing so, Orkney would be demonstrating that it is achievable to accelerate decarbonisation and lead by example in reaching the net zero carbon emission target by 2045 as suggested by the Committee on Climate Change in May of 2019.

BACKGROUND

Orkney has been a demonstration region for numerous 'green' hydrogen demonstration projects that have generated hydrogen through electrolysis powered by renewable sources such as community wind and tidal energy. Producing hydrogen during periods of wind turbine curtailment can minimise the potential for lost earnings for community development trusts allowing the trusts to collect Feed in Tariffs (FiTs) as well as producing a product with commercial value (hydrogen) that can be used in a multitude of applications including: heat, power, mobility, grid balancing and storage.

As a host to several highly innovative and significant green hydrogen projects (see Table 1), Orkney has gained an early mover advantage with regards to hydrogen systems development. Consideration needs to be given as to how Orkney can best integrate hydrogen into the energy mix as the region transitions towards a fully integrated low carbon future. While Orkney has a world leading reputation in terms of developing innovative renewable applications, renewable business development in Orkney has been somewhat hampered due to the limitations of the existing electrical grid connection to the Scottish mainland. To a certain extent, this grid restriction can be seen as a driver of innovation in Orkney.

Scotland and the UK governments have committed to fulfilling ambitious energy decarbonisation targets and have stated the importance of the role of regional solutions and community input to develop localised systems. Orkney has demonstrated that despite challenging conditions for integrating renewable developments, it is possible to develop the right solutions and strategies to address climate change and a host of other more localised issues that arise from being in a rural setting. Orkney understands that there are solutions to address rural energy issues and that these strategies, demonstrations and ultimately solutions are exportable/transferrable to other rural or islanded regions facing similar issues throughout Scotland, the United Kingdom and Europe. Orkney's experience of integrating hydrogen into its low carbon energy transition should provide an inspiration for other regions to follow in creating their own unique energy landscape tailored to address the regions' own energy related issues.

Developing a strategy requires input from a broad range of stakeholders that bring expertise from a wide range of sectors. The aim of this strategy is to look, from above, at how hydrogen can interact with energy infrastructure in Orkney as a whole and which areas might be best for Orkney to direct focus on. A wholistic approach should see gains for both a well-functioning and efficient electricity network with a supportive role for hydrogen to fulfil storage and energy demand that cannot be fulfilled by electricity alone.

Orkney has already demonstrated a number of key hydrogen projects and concepts at demonstration phase. The BIG HIT and Surf 'n' Turf projects demonstrate the principles of a green hydrogen economy by utilising hydrogen generated locally in various local applications such as heat, power and transport. Some potential routes to integrate hydrogen into the Orkney energy system across all sectors are considered later in the document with care taken to consider Orkney's current energy demand, potential energy strands viable for replacement with hydrogen and what a future hydrogen scenario may look like for Orkney across Low, Medium and High integration routes.

Orkney is on course to achieve the Low integration route proposed in the sections below by 2022. In order to achieve the Medium and High integration routes will require attracting additional investment to support the conversion to hydrogen of additional transport applications, wider role out of multi-scale hydrogen for heat applications and investigating grid balancing opportunities.

Project	Timeline	Outcomes	Value
Surf 'n' Turf	2016-2022	Orkney's first hydrogen demonstration project. 0.5MW electrolysis on Eday from tidal and community wind. Developing logistics for hydrogen transport and generating power for harbour-side vessels.	TOTAL BUDGET £ 2m
BIG HIT – Building Innovative Green Hydrogen Systems in Isolated Territory	2016-2022	Developing upon the principles of Surf 'n Turf and implementing a fully integrated model of hydrogen production, storage, transportation and utilisation for heat, power and mobility. 1MW electrolysis on Shapinsay from community wind.	EU FUNDING € 5m TOTAL BUDGET € 7.3m
Dual Ports	2016-2019	DUAL Ports aims to decarbonise Regional Entrepreneurial Ports (REPs) resources through a shared eco-innovation port programme that minimises their environmental footprint.	TOTAL BUDGET € 5.2m
HyDIME	2018-2019	Design and physical integration of a hydrogen injection system on a commercial passenger and vehicle ferry which will be the first of its kind worldwide.	TOTAL BUDGET £ 1.2m
HySEAS III	2019-2023	Integration of hydrogen fuel cell propulsion system onboard Kirkwall to Shapinsay ferry.	EU FUNDING € 9.3m TOTAL BUDGET € 12.6m
ITEG - Integrating Tidal energy into the European Grid	2018-2021	Develop an all-in-one solution for the generation of clean predictable energy, grid management, and the production of hydrogen from excess capacity.	EU FUNDING € 6.46 m TOTAL BUDGET € 11.79 m
ReFLEX Orkney – Responsive flexibility	2019-2023	Demonstration of a first-of-its-kind Virtual Energy System interlinking local	TOTAL BUDGET £ 28.5m

		electricity, transport, and heat networks into one controllable, overarching system	

Table 1. Ongoing hydrogen projects in Orkney.

MISSION

Hydrogen is fast becoming a key energy resource in the world transition to a low carbon future. The *Orkney Hydrogen Strategy* seeks to aid development towards an Orkney appropriate sustainable hydrogen economy to provide economic benefits such as: local jobs; establishing a local supply chain; and an increased resilience in the local energy system. Orkney will maintain its leading edge on the development of local energy systems that make use of a range of renewable technologies, develop local hydrogen economies and increase the efficacy of local grid infrastructure to better meet the needs of the local population. This strategy should seek to attract further inward investment to build on hydrogen technology deployments where appropriate.

Orkney seeks to develop and proliferate best practice in integrating smarter local energy models, including generation of renewable hydrogen to other 'islanded' communities where there is ambition to transition to a low carbon future. Integrating hydrogen to Orkney's energy system has the potential to reduce reliance on carbon intensive costly fossil fuels and measures should be considered as to how the low carbon transition can reduce energy costs and contribute to access to energy at fairer cost to reduce high levels of fuel poverty in the area in line with the *Just Transition principles* as set out by the Scottish Government (2018b) and set out by the International Labour Organisation (international Labour Organisation, 2018).

Orkney's world leading hydrogen demonstration projects will provide a basis for the development of a proactive approach to establish hydrogen within the local context for Orkney. Hydrogen developments in Orkney will continue to support the removal of barriers currently inhibiting rural communities to realise the full benefit that the wider electricity network provides to more central communities at present (Scottish Government, 2018a). Outputs already delivered from Orkney hydrogen projects continue to inform the global hydrogen economy and can continue to solidify Orkney's ability to attract additional inward investment.

Vision: Orkney becomes the global exemplar on green hydrogen integration into a robust rural-centric and sustainable hydrogen economy, aiding delivery and access to ultra-low carbon energy on demand across the spectrum of end users.

TARGETS AND POLICY DRIVERS

There are numerous policies established at an intra-national and international level that support the proliferation of hydrogen technologies. A 'hydrogen future' was envisioned in the Scottish Governments *The future of energy in Scotland: Scottish energy strategy* which stated the need to support 'smarter, local energy systems (Scot Gov, 2018a). This aids communities to become more invested in their energy choices.

Developing a hydrogen economy in Orkney in the short to medium term can: contribute to reduced greenhouse gas and particulate emissions; increase the security of energy supply; contribute to decarbonisation of transport; increase and economise renewable electricity generation; aid in the development of a fairer model of electricity supply that could lead to reduced consumer costs by supporting storage for intermittent generation and addressing market failure as experienced by many rural energy users.

There are a wider range of policies and targets that will relate to the introduction of hydrogen into local energy systems to varying degrees. Table 2 provides a summary of the policies and targets that directly affect a strategic approach to hydrogen integration in Orkney.

Strategy/Policy/Plan	Target/Aim
UK	
Clean Growth Strategy 2017	Accelerate pace of clean growth
Industrial Strategy 2018	UK shift to clean growth
Clean Air strategy 2019	Air quality targets
25 Year Environmental Plan 2019	Protect air & water quality and threatened plants, trees and wildlife species
Climate Change Act 2008	Reduce greenhouse gas emissions by at least 80% by 2050
Road to Zero 2017	End sale of conventional petrol and diesel cars and vans by 2040
Emissions Intensity Ratio (EIR)	Measurement proxy for economic progress associated with carbon emissions - 720tonnes/£m 1990 - 270tonnes/£m 2017 - 100tonnes/£m to meet targets
Maritime 2050 - TBP	Targets to decarbonise the marine industry
Aviation 2050 – TBP	Targets to decarbonise the aviation industry
The Climate Change Committee	Net zero carbon emissions for Scotland by 2045 & England by 2050
Scotland	
Climate Change (Scotland) Act 2009	Reduction of greenhouse gas emissions of at least 80% by 2050
Climate Change Bill 2018	Reduction of greenhouse gas emissions of at least 90% by 2050
Public Bodies Climate change duties 2011	Climate responsibility for public bodies
Scottish Energy Strategy: The future of energy in Scotland 2017	Whole system approach to power heat and transport
Scotland's Network Vision 2019	Whole system view, inclusive transition, smarter local energy models
Orkney	
Council Plan 2018-2023	
Orkney Sustainable Energy Strategy 2017-2025	
Orkney's Fuel Poverty Strategy 2017-2022	
Orkney Local Development Plan 2017-2022	
Carbon Management Programme 2016-2026	

Table 2. Policy drivers that support and encourage the development of renewably produced

KEY STRATEGIC THEMES TO SUPPORT GREEN HYDROGEN GROWTH IN ORKNEY

In *The future of energy in Scotland: Scottish energy strategy (2018)* the Scottish government has set out three principles designed to deliver on Scotland's ambitions to decarbonise economic growth whilst also delivering economic growth and ensuring that everyone is able to benefit. These are a whole system view, an inclusive transition, and smarter local energy models.

The following section seeks to align the Scottish Government's vision with the five strategic themes identified in the *Orkney Sustainable Energy Strategy*, to develop key strategic themes to support the growth of a green hydrogen economy in Orkney. The key strategic themes are outlined in more detail below.

1. **Innovative Local Energy Systems & Hydrogen Economies**

2. **Renewably produced Low Carbon hydrogen**
3. **Energy Security, System Flexibility & Self-sufficiency**
4. **Just Transition**
5. **Promoting Innovative Development using a Collaborative Approach**

While there are numerous hydrogen production methods such as Steam Methane Reformation (SMR) and coal and biomass gasification this strategy will focus on the production of green hydrogen from renewable sources via electrolysis. The carbon footprint of hydrogen depends upon the source of the power for generation. There is room to improve on hydrogen production rates, longevity of the electrolysers, reduction of capital costs and further research into potential for electrolysis.

INNOVATIVE LOCAL ENERGY SYSTEMS & HYDROGEN ECONOMIES

Contributes towards the following Orkney Sustainable Energy Strategic Action Themes

- Maximising local value and efficiency (from local resources)
- Smart, Low Carbon Transport and Heat
- A secure transition to renewable and carbon energy systems
- Smart, Supportive Infrastructure Investment
- Influencing and developing policy and access to energy markets

At all consumer levels - industry, commercial and community – Orkney is reliant on fossil fuels for heat, power and transport despite Orkney generating a large amount of electricity from renewable sources. **19% of Orkney's carbon emissions can be attributed to electricity consumption across end users which rises to nearly 50% when looking at domestic electricity use alone (BEIS, 2016).** Figure 1 below gives an indication of Orkney's carbon emissions by sector and how overall carbon emissions for energy use compare with wider figures across the UK. Figure 2 shows a cross-sectoral energy usage by fuel type in Orkney.

Although Orkney generates much of its local electricity demand from renewable sources there are periods of import from the wider UK network and as such Orkney's electricity generation is broadly classified along the same lines as the rest of the UK giving a carbon density of 0.30720 kg CO_2e / kWh.

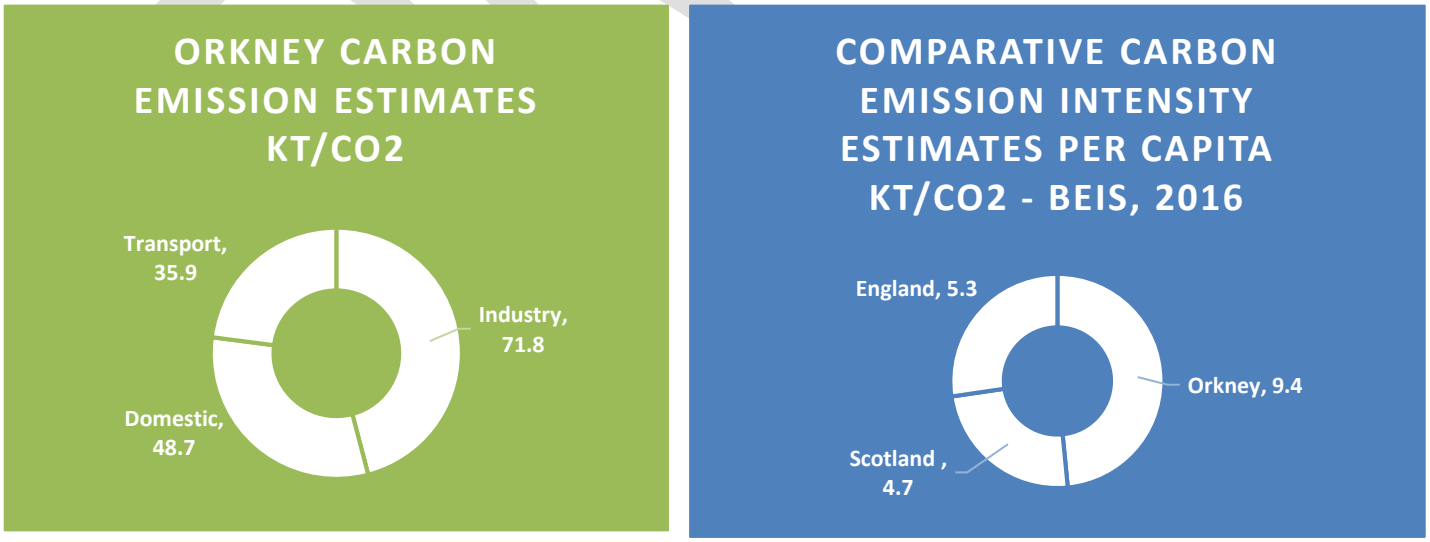

Figure 1. Orkney Carbon Emission Estimated by sector, Kt/CO2 and Orkney's comparative carbon emissions figures with Rest of UK average, per head of population – Source: BEIS, 2016.

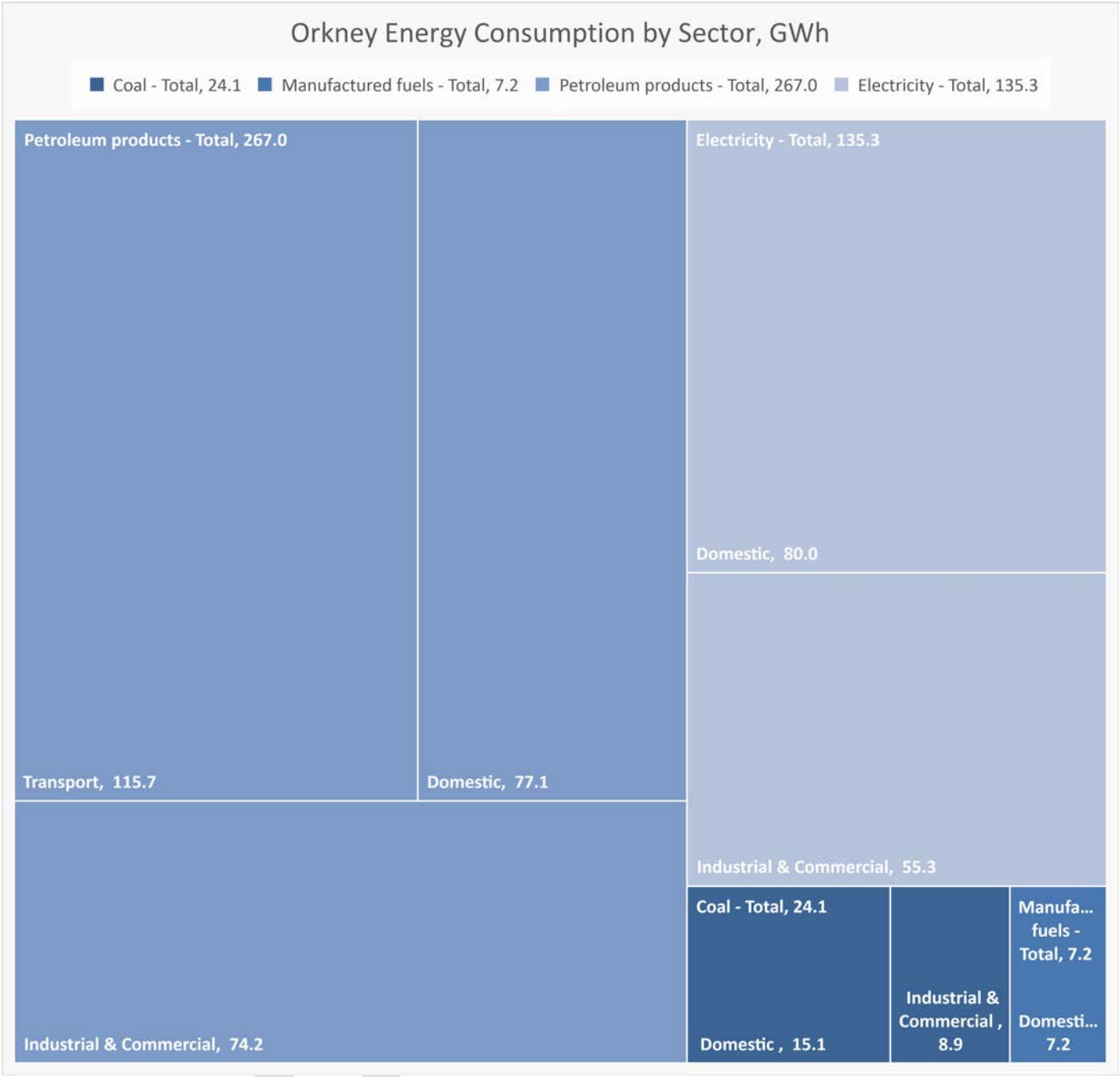

Figure 2: Total Orkney Energy Consumption by type by sector, GWh – Source: BEIS, 2016.

A major strength in developing localised energy systems is that the system can be built around the relevant local resource and can closely match and deliver energy to the end user when required. Wind, wave and tidal are likely to be the resources required for generation of energy within a decentralised local energy system. The carbon intensity of the system can also be monitored and reported in a manner that more closely reflects the true carbon density as opposed to a national average. Smarter management of the grid will allow for additional renewable resource to be connected.

While arguably the most efficient way to do this is to produce electricity directly from the natural resource using a turbine or otherwise. It is, however, well established that renewable generation is intermittent which requires a back-up generation, from fossil fuel sources, in times where generation does not match demand. Intermittency of renewable generation not only creates a problem for the end user of the electricity but for

the current electricity network operator who is responsible for managing the electricity network. In addition to the intermittency issues when generating from renewable resource there is also intermittency on generators accessing the grid for export. In times of peak renewable generation Orkney renewable generators are curtailed therefore they receive neither the Feed in Tariff or the grid export payment. The Orkney renewable generators also do not get financial recompense in the form of constraint payments (UKgov, 2013) or the trading system known as the 'balancing mechanism' to bid for payment to voluntarily curtail (bmreports.com, 2019). Despite Orkney generating in excess of their regional demand from renewable sources, the community at all levels are heavily reliant on fossil fuel generation sources. Fossil fuels, for all applications, require import from out-with Orkney.

Despite Orkney generating in excess of its regional electricity demand from renewable sources, the community at all levels is heavily reliant on fossil fuel generation sources.

In addition to the reliance on fossil fuel from large demand to heating and power on the individual level, consumers in Orkney rely on electricity to generate heat, power and transport. Hydrogen has the potential to cut across all these sectors as has been demonstrated with the early projects and utilise a fuel source that has been generated in the County and supports a local supply chain throughout.

RENEWABLY PRODUCED ULTRA LOW CARBON HYDROGEN

Contributes towards the following Orkney Sustainable Energy Strategic Action Themes

- **Maximising local value and efficiency (from local resources)**
- **Influencing and developing policy and access to energy markets**
- **A secure transition to renewable and carbon energy systems**
- **Smart, Supportive Infrastructure Investment**

Various regions worldwide are looking at the interim measure of greening up hydrogen production at steam methane reformation sites. The strategy for Orkney will however focus on the development of *green hydrogen* production in Orkney, where hydrogen production is sourced from renewable energy sources.

There may be potential to partially decarbonise the existing oil and gas infrastructure, for example on Flotta, or capture and decarbonise outputs from potential waste plant solutions, as we transition to a low carbon future it would may be necessary to consider a small percentage of brown/blue hydrogen as we make the transition to fully green hydrogen. Cases as such would need to be weighed up considerably and considered only as a transitionary step towards green hydrogen production.

Focusing on green hydrogen production plays strongly into Orkney's knowledge, resources and expertise and outputs are highly replicable in many remote and rural locations both nationally and internationally in other 'islanded' regions. Focussing on renewably produced hydrogen plays to Orkney's *natural advantage* in utilising the natural resource.

The UK and Scotland are considering decarbonisation of the entire gas grid, in which case mobility and power become secondary to heat provision being generated from hydrogen. Hydrogen production in this case is likely to come from centralised steam methane reformation (SMR) which require symbioses with carbon capture and storage to be less carbon polluting than the natural gas used at present. **Carbon Intensity of hydrogen produced via SMR without Carbon Capture and Storage is similar to that of natural gas at 230g CO_2/kWh (Royal Society, 2018).**

At present there are no public plans published to establish a gas grid within Orkney and as such micro combined heat and power projects should be explored with the opportunity to co-locate electrolysis with micro-scale generation.

ENERGY SECURITY, SYSTEM FLEXIBILITY & SELF-SUFFICIENCY

Contributes towards the following Orkney Sustainable Energy Strategic Action Themes

- **Maximising local value and efficiency (from local resources)**
- **Influencing and developing policy and access to energy markets**
- **A secure transition to renewable and carbon energy systems**

At present Orkney has a moratorium on any new connections as the local electricity grid is operating at capacity. Actions are being taken in an attempt to develop satisfactory terms for a new subsea inter-connector between Orkney and the Scottish mainland. If the subsea inter-connector does get commissioned it is likely to be completed in 2023 at the earliest and will not solve all of the issues of curtailment that the Orkney Islands experience at present.

Legislation surrounding accessing the electricity grid for both generation and demand purposes and the complexity of local renewable generators acutely managed by the Active Network Management scheme make connection of additional electrolysers, a load drawing asset, challenging. In the short to medium term the electricity grid in Orkney could be managed using strategically placed electrolysers which could alleviate curtailment on the local electricity grid. It would also be possible to generate electricity back to the grid using fuel cell technology which would negate the use of fossil fuels.

Managing the grid using hydrogen could potentially allow further renewable generation connections. Access to the electricity grid is one of a number of regulatory barriers that have the potential to be detrimental to the further integration of hydrogen projects in Orkney. These include the complexities surrounding connection to the electricity grid due to the volume of renewable connections. Orkney partners should continue to inform the transition from Distribution Network Operator (DNO) to Distribution System Operator (DSO) which should have an impact on how generators are able to access the grid and allow consumer access to a greater range of services (SSE, 2018).

JUST TRANSITION

Contributes towards the following Orkney Sustainable Energy Strategic Action Themes

- **Maximising local value and efficiency (from local resources)**
- **Smart, Low Carbon Transport and Heat**

Shifting the economy away from fossil fuels is an opportunity to build a fairer and more equal society throughout Orkney and Scotland. Orkney Islands Council Fuel Poverty strategy (2017) indicates that Orkney has the highest rates of fuel poverty in the UK with around 63% of households being classed as being in fuel poverty. Fuel poverty in Orkney is attributed to a number of factors including older housing stock, lower than average income, the climate, and higher cost of heating. Low carbon hydrogen technologies carry the risk of increasing costs for householders and the cost per kilowatt hour of hydrogen is higher than most alternatives at present.

It is important to establish that there will be a transitionary period where traditional oil and gas industries decline and skills need to be established to bring workers with the low carbon change (Friends of the Earth, 2018). A skills-based approach should be developed to provide a range of hydrogen training to provide job roles across a range of technical levels.

PROMOTING INNOVATIVE DEVELOPMENT USING A COLLABORATIVE APPROACH

Contributes towards the following Orkney Sustainable Energy Strategic Action Themes

- **Maximising local value and efficiency (from local resources)**
- **Smart, Low Carbon Transport and Heat**
- **A secure transition to renewable and carbon energy systems**
- **Smart, Supportive Infrastructure Investment**
- **Influencing and developing policy and access to energy markets**

The hydrogen projects at present have demonstrated that stakeholders in Orkney are able to collaborate and share learning across projects to achieve aims. Learning is an active approach and sharing outcomes and differing perspectives can lead to quicker problem solving.

It is essential for the successful integration of hydrogen into the local energy system that stakeholders from the community, private enterprise, public bodies and education continue to work together to identify the correct opportunities to support the development of hydrogen supply and integration of technologies.

BARRIERS TO IMPLEMENTATION

There are a number of barriers, perceived or otherwise, to the implementation of hydrogen into energy systems. Many of these have been experienced through engagement in hydrogen demonstration projects such as Surf 'n' Turf and BIG HIT. Barriers have a negative impact on the budget and timescales of projects and carry the risk of preventing or delaying progress to timescales as required, creating additional costs and reducing viability. It is necessary to continue to evaluate and monitor these potential risks as they evolve as hydrogen systems develop. Great potential benefits can also be realised by addressing these barriers.

Perceived Barrier	Effect
Regulation / Legislation	Electricity market regulation: Inability to implement decentralised local energy system due to regulatory barriers connecting to the grid.
Moratorium on connection of additional generation capacity in Orkney	Cannot expand hydrogen production through new generation or connect fuel cells to grid.
Energy provision issues due to market failure in rural areas	More expensive energy tariffs and a higher cost to the consumer.
Per capita model to measure economic activity	Service provision more expensive in and often less fit for purpose in less densely populated areas
Uncertainty of viability of hydrogen as a future fuel	Reticence to commit to investing in hydrogen for future energy needs, there are other energy carriers such as electricity and other transitionary fuels and technologies that may be given precedence.
Innovation risk	Many organisations (public/private) are risk averse which can delay the development of new technologies and systems.
Technological readiness	Hydrogen produced through renewably powered electrolysis is the only way to produce 'green hydrogen', other forms of hydrogen production rely on unproven Carbon Capture and Storage methodologies which would lower carbon emissions but not negate them. There is no recognised standard for green H_2 production although there are a number of projects that have been developing

	this. No standard for green hydrogen production can create market uncertainty.
Drive to reduce fuel poverty	Without careful management of energy systems the low carbon transition has a real likelihood of increasing bills for the consumer in the short to medium term.
Cost competitiveness	Innovative energy solutions are often required to be economically equal to fossil fuel alternatives despite fewer operational years. Although there are mechanisms in place for monitoring social and environmental benefit/harm, in practice (in the UK) these measures are often principle based and do not carry any significant weighting and economic parity of low carbon and fossil fuel is expected. Considering only financial impacts can lead to decision making weighted towards fossil fuel solutions.
Perceived Safety Concerns	The safety case for the use of hydrogen is different depending on application and significantly different from standard fuels in similar applications. Stringent processes to demonstrate safety.
Efficiency Losses	The efficiency trail of hydrogen utilisation is different from current patterns of energy consumption. Well to wheel should be considered for comparisons.

Table 2. Barriers to hydrogen development

ROUTES TO IMPLEMENTATION

Hydrogen can disrupt the energy system in a number of different integration levels and across a number of different applications. Each application can use hydrogen via direct combustion or can utilise the more efficient Fuel Cell technology which will broadly reduce the amount of hydrogen required to reach the same output. Hydrogen applications that are relevant to Orkney are explored below.

HEAT

There is potential to replace traditional fossil fuel heating systems with hydrogen boilers such as catalytic boilers or micro-scale combined heat and power units. Fuel Cells convert hydrogen back to electricity and generate excess heat in the process, both the 'waste' heat and the electricity can be used for heating for domestic purpose.

The committee for climate change has suggested that the UK government should explore a low-carbon heat strategy to encourage commercial investment in hydrogen production (2019). Efficient heat pump technology can be powered by low carbon sources like hydrogen.

POWER

Orkney has one 75kW Fuel Cell which provides auxiliary power to two vessels while they are docked at Kirkwall harbour. The ReFlex project is looking to add a 440kW fuel cell to provide heat and power to the local sports centre.

There would be an opportunity for Orkney to demonstrate the potential of hydrogen fuel cells to balance the local electricity grid.

TRANSPORT

The UK H2 mobility project predicts that there could be over 1.6 million Fuel Cell Electric Vehicles in the UK by 2030. A number of transport applications as well as propulsion methodologies are explored below. It is worth noting that there are no plans within the H2 mobility project to develop further hydrogen infrastructure in Orkney which indicates the importance of developing a local energy system that is suitable for Orkney as opposed to waiting for more centralised initiatives (H2 mobility, 2017). This is a symptom of a different view of the energy world which focuses on volume rather than self-sustaining local systems. Indeed, Orkney already hosts a refuelling station and five hydrogen powered vans. It would however be highly beneficial for Orkney to add a second hydrogen refuelling station to refuel at 700 bar pressure as well as 350 bar and to eliminate periods of unavailability which would prevent hydrogen vehicle users from refuelling.

There are other local authority areas in Scotland such as Aberdeen and Fife that are currently demonstrating a wide range of hydrogen transport applications including buses, public refuse lorries, street sweepers and passenger vehicles. Orkney Islands Council has integrated five hydrogen electric Renault Kangoo vans into the fleet as part of the BIG HIT project.

There are two realistic routes to implementing hydrogen for mobility, the first converts hydrogen into mechanical energy utilising an Internal combustion engines (ICE). Modifications can be made to existing engine concepts in order to accept hydrogen for combustion (H_2-ICE). Hydrogen can be blended or co-injected with fossil fuels up to a 100% hydrogen intervention rate (marigreen, 2018). H_2-ICE is suitable for high propulsion power and low energy consumption application for auxiliaries (marigreen, 2018), for example ships auxiliary power loads or heating systems onboard electric vehicles or buses. H_2-ICE technology has the advantage of reducing fossil fuel consumption compared with technology equivalents used at present. H_2-ICE can be designed and applied to new transport modes or it can be applied retrospectively to convert plant or other vehicles near the start of their operating life. Carbon and other particulate emissions will depend on the percentage rate of hydrogen but are unlikely to be a net zero.

Hydrogen can also be converted into electrical energy for propulsion using a fuel cell. Fuel cells require combination with an electric battery for propulsion. Fuel cells tend to be more efficient for many transport applications than the H_2-ICE but also tend to be more expensive. Fuel cells also require a much higher purity of hydrogen than H_2-ICE, with electrolysis providing the purity required. Capital costs for H_2-ICE tend to be lower than that of Fuel cell equivalents but running costs tend to be higher due to efficiencies and additional moving parts (H2FC Supergen, 2017b).

In terms of market opportunity in Orkney, marine transport is the largest user of energy with road transport uses also significant (see Figure 3).

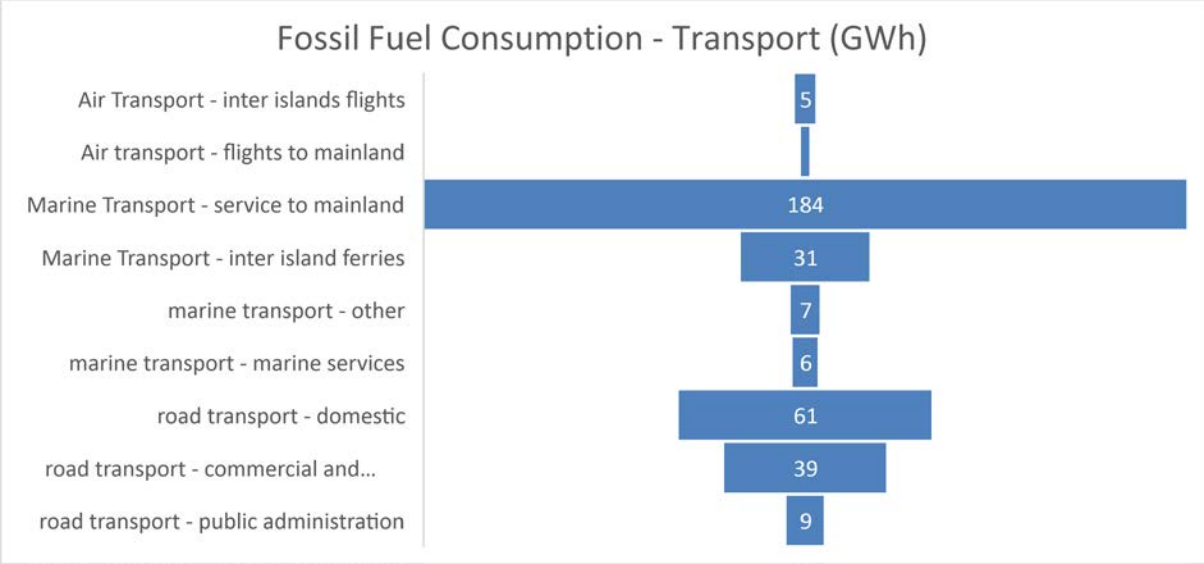

Figure 3. Consumption of fossil fuels, Transport in Orkney (GWh), OREF, 2014.

Potential transport conversions to hydrogen include:

- Ferries
- Buses
- Planes
- Local Authority Fleet
- Other captive fleets (SME's and large enterprises)
- Passenger Vehicles
- Agricultural Vehicles
- Medium and Heavy Plant

DISSEMINATION

Existing hydrogen projects in Orkney have been successful in their communication thus far by presenting to a wide range of stakeholders across a breadth of age groups. While project partners have been invited to present at conferences and events across the world, hydrogen demonstrations have been brought into the local schools and community engagements across Orkney.

The hydrogen story in Orkney has been publicised by numerous media agencies including the BBC, the Herald and Forbes, the hydrogen thread was raised on social media by the DiCaprio foundation and the ReFLEX energy systems project made it onto national news. The BIG HIT project won a UK wide local authority award and hundreds of visitors from across the world have visited the hydrogen infrastructure on Orkney.

Continuing to reach out to the community allows projects to be tailored to their specific need and including communities in developments from the very beginning allows for concerns to be addressed appropriately. It will also help develop the next step appropriate for integration of hydrogen technologies at the community level.

FUTURE DEVELOPMENT POTENTIAL FOR ORKNEY

Energy decisions made now will play a large role in shaping the future landscape of energy in Orkney. Orkney has demonstrated that it is possible to produce well in excess of 100% of local electricity demand from

renewable sources. The capital investment to fund these renewable sources has come from a variety of sources from public, private and community owned renewable business models.

To offset the contemporary reliance on fossil fuels to fulfil our energy needs at the instant flick of a switch will require developments in storage technology whether divergence from carbon rich fuel sources is electrified or otherwise. There is potential for hydrogen to address this gap with present day storage solutions being more mobile, with similar cost effectiveness (Supergen, 2015) and less reliant on specialist resources than battery storage.

The benefits to developing a low carbon local energy system should be universal in their application. Solutions proposed should be available to all members of society. Attention should be paid as to how to deliver access to low carbon markets across the socio-economic spectrum. Smart, efficient use of electricity and hydrogen innovations have the potential to become an attractive energy alternative for heat and power in domestic properties.

While it is impossible to define today the future energy mix of tomorrow, this strategy seeks to lay out some potential scenarios for hydrogen within the Orkney energy system. These vary from *Low Integration* to *High Integration* which spans from soaking up excess power that is currently wasted from current renewable production to seeing Orkney as a net hydrogen exporter.

Recognising that the hydrogen industry is changing and developing rapidly it is impossible to identify exactly what the future of hydrogen will look like. The sections below create some hypothetical scenarios at various levels in the local area.

The integration scenarios in Figure 4 below are based on hydrogen production values as modelled in the projects running at present as well as a split between hydrogen produced by the local energy grid and additional curtailed renewable resource or other smart management mechanism needs that develop over time. It is assumed that hydrogen transport and heat applications will become viable over time. More detail is given in the sections below.

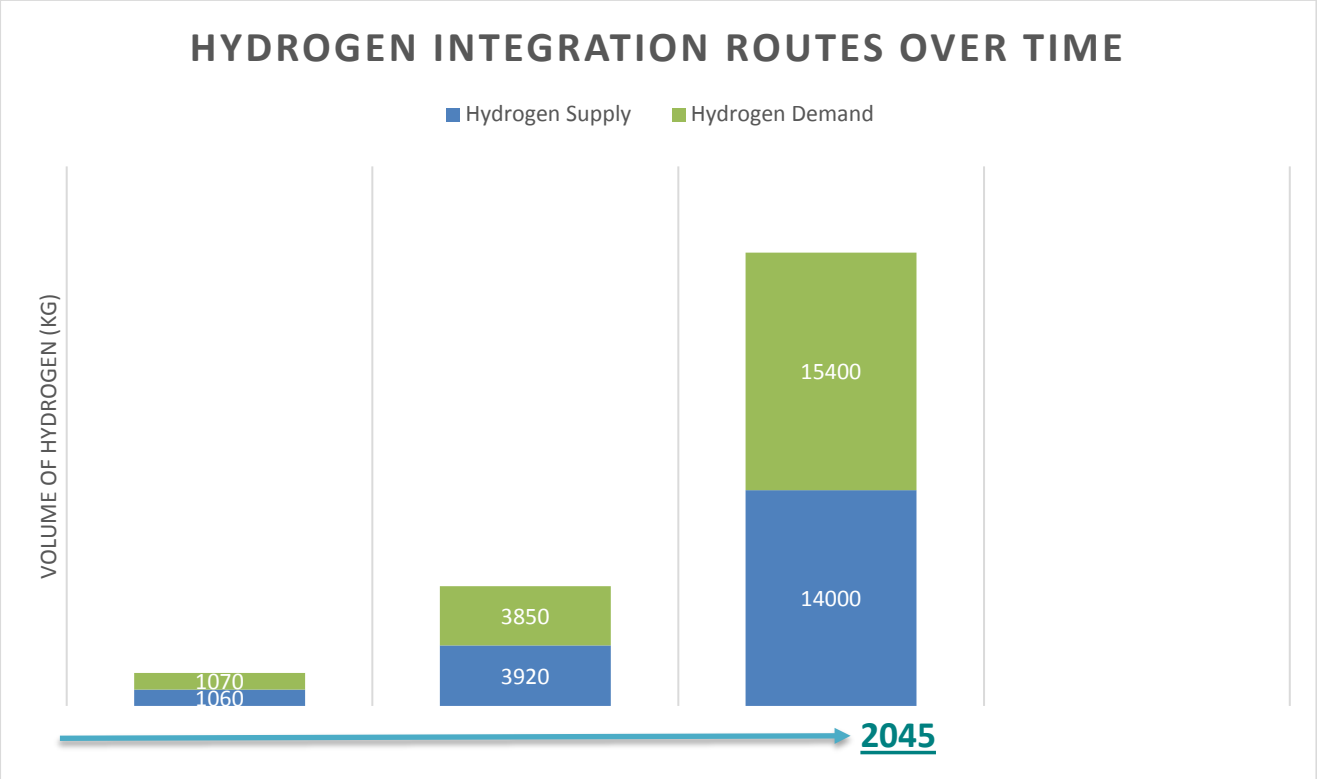

Figure 4. Potential Hydrogen Integration Routes over time.

LOW INTEGRATION MODEL

A low integration route for hydrogen would see hydrogen support the role of smart electrification in the region. The main bulk of energy provision across all energy streams will be electricity and hydrogen will support this role minimally. Many of the assets required to achieve the output below are already deployed or are in the process of being deployed at time of publication. Adoption of hydrogen at this lower integration scale can be expected by 2022/23.

If hydrogen for this route was to be generated from curtailed wind with no back up generation from the grid it would require an additional 2MW of electrolysis to be installed on a further two 900kW wind turbines. It would be possible to scale down the Megawatts of electrolysis required if the electrolysers were connected to the electricity grid.

There will be limited job roles supported by this integration route growing from ~25 roles in 2019 to 40 in 2023. There may be a rise of up to 20 relevant studentships available in the region per annum. Focus will be on research and development of hydrogen with scope for around 5 technician or engineering roles for maintenance and repair.

Hydrogen supply	Hydrogen Demand	Volume of Hydrogen (+Gen/-Use) day (kg)
3-4MW electrolysis		+1060
	1st ferry	-270 (+ 1500 stored)
	20 hydrogen vehicles	-300kg
	Heat at 2 public buildings	-100kg
	500kW Fuel Cells combined	-400kg
	Total Demand	1070kg

Table 3. Low Integration scenario for green hydrogen.

ASSOCIATED ACTIONS FOR SUCCESS

- Keep current projects on target for delivery and maintain operation
- Identify additional sources of electrolysis for green hydrogen production to satisfy demand
- Increase the number of operational vehicles.

MEDIUM

A medium integration route would see hydrogen support the role of smart electrification in the region and start to develop a commercial business case for hydrogen supply and production. The main bulk of energy provision across all energy streams will be electricity and hydrogen will support this role more fully than the low integration route. There will be some grid balancing using fuel cell and hydrogen storage technologies of multiple scales (vehicles to Fuel Cells), this will ease pressure on the electricity grid and provide consumer options. Access to the grid would be less prohibitive both economically and operationally than at present.

The assets required to achieve the output below will require additional capital investment and consumers may have to be convinced to uptake technologies using subsidies or other appropriate cost parity measures. Adoption of hydrogen at this medium integration scale could be achieved by 2025/30.

If hydrogen was to be generated from renewable resources, it would likely require dedicated commercial scale marine energy or a wind farm for hydrogen production. Curtailed wind would struggle to cope with these

quantities. It would be possible to scale down the Megawatts of electrolysis required if the electrolysers were connected to the electricity grid to increase utilisation rates to 100%. The fuel cells may help with electricity grid balancing applications. Micro-scale wind generators (domestic, commercial and agricultural) can generate small volumes of hydrogen for domestic combined heat and power units and transport applications.

Job roles would rise to include hydrogen transport and an increased function for research, development and replication and potential to develop some higher-level research roles.

Hydrogen supply	Hydrogen Demand	Volume of Hydrogen (+Gen/-Use) day (KG)
14MW electrolysis @ 70% utilisation		+3920kg
	2 ferries	-1200kg + 3000kg stored
	100 hydrogen vehicles	-1500kg
	Heat at 2 public buildings and 50 micro CHP projects	-250kg
	3MW Fuel Cells Combined	-900kg
	Total Demand	3850kg

Table 4. Medium Integration scenario for green hydrogen.

ASSOCIATED ACTIONS FOR SUCCESS

- Dedicated renewable resource for production
- Access to the electricity grid for generation
- An additional ferry is added to the fleet and captive fleet and buses begin transition to hydrogen
- General public utilise hydrogen for domestic heat and transport

HIGH

A high integration route would see hydrogen support the role of smart electrification in the region and start to develop a larger scale commercial business case for hydrogen supply and production. The main bulk of energy provision across all energy streams will remain to be electricity and hydrogen will support this role more as well as becoming commercially viable. There will be some grid balancing using fuel cell and hydrogen storage technologies of multiple scales (vehicles to Fuel Cells), this will ease pressure on the electricity grid and provide consumer options. Access to the grid would be less prohibitive both economically and operationally than at present.

The assets required to achieve the output below will require additional capital investment and consumers may have to be convinced to uptake technologies using subsidies or other appropriate cost parity measures. Adoption of hydrogen at this high integration scale could be achieved by 2045.

If hydrogen was to be generated from renewable resources, it would likely require dedicated commercial scale marine energy or a wind farm for hydrogen production. Curtailed wind would struggle to cope with these quantities. It would be possible to scale down the Megawatts of electrolysis required if the electrolysers were connected to the electricity grid to increase utilisation rates to 100%. The fuel cells may help with electricity grid balancing applications. Micro-scale wind generators (domestic, commercial and agricultural) can generate small volumes of hydrogen for domestic combined heat and power units and transport applications.

Job roles will be wide reaching and varied in the high integration routes including roles in ports, maintenance, compliance, logistics, administration, and community development. Job roles supported by this integration route would grow to ~200 by 2045. Orkney could develop itself to be considered a centre for excellence around hydrogen education across all educational levels.

Hydrogen supply	Hydrogen Demand	Volume of Hydrogen (+Gen/-Use) day (KG)
50MW @ 70% utilisation		+14000
	H2 on most passenger ferries	-5000kg
	400 hydrogen vehicles	-6000kg
	Heat in public, commercial and in 50% of homes	-2000kg
	10MW Fuel Cell	-3000kg
	Total Demand	15,400kg

Table 5. High Integration scenario for green hydrogen, does not include volumes for chemical applications

ASSOCIATED ACTIONS FOR SUCCESS

- Ferry fleet switches to hydrogen
- Captive fleets increase their transition to hydrogen vehicles and 10% of passenger vehicles are hydrogen powered
- Fuel Cells to manage grid balancing
- Hydrogen hub to manage the logistics

EVALUATION, MONITORING & ENGAGEMENT

Evaluating and monitoring how real-world interactions affect the key priorities identified in this strategy is vital to achieving these goals. It is proposed that this could be achieved by producing a short *local energy statement* annually which defines the most recent energy statistics; progress towards regional targets; developments under key strategic themes; assessment of technological change and any other relevant changes to the energy system.

In addition to the monitoring and evaluation benefits a *local energy statement* would help:

- *Raise awareness* and improve the understanding of the choices and challenges facing Orkney community members as we move towards decarbonisation
- *Develop a Sense of Ownership* and control amongst communities, consumers, producers and investors in the local energy system to provide the greatest benefits from a low carbon transition
- *Continued Collaboration* to feed in sensible ideas to the energy system by having the ability to implement sensible design ideas via stakeholders' experience with the energy system

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ORKNEY
ISLANDS COUNCIL

Equality Impact Assessment

The purpose of an Equality Impact Assessment (EqIA) is to improve the work of Orkney Islands Council by making sure it promotes equality and does not discriminate. This assessment records the likely impact of any changes to a function, policy or plan by anticipating the consequences, and making sure that any negative impacts are eliminated or minimised and positive impacts are maximised.

1. Identification of Function, Policy or Plan	
Name of function / policy / plan to be assessed.	Orkney Hydrogen Strategy
Service / service area responsible.	Development and Infrastructure
Name of person carrying out the assessment and contact details.	Adele Lidderdale Adele.lidderdale@orkney.gov.uk 01856 852273
Date of assessment.	9 May 2019
Is the function / policy / plan new or existing? (Please indicate also if the service is to be deleted, reduced or changed significantly).	This will replace the previous Hydrogen Economic Strategy which was approved by committee but not fully published.

2. Initial Screening	
What are the intended outcomes of the function / policy / plan?	To conglomerate existing hydrogen projects and provide a more strategic direction for future actions associated with hydrogen developments. The Orkney Hydrogen Strategy seeks to incorporate the views from a variety of a range of local, national and international stakeholders.
Is the function / policy / plan strategically important?	Stakeholders such as the general public, agencies, community development trusts, electricity producers, Orkney's Distribution Network Operator (DNO), Scottish and Southern Energy (SSE), planning authorities, private enterprise, public bodies, educational establishments and the wider supply chain.

State who is, or may be affected by this function / policy / plan, and how.	The Orkney community is intended to benefit from this policy, in the wider context to help reduce carbon emissions and thus climate change. It may also provide opportunities for locals to divest from fossil fuel energy sources across a number of applications.
How have stakeholders been involved in the development of this function / policy / plan?	The relevant stakeholders are aware of the drafting of the Orkney Hydrogen Strategy, an Orkney Hydrogen Network has been established through the Orkney Renewable Energy Forum, this will provide a platform for discussion at the consultation phase. A number of additional stakeholders have been identified and will be contacted when the draft is published for consultation.
Is there any existing data and / or research relating to equalities issues in this policy area? Please summarise. E.g. consultations, national surveys, performance data, complaints, service user feedback, academic / consultants' reports, benchmarking (see equalities resources on OIC information portal).	No, although the Equalities Act 2010 requires that no-one be disadvantaged in receiving services from public agencies.
Is there any existing evidence relating to socio-economic disadvantage and inequalities of outcome in this policy area? Please summarise. E.g. For people living in poverty or for people of low income. See The Fairer Scotland Duty Interim Guidance for Public Bodies for further information.	(Please complete this section for proposals relating to strategic decisions).
Could the function / policy have a differential impact on any of the following equality areas?	(Please provide any evidence – positive impacts / benefits, negative impacts and reasons).
1. Race: this includes ethnic or national groups, colour and nationality.	No negative impact
2. Sex: a man or a woman.	No negative impact
3. Sexual Orientation: whether a person's sexual attraction is	No negative impact

towards their own sex, the opposite sex or to both sexes.	
4. Gender Reassignment: the process of transitioning from one gender to another.	No negative impact
5. Pregnancy and maternity.	No negative impact
6. Age: people of different ages.	No negative impact
7. Religion or beliefs or none (atheists).	No negative impact
8. Caring responsibilities.	No negative impact
9. Care experienced.	No negative impact
10. Marriage and Civil Partnerships.	No negative impact
11. Disability: people with disabilities (whether registered or not).	(Includes physical impairment, sensory impairment, cognitive impairment, mental health) No negative impact
12. Socio-economic disadvantage.	Positive impact – socio-economically disadvantaged can be worst affected by rising fuel prices and the effects of climate change and carbon and particulate emissions, may provide access to low carbon technologies or transport that are otherwise unavailable. Negative impact – could increase energy costs, low carbon technologies may be more expensive than existing.
13. Isles-proofing.	positive impact – potential low carbon transport ferries, buses, cars, energy security, new skills generation, new job roles, additional industry creation, contribute to negate the effects of climate change.

3. Impact Assessment	
Does the analysis above identify any differential impacts which need to be addressed?	Positive and negative impacts should be addresses and balanced before any solutions are adopted.
How could you minimise or remove any potential negative impacts?	Employ measures to reduce fuel costs, such as thermal improvements.
Do you have enough information to make a judgement? If no, what information do you require?	N/a

4. Conclusions and Planned Action	
Is further work required?	Consultation events with the local community.
What action is to be taken?	N/a
Who will undertake it?	Hydrogen project officer
When will it be done?	Q3-Q4 2019
How will it be monitored? (e.g. through service plans).	Ongoing monitoring process of the Orkney Local Development Plan

Signature: [redacted] Date: 13/05/19

Name: ADELE LIDDERDALE (BLOCK CAPITALS).

Please sign and date this form, keep one copy and send a copy to HR and Performance. A Word version should also be emailed to HR and Performance at hrsupport@orkney.gov.uk