



## **Social Impact Assessment of BIG HIT**

A report into the societal impact of the project

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BIG HIT: Building Innovative Green Hydrogen Systems in an Isolated Territory: a Pilot for Europe

# Social Impact Assessment of BIG HIT

A report into the societal impact of the project

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## List of Abbreviations

ANM ---- Active Network Management

CAL ---- Calvera Maquinaria S.L

CES ---- Community Energy Scotland

DTU ---- Technical University of Denmark

EMEC ---- European Marine Energy Centre

ERE ---- Eday Renewable Energy

FHA ---- Foundation for the Development of New Hydrogen Technologies

GIA ---- Giacomini

HRS ---- Hydrogen Refuelling Station

LCA ---- Life Cycle Assessment

LCC ---- Life Cycle Cost

OHT ---- Orkney Hydrogen Trading

OIC ---- Orkney Islands Council

PEM ---- Polymer Electrolyte Membrane

ROCs ---- Renewable Obligation Certificates

SDT ---- Shapinsay Development Trust

SHFCA ---- Scottish Hydrogen and Fuel Cell Association

S-LCA ---- Social Life Cycle Assessment

SMEs ---- Small and Medium Enterprises

SnT ---- Surf 'n' Turf

SYM ---- Symbio FC

## 1. Executive Summary

The BIG HIT project will create a replicable hydrogen territory in the Orkney Islands (Northern part of Scotland) by implementing a fully integrated model of hydrogen production, storage, transportation and utilised for heat, power and mobility purposes. The system will utilised otherwise curtailed electricity from one wind turbine on the island Shapinsay and from one wind turbine and 7 tidal test sites on the island Eday. It will make use of in total 1.5 MW capacity of Polymer Electrolyte Membrane (PEM) electrolyser to convert the electricity into ~50 t pa of hydrogen. Part of the hydrogen will be used to provide heat to local primary schools. Part of hydrogen will be transported by ferry in hydrogen tube trailers to the largest town of the Orkney Islands named Kirkwall, where it will be used to fuel a 75 kW fuel cell (which will provide heat and power to the harbour buildings and 2 ferries when docked). Finally, a part of the hydrogen will be used at a refuelling station to fuel a fleet of 5 fuel cell vans.

This report presents an estimate of the potential social impacts of solutions implemented by the BIG HIT project. The social life cycle assessment methodology is used to analyse the potential social impact. There are five main stakeholder categories included: workers, local community, society (national and global), consumers, and value chain actors. Under each stakeholder, subcategories are addressed and analysed.

The objective of this report is to explore whether there are significant social impacts one should be aware of in the project. The input data used for the impact analysis is from surveys, interviews, and national statistical data.

Furthermore, a master thesis has been conducted analysing the social impact of the hydrogen technologies at the Orkney Islands as a supplement to the analysis carried out within the project. The master thesis builds on interviews, surveys and literature studies.

The impact results for each stakeholder and subcategories were as follows:

**Workers:** Freedom of association and collective bargaining are positive; the working hours follows national standards, no health and safety issues of concern, and no risk of child labour as part of the project.

**Local community:** Local community have been highly involved in this project; the local employment increased due to very good collaboration between local community and companies/partners; the project shows positive support from local community to access material/immaterial resources. This project does not cause any potential safety issues to the local community. There is a slight concern that the new economy could have a negative effect on the cultural heritage and traditional industry like fishing.

**Society:** The public is highly committed to sustainable development including renewable energy and green hydrogen. The project has positive potential contribution to economic development of renewable energy. The project is supporting technology innovation and development of electrolyser technology and fuel cell technology.

**Consumers:** There is no potential health and safety issues from this project. The public shows concerns about the safety of hydrogen distribution and use. The public needs further communication and confidence with the safe use of hydrogen.

**Value chain actors:** Fair competition and loyal supplier relationships within the project have positive effect on promoting social responsibility.

The main finding from the master thesis conducted is that both positive and negative impacts have emerged: "The properties of renewable energy development have already brought benefits to the region and the communities. It has brought employment opportunities through working directly for the BIG HIT Projects and indirectly through knock-on effects and initiatives. Over the life-cycle of the project, there would undoubtedly be increased job opportunities, energy security, and innovation, development of skills and transfer of knowledge along with much more as previously discussed. However, there have also been some unintentional negative impacts. [...] At the community level, what is primarily an issue is whether local communities will receive an appropriate balance of benefits to compensate for the costs associated with negative impacts on their livelihoods."

**The hydrogen energy system implemented by the BIG HIT project can have positive social impact to local communities regarding local job creation and renewable energy transition. It also has positive impact for the society with respect to technology innovation. This study did not show any significant negative social impact of the concept implemented by the project.**

## 2. Report Objective and Scope

The BIG HIT concept has been developed on the basis that this demonstration will be positioned to expand the scope of the hydrogen production and application in future, and with the objective to enable replication of the technical and commercial solutions developed through the project in other areas in Europe and other continents. The BIG HIT will not only contribute to fulfilling the delivery of the Orkney hydrogen strategy, but ultimately it will initiate a wider market for hydrogen and fuel cell technologies.

The main objective of the societal impact is to analyse the societal impact of building innovative green hydrogen systems in isolated territories. The social life cycle assessment (S-LCA) methodology is applied to achieve this objective. The data has been collected by questionnaires, interviews and national statistical information. The questionnaire was designed with the aim of containing all the necessary information to conduct a complete and comprehensive analysis of the potential social impacts of the hydrogen energy solutions deployed by the BIG HIT project.

Five main stakeholder categories are defined: workers, local community, society (national and global), consumers, and value chain actors. Of special interest is the number of jobs created and the attitudes towards hydrogen within the local population. The latter will take the form of a survey of the public and stakeholders in year 1 and year 5 of the project.

## 3 BIG HIT Introduction

### 3.1 Background

The Orkney Islands containing 20 inhabited island with a total population of 21000, have around 66 MW of renewable energy generation (11 MW of wave and tidal and 55 MW of wind) (SSEPD 2014). The demand for electricity is a proportion of the winter peak demand, as there is normally high-energy demand during wintertime. The actual electricity generation from renewables in the Orkney Islands is only a part of the total renewable capacity. The possible generation is greater than the local demand, which means that the excess electricity from renewable sources will need to be exported to the Scottish mainland via two undersea cables. The electricity demand will be less than the electricity generation during the summer time. The electricity transmission by the Active Network Management system (ANM) within the Orkney Islands is around 65% of the electricity demand (Fig. 1, Fig 2). Remote communities operating a wind turbine have several challenges relating to energy, as the electricity grid is overloaded, leading to high levels of curtailment. The project is based in the Orkney Islands, which although they are technically grid connected to the Scottish mainland, the connection is at its capacity limit (not all the time), resulting in the archipelago having many of the features of an isolated grid including significant difficulties balancing supply and demand. In the Orkney Islands, this weak electricity grid leads to reduced security of supply, high-energy bills for the end users and difficulties in balancing supply and demand for the local power grid, leading to recurrent curtailment of renewable sources. This otherwise curtailed generation is a zero carbon electricity leading to a low-cost source of energy that can be used to produce green hydrogen. Hydrogen, as an energy carrier, can be used to produce electricity and heat and meet the demand of the local communities of the islands of Orkney to replace conventional energy sources, when the electricity demands is higher than electricity generation.

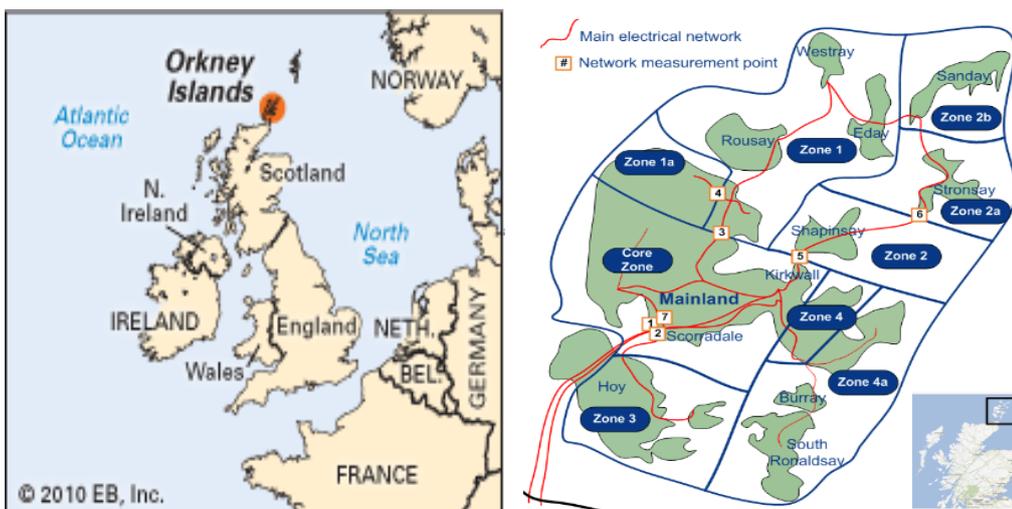


Figure 1 The location and the main electrical grid of the Orkney Islands, showing the Active Network Management zones and main connection to the Scottish mainland. Source: (SSE 2017a)

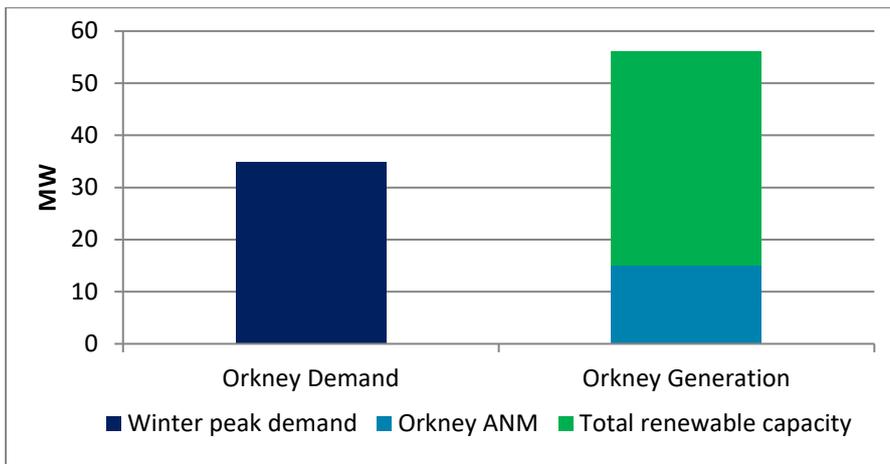


Figure 2 Renewable energy generation and demand in the Orkney Islands in 2017. Modified from SSE 2017b

### 3.2 BIG HIT Description

The BIG HIT project will absorb curtailed energy from two wind turbines on Shapinsay and Eday and tidal test centre on the islands of Eday, and use electricity to convert water into 50 t pa of hydrogen by 1.5 MW of proton-exchange membrane (PEM) electrolyser. The hydrogen will be used to heat local schools (on Shapinsay and possibly on Eday); some of the hydrogen will be transported to Mainland (Kirkwall) by ferry in hydrogen tube trailers. In Kirkwall, the hydrogen will be used to fuel a 75 kW fuel cell unit, which will provide heat and power to the harbour building, and 2 ferries when docked, and a refuelling station for a fleet of 5 fuel cell vans.

There is one wind turbine located on the island Shapinsay; there are one wind turbine and 7 tidal test sites on the island Eday. In the two islands, wind and wave turbines and tidal sites together with solar energy can generate over 46 GWh of renewable electricity each year. The Orkney Islands have been a net exporter of electricity since 2013. Due to the low power distribution capacity with the Scottish mainland, a large amount of electricity has been curtailed by the power grid. The electricity used to produce the hydrogen in BIG HIT will be provided by the community-owned wind turbines on Shapinsay and Eday, and energy from EMEC tidal sites on Eday. Before the deployment of electrolysers, the wind turbines installed in Shapinsay and Eday have often been switched off, losing on average more than 30% of their annual output, with their electricity output limited by grid capacity restrictions in the Orkney Islands. With the BIG HIT project, the curtailed electricity will be harvested to produce hydrogen, which will be used to provide heating to schools, be transported to Mainland for electricity and mobility purposes (Fig. 3).

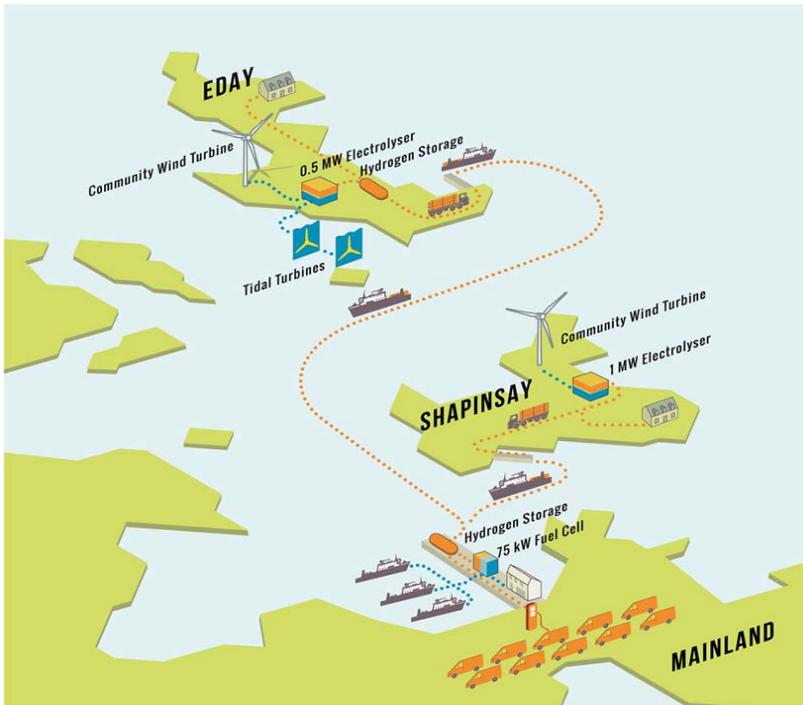


Figure 3 Schematic of BIG HIT project in the Orkney Islands

### 3.3 Equipment Review and Stakeholders

BIG HIT consortium includes a planning authority: OIC (Orkney Islands Council), the research community: Technical University of Denmark (DTU) and Foundation for the Development of New Hydrogen Technologies in Aragon (FHA), Spain, local charities and SMEs from the UK: Shapinsay Development Trust (SDT), Scottish Hydrogen and Fuel Cell Association (SHFCA), Community Energy Scotland (CES), ITM Power, and European Marine Energy Centre (EMEC), and industrial companies from other EU countries: Giacomini from Italy, Calverva from Spain, and Symbio from France.

#### Hydrogen production

When the BIG HIT concept is fully implemented, the situation will be as follows: The 1 MW of PEM (Polymer electrolyte membrane) electrolysis is installed on Shapinsay. The Shapinsay community owns 900 kW wind turbines (operated by Shapinsay Renewables Ltd, a subsidiary of SDT). ITM Power owns a 1 MW electrolyser on Shapinsay. On Eday, an 0.5 MW PEM electrolyser produced by ITM Power is installed. The European Marine Energy Centre (EMEC), a BIG HIT partner, owns a tidal testing site with a 4 MW connection to the power grid. Eday community owns a 900 kW wind turbine. The produced hydrogen will be compressed and stored in 500 kg static storage equipment.

**ITM Power**, located in Sheffield in UK, ITM Power is a dynamic, innovative company committed to clean sustainable energy solutions based on water electrolysis using PEM technologies. From its original platform of

novel hydrophilic polymeric electrolytes (for water electrolysis and hydrogen fuel cells), ITM has now established itself as a technology provider.

**The Shapinsay Development Trust (SDT)**, located on the Orkney Islands, was formed by the residents of Shapinsay in 2002. SDT operates the 0.9MW wind turbine with the purpose of passing the profit generated to SDT for the benefit of the community of Shapinsay. Its role in the greater scheme of things is to be the vehicle through which the islanders can collectively help to maintain and improve their lives on the beautiful, peaceful island of Shapinsay.

**Community Energy Scotland (CES)**, located on the Orkney Islands, has been at the forefront of community energy developments in Scotland since 2002. Its aim is to build confidence, wealth and resilience at local level through sustainable energy development. It is an independent, membership based charity and social enterprise that has worked with over 1,000 community groups to develop on- and off-grid renewable energy projects.

**Marine Energy Centre (EMEC)**, located on the Orkney Islands, was established in 2003 as a non-profit SME. EMEC is the first and only centre in the world to provide and develop both wave and tidal energy converters with purpose-built open-sea testing facilities.

### **Hydrogen transport**

Both islands will implement the same methodology for transporting hydrogen to the Kirkwall, the largest town in the Orkney Islands. The travel to Kirkwall, by road and by sea, is an expensive and time-consuming process. Thus, to minimize the capital cost, the consortium of BIG HIT decided to employ a logistic company to handle transportation activity. The main equipment for hydrogen logistic is the five tube trailers supplied by Calvera. Calvera designed and produced the tube trailer, which is light enough to comply with a 25 tonne weight limit of Orkney roads. The tube trailers containing hydrogen will be transported by road and sea from the EMEC site on Eday and SDT site on Shapinsay respectively, to Kirkwall pier, where the hydrogen will be delivered.

**Calvera Maquinaria S.L. (CAL)** located in Zaragoza, Spain, specialises in the manufacture of storage and transport systems for compressed gas, and particularly Hydrogen. The company has provided bespoke systems for 30 years to industrial and medical gas companies and is a certified official supplier to these organisations. The company is composed of 2 production facilities, with a workforce of 60 people, and provides turnkey solutions including European approvals. In addition, the company maintains and refurbishes gas transport systems.

### **Hydrogen application**

Two catalytic hydrogen boilers will be installed in two small primary schools to supply heat, working together with two conventional heat boilers based on oil on Shapinsay and Eday. Giacomini manufactures the two hydrogen boilers. On the harbour of Kirkwall, a 75 kW fuel cell unit, supplied by Arcolar Energy, is installed. It will provide heat and power to the harbour buildings (offices, waiting rooms, etc.) and 'cold ironing' (provide auxiliary power) to two large ferries which berth at the harbour most nights. The hydrogen refuelling station

(HRS) is installed next to the sailing club at less than 1 km from the harbour installed in Kirkwall, Mainland. This will provide hydrogen for 5 Kangoo ZE-H2 vans supplied by Symbio. These vans will enter the vehicle pool of OIC and be used for a variety of tasks including as day-to-day vehicles for the council's buildings and maintenance team to conduct repair of the council's housing stock.

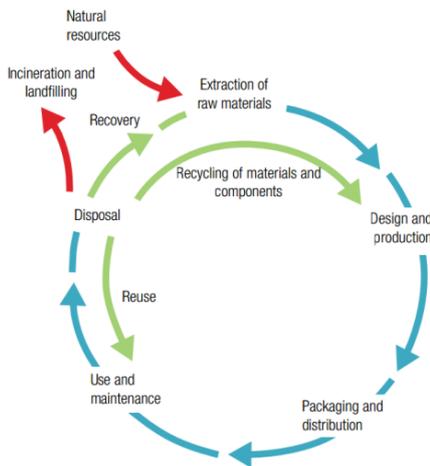
**Giacomini (GIA)** founded Italy in 1951 is a leader in the field of components for heating and cooling. Giacomini has been involved for more than 10 years in the field of hydrogen as renewable energy source. The main result in this field is the development of an innovative condensing boiler based on a hydrogen catalytic burner. Giacomini has also been involved in other projects regarding hydrogen storage and fuel cell systems.

**Symbio FC (SYM)** develops industrial fuel cell systems, based on PEM technology, designed for utility cars, boats, trucks, industrial vehicle and racing cars. Symbio FC offers a range of PEM-based embarked energy solutions that address density and reliability issues, and are ready for cost effective mass production.

**Orkney Islands Council (OIC)** as a local authority has an impact on many aspects of everyday life for the entire community. With around 1,800 staff, it is Orkney's biggest employer. Through independent operating units, OIC is also responsible for harbour infrastructure and inter-island ferry transport. OIC aims to act as a leader through transition to a low carbon economy.

## 4 Social Impact Assessment

Social impacts are consequences of positive or negative pressures on social endpoints (i.e. well-being of stakeholders). Social impacts are understood to be consequences of social relations (interactions) weaved in the context of an activity (production, transport, consumption, and final disposal) and/or engendered by it and/or by preventive or reinforcing actions taken by stakeholders (ex. enforcing safety measures in a facility). Social life cycle assessment (S-LCA) methodology is chosen to do the social impact analysis in the project. Life cycle thinking is the conceptual idea behind social life cycle assessment (S-LCA) that reflects the comprehensive approach in a completed cycle systems perspective (Fig. 4). S-LCA works together with life cycle cost (LCC) and life cycle assessment (LCA) to analysis the three dimensions of sustainability development in relation to various products or services.



**Figure 4** The concept of product life cycle thinking  
Source: (UNEP 2007)

S-LCA is defined as the methodology for the assessment of positive and negative social impacts that are generated by a product/service in its life cycle, and in relation to different groups of stakeholders involved within the whole life cycle of the product. The methodology refers to the steps proposed by the JRC researchers and UNEP (Sala et al. 2015). Although the methodology is at an early stage of development, examples of its application to specific products can already be found. The framework of S-LCA approach is shown below. The basic step of an LCA can be adopted also in S-LCA, namely: 1) Defining goal and scope, 2) Life cycle Inventory, 3)

Impact assessment, which is based on the selection and calculation of proper indicators of impacts; and 4) Interpretation of the results (Fig. 5).

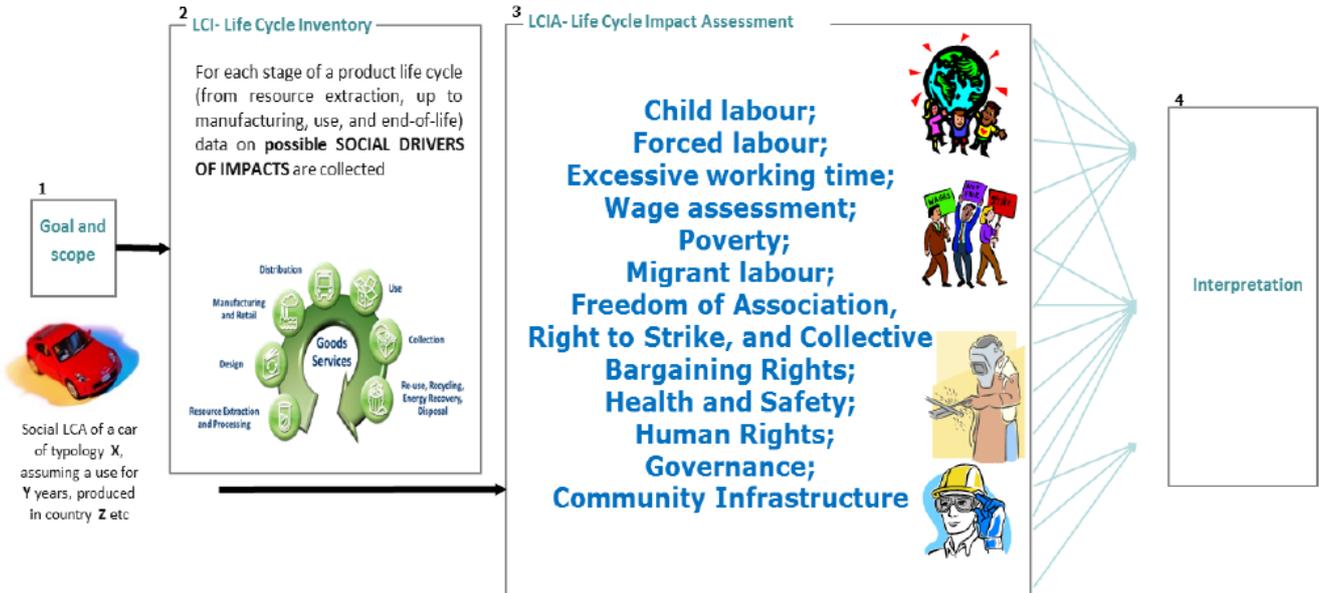


Figure 5 Four steps of Social life cycle assessment Reference (Sala et al. 2015)

## 4.1 Goal and Scope

The scope is defined in the first phase of S-LCA methodology. It encompasses issues of depth and breadth of the study. The system boundary includes the hydrogen production by PEM electrolyser, hydrogen transport, and hydrogen application for electricity, heat and mobility (Fig 6).

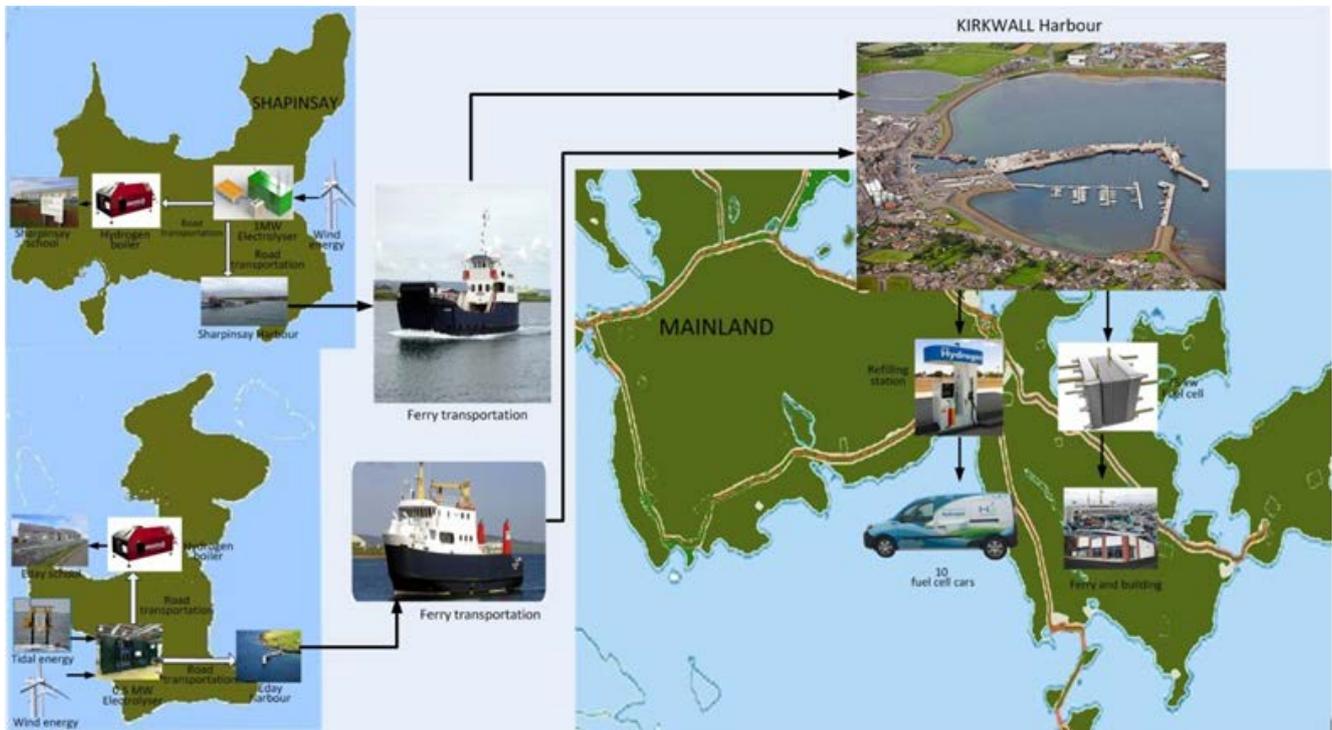


Figure 6 Energy/material flow of BIG HIT project

The goal of the report is to conduct the potential social impact of hydrogen production, distribution, and applications based on BIG HIT project. The system starts from hydrogen produced by PEM electrolysis on the islands of Eday and Shapinsay. It will be transported to Kirkwall on Mainland, which is the largest island of Orkney. The transportation will take place by road and ferry in the tube trailer. The hydrogen will be used to supply heat for two primary schools on Shapinsay and Eday by the use of hydrogen boilers. On the Kirkwall harbour, a 75 kW fuel cell unit installed to supply electricity and heat for the harbour buildings. In Kirkwall, a hydrogen refuelling station will be installed and provide fuel to 5 hydrogen vehicles.

A number of different stakeholders are considered as part of the S-LCA. The assessment covers five stakeholder groups: Workers, Consumers, Local communities, Society, and Value chain actors. Different groups of workers can be involved in the life cycle of the product: employees (i.e. workers with formal contracts, including temporary and part-time employees), workers employed through agencies or contractors, informal workers (i.e. workers without formal contracts). The subcategories are listed in Table 1.

**Table 1 Stakeholder classification from the United Nations Environmental Programme- Guidelines for Social Life Cycle Assessment of Products (UNEP 2009)**

Stakeholder categories	Subcategories
Workers	<ol style="list-style-type: none"> <li>1. Freedom of association and collective bargaining</li> <li>2. Child labour</li> <li>3. Working hours</li> <li>4. Forced labour</li> <li>5. Equal opportunities/Discrimination</li> <li>6. health and safety</li> <li>7. Fair salary</li> <li>8. Social Benefit/Social security</li> </ol>
Local community	<ol style="list-style-type: none"> <li>1. Access to material resources</li> <li>2. Access to immaterial resources</li> <li>3. Cultural heritage</li> <li>4. Safe and Healthy living conditions</li> <li>5. Respect of Indigenous rights</li> <li>6. Communities engagement</li> <li>7. Local employment</li> <li>8. Secure living conditions</li> </ol>
Society	<ol style="list-style-type: none"> <li>1. Public commitments to sustainability issues</li> <li>2. Contributing to economic development</li> <li>3. Prevention &amp; mitigation of amending conflict</li> <li>4. Technology development</li> <li>5. Corruption</li> <li>6 Cultural heritage</li> </ol>
Consumer	<ol style="list-style-type: none"> <li>1. Health and safety</li> <li>2. Feedback mechanism</li> <li>3. Consumer privacy</li> <li>4. Transparency</li> <li>5. End of life responsibility</li> </ol>
Value chain actors	<ol style="list-style-type: none"> <li>1. Fair competition</li> <li>2. Promoting social responsibility</li> <li>3. Supplier relationships</li> <li>4. Respect of intellectual property rights</li> </ol>

## 4.2 Life Cycle Inventory

The second phase consists of the preparation of the inventory. It defines the most appropriate relating to the sub categories shown in Table 1. The objective of the inventory analysis is to collect and analyse relevant information (inventory indicators) identified during the scope definition. Whether or not to include all social topics in your assessment depends on the goal of the assessment. The data collection is conducted in this phase.

The collected data will be put in the impact categories to do further analysis. It is also important in estimating the need for and setting targets for site-specific data collection.

There are two approaches to collect the data, which are primary data and site-specific data. Primary data is gathered during the study in question, rather than published prior to the study. Data may be gathered from a sample of unit processes, in order to estimate the average parameters for a group of unit processes. Primary data estimated from the partners is not site-specific. Site specific data refers to data collected for a specific process, occurring in a specific enterprise, in a specific location with those stakeholders involved or affected. Site specific data does not mean that the data is all collected on-site as data might be collected elsewhere. It is important to gather as much site specific and related product specific social data as possible for the assessment. The data is collected directly from the supplier companies/organisations and the national regulation and EU regulations. There are two reasons that site-specific data has to be collected as part of the present study. Firstly, hydrogen generation and application technologies are technologies under development. Secondly, there is no S-LCA database available for this analysis.

Data collection is a time-consuming process. Qualitative and quantitative surveys were conducted. One approach of data collection is to direct talk with and interview the stakeholders by attending project meetings or extraction of data from internal systems. With respect to the quantitative survey, a set of items were adopted as specific questions in the descriptive phase. The questionnaire was designed and administered. The questionnaire was composed of 13 questions (multiple choice and open ended), see Annex 1. The survey was carried out via email and face-to-face delivering.

## **4.3 Social Impact Assessment**

### **4.3.1 Stakeholder and Impact Category**

The addressed topics relate to five stakeholder groups, which are workers, local community, society, value chain actors, and consumer. For each social category, several subcategory will be analysis. The subcategory are defined and explained later in the text. One limitation of this social impact assessment is that the impact results are not quantified due to the limitation of the methodology of S/LCA. The process of the social impact analysis is described. Firstly, the inventory data will be collected organized by each subcategories. After that, the result of characterization will be presented. The characterization results will be assigned a level of risk. In order to arrive at an estimate of risk levels, data distribution, expert judgement, and literature are considered to put the risk level into positive, no, low, medium and high risk in each subcategory.

## **Stakeholder: Workers**

### **Subcategory: Freedom of Association and Collective Bargaining**

All workers have the right to establish and to join organizations, without prior authorization, to promote and defend their respective interests, and to negotiate collectively with other parties. The right to organise includes: the right of workers to strike, the rights of organizations to draw up their constitutions and rules, to elect their representatives in full freedom, to organize their activity freely and to formulate their programmes. The assessment aims to verify the compliance of the organization with freedom of association and collective bargaining standards.

### **Subcategory: Child Labour**

Child labour is usually defined as work that deprives children of their childhood, that is harmful to physical and mental development, and that is harmful to their health, safety or that is not impeding school attendance. This subcategory aims to verify if the organization might or is employing children and to identify the nature of any child labour.

### **Subcategory: Fair Salary**

Fair wage means a wage fairly and reasonably commensurate with the value of a particular service and, in establishing a minimum fair wage for such service or class of service. This subcategory aims to assess whether practices concerning wages are in compliance with established standards and if the wage provided is meeting legal requirements.

### **Subcategory: Hours of work**

The hours of work comply with applicable laws and industry standards. Workers are not on a regular basis required to work in excess of 48 hours per week and have at least one day off for every 7-day period. There are also higher restrictions if the hours of work are made during the night. Hours of work are considered in function of different time arrangement (from part time to full time) and work places (e.g. from home workers to field workers and manufacture) This subcategory aims to verify if the number of hours really worked is in accordance with the standards and when overtime occurs, compensation in terms of money or free time is planned and provided to workers

### **Subcategory: Health and safety**

All workers have the right to a safe and healthy workplace. Another possible definition of safe workplace, provided by OSHA, is a workplace that is free of serious recognized hazards and in compliance with OSHA standards. Workplace covers all the places where workers need to be or to go by reason of their work and which are under the direct or indirect control of the employer. This subcategory aims to assess both the rate of incidents and the status of prevention measure and management practices. An incident is defined as a work-related event(s) in which an injury or ill health (regardless of severity) or fatality occurred or could have occurred.

## **Stakeholder: Local Community**

### **Cultural Heritage**

Cultural heritage includes language, social and religious practices, knowledge and traditional craftsmanship, as well as cultural spaces and objects (e.g. burial grounds). Organizations can more actively promote the preservation of cultural heritage by encouraging the sustainable use of traditional products and craftsmanship in their product design and production methods. This is especially relevant to agricultural production methods and clothing/craft design.

### **Community Involvement**

Community stakeholders include individuals or community groups that may be affected by the actions or products of an organization. Organizations should consider these stakeholders in the development and implementation of business policies, particularly those that affect local environment, health and well-being. An organization should attempt to engage with a broad range of stakeholders that represent balanced community interests. Community engagement should provide community members and leaders with a venue to voice concerns. This subcategory is to assess whether an organization includes community stakeholders in relevant decision-making processes. It also considers the extent to which the organization engages with the community, in general.

### **Local Employment**

Local hiring preferences provide important income and training opportunities to community members. Organizations that develop relationships with locally-based suppliers will further encourage local employment and development. Organizations also may encourage local community development by training local employees in technical and transferable skills. Organizations can have a particularly strong effect on local community development when they hire local employees for senior management positions. This is likely to encourage open communication and trust with the community.

### **Relevance to Sustainable Development**

Organizations have great potential to encourage sustainable development through local hiring preferences. Local employees have unique knowledge of important community issues and can help the organization build strong community relations. Organizations that work to build transferable business skills among employees will encourage sustainable development as this knowledge may eventually transfer to locally-owned organizations.

### **Access to Material/Immaterial Resources**

Communities and organizations may share the use of material resources (natural and man-made) and immaterial resource (social, and cultural etc.) and have a mutual interest in protecting and enhancing the quantity and quality of local resources and infrastructure. Expanding operations carry the potential for depletion of and conflict over natural material resources (e.g. water, forest land, home lands), especially in emerging or unstable countries. Organizations should conduct risk assessments with attention to potential conflict over material resources and engage with the local community over sustainable methods for sharing resources.

Organizations should institute risk management plans for preventing, mitigating and controlling environmental damage. The aim of this category is to assess sustainable development to both the material and immaterial resources and to prevent the pollution and water of resources.

### **Safe and Healthy Living Conditions**

With regard to general safety, operations can influence community safety through equipment accidents or structural failures. Project-related land use changes can also lead to natural disasters, such as landslides. Disease may spread as a result of business related land use changes, for example when poor water drainage contributes to the spread of malaria. The generation and/or use of hazardous material and pollution emissions may also lead to adverse health impacts. Organizations may also contribute to the health of local communities, for example by shared access to employee health services. Organizations should also communicate potential health and safety impacts of their operations to surrounding communities.

### **Stakeholder: Society**

#### **Public Commitment to Sustainability Issues**

A public commitment is a promise to its customers, employees, shareholders, local community to a sustainable society. Typically, this will take the form of performance improvement targets with defined dates for achievement and public reporting of progress. This subcategory can relate to the contribution of organizations to the sustainable development of the community or society as the reduction of impacts from their activities.

#### **Contribution to Economic Development**

Organizations can foster economic development in many ways. They generate revenue, create jobs, provide education and training, make investments, or forward research. This subcategory assesses to what extent the organization/product or service contributes to the economic development of the country.

#### **Technology Development**

The development of technology includes technology needs, technology information, enabling environments, capacity building, financial and institutional mechanisms and so on. Technology transfer is the process of using technology, expertise, know-how or facilities for a purpose not originally intended. It is also defined as a process for converting research into economic development. Technology development is also the key for the improvement of social conditions and to prevent further environmental damage related to old technology use and it is formally part of many international instruments.

### **Stakeholder: Value Chain Actors**

#### **Fair Competition**

Anti-competitive behaviour may result in collusion with potential competitors to fix prices, coordinate bids, create market or output restrictions, impose geographic quotas, or allocate customers, suppliers, geographic areas, and product lines with the purpose of limiting the effects of market competition. Anti-trust and monopoly

practices also erect barriers to entry to the sector, unfair business practices, abuse of market position, cartels, anti-competitive mergers, price-fixing, and other collusive actions, which prevent competition.

### **Supplier Relationships**

Supplier relationships are defined as affiliations with organizations that supply another organization with goods and services. The supplier relationships also concern all mutual activities, co-operations, agreements that regulate the exchanges, trade and relation among organizations, bearing in mind that every organization in the value chain is responsible for complying with applicable laws and regulations. Organization's suppliers can be any business or individual, including subcontractors, agents, manufacturers, distributors and consultants that provide goods and services.

### **Promoting Social Responsibility**

Social Responsibility is an organization's obligation to consider the interests of their stakeholders as customers, employees, shareholders or communities. This subcategory seeks to assess whether the enterprise promotes social responsibility among its suppliers and through its own actions. This measure considers whether the enterprise manages its suppliers in a socially responsible way, including monitoring, auditing and training efforts. This subcategory also examines whether enterprises take corrective action towards suppliers when warranted. Enterprises also can promote social responsibility by encouraging suppliers to join foundations and initiatives with a related focus. Promoting the use of social responsibility certifications and/or product labels is another positive indicator.

### **Stakeholder: Consumer**

#### **Health and Safety**

Consumer health and safety refers to the consumers' rights to be protected against products and services that may be hazardous to health or life. Customers (end users) expect products and services to perform their intended functions satisfactorily and not pose a risk to their health and safety. This subcategory helps to identify the existence and scope of systematic efforts to address consumer health and safety across the organizations involved in the life cycle of a product and/or service.

#### **4.3.2 Impact Result**

When using qualitative indicators and data in S-LCA, it may be difficult to link the results specifically to the functional unit. It is still necessary, though, to define the functional unit, as well as the product utility, in the goal and scope phase of the study, as this provides the necessary basis for the product. Impact categories are chosen to analyse the social impact from hydrogen production and application on the Orkney Islands.

The impact results from the interviews are presented in Table 2.

Table 2 Social impact results

Category	Subcategory/ Indicators	Impact results	Comments
Worker and Customers	Freedom of Association and Collective Bargaining	Positive	Follow EU and national working contract
	Child Labour	No	No
	Fair Salary	Positive	National standards
	General equality	Slightly negative	Depends on the company /institute
	Hours of work	No	35-40 hours/ week
	Health and safety	No	Follow standards
Local community	Cultural Heritage	Slightly negative	Potential effect on traditional industry like fishing.
	Local Employment	Positive	More activities involved in the local community
	Community Involvement	Positive	High commitment to local initiative, government initiative for the project
	Access to Material Resources	Positive	Good collaboration
	Access to immaterial resources	Positive	Good collaboration
	Safe and Healthy Living Conditions	No	Have done the risk assessment
Society	Public commitment to sustainability issues	Positive	Public high aware of renewable energy
	Contribution to Economic Development	Positive	Big contribution from renewable energy on the Orkney Islands
	Technology Development	Positive	Highly support for renewable energy, hydrogen production and application technology
Value Chain Actors	Fair Competition	Positive	Public high aware of renewable energy
	Supplier Relationships	Positive	Well. Good relationship
	Promoting Social Responsibility	Positive	Concern about the social consequence of their companies or organisation
Consumer	Health and Safety	No	There is no health and safety risk shown in the project

For the 'worker' category, we obtained positive results for all considered indicators. For all the worker/employee from the interviewed institutes/companies, the employments follow the EU regulations and all have work contracts. They have the right to strike, no risk of average wage below minimum wage. The involved companies/organisations have working contracts of 35-40 hours per week. Wages paid for a normal work period meet the minimum wage established by national laws. The wage received by workers will be sufficient to provide a decent standard of living for the workers and the family. There is no high degree of physical, mental and social well-being threat. Health and safety aspects become a key social issue to integrate, in order to assess the social performance of the associated hydrogen production, distribution and application. Thus, production/application activities should not harm or have negative effects on the workers' health. The companies have done health and

safety assessment, there will be no risk of fatal injuries. There is no potential risk incurred at work, which will cause detrimental effect to health. The survey shows that each partner complies with local regulation on workers' health and safety. There is no toxic chemicals or products handling in this project. The inventory shows slight negative impact of inequality relates to gender bias. There is no risk of gender inequality in the OIC and CES, but in the other interviewed companies/institutes, the number of male employees are higher than the number of female employees.

The local community has been highly engaged in the whole process of the project starting from the local citizen to the Orkney Islands Council. The engagement of the local community has significant importance for long-term projects such as development of new renewable energy solutions that involves local people in a range of activities, and requires increase of their knowledge, skills and confidence towards the new technology. By making collective decisions about the use and distribution of income, local communities also develop greater self-determination through the direct control of local resources. The Orkney Islands Council changes the vehicle based on fossil fuels to fuel cell electric vehicles. One or two local schools change the heating supply from crude oil boiler to catalytic hydrogen boiler, which will one more step on the road of changing the energy system of the Orkney Islands into a renewable energy system. In the meantime, the local production of hydrogen will lower the risk of lacking fuel supply in wintertime, as fuel needs to be transported from Scotland by sea.

An important factor for the evaluation of the impact on the local community is that the impact to the current social structure that have been working entirely satisfactorily for the local stakeholders. During the period of the project, local civil construction job opportunities are offered to the local community. The potential job opportunities are mainly the skilled-trained worker. The distribution of hydrogen also increases the income to the local ferry company, which might bring the potential to expand their business. The potential business for hydrogen production from water powered by renewable electricity will bring more investment of renewable energy, especially wind and marine energy, because the Orkney Islands have the one of the best European wind and marine energy source. Employment improves the economic livelihood of the workforce and their families. Employment also creates ripple effects of sustainable development across the community. The local communities commit themselves to the future of renewable system and low carbon energy supply. Moreover, the wind and marine energy sources have not been fully exploited for energy supply. It is a great economic potential both for the renewable energy investment companies like EMEC and local communities. The commitment to the renewable energy of OIC and British government brings the potential business and time to small and medium enterprises like ITM Power, EMEC, Giacomini, and Symbio FC to improve renewable technologies.

The project is located in the Orkney Islands. Many of the small islands have wild nature and beautiful views and a number of major archaeological sites. The Orkney Islands have landscape of ceremonial stone circles, tombs, prehistoric villages and many other ancient monuments. Across the island Mainland, there are a staggering number of archaeological sites. The local community shows concerns that the production and application of

hydrogen energy might have the risk of affecting the cultural heritage. One income for the local inhabitant is from tourism. The local community shows concerns about the promotion of hydrogen might have negative effects on the local landscape. The only slightly negative impact indicator is 'cultural heritage'.

For the 'society', all the impact are positive. The public has been high committed to the sustainable development. Moreover, the public has high awareness of renewable energy contribution to economic development. The long-term sustainable development of local communities could be achieved by enhancing and unlocking their human potential through improved access to knowledge, information, technology and skills.

While it would be most accurate to speak with each one of the value chain actors involved in each supply chain, the scale at which supply chains operate makes it impossible. Hence, we have to use estimates. In this project, the value chain actors include the partners of the project who are also suppliers of equipment and providers of equipment in the project. The value chain actors are spread over thousands of kilometres and hundreds of production activities take place within weeks, months or years. The selection of the suppliers are based on the fair commercial competition, and there is no risk of corruption or legal issues.

For the consumers, the application of hydrogen for electricity and heat by PEM fuel cell stack do not have potential risk for the consumers. It is safe to fuel hydrogen to hydrogen vehicles. The electrolyser facilities have done healthy and risk assessment. The use of water for electrolysers will be a limited amount. The installation of two hydrogen boilers will permit energy savings from crude oil. In order to increase public participation, ITM Power and OIC also offer free teach of the use of the hydrogen refuelling station and test drive of the fuel cell electric vehicles.

#### 4.4 Interpretation

This social life cycle analysis concerns the BIT HIT project in the Orkney Islands. The project has well-defined location and suppliers. Thus, during the inventory analysis, the data collection is done specifically within the project partner organisations and only a small part of the outside suppliers are considered in this analysis.

The significant concerns in this study are the potential impact to the cultural heritage and traditional industry like fishing. The energy application of 'green hydrogen' could increase the demand of renewable energies, which are wind energy and marine energy in the BIG HIT project. The investment in wind and marine energy has potentially negative impacts on the traditional fishing industry. The local communities, especially local residents, show concerns about the health and safety aspects of hydrogen production and applications. A detailed analysis of potential social impacts to the local communities has been conducted by Rebecca Kavanagh in her master thesis, which DTU has been co-supervising (Annex 2). Even though there is no sign of safety issues to be concerned about, the members of the local communities still need more information and knowledge about safe

use of hydrogen. More hydrogen demonstration projects like BIG HIT can help the public build confidence that hydrogen will be as safe as the fuels in use today.

The use of 'green hydrogen' for energy purposes is still at an early stage. The system boundary is limited to the partners and part of the external suppliers within the BIG HIT project. The technologies of electrolysis and fuel cells are emerging technology that are still in development with little data available about its inputs and outputs, which means that almost all the inventory data needed for the assessment would be collected from the project. It has not been possible to include all suppliers and sub-suppliers in this assessment, like steel, platinum, vehicle manufacturers. There are few generic data available for social impacts such as "social hotspot" where you can get the social data for the UNEP/SETAC indicators at country/sector levels. As this social impact analysis focus on the demonstration project of the emerging technologies, the stakeholders are clearly defined by the project. The potential social impacts at the national level will need further investigation. It cannot be ruled out that there might be a negative social impact due to the material supply from places in different parts of the world. These social risks may be negative external effects of the production of the intermediate products which are imported through the globalized trade routes to the European hydrogen production sites.

## 5 Conclusion

Social life cycle assessment (S-LCA) methodology can be used to assess the social and sociological aspects of products, their actual and potential positive as well as negative impacts along the life cycle of the product or service. The current framework of S-LCA is provided by UNEP. The S-LCA guidelines propose a comprehensive approach and impact categories for conducting a S-LCA.

A S-LCA has been performed to estimate the social impacts of the BIG HIT project and the energy solutions it provides. The study showed that the project can have positive social impact to local communities regarding local jobs and renewable transition. It will also have positive impact on the society due to the technology innovation. This study did not show any significant negative social impact of the project. In the early stage of the project, it might be beneficial to identify potential social impact risks related to consumers, workers or local communities, society, and value chain actors as well as further potential innovation and business opportunities.

**Workers:** Freedom of Association and Collective Bargaining are positive, the working hour follows national and EU standards. There are no health and safety concerns. There is no use of child labour.

**Local community:** The local community has been highly involved in the project. There has been job creation, there is very good collaboration with local companies and the community has access to the material/immaterial resources. The project does not cause any safety issues towards the local community. There is a concern of slightly negative potential impact to the cultural heritage referring to traditional industry like fishing.

The local communities of the Orkney Islands are highly engaged in the project with open dialogue, responses to their concerns and inquiries fairly and promptly. In order to continuously foster greater trust and the relationship with the local community, particular attention should be paid to engaging representatives of diverse groups such as indigenous people and women.

**Society:** The public is highly committed to sustainable development referring to renewable energy and green hydrogen. The project has positive contribution to the economic development of renewable energy. The project has a high positive impact on the technology innovation and development of electrolysis technology and fuel cell technology.

**Consumers:** The project has no impacts with respect to health and safety issues. However, the public shows concerns about the health and safety associated the hydrogen production, distribution and application. Further social impact results can be found in the master thesis by Rebecca Kavanagh (Annex 2).

**Value chain actors:** Fair Competition and loyal supplier Relationships, and positive effect on promoting social sustainable environment.

There is a very limited amount of case studies, which apply the S-LCA methodology to hydrogen production and application technologies. The S-LCA methodology is still in the development stage, so are electrolysis and fuel cell technologies. There are almost no databases available with information on social impacts, especially with respect to the upstream of material acquisition (e.g. steel and platinum). Further social impact analysis would be required in order to include impacts of the upstream material acquisitions.

The study showed that BIG HIT project have positive potential social impact to local communities regarding for local job and the transition towards a renewable energy system. The project also has positive impacts to the society due to technology innovation. The public shows concerns about the safety of hydrogen use. No significant negative social impacts of the project was found.

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## Annex 1. Survey to the Stakeholders

### Social impact survey to partners / suppliers of BIG HIT project

(None of the questions are mandatory, any or all can be left unanswered)

1. Which company/organisation are you in?

Name of the company/organisation \_\_\_\_\_ location (country and city) \_\_\_\_\_

Public sector

Private company

Non- profit organisation

2. How many employees are engaged in the BIG HIT project in your company/organisation?

No.: \_\_\_\_\_ (both full-time and part-time)

3. What are the nationalities of the engaged employees? Please provide nationalities and number of employees.

Nationality \_\_\_\_\_ No. \_\_\_\_\_

4. What is the age of the engaged employees?

18-30 yr. No. \_\_\_\_\_

30-40 yr. No. \_\_\_\_\_

40-50 yr. No. \_\_\_\_\_

60+ yr. No. \_\_\_\_\_

5. Which type of employment do the employees involved in BIG HIT have? How many of them?

Full-time contract: No. \_\_\_\_\_

Part-time contract: No. \_\_\_\_\_

6. Usually, what are the average working hours per week at your company?

Please provide the number \_\_\_\_\_ (hours/week)

7. What is the job category they have?

Trade (ie. Manufacture/logistic/maintenance etc.) : No. \_\_\_\_\_

Professional (ie. Administration/ research/ legal etc.) : No. \_\_\_\_\_

8. How long has your company had contracts with materials/components suppliers for the BIG HIT project? And for how many years has your company been cooperating with these suppliers in general?

Contract type	No. of contracts	For how long has your company cooperated with these suppliers, in general? (No. of suppliers)			
		< 1 yr.	1-2 yr.	2-5 yr.	> 5 yr.
Long-term contracts					
Short-term contracts					
One-time contracts					

9. How long has your company had contracts with non-material product suppliers (e.g. service, communication) for the BIG HIT project? For how many years has your company been cooperating with these suppliers in general?

Contract type	No. of contracts	For how long has your company cooperated with these suppliers, in general? (No. of suppliers)			
		< 1 yr.	1-2 yr.	2-5 yr.	> 5 yr.
Long-term contracts					
Short-term contracts					
One-time contracts					

10. Are you aware of any effect on **cultural heritage because of BIG HIT in the Orkney Islands?**

If yes, please specify what kind of cultural heritage?

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11. Do you think the BIG HIT project can help with the technological innovation in your company?

- No
- Yes, slightly
- Yes, some contribution
- Yes, strong contribution

12. Does your company take part in community engagement activities regarding this project?

Yes/no: \_\_\_\_\_ If so, when was the first one: \_\_\_\_\_ How often: \_\_\_\_\_

What kind of engagement activities:

- Newsletters
- Announcement in newspapers
- Information bulletin home delivered
- Information bulletin at a central point
- Information meetings
- Consultation meetings

Other: \_\_\_\_\_

13. In what ways do you see BIG HIT contributing to the local community? Please select an order of the contribution based on your view (you do not have to choose all of the options).

- a. Economic benefit
- b. Employment benefit
- c. Reliable energy supply
- d. Climate change adaption
- e. Local service (electricity, mobility)
- f. Technology innovation
- g. Social cohesion (positive or negative effects)
- h. Renewable energy awareness
- i. Education ('green hydrogen', curtailment of renewable energy, climate change, etc.)



j. Other \_\_\_\_\_

Your order (e.g. a, b, c): \_\_\_\_\_

## **Annex 2. Master Thesis by Rebecca Kavanagh**



A Social Impact Analysis of Hydrogen Production in the Orkney Islands Based on the Water  
Electrolyser

Submitted for the degree of MSc in Marine Planning for Sustainable Development

Heriot-Watt University

*International Centre for Island Technology*

Rebecca Kavanagh

August 2017

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## List of Acronyms

ANM	Active Network Management
BIG HIT	Building Innovative Green Hydrogen Systems in Isolated Territories
CES	Community Energy Scotland
CO2	Carbon Dioxide
EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
ESS	Energy Storage Systems
The EU	European Union
GHG	Greenhouse Gases
H2	Hydrogen
Ha	Foundation for the Development of New Hydrogen Technologies in Aragon
HFC	Hydrogen Fuel Cell
HFCV	Hydrogen Fuel Cell Vehicles
LIFO	'Last in First Off'
MV/MWH	Megawatt/Megawatt Hour
P/KH	Per Kilowatt Hour
SA	Sustainability Assessment
SIA	Social Impact Assessment
S-LCA	Social Life-Cycle Assessment
UN	United Nations
UNEP	United Nation's Environmental Programme

## Abstract

This dissertation examines the creation and evolution of hydrogen as a means of energy storage, providing a solution to the curtailment issues presently being experienced. It shows the importance of the social, political and environmental landscape of Orkney at this time. This analysis is achieved through the use of existing literature, interviews, surveys and a general exploration of the evolution of Orkney's renewable journey building an account of an isolated community's ability to mitigate energy issues, taking a giant leap to becoming self-sustainable. This dissertation portrays how the framework enhances the understanding of prediction social impacts by tracing and exploring the causes of social change and connections about the social implications emanating from the BIG HIT Project. Factors that contribute positively can be identified and used to support the activities of the development. With this, factors that contribute negatively can be reduced through mitigation, monitoring and evaluation. The study analyses the extent of the effects and implies an integrated framework for the monitoring and evaluation of the identified social impacts on society through a community empowerment framework, properly addressing social impacts that may arise from this development. This study presents research undertaken to adequately understand community development and regional economic benefits located primarily within small island communities.

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# 1 Introduction

## 1.1 Background

Following the discovery of mass oil and gas deposits in the North Sea throughout the 1960s, subsequently, after the oil crisis of October 1973, the UK government invested in and directed various research and development in renewable energy. Despite this discovery and ever-growing faith in nuclear energy, the government was keen to uncover the possibilities of renewable energy resources.

After the 1973 oil crisis shook the UK government's complacency towards energy policy, it responded with the creation of the 'Department of Energy', focusing upon the forecast of energy, for the first time attempting to plan the future energy consumption in the UK. Until privatisation, 15 years post the emergence of the oil crisis, various attempts in formulating energy policy were made. This period in energy policy history throughout the 20th century, when the UK government attempted to control and monitor the development of energy planning was imitable.

Although the focus was placed heavily on traditional fuels such as coal and nuclear, as well as the newly discovered North Sea oil and gas reserves, the attempt at formulating energy policy in the UK extended towards energy conservation and renewable energy sources. Social responsibilities and political obligations dominated the energy debates throughout the 1970s. This had a profound influence on economic impact assessments of renewable energy sources. This dissertation intends to centralise the importance of socio-political factors and their precedence over socio-economic considerations in government decisions and policies on renewables. The social and economic elements of the project are considered throughout the project chapters, some key socioeconomic aspects of the development of a hydrogen economy in Orkney will be explored.

In the 21st century, it is hard to separate the development of new renewable energy technologies from climate change. Concerns about climate change have emerged over the past few decades and have been since become a major concern. With previous post-privatisation instruments including Renewables Obligation & Non-Fossil Fuel Obligation, the close-knit relationship between these and publications such as 'The Limits to Growth' and

the world first 'UN Conference on the Human Environment' in 1972, the environment became paramount in the consciousness of the developed countries. This encouraged a free-fall of knock-on effects, spurring social movements and the creation of 'Friends of the Earth' and 'Greenpeace' throughout the remainder of the 1970s and were mainly focused on and driven by depletion and the development of Climate change as a Science.

The Orkney Islands are an archipelago off the north-east coast of Scotland. In total, there are 20 islands with a total population of 21000. At present, the islands have 56MW of renewable energy generation capacity, divided into 11MW of wave and tidal and 45MW of wind power production. The electricity grid is currently overloaded, leading to curtailment.

Plans were devised, and Orkney was chosen as a demonstration for wind energy in the UK. The investiture of the Orkney turbine in 1987 concluded the UK government's involvement in wind power, becoming the final act of the UK renewable energy programme. Shortly after this, the government announced plans for the privatisation of electricity. Following 1989, direct government funding for renewables ceased. The government's original plans were significantly altered, and as a result, it took over five years to construct and erect the Orkney turbine. In 1987, almost ten years post the initial design reference period for a 3.7MW demonstration turbine was communicated and the Secretary of State at the time 'Cecil Parkinson 'inaugurated the UK's largest wind turbine' on Orkney (59).

Orkney's Council developed and published a 'Sustainable Energy Strategy' in 2009 on behalf of the Orcadian community. Although not statutory, it reflected the growing need for a solution to the range of energy issues challenging Orkney and its economy. The strategy aids Orkney in facing these difficulties by 'ensuring Orkney uses energy as efficiently as possible and has a secure and affordable energy supply to meet its future needs', to '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 footprint'.

The 2013-2018 Council Plan emphasises the commitment levels the council has to lower the carbon emissions of Orkney through renewables, energy and opportunities. The council has brought forward a means of achieving this through the development and implementations of necessary policies to meet EU, national and local requirements. As well as work in

partnerships, attract new investment opportunities, make good and innovative use of natural resources, ensure policies are in line with 'Section 44' of 'Climate Change (Scotland) Act 2009' while managing development. It aims to encourage Orkney's competitiveness and explore the community benefits arising from renewables and guarantee a skilled workforce.

The Sustainability strategy intends to place the ownership on Orcadian communities supporting the local industry and wider community as a whole while delivering significant national priorities. Various stakeholders and groups exist within the Orcadian communities. OREF represents the local community of expertise and mechanisms, enhancing a collaborative and constructive forum aiding the investment and development strategies helping place Orkney and its communities as a world example in demonstrating efficient and sufficient renewable energy developments, enabling a low carbon future.

Community wind power projects offer a percentage of generating revenue to the landowner of approximately 5%. Local companies have previously been awarded contracts from the design stage through to the stage of commissioning. However, all profits from community wind turbines initially go to the organisations outwith the islands. The Orkney Islands designed and developed locally owned wind turbine projects. Dedicated companies were established. For this study, Shapinsay Renewables Ltd. and Eday Renewable Energy Ltd. will be further studied later in the dissertation. These established companies put the planning forward for approval and gained consent for the wind turbines including the establishment of a local ownership mechanism. Profit is gift aided to the dedicated community institutions. In this case; Shapinsay Development Trust and Eday Partnership. The projects were funded by local investment, retaining revenues within Orkney. A local community investment fund is distributed to the community associations and is reinvested into the local community for various uses in enhancing the quality of life in isolated territories. The annual income, after operation and maintenance, is made available to the community. Locally-owned wind energy developments have contributed to the minimisation of social and environmental impacts arising from fuel poverty and lack of innovation, at the same time, ensuring maximum returns to the communities.

Orkney's bounty and strength of the wind, wave and tidal resources and long daylight hours in the summer months, make it one of the most robust renewables locations in Europe.

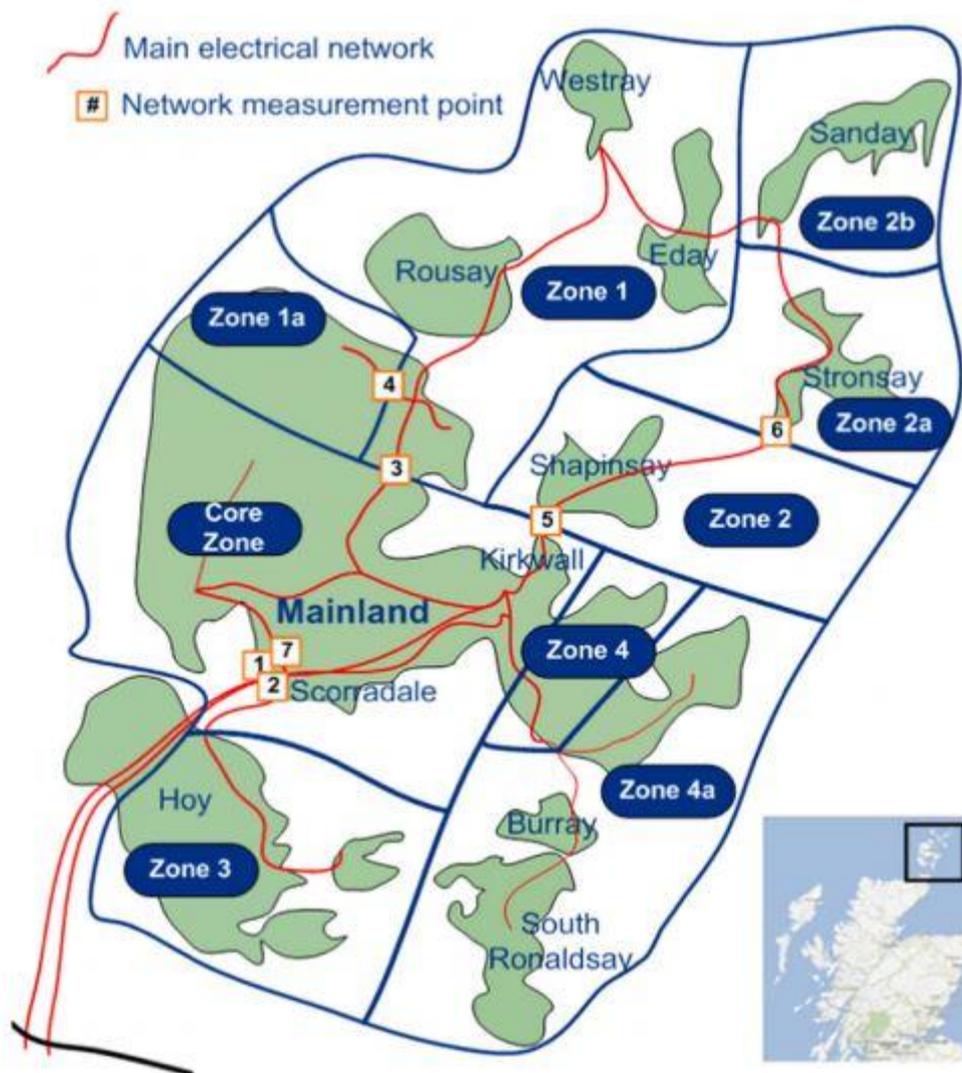
Orkney has encompassed renewable electricity production and utilisation an extent that has

enabled it to produce 104% of electricity needs through renewable energy sources in 2014. Grid constraints and lack of connections are a major weakness for Orkney and its renewable energy generation ambitions. This has resulted in the curtailment of existing renewable energy projects. Scottish and Southern Energy has imposed a cessation on new grid connections since September 2012, placing stagnation on renewables investment opportunities in Orkney including substantial revenue from the exportation of electricity from Community based schemes already in place, from UK Government Feed in Tariffs FITs). (Scottish and Southern Energy Power Distribution, 2013)

The ANM scheme in Orkney is the first of its kind in the UK. Once curtailment is required, the ANM controllers signal the generators behind the constraint in the order predetermined by the LIFO priority stack (Curie et al., 2007). This occurs in a 'last in first off' manner. Meaning that generators at the bottom of the stack will be curtailed first. The network is divided into 'constraint zones'. Each zonal boundary becomes a limitation point. This was created as an alternative solution to expensive network reinforcements. Regardless of the construction of the subsea cable, local network constraints would still occur, still requiring management. The Orkney ANM scheme took from 2003-2009 to reach its operational stage.

This system aided the recognition of the growing importance of communication systems. The responsibility of each curtailable site fell on the generator of that particular site. Initially, there was unreliability of some communication links in the system. To begin with, only generation greater than 50kW required curtailment Instructions. The impact that the individual curtailment had little impact on network constraints, preventing the further increase of curtailment.

Figure 1 Orkney Distribution Network with Zone Boundaries



## 1.2 Problem Statement & Justification

The Orcadian community has been in favour of the production of electricity through renewable resources over the past number of years. The success of Orkney's renewable energy production reflects the fact that it has exceeded the capacity of the existing grid and export connection to Mainland Scotland. Despite the pioneering use of the grid network, the production of green energy's curtailment remains a predicamental issue regarding the investments made by Orcadian individuals, communities and businesses.

The Orcadian communities, industry and council are keen to immerse themselves into the storage, and use of green produced electricity in the form of hydrogen as a solution to the

problems caused by curtailment. Orkney has a wealth of natural energy resources, yet still has a relatively high level of fossil fuel imports, also have elevated levels of fuel poverty.

The transformation of a problem into an innovative, economic opportunity gives Orkney a chance to make use of this lost energy. With the Orcadian community being 'energy literate', a supportive public sector and industry constantly creating new, innovative technology and has a track record of successfully implemented renewable energy projects, the support of a hydrogen economy in Orkney will be straightforwardly executed.

Policies, as well as factors of practicality, have been driving such opportunities forward, especially with the earlier identification of a niche through EMEC's electrolyser and the already existing 'Surf n Turf' project. This which involves producing hydrogen from curtailed marine and community-owned wind energy developments, to be transported and utilised, providing electricity at Kirkwall Harbour.

Hydrogen production in Orkney will be by the utilisation of green electricity which would otherwise be unused and wasted. This approach as a solution to the current grid constraints utilises the technology developing the local island energy economy.

### 1.3 Orkney & the BIG HIT Project

Demonstration of innovative technologies as solutions for issues that face isolated territories such as grid constraints, socioeconomic, political and environmental issues remains central to the project objectives. Orkney will benefit immensely from the use of curtailed energy to generate and store hydrogen through electrolysis. This strategy aims to demonstrate the use of hydrogen produced through the means of renewable energies as an energy vector, utilising Orkney's curtailed energy, storing intermittent renewable energy, reducing Orkney's footprint and reduce the level of fossil fuel imports.

Energy generated from the Shapinsay and Eday community-owned wind turbines and tidal power will provide the energy that will be used to produce hydrogen for the BIG-HIT project, as much of the electricity generated through these means are curtailed. On average, over 30% of the annual electricity output on the islands is curtailed, and their electricity output is limited by Orkney's grid capacity restrictions and constraints. BIG-HIT will absorb the curtailed energy that has been harvested on islands generated from two wind and one tidal turbine. It will use 1.5MW of PEM electrolysis to produce 'green hydrogen'.

The hydrogen will then be used to heat two local schools and transported by ferry to Kirkwall in 5 hydrogen tube trailers. The total storage of hydrogen amongst the different locations is approximately 200kg. The hydrogen will be used to fill a 75kW fuel cell. This fuel cell will provide power and heat to the harbour building, a marina and three docked ferries. It will also facilitate a refuelling station in Hatston (Kirkwall), to accommodate a fleet of 10 fuel cell Renault Kangoo fuel cell range extended vehicles.

Figure 2. Overview of Integrated Hydrogen Scheme



Ensuring the implantation of this project without adversely affecting or impacting on natural and cultural heritage properties, public health and safety and amenity remain integral to the development of this project. Project outcomes aspire to promote Orkney as a destination that entails a fully functioning hydrogen economy, support the development of a local hydrogen supply chain. They also aspire to encourage new opportunities for investment into the hydrogen economy in Orkney and contribute to strategy and policy development in support of hydrogen technology, working collaboratively with local authorities, governments and industry, altogether advancing the use of green hydrogen activities that are replicable in other areas.

#### 1.4 Focus & Structure of Research Objectives

This study concentrates on the social impacts that the production and storage of hydrogen can have on a small island community level. The 'Building Innovative Green Hydrogen in an Isolated Territory' (BIG-HIT) project is integrated into the already existing 'Surf n Turf' initiative in place amongst the islands. This study undertakes a social impact analysis of hydrogen production and storage as part of the pilot EU research project (BIG-HIT Project).

BIG-HIT will create a replicable hydrogen territory in the archipelago of Orkney. It will implement an integrated demonstration system of hydrogen production, storage, transportation and utilisation for power, heat and mobility. This study aims to grasp an understanding of the effects of the project in a context of a certain level of development.

The study will aid the representation of an opportunity for a departure from previous means of generating energy that has are currently expensive and taxing on the environment, to delve into an area where the emergence of clean, green energy production can benefit commercially but particularly smaller communities such as these islands.

This dissertation explores the development of a theory-based monitoring and evaluation framework, using S-LCA, assessing social impacts on an island community level, about hydrogen conversion and storage through electrolysis. It will inform the design implementation strategies and actions, and identify possible risks emanating from actions of the project itself, the suppliers, customers and any other relevant stakeholders. In this research report, this is undertaken by questionnaires, interviews with experts, and in-depth interviews with the principal informants who had expert knowledge of the process and the local community and by evaluation the experiences of those likely to be affected and that can capture the complexity of local social dynamics and lifestyles.

## 1.5 Specific Aims & Objectives

The overall aim of the dissertation is to assess the social impacts emanating from the activities of the BIG HIT Project. It intends to capture the complexity of the local social dynamics of island community settings and formulate a well-rounded, robust piece of research portraying this, for the project partners and decision-makers to use. The objectives are to fulfil the 'research questions' through an appropriate methodology that gathers the essential information necessary to build this impact assessment. The objectives will follow suit through the means of qualitative and quantitative data collection.

1. Inform and design implementation strategies and actions
2. Identify possible risks emanating from the actions of the project itself, suppliers, customers and relevant stakeholders.
3. To test the theoretical framework developed in this dissertation and to determine the user-friendliness of this framework and its effectiveness in capturing measuring identified social impacts.

## 2 Methodology

This section introduces the research method used for this study and how it has guided and formed the data collection, analysis and the development of an S-LCA for the BIG-HIT project. Firstly, necessary background and fundamental guidelines common to different approaches to primary sources and using grounded theory methodology (GTM) are provided. Subsections follow a linear pattern, describing the phases of data collection for this study. These phases included in-depth interviews with the principal stakeholders, focus groups and workshops with members of the communities likely to be affected by the production and storage of hydrogen in their areas, questionnaire surveys for both the public and stakeholders and meetings with students undertaking similar or related research studies. This section concludes with an explanation of the analysis approach for the collected data.

- Identify and clarify principal actors in hydrogen production supply chain
- Identify preliminary social areas of project influence
- Identify likely impacted/beneficiary communities and stakeholders
- Actors: Producer, consumer, government
- Local Community impact considerations
- Social Life Cycle Assessment Methodology
- Set up assessment framework

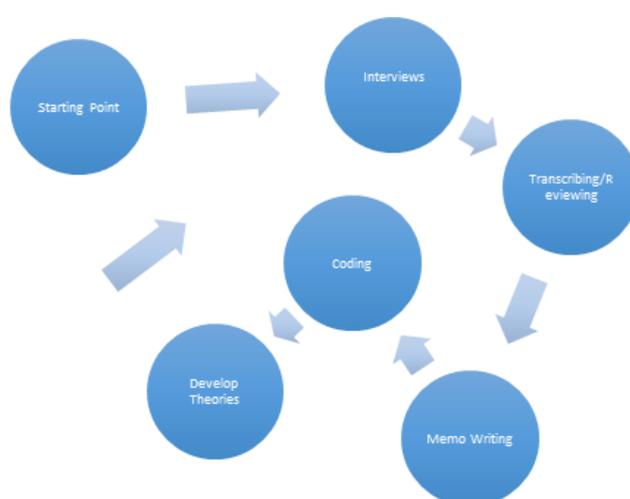
### 2.1 Data Collection

#### Grounded Theory Method

The collection and analysis of data in grounded theory use the form of theoretical sampling, where participants are selected according to criteria specified by the researcher, based on initial findings. Analysing early on and throughout the processes indicates the issues which require further exploration. The sampling process is thus, guided by continuous theory evolution and development. The collection and analysis of data occur in an iterative cycle of induction and deduction which consists of the collection of data and constant comparisons between results and discoveries (Strauss and Corbin, 1990; Miles and Huberman, 1994).

The development and identification of variables take place as a component of the data collection process. The variables/concepts initiated by interviewees are further conceptualised by the researcher. The steps involved in the development of GTM theory include coding development theory, transcribing memo writing which can be openly focused, seen in the figure below.

Figure 3. Steps Involved in GTM



The questions drawn up for interviews should have little guidance to allow interviewees to express their opinions and what is of importance to them regarding the given context. The researcher should extract those phenomena or experiences which are significant to the interviewees by assigning a code (conceptual label) multiple codes can be categorised into more abstract groupings that will, in turn, form the basis of the evolving and developing theory.

### Qualitative Research

Qualitative research approaches offer explanations and in-depth issue recognition that number often neglect or fail to understand or consider. More in-depth, whole and insightful data can be collected which results in a more “serendipitous finding” (Miles & Huberman, 1994). Further, links are distinguished and tend to have an influence when conveying ideas, concepts, experiences and the project itself (Miles & Huberman, 1994).

This approach was carried out inductively, starting with the specific details, flowing onto the more generalised information. Interviews and other forms of data collection were conducted, and this set out the specific, concrete information/knowledge to be used in the forefront of the analysis.

Post data specific accumulation, the process of analysis began. Followed by generalisation and the incorporation of theory used to describe the BIG-HIT project and its impacts on society. Taking a step back allowed a wider perspective on the empirical research where patterns and themes arose because of this process. Thus, the framework and working theory began to emerge in a clear sense.

### Interviews

Interviews were chosen and conducted to form a holistic understanding of the potential impacts of the pilot hydrogen demonstration project. The interviews were semi-structured to acquire the general understanding of the demonstration projects and questions/issues to be constructed and answered in a questionnaire that is to be distributed later on in the fieldwork process of the research. The interviews were semi-structured to create a dialogue that allows a free-flowing conversation, touching on many other elements regarding the project that was not initially perceived. (Husband & Foster, 1987).

### Chain Referral Sampling

This involves the 'ripple effect' or purposive sampling. The researcher asks interviewees to suggest new actors within the community relevant to the research including stakeholders. This way added context to the collected data and analysis of this data that have not be apparent from the beginning of the study until this point (Robinson, 2014).

This depends on a key interviewee who allows their community, organisations, social life and connections to be utilised by the researcher (Robinson, 2014). In this research study, this was gained through links in a small local environment, academic setting with connections, emails and personal visits. The interviewee was asked if they knew anyone involved or anyone that would be beneficial to the nature of this study. Aiming to gain a holistic understanding, a framing of reference and opinion concerning the impacts of this project from perspectives that would potentially have been neglected and hard to gain.

## Questionnaire/Survey

Three questionnaires were created. Two of which were for the general public of the Orcadian communities. One referred to the heating and power of buildings; the other referred to the fuel cell vehicles. Both began with a demographic section to set the scene, a general knowledge/familiarity of hydrogen technology section. They then broke down into the two topics. Both surveys consisted of the same relevant and other variables sections to gather a general and variable perspective. The third survey was sent out to the stakeholders via email and consisted of economic/market, technical and other questions driving the opinions of the stakeholders of the potential impacts on society that would be created by the project.

## 2.2 Secondary Data

### Literature Review

The literature review set the stage for the research. It gained a relevant background of knowledge drawn from many different sources. Much of the literature has been found in online journals and publications referring the main topic of the dissertation; hydrogen production, storage and utilisation, social impacts, empowerment, community development and involvement, management and S-LCA. Other information has been derived from books providing the basis of the framework and the development and implementation of theory in the sense of previous projects to help gain the necessary perspective. Websites are specific to the municipalities of the Orcadian communities to be affected by the impacts identified. National statistics and numerical data were accessed to gain an in-depth view of the specific areas and also to check general facts against statements made during interviews and focus groups.

## 3 Critical Review

### 3.1 Social Impact Assessment

The Inter-Organisational Committee on Guidelines and Principles for Social Assessment (1994) define social impacts as: ‘the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society’ (Glasson 2000). Social impacts can be described as the ‘people impacts’ of development. Social impact assessments concentrate on the humanised dimensions of the environment. They seek to identify both beneficial and adverse impacts on individuals. SIA plays a huge role in making sure the needs and the voices of ALL groups within the affected area are considered early on in and throughout the development process.

These impacts include changes in people’s livelihoods, cultures, communities, political and environmental systems, health, safety and well-being. Cases of projects with significant social implications include power and industrial plants, landfill and hazardous waste disposal sites. This is due to the perceived risks on health and safety, community stresses due to an influx of work force, pressure on infrastructure, lifestyle destruction and loss of amenity.

Types of social impacts can be categorised into overlapping groups that may arise a result of development.

- Lifestyle Impacts: Relate to the behaviour of everyday interactions of society
- Cultural Impacts-
- Generic customs, values, dialect, beliefs, obligations and anything else that distinguishes a community
- Community Impacts: Services, infrastructure, cohesion, networks and organisations
- Quality of Life: Sense of place, heritage, sense of belonging, aesthetics, security and future aspirations
- Health Impacts: Social well-being (mental and physical)

What does social impact mean? Social impact is the consequences to human populations due to any private or public actions that alter the livelihoods of people. It also includes impacts on cultural heritage that may involve changes to the norms of society that have essentially been unwittingly set in stone for years before this development.

Efforts to assess and estimate social consequences potentially arising from new development projects and government actions can be analysed through the process of SIA. The framework prioritises, gathers and analyses social information with participation into the delivery of development interventions. Focal to the SIA is that development interventions are informed, and relevant social issues are considered; a stakeholder involvement strategy is incorporated is ensured. SIA is a process providing a framework that prioritises, gathers and analyses social information with involvement into the delivery of development operations (Rietbergen-McCracken and Narayan 1998). It is an analyzation process of social impacts of the human environment which analyses how people cope with

- Economy, social systems, cultural values and beliefs
- Use of natural environment
- Organization of the community
- Preservation of cultural identity
- Expressive aspects of culture and heritage
- Aesthetic character and community ambience

It involves the characterisation of the present aspects, forecasting how they may become changed due to the development. It is also a means of mitigating these potential changes that are likely to affect the community and their beliefs adversely.

Figure 4. The Impact Value Chain (Adapted from the Goldman Sachs Foundation 2003)



The output can be any measurable results from an organisation's development. They are the specific changes in attitudes, knowledge, behaviours, status or skills arising from enterprise activities. The use of social science tools such as program evaluation, business practice in determining these social outputs, in this case, impacts of development. Some key advantages of regular SIAs include:

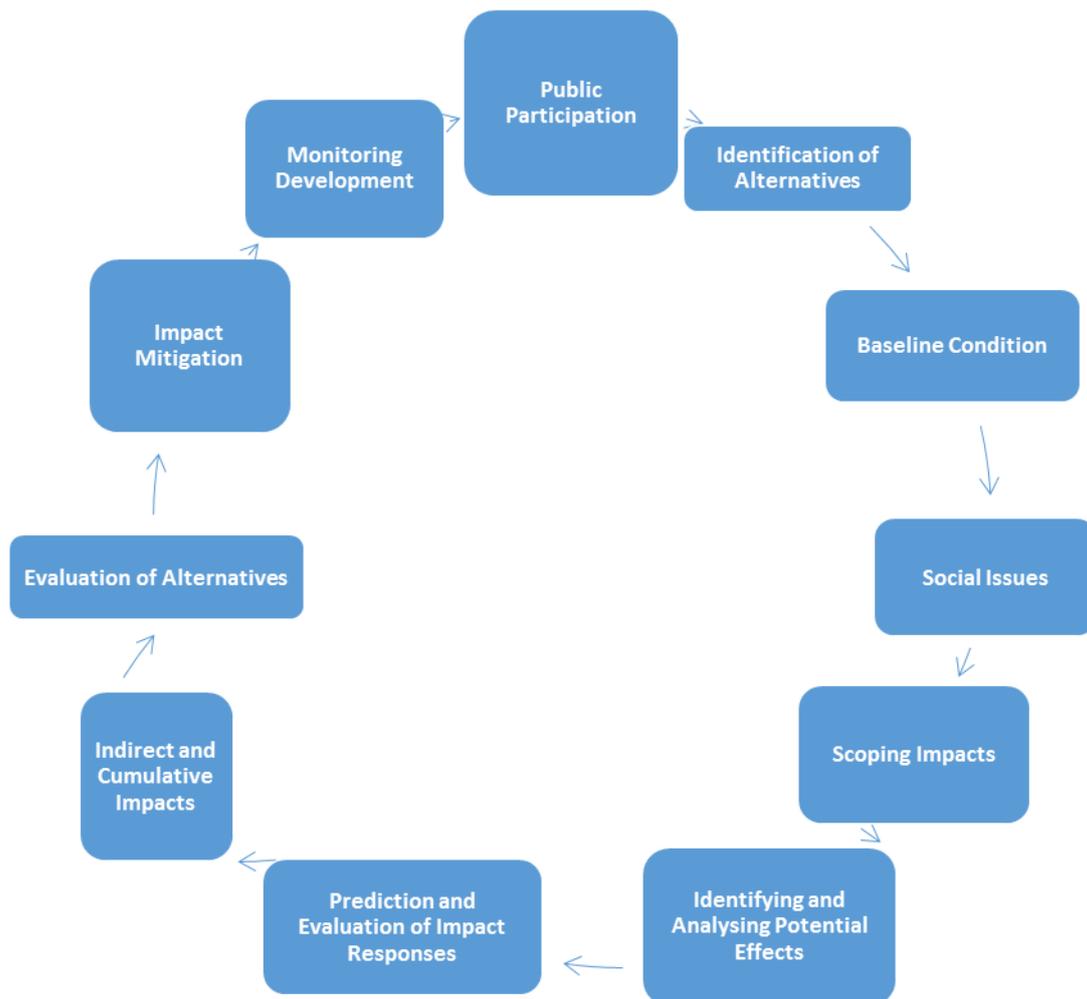
- Identification of stakeholders
- Identification and prioritisation of social issues arising from project
- Mitigation of negative impacts on communities/individuals
- Ensuring benefits outweigh negative impacts
- Mitigation of negative impacts on communities
- Avoidance of delays and obstruction to infrastructure during development
- Acts as precautionary measure, avoiding errors that may result in high costs in the future
- Building of trust and cooperation between stakeholders and community, ensuring successful project implementation

#### Process of Social Impact Assessment

The SIA process ensures that development activities are informed and consider social issues. They formulate mitigating measures and incorporate strategies for the participation of stakeholders and communities. SIA is conducted through several stages. The Inter-

Organizational Committee on the Guidelines and Principals for SIA (1994). It involves undertaking multiple actions throughout these focal stages. The stages are presented in the diagram below, and the explanation for each of these can be found in appendix A.

Figure 5. Social Impact Assessment of SIA



### 3.2 Social Life-Cycle Assessment (S-LCA)

Social Life Cycle Assessment (S-LCA), is a UNEP standardised (2009) methodology catering for the entire lifecycle of a product or service. It is a recently emerging methodology that remains in its embryonic stage. However, the results of multiple assessments have proven beneficial and transparent, allowing the framework to be replicated for a variety of diverse products and services. There is evidence of growing interest in the methodology of academic research and case studies. SIA has given rise to the concept of positive impacts,

the importance of recognising not only negative but highlighting positive impacts has recently been emphasised. (Vanclay, 2003).

“the consequences on human populations of any public or private actions that alter how people live, work, play, relate to one another, organise themselves to meet their needs and cope as members of society.”

- Guidelines and Principles for Social Impact Assessment  
(1994)

The rising concept of positive impacts in the field of SIA has been made apparent. The S-LCA Framework aids communities and stakeholders in identifying development objectives while ensuring the maximisation of positive results. Positive outcomes should be paramount in the development phase of a project. Positive impacts contribute to the driving factors for sustainable development. When the indicators in an S-LCA can be identified, it is anticipated that future development will examine their roles. Careful and attentive research must be undertaken, not only in the preliminary stages but early, often and sustained throughout the project (Luigia Petti, Cassia Maria Lie Ugaya, Silvia Di Cesare, 2014)

Social welfare is a high priority goal of modern society. Understanding and considering improvements well-being is a paramount component of public policy. The assessment evaluation of social impacts and benefits can be difficult and often controversial. This is due to cultural elements, differences in values and lifestyles. S-LCA integrates the traditional life cycle assessment method with social impacts being the focal point of the study to be carried out. It is still very much in an embryonic stage. The European Commission S-LCA report intends to present:

1. The State of the Art in S-LCA illustrating the main theoretical and methodological elements under discussion in scientific literature
2. The overlaps and synergies with traditional LCA, towards a shared and integrated assessment framework
3. Examples of the application of S-LCA methodology at macro scale (EU-28) and sector scale

The method of sustainability assessment is a tool that aids decision-makers and policy-makers. It helps them decide what actions should be taken and what actions should not be taken, attempting to help society become more sustainable (Devuyst, 2001). Verheem (2002) suggests that the aim of sustainability assessments ensure that; “Plans and activities make an optimal contribution to sustainable development.”

Gibson (2006) relays the concerns of the scientific community asking whether the examples of sustainability assessments (SA) are comprehensive. Concerns are largely about the intrinsic vagueness of the concept of sustainability and the capability of addressing social, environmental and economic issues, including interactions between them with ‘robust and fit-for-purpose’ methods (Bohringer and Jochem, 2007). This methodology states that The United Nations (UN) has set an Agenda for 2030 (transforming the world). It consists of 17 goals for sustainable development (6/17 of these goals focus on social issues).

Foreword from these policy documents, the need for more robust and rounded methodologies has become a necessity. Undertaking an SA requires the integration of sustainability principles into boundaries appraisal in the search for the maximisation of social benefits. It is important to identify cultural elements and values within the evaluation framework transparently. Interrelated challenges include global market, supply chains and social and environmental pressures. Social and environmental impacts must be considered early, often and sustained throughout the process of an SA. This should be through an integrated form in the sense of integrating life cycle thinking with human intervention. These methods can be useful in comparing scenarios. Priorities are identified early, inclusively, and they are often transparent.

### 3.3 Renewable Energy

Traditional energy sources are becoming less popular due to the high costs of installation, running, maintenance and immense stress on the environment. The past number of years has seen a shift in attitude and acceptance of alternative energy sources. Drivers of seeking cleaner forms of energy include global warming, high population levels, the decommissioning of nuclear power plants and the ever-increasing cost of conventional energy resources.

Although renewable energies have become widespread and a popular alternative, one of the main challenges to overcome is intermittency. This can be in the form of weather conditions, curtailment due to insufficient capacity of the grid. In recent years, new technology has emerged. The idea and development of energy storage are becoming increasingly feasible, and demonstration projects have already proven successful. Energy storage technology is a response or a solution to the above challenges. In the case of the Columbia River Gorge, a hierarchy model for decision making was put in place. The factors considered here were politics, social & environmental issues, technical and economic problems. The result of this paper emphasises the technological and economic factors as the most significant criteria for the decision makers (Daim, T. U., Lim, D., Gomez, F. A., Schwarz, J., & Jovanovic, S, 2014).

### 3.4 Challenges & Solutions for Curtailment Issues

Curtailment is the reduction of a given purchase power resource below its output level. It is an issue that does not rely on energy storage. Conventional generation of resources is capable of stockpiling the fuel supply. A decrease in the dispatch of the resource from its maximum output does not forego sales inevitability. It simply puts a delay on the conversion from the fuel source to electricity. However, for tidal and wind assets, it is permanently foregone. The reality of curtailment is becoming an increasingly reoccurring pattern throughout Orkney. These kinds of resources are not capable of deferring the production time to become more valuable. This results in a loss of income.

Although curtailment can be voluntary and known in advance, social and economic impacts can still be potentially significant. For island systems with connections to the national grid, it is highly susceptible to system disturbances such as regular blackouts and bottlenecks within the grid itself. The uncertainty of weather has a lot to do with the adaptability of such a system. A careful balance of demand and supply requires consistent management (Sterling et al., 2016).

The increasing evolution and growth of wind power are starting to influence the energy systems of many countries. It is mostly small to medium scale renewable energy developments that connect to national distribution due to lower levels of costs and the ease of accessibility (Jenkins et al., 2000). The traditional 'fit-and-forget' has been applied for to

wind energy generation for the past several years. The capacity factors are approximately between 0.2 and 0.5, making an inefficient use of the capacity of the generator. An example of this is in Orkney, where the distribution network has reached its capacity under the traditional 'fit-and-forget' regime (SSE, 2004).

A solution to the problematic increasing distribution of energy generation is active management. "Active Network Management' (ANM) can be related in some ways, usually beneficial in voltage/power flow management (Curie et al., 2006 & Strbac, et al., 2007). One form is 'generation curtailment' whereby producers are required to curtail output though specific conditions for the network (SSE, 2004). Generation curtailment gives rise to an increase in 'fit-and-forget' in the sense of maximum output distributed that can no longer be connected. Curtailed energy signifies lost income. Energy Storage is an evident instrument for solving the problem of loss of revenue due to curtailment. Energy Storage Systems (ESS) have the ability to 'time-shift- energy from phases of high productivity but having a challenging limitation in the capacity of exporting this energy. ESS applications can reserve the provision and aid the mitigation processes of variability (Beaudin et al., 2010).

Today, there are various technologies available, providing the ability to 'time-shift' energy over several days with multiple MW capacities. Some of which, include flow-battery, lithium ion, lead acid battery (Swierczynski et al., 2010). ESS plays a huge role in solving curtailment issues, particularly for wind power (Gills et al., 2013). Economic viability depends heavily on the market structure. The objective of ESS is to maximise revenue (combined) of the generation of energy and the storage of it in its curtailed state. An assumption is made that energy has the capabilities to be traded on the electricity market (Farhat et al., 2009). Working on the maximisation of the output of energy small-scale tidal devices was carried out, but no research has quite investigated to the maximisation of combined revenue for energy storage at the level of distribution concerning curtailment schemes (Barbour et al., 2011).

### 3.5 Hydrogen

This study is an exploration of the public's understanding and perception of 'sustainable energy'. It focuses on hydrogen, which is currently considered the least common alternative means of energy and storage. The report accounts for the reactions in the Valleys of South

Wales to an established 'Hydrogen Research and Demonstration Centre'. All the visitors resided within 80km of the establishment and were split into age categories, they then took part in a series of focus groups that were recorded and analysed thematically. The analysis determined the level of agreement and clarity of their discourse. The consensus was concluded on the safety, cost and benefits of hydrogen technologies (Bellany et al., 2016).

Hydrogen Fuel Cell Vehicles (HFCV) are becoming increasingly more attractive due to their clear benefits and ability to surpass the expectations of the standard electric car. The abundance of refuelling stations will determine the density and distribution of HFCVs. This piece of research utilises multinomial logic analysis to determine the attitudes of local communities in London towards the installation of hydrogen services. This research has scoped findings that suggest opposition occurs mainly due to the lack of trust in health and safety issues, attitudes that lie outside of an environmental framework and concerns regarding current fuel facilities in the area. Atkinson et al. (2004) developed a method to determine the time scale local communities are likely or willing to oppose the new development. Using the 'leisure rate of time', this resulted in approximately £14 per local individual who opposed the development (O'Garra, T., Mourato, S., & Pearson, P. 2008).

The growing interest in HFC energy has been international. Its awareness has grown partly due to the security issues of energy and the existential stress that is placed upon the environment. Research and development have shifted focus from the development of new technology (however, it should be noted that new technologies are explicitly significant and ever growing/evolving), towards a means of storage and fuel cell utilisation. Natural and social scientists have been drawn to hydrogen production, giving rise to questions regarding the public perception- health & safety, the solution to curtailment, growing industry. Over the past number of years, several papers have been published concerning hydrogen as a clean, green means of energy. This piece of research intends to raise awareness or add to the current level of knowledge in the area.

Firstly, the paper gives a broad overview of previous survey-based research to identify any significant gaps in knowledge. This is through critically analysing previously used methods and results. Five key issues were determined as follows:

1. How to draw upon the unknown opinions
2. Key drivers of current public perception & the role in which risk plays
3. How 'public acceptance' is to be conceptualised
4. Would people pay for more goods?
5. Acknowledgement of trust issues

These five fundamental issues are addressed by the representation of qualitative social research findings in the UK, which have been funded by the Engineering and Physical Research Council and the Department for Transport (Ricci, M., Bellany, P., & Flynn, R, 2008).

This paper is an observation of the general public's understanding of hydrogen in the sense of 'system innovation' across the UK in the locations of which have small-scale early stage hydrogen developments taking place: London, South Wales and Teeside. This study followed a process where it conducted a 2-phase focus group programme. These groups were brought together twice throughout the course of this study. Information was distributed amongst the participants that expressed multiple scenario possibilities for a hydrogen economy. This aided the group's ability to identify prominent criteria for decision-makers.

This research proved that there is minimal public awareness of hydrogen local demonstration projects except for some local individuals with direct chemical industry experience. An informant and engaging debate took place between the communities, resulted in a public willingness to learn about the possible options, and the impacts hydrogen projects can place upon their everyday lives.

Risk assessment is prominent in the configuration of the public perception of hydrogen systems. Most prominent is the level of trust and the attitudes towards political bodies, industry, the providers of information, between and across social groups within their community and 'expert sources'. The evidence found in this research is helpful in not only informing policy but addressing public engagement as a priority or a political strategy (Ricci, M., Bellany, P., & Flynn, R. 2010).

HFC vehicles are a growing phenomenon that potentially has positive impacts on the environment. However, it is the situating of refuelling stations that are potentially under the influence of the public's attitudes towards the stations. This study is an investigation of the public's evaluation of local hydrogen fuel station implementation. An analysis of socio-economic psychological and spatial variables was conducted. This survey resulted that psychological variables explain the public acceptance more thoroughly and transparently than the socio-demographic and spatial variables. Predictions that were strong include; positive impacts, negative impacts, local, societal and environmental impacts.

Most socio-demographic and spatial effects are mediated by psychological effects. This research showed that citizens living near a refuelling station had negative attitudes towards the placing of a hydrogen refuelling station than those residing farther away. This is a case of 'Not in My Back Yard' (NIMBY). However, this is contrary to that of previous results. The analysis indicates the possible reasoning for this negative attitude as being due to a low level of trust in the industry, in the sense of a safe and responsible delivery of developing and maintain a hydrogen refuelling station.

All three categories of variables explain public acceptability local hydrogen refuelling stations. Psychological variables are stronger than socio-demographic and spatial variable regarding effect. The strong predictors are positive and negative emotions relating to the idea of the technology being locally implemented. Trust towards the government also permitted a robust and positive acceptability. Socio-demographic variables such as age, gender, and housing played a crucial role in providing explanations for acceptability. However, income and education have played no part at all in this. Spatial variables contribute significantly to the explanation (Huijts, N. M. A., & Van Wee, B, 2015).

### 3.6 Summary of Literature Review

A Social Life Cycle Assessment (S-LCA) is a process which integrates the traditional life cycle assessment methodological stages, with social impacts being the paramount focus. Social welfare is high on the agenda of modern society goals. Deliberating an understanding and undertaking an assessment of potential improvements or adverse impacts on social welfare is a paramount constituent embedded in public policy, which aims to improve social and economic benefits while lessening impacts on society and the environment. S-LCA is in its

embryonic stage. Appraisal of social impacts and benefits can be challenging and controversial due to cultural elements, varying lifestyles and values. These can potentially affect the way social issues are often perceived.

Renewable energy is happening now. These new technologies provide generous benefits and promising outcomes. However, there is always some degree of risk. This risk can be controlled and mitigated through an assessment of the potential impacts on human populations. Traditional sources of energy are too becoming alarmingly harmful to the human race and their ecosystems in which they inhabit. As well as this, the level of installation, running and maintenance has reached an all-time high, with its immense stress on the environment, drives the need and desire for a cleaner, greener energy source. Significant consequences occur if nothing is done to lower the carbon footprint, the human race leaves as a legacy. A better legacy is the shift in attitudes towards the acceptance of alternative energy sources over the past several years. This, with goals for mitigating climate change among other reasons or justifications to develop innovative, long-lasting and clean energy sources has seen some communities step up and take action.

The reduction of a given purchase power resource below its output level is causing much damage to the sustainability of communities. Curtailment of renewable energy leaves no option for stock-piling. Therefore energy is lost, and income is no longer generated. Curtailment is becoming increasingly frequent for the likes of communities around Orkney. There is a variety of Energy Storage Systems Technology available to solve this problem. ESS has been actively helping to solve curtailment issues globally but on a small-scale. Its objective is to maximise revenue, therefore generating income that was lost over and over again due to the strategic and regular curtailment (Loisel et al., 2010).

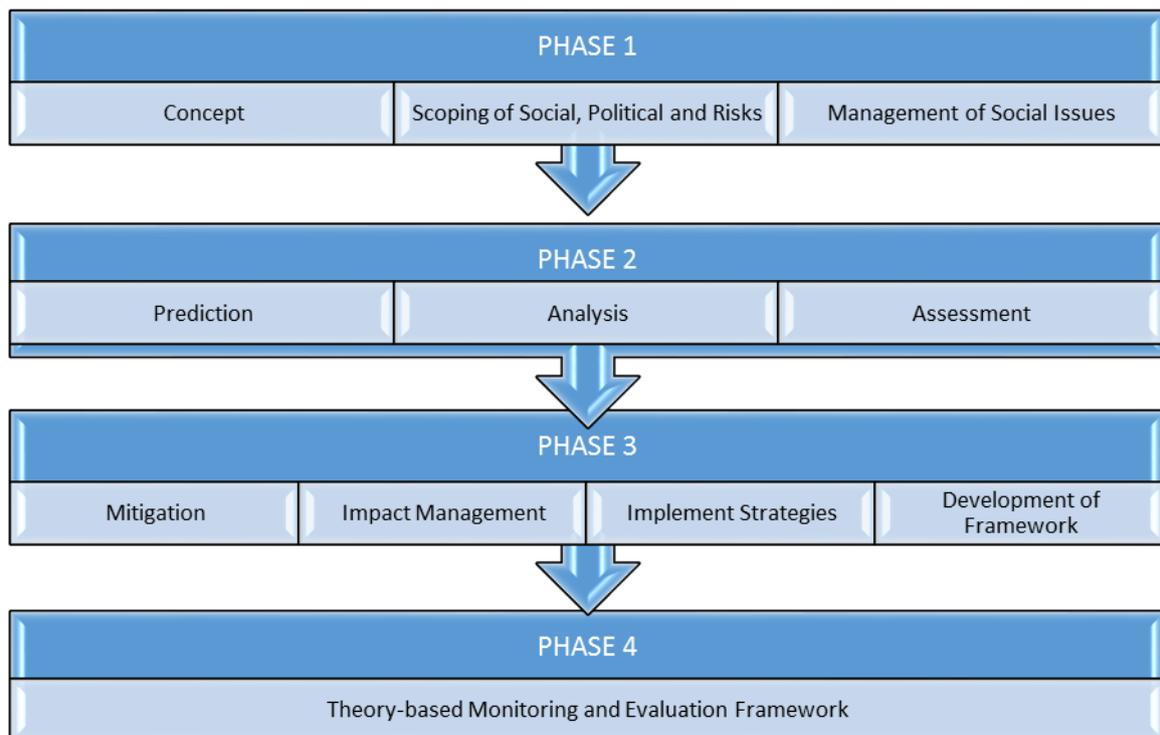
Hydrogen is becoming an increasingly more attractive form of energy storage, mainly due to its specific properties that expel significant benefits that have been surpassing the benefits of other technologies that can be somewhat more expensive. The growing interest in this type of energy has been international. Issues of energy security have given rise to mass research and development, shifting the focus from the development of new generating technologies to a means of storing it and 'saving it for later'.

This literature review has set the stage for an uncovering of new results help depict the perspectives, feeling and opinions of the interested parties as well as the local people who come from the potentially affected communities. It provides a good and inherent grounding for the research to take place, taken from previous literature written by engineers and social scientists who have worked on similar syntheses, gathering information for the promotion of hydrogen as a means of energy storage.

## 4 Conceptual Framework and Theoretical Perspectives

The Assessment Framework follows a linear fashion entailing both the small and large details, ensuring that there will not be any absences or gaps in the data obtained. The framework intends to define issues for the obligatory impact categories within an S-LCA. It lies its focus on the types of impacts the project will potentially influence either it directly or indirectly due to cumulative impacts. It is an adaptation of the framework was developed for organisations and companies to facilitate the conduction of business in a socially responsible manner (Dryer and Whetten, 2006). This has been applied in the sense that the project partners will be able to use this framework to perform the project with ease and without altering the health and well-being of society and future societies. It rots itself from a societal perspective. Within this contextual framework, the activities within the life-cycle of the BIG HIT project that is most likely to affect people and the physical conditions of the project process are considered here. It aids decision-makers to highlight what is of direct value to that specific human society. Thus, this must be shielded from potential harm to these values.

Figure 6. Assessment Framework Model



## 4.1 Phase 1

The first step of the framework sets out to gain an in-depth and well-rounded understanding of the BIG-HIT project and Socioeconomic Baseline Assessment. This includes all activities required for the support of the demonstration projects development and operations. This includes clarifying the roles and responsibilities of all those involved in the supply-chain, general overseeing and other interested parties including the relationships between them. Phase one also involves determining policies, guidelines and standards for the procedure. This phase identifies the influencing Social Area, and the communities likely to be impacted. Gaining a good understanding of these communities includes:

- Stakeholder Analysis
- Discussion of Socio-Political Setting
- Assessment of characteristics
- Experience of communities past resilience and adaptation to previous projects
- Discussion of trends
- Discussion of current strengths and weaknesses within the communities
- Results of Opinion Survey
- Scoping of Potential Social and Human Rights Concerns
- Collate all relevant baseline information to determine key issues

## 4.2 Phase 2

Phase 2 encompasses the prediction, analysis and assessment of the most likely social impact pathways. Through the analysis, social changes and impacts likely to occur from the project and alternatives to these means will be determined. Indirect impacts arising from the project will also be taken into careful consideration as well as how the project may develop cumulative impacts on the communities most likely to be affected. The likely response from communities will be determined with the establishment or prioritisation of any significant changes. Phase 2 will actively contribute to the development of a theory-based monitoring and evaluation framework which will harness all options available to project developers.

## Community Impact Considerations

1. Migration & Delocalization
2. Community Engagement
3. Culture & Heritage
4. Respect of Indigenous Right
5. Local employment
6. Health & Safety
7. Education
8. Working Conditions
9. Local Employment
10. Heavy Duty Infrastructure Usage

### 4.3 Phase 3

This section includes the identification and addressing of any potential negative impacts that may arise and affect the communities. It intends to develop and implement strategies for enhancing development opportunities and benefits and supporting the communities coping mechanisms for these potential changes and impacts. Within this phase, the further development of a theory-based monitoring and evaluation framework will begin to take its form. The purpose of this phase is to enable stakeholders to engage and work with communities for the greater good of the project outcome as well as the best available opportunities for these communities

### 4.4 Phase 4

This phase includes the implementation of the theory-based monitoring and evaluation framework. It involves the development of indicators aiding the monitoring the evolution of changes. It is important to take into consideration how adaptive management can be implemented. This can be succeeded by the undertaking the evaluation process and reviewing/auditing regularly throughout the 5-year period.

## 5 Scoping & Observation of Study Areas

The natural growth rate of Orkney has remained negative for the past number of years. However, recent trends suggest that this could contribute to an estimated in-migration, which might be triggered prevailing difficult economic conditions following the downturn and Orkney's relatively affordable housing (Orkney Islands Council, 2014).

### 5.1 Socioeconomic, Political & Cultural Setting

#### History of Isolation & Vulnerable Economic Status

The current regulatory grid regime and market incentives have neglected the new generation of island connections for many years. Efforts to secure new and reinforced have been deplorable leading to a continuous loss of investment opportunities due to inefficiencies. Orkney has a vulnerable economic status due to the constant threat of depopulation, limited scope and levels of services for society such as health, education, and specialist care. There is a higher living cost than that of the rest of Scotland, making it susceptible to boom/bust situations.

#### Geographical Location

Orkney is widely advanced regarding its resources due to its geographical location. Together with Shetland, they account for 30% of the UK's oil and gas supply, making it a hub for this sector. Orkney's access to the North, Atlantic and UK mainland suggests its location accounts for much of its success in importing and exporting. The geographic location transmits a bounty of natural resources, particularly its capacity for renewable energy. Orkney of the Northern Isles hosts some of the most intense energy within the UK. Orkney has the capacity for multiple technologies utilising the wind, waves and the tides.

#### Installed Capacity

Orkney has large capacities for the generation of renewable energy. At present Orkney is over 100% Renewable. The electricity produced is exported to the national grid. Projects like the BIG HIT give Orkney the chance to be completely indigenous with the generation, production and utilisation of their energy. Below is a table portraying the potential for renewables in Orkney.

Table 1. Renewable Energy Potential in Orkney

ENERGY SOURCE	High	Medium	Low
Tidal current	1462	2443	3571
Offshore wind	0	385	986
Offshore wave	101	226	226
Onshore wind (1 MW units)	0	46	256
Tidal head	1	6	7
Coastal wave	0	0	0
Energy efficiency	19	33	47
Micro-renewables	16	29	47
Biomass crops	3	7	14
Biomass harvest	2	3	3
Bio-digestion	0.1	0.4	0.7
Energy from waste	0	0	0
Total installed capacity (MW)	1603	3177	5158
Annual power production (GWh)	5580.1	11057.6	17951.3

(Orkney Islands Council, 2009)

### Investment and Reliance on Renewables Industry for Employment & Wealth Creation

Orkney currently has the highest level of community wind schemes in the UK. Through public, private & voluntary, the community of Orkney have invested approximately £150M in renewable energy. At present, there are over 500 micro wind projects with one of the highest global level of adoption of onshore wind technology. Micro wind projects have generated millions of pounds to be pumped back into the local economy, as well as local community wind projects and large scale private wind developments. Standard practice in Orkney is to reinvest revenue into the future conditioning of Orkney as an isolated territory in sectors such as housing and the growth and development of the business.

Renewable Energy has aided the local supply chain to develop and sustain employment levels in Orkney and continues to do so with evolution in technology and training becoming more and more accessible to members of the communities. Orkney has shared costs-grid connections, transport. There are many shared opportunities to work together to increase capacity and the connection of multiple technologies. Links between communities and earned revenues are in place to combat fuel poverty. New and feasible opportunities for sustainable economic development are always on the rise for Orkney (Orkney Renewable Energy Forum, 2017).

## Culture

Orkney has a wealth of cultural heritage that trickles through everyday life on the islands. Traditionally, employment lies in multiple smaller scale jobs rather than one large job and remains the same for many today. Orkney's landscape is vast and wild. This poses nature as a precious cultural asset for the communities of Orkney to enjoy. Tourism has become part of the culture and generates much of the island's income. Without the heavy in a stream of people throughout the warmer months, 'some places around Orkney would not be what they are today'. Orkney's folklore and music scene is a vital piece of culture and heritage amongst the different islands (Orkney Renewable Energy Forum, 2017).

## Community

Orkney hosts many diverse and complex communities. Community mechanisms and structures differ largely from island to island. Inner community 'politics' have a way of defining how a community is to be run and how it is to be benefited by developments, especially in renewable energy developments as it has an abundance of resources. The community owned turbine curtailment problem is a major issue which has been causing constraints not only in an economic sense but a political sense as well. The wealth of islands differs greatly when it comes to sustainability and economic prosper, this can be hard on smaller island communities. Some communities have excellent facilities and amenities, others do not, and some communities have many opportunities to raise concerns as there is a 'willing ear to listen', others do not (Orkney Renewable Energy Forum, 2017).

## Political Status

Orkney's strategic importance of an islands-social and economic fragility with Commitments to protect the sustainability of islands at national, UK, EU and UN level. Orkney falls in line with National, UK, European and Global policies, including Orkney's green target policy (Orkney Renewable Energy Forum, 2017).

## 5.2 Past Experience of Community Acceptance, Resilience & Adaptation of Implemented Renewable Energy Projects

The Orkney Islands have renowned wind resources. The island communities were encouraged to investigate opportunities for community-owned turbines. Along with other islands, Eday and Shapinsay erected a community turbine each. This produced a feed in

tariff. However, with voluntary curtailment in place, it was on a 'first up last off bases'. This meant that the community has copious amounts of electricity being produced while there were constraints to the national grid. The national grid does not have the infrastructure necessary to take such amounts of energy. This is a major issue that is currently being addressed through new hydrogen opportunities.

Planning permission for the community-owned turbine was submitted following feasibility studies and Environmental Impact Assessments (EIA). The results and discussions that arose from these studies were displayed in the local shop, the library and Council. A significant local objector in Shapinsay gained support from objectors on the mainland and further afield. Interference with the aeroplane's radio transmissions urged the local airport to submit an objection. However, the objection was late. This objection was later withdrawn as there was no evidence based on interference with the transmissions. It is also important to note here that the resident's objection was dismissed. This was a negative impact arising from the community-owned turbine as the local objector and his wife moved off the island after the dispute (der Waal, 2012).

Upon the erection of the turbine, the residents were proud of the efforts made by the community and officials in charge of seeing the project through. Post initial concerns regarding safety and other risks, much of the community was inspired and thrilled, following the erection of the turbine with its benefits to come. Benefits began to flow into both of the communities. However, due to differences between island dynamics and the running of trusts, partnerships and subsidiaries, different outcomes arise the affluence of generating, clean and green electricity soon turned to perish when grid constraints began to slow things down for both islands. Both communities were affected by this issue and the changes to come.

Both communities have adapted to change differently and on different time-scales. This is mainly due to the different dynamics between the two communities residing on each of the islands. At first, communities are often reluctant to change, especially when traditions are still heavily in motion during day-to-day life on the islands. With Orkney being an incredibly 'energy literate' place, residents experiencing harsh winds and witnessing gravely powerful tides and waves, it is no surprise that once demonstration has been successful, renewable energy is usually, largely accepted. However, this is in reason. It is important for

communities to be informed before, throughout and after the development. It is important to note here, that there will always be members of communities who will remain reluctant to accept new information. This is due to the way of life on islands being heavily embedded in tradition and inevitably lost contact with other islands and the mainland. Although interconnections and wider connections have been sporting their best efforts to keep islands like Eday (in particular) and Shapinsay connected, change is deemed negative and risky due to fears of change than having lingered from the past.

Over the past number of years, Orkney has become increasingly aware of the benefits their strategic geographical location has to reap. Public awareness has started to become paramount throughout the process of renewable energy development in Orkney. This has evolved over the years. Renewable energy has not only been about innovative technologies and international competitiveness for Orkney but has also been about and remains a means for solution. Renewable energy has stood as a solution for high carbon emissions emanating from a relatively small set of islands when in comparison on a global scale. Presently, renewable energy generation has been evolving. Energy storage poses a feasible and prosperous solution for the curtailment issues currently experienced by these islands and their community-owned turbines.

## 6 Assessment of Island Community Dynamics & Characteristics

This section portrays the characteristics of both Shapinsay and Eday, a comparison of each island's trends and a Strengths and Weaknesses Analysis that was formed through the discoveries of island activities, dynamics and tensions. It was formed through baseline studies and visits to the islands where interviews with local bodies and members of the local community were conducted, as well as general discussions with local people.

### 6.1 Shapinsay

Shapinsay is the 8th largest island in the Orkney archipelago. The east coast comprised of low cliffs with many sea caves. Elwick Bay is a sheltered anchorage facing Mainland Orkney on the South Coast. With several Ayres forming narrow spits of shingle and sand, oyces are often formed due to the cut of bodies of water. There is a tidal islet to the east of the Balfour Harbour entrance which entails a lighthouse and a broch. A stretch of water known as 'The String' lies between 'Helliar Holm' and Mainland Orkney.

Shapinsay's population has seen growth since 2001. The general shift in age has been towards an elderly category. The rates of economic activity on the island are below that of Orkney as a whole with a relatively high number of retirees. The addressing of this issue and the raising of all economic activity on the island is a vital component to sustaining the island.

Employment is traditionally embedded in agriculture. 'The number of individually owned turbines has been increasing over the past number of years'. There is an incentive for outsiders to erect a turbine on an individual's land. The individual is provided with free electricity, and the outsider reaps the income generated. A large proportion of the residents are employed in skilled trade occupations (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016)). The levels of car ownership on Shapinsay are similar to that of Orkney overall with an increase in electric vehicles over the past few years.

Shapinsay is geographically located in a way that makes inter-island connections slightly easier than that of the other islands in Orkney. This is due to the relatively short 25-minute ferry from Kirkwall which travels multiple times per day, allowing members of the community to travel to the mainland for work and recreational activities (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016)). There are two nurse practitioners on the island who are supported by a GP that visits the islands for surgeries. It

is not uncommon for Shapinsay community members to visit the Balfour Hospital in Kirkwall with the use of the 'Out-of-Hours' ferry service.

The primary school on Shapinsay currently caters for 19 pupils, with the support of two teachers and is of excellent quality. Kirkwall Grammar School caters for secondary level students who travel on the 7 am ferry and return on the 4 pm ferry that evening. (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016). The primary school building is also the doctor's surgery practice, the leisure facility and also has an open community room where lunches and community social events are often held. This is the building that will directly benefit from the BIG HIT project where a catalyst boiler system will be located. The compound storage system will act as a secondary heating system, allowing the temperature to reach a certain point and the already existing heating system will take over from there. The boilers are 5KW each, and the deliveries of H2 will occur during off-peak hours when the building is not in use.

The Shapinsay Development Trust is a community run trust that was formed in 2002. Nic Thake described it as 'a vehicle that collectively helps maintain and improve lives.' The trust is a company that is limited by guarantee, achieved a charitable status in 2003. Members are liable for £1 should the trust become insolvent. Members have the opportunity to vote at the AGM, a meeting where the community is informed by the board of directors of the year's activities and financial accounts. The meetings are held to assess the opinions of the community. Its objectives lie in enhancing the sustainability and quality of life on the island. Shapinsay Development Trust has outlined its objectives as:

1. To provide in the interests of social welfare, facilities for recreation and other leisure time occupation available to the public as a whole in Shapinsay to improving their conditions of life
2. To advance education and in particular to promote opportunities for learning for the benefit of the general public
3. To protect and preserve the environment for the good of the community and the general public

4. To provide or assist in the provision of housing for people in necessitous circumstances within Shapinsay
5. To relieve poverty particularly among the residents of the island of Shapinsay
6. To promote Shapinsay trade and industry for the benefit of the community and the general public
7. To promote, establish, operate and support other schemes and projects of a charitable nature for the benefit of the community of Shapinsay

(Shapinsay Development Trust, 2011c)

Developed and funded by the trust, the 'Out of Hours Boat' which is managed by a local Shapinsay man called Harvey Groat. This allows the residents of Shapinsay to have 'a more comfortable standard of living'.

Upon a visit to Shapinsay, during an interview with Nic Thake of SDT, he spoke about the beginning of new sources of alternative energy, Nic said that Aquatera ran a survey on 'low carbon transport' in the past which aided the gravitation towards hydrogen. ITM engaged in a project that was to use an electrolyser for the CO<sub>2</sub> from distilleries, producing synthetic processes. The appropriate solution being red diesel, phase 1 was fully funded. After one year of the developing project, the phase 2 application fell through as the BIG HIT project evolved which in turn superseded the energy project on the horizon. Shapinsay signed the BIG HIT agreement. BIG HIT was set to absorb all curtailed energy from the community owned wind turbine 'Whirly'. Nic raised the concern for the need for a 'hydrogen market' here. The turbine was paid by a feed in tariff (FIT) to encourage which is based on p/KW produced. Thus, with curtailment, no energy is being generated, no electricity is being produced, and therefore, no income is being generated and put back into the community. This challenge has several solutions. Hydrogen is a new opportunity to create an innovative, new value to the economy based on hydrogen as new renewable energy applications for the future. BIG HIT sets the stage for what is to come in the future. Hydrogen technology can be applied to the shipping industry in the future.

During one of the island visits, engaging with the community was of great benefit and some members of the community were more than willing to participate in an interview and

general discussions regarding life on the island, community activities, renewable energy and the BIG HIT project. The community is in broad support of the BIG HIT project. Citizens were written to, informing them of the project. The priority concern is based on the safety of hydrogen itself. Safety and how it is managed were explained and noted as ever evolving. 'Transporting hydrogen has no regulatory framework'. 'Surf n Turf' project hold the responsibility for implementing a safety strategy. The project provides the opportunity for local people to train to become a handler of hydrogen on board vessels and at the Kirkwall Pier.

There are hopes and aspirations of the community of the BIG HIT project. It is anticipated to provide the basis for a future solution to target fuel poverty. The level of acceptance is unknown. It is estimated to be broadly accepted for domesticated use of hydrogen to provide heating systems to homes. Seventeen-year-old Abbey from Shapinsay wishes to pursue a career offshore. Having grown up in Shapinsay and made the decision to attend the maritime college in Stromness, she has obtained certificates and wishes to continue to do so. When asked about the hydrogen scheme in Shapinsay, her excitement took the lead. Abbey has enjoyed the progress Shapinsay has made and its transition to a cleaner, greener future, she feels this type of technology is 'exactly what is needed right now'. Her particular enjoyment and excitement have a lot to do with the community interaction, support and inclusion. Abbey has said she feels that she has the opportunity at any time if she wishes to speak with a member of the trust regarding any aspect of the project.

Fiona, who is a hardworking and kind individual has also expressed her excitement and acceptance of the new project, especially as it is a solution for the current curtailment issues her community is experiencing. She too feels that should any concerns or issues arise; she has the freedom to approach the trust. As well as those involved with the hydrogen scheme to express her opinions and feelings with confidence that they will be considered and brought to the route of the concern to prevent any misunderstandings or to assist the success of the implementation of the project.

Nic also addressed the issue of 'dirty ferries'. His aspirations are for the 'out of hour's boat to be run on hydrogen. However, for reasons unknown, Nic has since stepped down from his position at SDT. Despite efforts to understand a reasoning behind this and to speak to those who have replaced his role, stepping into his place regarding the BIG HIT, in particular,

it was difficult to manage. After talking to the communications manager of SDT multiple times, she was not able to provide information regarding the new officers due to a lack of permission from the SDT Chair, whom also was reluctant to speak about the project and the recent changes that had come to light. This suggests tension within the trust and potentially between the subsidiary and the trust as well. The community remains well informed. However, with past experiences being sensitive with regards to the development of 'Whirly' the community owned turbine.

Initially, SDT were keen to help with the distribution of a survey. However, after a short time, they became reluctant to distribute a survey questionnaire as they had prioritised other surveys and did not wish for their community to fill the out. It was assumed that they prioritisation of the other survey formulated and distributed by SDT was of primary concern to them. Questions were raised as to, how much information was being distributed? Did ALL community members receive a chance to voice their opinion? Perhaps a survey regarding the BIG HIT project could help with informing the community further, reminding them of their rights to express how they feel.

## 6.2 Eday

Eday consists of upland moor, grasslands and freshwater lochs. Beaches of sand, flagstone and boulder dominate the coastland. Eday has a Heritage Centre which offers an insight into island life and salvaged items from the 'HMS Otter'. The community cooperative and post office is part of its amenities. A gateway house allows visitors to try our island life before making the big move.

Eday's population has seen a rise since 2001. However, the proportion of the working age population has been declining, with the ages of retirement increasing (over 65). This imbalance in population is a major issue. This hinders development prospers and sustainability on the island. (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016). The rate of economic activity is below that of Orkney as a whole. Eday has quite a large proportion of retirees and long-term sick or disabled individual members of the community. However, now, official statistics are likely to disguise a significant amount of work within informal economies. Addressing the above issue remains a paramount intent to successfully raise the overall economic rates of activity which are vital to the future

sustainability of the island-regardless of the above statement (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016).

Historically, past industries included kelp and peat processing to be sent to Scottish whisky distilleries. Some community members are employed in the public sector; agriculture has remained the most dominant industry on the island (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016). An increase in home working has been consistent with the pattern across other major Scottish islands, while the proportion of people driving to work has declined over the past number of years. Car ownership on Eday is above that of both Orkney and Scotland as a whole Horizon (Peter Brett Associates, 2016).

Property prices on Eday are lower than the average in Orkney and Scotland in general. The turnover of these houses is slow, resulting in high rates of vacancy. This gives rise to the opportunity for growth when attracting people of the working age who may not be able to afford to purchase a house elsewhere on Scottish or Orkney mainland, Eday's housing pricing provides an opportunity for homeowners.

Eday has two nurse practitioners working two weeks on and two weeks off. A visiting GP provides support for these nurses one day a week, coming from Stronsay. Hospital attention is in Kirkwall or Aberdeen, upon requirement (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016). The primary school on Eday provides UK standard primary education on the island. The school currently caters for approximately six students. Secondary education is provided by Kirkwall Grammar school, where a boarding style education system takes place. The younger students are flown on a Monday morning to Kirkwall and return on a Friday evening. The older students take the Sunday evening ferry and return on a Friday (OIITS Economic Baseline & Future Planning Horizon (Peter Brett Associates, 2016).

Eday is at the centre of the Northern Isles, making it rich in history and culture, as well as being at the forefront of renewable energy research. Over the past number of years, Eday has become a hub for the emerging tidal energy industry. Marine currents at The Fall of Warness reach 8.7 knots on the spring tide and is the focal point for European Marine Energy Centre's testing facilities.

Eday Partners was formed in 2004. It is also a company that is limited by guarantee, having obtained a charitable status. The board meets monthly and currently have three paid employees. The Community Wind Turbine was commissioned in November 2012 and is managed by the Partnership's subsidiary Eday Renewable Energy Ltd. (ERE) The income generated has been intended to fall in line with the aims and objectives of the 2014-2017 Development Plan.

ERE manages the community owned wind turbine. The profit is gift aided to the Partnership which is responsible for deciding where the profit is allocated. Through the economic downturn, the subsidiary and the Partnership have survived. However, the income generated by the community owned wind turbine has only been enough to sustain the company and the partnership, leaving little surplus to be put back into the community. Upon a visit to the island, it was apparent that this has left the community distressed and disappointed. Eday Partnership has expressed their concerns regarding the fact that they are the third point of contact when it comes to the hydrogen scheme in place on Eday. "Everything goes over our heads when it comes to EMEC and the BIG HIT project, it even goes over Eday Renewable Energy too". - Stephen Vegan. It largely concerns that the subsidiary and partnership set up to aid the community and enhance the sustainability of the island is no longer consulted on further actions taken forward regarding the projects.

Tensions have arisen between the subsidiary and the partnership for the last number of years. With this, 'inner-politics and tensions within the subsidiary as well as within the partnership have portrayed a lack of solidarity and a lack of connectedness which a small, isolated island community is in need of, especially to manage its powerful resources and sustain the communities. Andrew Stennett, managing director of Eday Renewable Energy Ltd., has made efforts to display the information as the subsidiary receive it. Andrew listed examples of community engagement and awareness process taken to supply relative information to the Eday community members. Andrew mentioned the fact that Shapinsay has less curtailment (30-40%) than that of Eday (often reaching above 60%). He informs that this is what makes it most difficult to argue for new expenditure for the diversion to additional non-electrolyser loads.

During a meeting with ERE, the topic of hydrogen applications as a solution for curtailment resulted in the response; "We think that having priority access to the three point loads at

Kirkwall Pier gives the Eday community wind turbine excellent opportunities for energy reclamation. While ERE has invested money in return for access to switching assets and pier loads, the payback period based on the only moderately optimistic scenario is just over two years. The priority loads for 'Surf n Turf' appear to more substantial than the priority loads for BIG HIT. ”

Andrew concluded with “While the incremental revenue does not include export and embedded benefits (GSuoS, BSuoS, RCRC, Triads etc.) such as with the Demand Side Management System developed by Rousay, the latter project suits a generator that is much higher in the stacking order than Eday Renewable Energy. There may, however, be opportunities in the future, for Eday to partner with Rousay to supply local grid side demand”.

Upon a visit to Eday Heritage Centre, during an open discussion, there was notably confusion between authorities and projects on the island of Eday. Some have expressed concerns about safety, one woman exasperated by the ‘smell’ of hydrogen thus far. However, the project had not been in operation at that point. In contrast to Shapinsay, some members of the community do not feel that they have the opportunity to raise a voice of concern in fear of rejection, and others simply ‘could not be bothered’. “If I were to express me opinion t’would be to deaf ears”. Issues were also raised following questions on acceptance and awareness- some members of the community felt that they were ‘hurried out of the heritage centre’ upon the visit from project stakeholders. It was also said that many members of the community simply do not wish to be involved, nor hear about such a change. The conversation steered towards the community turbine when some members of the community group were eager to express their opinions about how it had been a negative experience for the community. Others simply looked away and did not wish to be engaged with the topic. Here is where a major issue lies.

Despite efforts from project stakeholders to relay information onto the communities that are likely to be affected be it negatively or positively, information is only received by those who are willing to listen. Not in contradiction, but at the same time, it is evident that more effort is needed to help the community of Eday to understand the process. It is the responsibility of the project stakeholders to identify an efficient means of advertising or informing the community. Resulting from this study, to reduce tensions, the most effective

way to distribute new information to the community is through the means of a newsletter that could be circulated into each home around the island of Eday as it ensures that at least one member of the household has received this. It is then the faith of that individual and responsibility to relay that information to the other household members. This also stimulates conversation amongst neighbours, friends and colleagues around the island, thus allowing the project news to be open and this creates a healthy open channel for feedback, opinions, concerns and other positive effects. Since the visit to the island and multiple meetings with residents and representatives from ERE and the partnership, a mail out to ALL Eday residents is anticipated for the new future (Please see Appendix G.-received on the 3rd of August 2017 in anticipation) which highlights a summary of the 'Surf n Turf' project through a pamphlet. It intends to update residents on progress, explaining the differences between 'Surf n Turf' hydrogen and BIG HIT hydrogen thoroughly as well as how the community is likely to benefit.

### 6.3 Contrasting Trends between Shapinsay & Eday

Significant contrasts exist between the Islands of Shapinsay and Eday. This is due in large part to the physical, socio-economic and political aspects resulting in different strategies and plans for the running of the island communities. Given the physical geographical locations of the islands, Shapinsay is better connected to the mainland in comparison to Eday. Eday's geographical location provides great tidal power, thus the development of tidal energy occurring there at the moment.

Aside from the production of hydrogen, the integration of the use of it integrated into everyday life, and the widespread of public acceptance must be introduced with sensitivity. Locally developed hydrogen is an economically viable renewable energy process, various production mechanisms can be locally developed, fuelling vehicles and providing heat and power. Hydrogen acts as a critical link that can be used as a medium of storage, counteracting effects arising from voluntary and involuntary curtailment, and the inevitability of intermittent availability.

It is socially important and a basic human right for communities that are likely to be affected by impacts emanating from the BIG HIT project to be informed by the project partners. The effects are likely to be minimal, with mitigating measures in place. However, it is still a moral

responsibility of the project partners to inform the public early on in the project, continue this sharing of information throughout the project and at the end. By continuing to build up rapport and synergies between communities and industry, small isolated communities like the inter-islands of Orkney are assisted in becoming more self-reliant, securing energy and enhancing the quality of life.

### Strengths & Weaknesses Analysis

The current strengths and weaknesses within both the communities of Shapinsay and Eday are largely down to local tensions present. This is due to their size and location. The current grid regulatory regime and market incentives are negligent of the generation of new island connections. It is becoming an increasingly critical issue for both islands as they have the means and resources to generate energy, yet little support from governing bodies. Deplorable efforts have been made to commit to securing new grid connections for the Isles. Both islands have incredible investment opportunities which would generate income lessening the problem if the inefficiencies of the grid connections were depleted and infrastructure reinforced. With the constant threat of depopulation and limited scope for the levels of services to be raised, both islands face challenges contributing to having higher living costs in comparison to Mainland Scotland. These issues leave both isolated territories heavily vulnerable for boom & bust scenarios, creating a false economy. A brief overview of the current strengths and weaknesses in Orkney is portrayed below.

Figure 7. Strengths & Weaknesses in Shapinsay

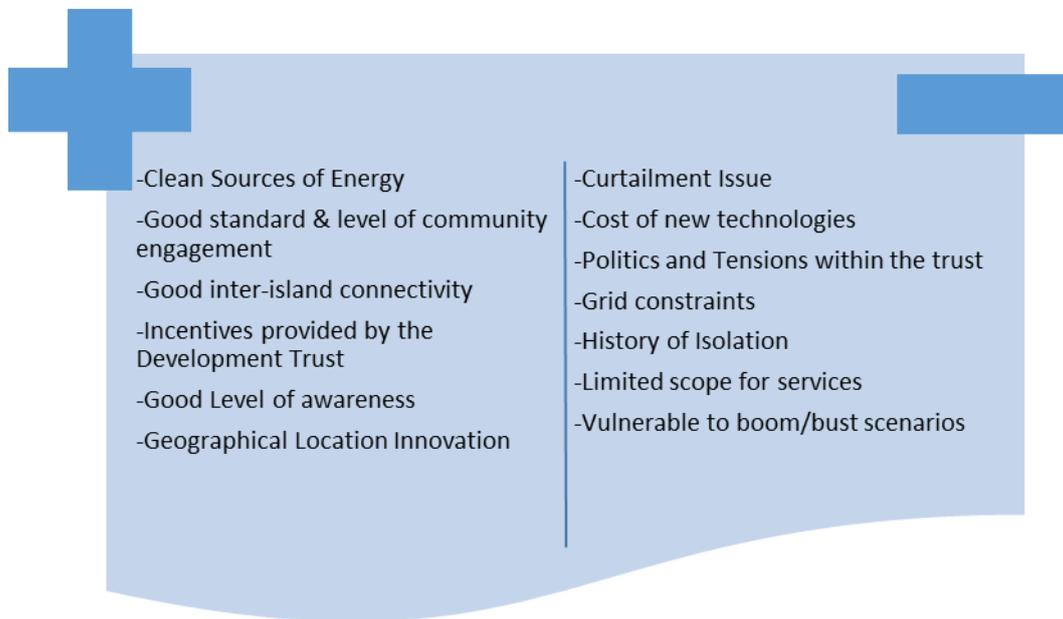
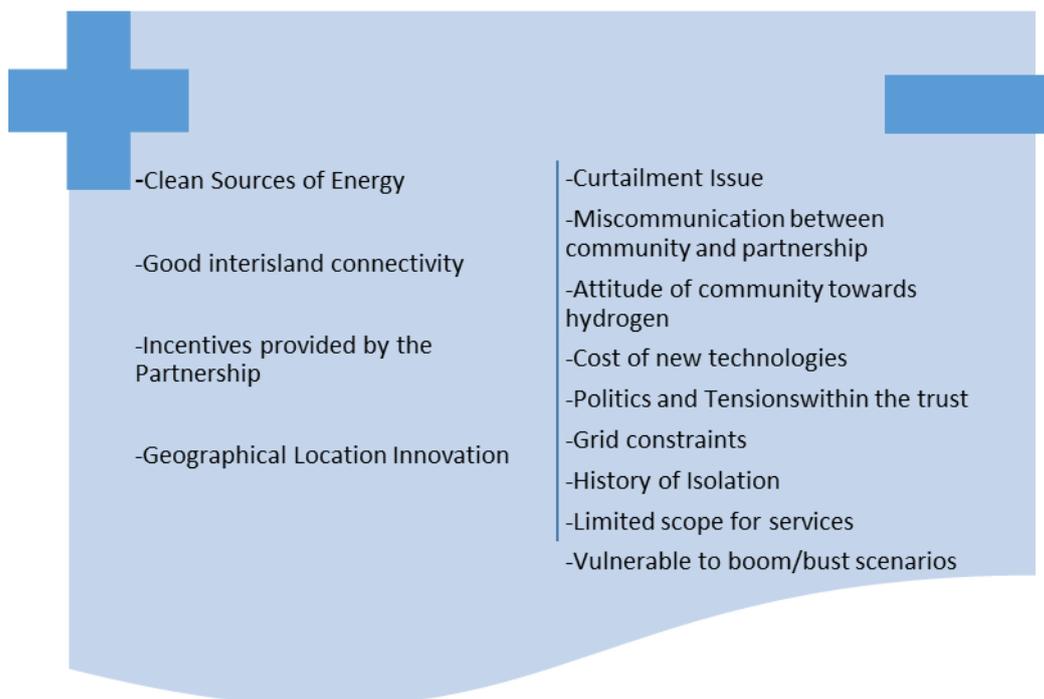


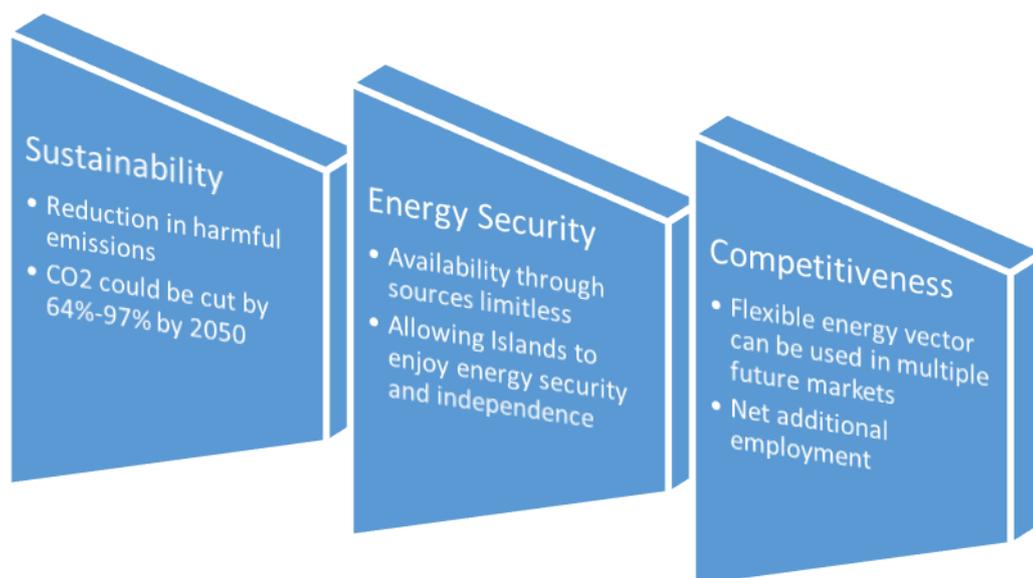
Figure 8. Strengths & Weaknesses in Eday



## 7 Social Impact Assessment Analysis

### 7.1 Identification & Addressing of Benefits

Figure 9. Key Benefits for Orkney



#### Green House Gas Reductions

The global need to reduce greenhouse emissions to combat climate change has become detrimental. The Climate Change (Scotland) Act 2009 set out goals for the reduction of Scotland's GHG emissions by a minimum of 80% by the year 2050 (Orkney Islands Council, 2014). Estimations of CO<sub>2</sub> are monitored annually under the scope of local authorities around the UK. The table below indicates minimal increases in some years, with notable increases in 2010 (Orkney Islands Council, 2014). The global increase in GHGs has given rise to a worldwide phenomenon. Majority rules climate change as an injustice act of the human population. Thus, the need for the human population to mitigate the effects GHGs have on the world's people, beginning within the community. The scope for new, cleaner forms of energy to mitigate GHG air pollution has seen an increase in the past number of years, particularly with the advancement of new technologies and processes such as hydrogen production and energy storage.

Table 2. Orkney Local Authority CO2 Estimations 2005-2012

Year	Industry & commercial	Domestic	Transport	Total	Population (000s mid-year estimate)	tonnes CO <sub>2</sub> per person
	kt CO <sub>2</sub>					
2005	76.7	76.0	33.8	186.5	20.1	9.3
2006	76.9	80.0	35.1	192.0	20.3	9.4
2007	77.7	78.5	36.0	192.2	20.6	9.3
2008	73.0	79.7	34.6	187.3	20.7	9.0
2009	69.1	73.0	33.4	175.5	20.9	8.4
2010	79.2	78.9	33.9	192.0	21.2	9.0
2011	72.5	71.1	33.0	176.5	21.4	8.2
2012	73.8	75.7	32.2	181.7	21.5	8.4
<b>Scotland total 2012</b>	14,418.6	13,192.2	8,297.7	35,908.5	5,313.6	6.8

(Orkney Islands Council, 2014)

Hydrogen production and storage contribute to the saving of approximately 2-3 years' worth of cumulative GHG and air pollutants by the year 2030 substituting the use of renewable for traditional fossil fuels. The atmospheric concentration will increase slightly should there be high levels of deployment activities of hydrogen as a consumer fuel due to leakage and evaporative losses. However, the safety of the technology shuts down should there be any sign of these. This risk is negligible in comparison to the benefits it will produce.

Monitoring and Evaluation systems should be put in place regarding the release of oxygen and the distribution of hydrogen to prevent risks before they potentially occur rather than taking care of something post its potential occurrence. This technology has the potential to hugely improve the quality of air due to the efficiency of the fuel cells and through electrolysis. Centralised hydrogen emissions from the production process are simple to control in comparison with ageing individual vehicles/traditional domestic heating systems. Replacing traditional combustion engines in slow phases will reduce GHG emissions, HFC vehicles produce zero emissions-contributing to national, EU and global GHG emission reduction targets. According to the UK H2 Mobility Phase 1 report, HFC electric vehicles have the potential to generate 75% fewer emissions than vehicles fuelled by diesel by 2030 and produce zero emissions by the year 2050. The overall reduction of CO<sub>2</sub> by a HFC electric vehicle fleet introduction would be close to 3M tonnes year by the year 2030. This is based on approximately 1.6M HFC electric vehicles (DECC 2050 Pathways Analysis, 2012). It is also

evident that reducing noxious emissions from transport sources will impact positively on human health. Cost reductions from the introduction of HFC electric vehicles displacing combustion engines were estimated to be close to £14M on an annual basis, by the year 2030 (DECC 2050 Pathways Analysis, 2012). It is important to note that emissions from pollutants such as NO<sub>x</sub> and SO<sub>x</sub> can also potentially be eliminated by a stationary fuel cell if it replaces conventional and traditional technologies for heating

### Renewable Energy Systems

With the energy for the process coming from a renewable source, the further integration has conditionally increased the flexibility of the system. Energy storage through periods of curtailment will solve the re-occurring issue and provide a demonstration for other isolated territories. When renewable energy systems are used, in this case, wind and tidal energy, zero carbon hydrogen is produced through electrolysis for storage and transportation. This option is interesting and stimulating given the geographical location of Orkney and its renewable resources. The produced hydrogen has the potential much potential. This demonstration project gives rise to other isolated territories with similar renewable energy systems with intermittency issues. It will give rise to hope and the stimulation of similar projects-benefitting a huge audience over the next number of years.

### Energy Security

With the use of indigenous wind and tidal turbines for the production of hydrogen through electrolysis with this availability for the Orkney Islands Council transport and potentially across other sectors, potentially reduces the need to import energy. With this, it has the potential to lead to massive savings on the average life-cycle of vehicles. With the introduction of the fleet of HFC electric vehicles, motorists can potentially save a huge amount in what they would have previously spent driving a conventional combustion vehicle. The council will promote the clean mode of transport in the hope that the evolution or transition of cleanly fuelled vehicles will occur at a more rapid rate than it has done over the past number of years. With this, on a European scale, the futuristic cost cuttings of citizen's bills will then allow funds to be allocated to other important spending's, reducing economies of scale and boosting the job market.

## Energy Efficiency, Distribution & Saving

Stationary fuels have the potential to have a significant role in the development of energy systems. The minimal emissions and noise categories place them in an ideal setting in sensitive and isolated areas. With this, the opportunity for communities to utilise their energy systems, giving the communities of isolated territories independence from centralised grid power. In this case, it allows these communities to benefit from hydrogen technologies while receiving a feed-in-tariff (FIT), giving them a wider variety of choice and lowers costs immensely.

The BIG HIT project system is semi-efficient. For the present time, it is an ideal solution for the current curtailment issues that both Eday and Shapinsay are experiencing. The project is a chance for the communities to begin generating energy again and to be a part of a world first, demonstration project, which in turn will provide multiple benefits both directly and indirectly from the ground up. As it is a pilot project, throughout the evolution of the technology and the implementation new uses for products have arisen. Although there is a use for oxygen in Orkney (medical, diving, welding), the O<sub>2</sub> market has not emerged as of yet but is set to do so shortly.

## Knowledge Creation & Dissemination

Orkney is said to be an extremely 'energy literate' set of islands. Investment in the promotion of generating knowledge and the diffusion of information is hugely important and a high priority for the project parties. BIG HIT is occurring at a time of change, regulation and new idealistic views of a renewable future. The generation and education of a pool of personnel directly support Research and Development in this field. Significant new education, training and re-training are required, and the islands now have an opportunity to train and become educated about the technological system. The hydrogen market and community will experience a rapid growth spurt amongst the sector in the coming years due to the increasingly alarming global concerns of climate change and the dire need to address these and put in place a means of preventing or combatting them.

## Research & Development

Research and development in the hydrogen industry have taken place over the last number of years. It has been on the horizon for a long time and is now coming into play under the wing of successful renewable energy developments already taking place in Orkney.

Organisations will continue to contribute to the research efforts across the UK and Europe. Orkney can be seen as a research and development hub, given the number of clean energy companies and organisations that have set up in Orkney over the past number of years. These businesses and organisations have proven to be a great success, being hit, but withstanding from the collapse of the economy during the downturn. Only to have come through it learning valuable lessons that have been contributed projects for the betterment of the Orcadian society given the extensive resources that are currently curtailed- providing a means to combat the problem and provide a solution while putting Orkney on the map for innovative technologies in isolated territories.

### Job Creation

Employment attributed to the activities generated by the BIG HIT project is proving bountiful. With the use of local, indigenous firms for the likes of installation has shown already the impact that the project intends to make on the island communities. In the wider arena, jobs have been created and maintained throughout the islands in many forms such as sustaining local accommodation, local shops and local markets. This strategic knock-on effect, in particular, has shown the communities a keen interest by project partners and associates and their intent to benefit them. Further job creation lies in the promise of training. Before BIG HIT, the only option to train was to leave the islands. Now, with the opportunity to train in Orkney to become part of the chain in handling, driving, refuelling and maintenance, more jobs will be created with more local people eligible to undertake these jobs. Significant new education, training and re-training will be required. Other knock-on effects include a pattern of in-migration, with a larger flow of people on the islands, infrastructure may need to be looked to, thus, creating more employment and economic benefits.

### Investment

The formation of BIG HIT has allowed an array of investors to contribute and take part in the project. The investment for the communities who will benefit from this project has made a huge investment on their futures-capital aside; the pilot project will act as a demonstration which should be replicable in other isolated territories. They have invested in the future well-being of their isolated territory and small engaged, communities.

The investment in the BIG HIT project also contributes to another series of knock-on benefits. Benefits such as cost reduction in any aspect play a significant role. The capital once used can now be derived from this and allocated elsewhere in funds that benefit communities, be it a special fund similar to that in Shapinsay (children turning 16 may apply for a fixed sum of money to fund the training of their choice, e.g. piano, ferry work, university). The investment in the future of the livelihoods of those inhabited on the islands is immense. Instead of seeing an outward migration pattern, this new technology has the potential to attract many skilled workers seeking a peaceful life, in the industry they trained. The possibility of further capital investment has not run dry.

### Creating Synergies & Strong Strategic Partnerships

Orkney has created extensive links globally over the past number of years. BIG HIT will aid Orkney in furthering these connections and encouraging the communities to use, support and be supported by them. The visibility of the BIG HIT project provides a focus for the promotion of these relationships between industry and nations. These links can encourage these other isolated territories to embark upon similar relations to better their energy situations as it is a demonstration project. These relationships provide greater assurance that international standards are to be put in place promoting competition, facilitating their platform for the global market.

### Community Success

The communities will be successful following the deployment of the BIG HIT project. The communities will reap significant benefits from the process itself and its results. A heating system will be installed in one of the schools as well as providing heat and power to the harbour buildings in Kirkwall. This portrays the process from generation to conversion to transport to utilisation within their communities. Another long-term benefit that these communities will reap is the enhancement of energy sustainability through clean, green measures.

The project is proven to have positive impacts on the health of society, endurance and security which is a direct result of positive contributions which aid the improvement of the environment. For example, the air quality and the mitigation of climate change. The safety elements of the process are already implemented before the beginning of the process of

conversion. Each risk has been assessed thoroughly and will continue to be monitored throughout the 5-year rollout plan.

### Stimulate Economic Growth

Energy storage systems and hydrogen powered energy systems offer a significantly greater independence and convenient refuelling stations in comparison to other technologies such as batteries and the recharging of them.

The economic losses that could occur if nothing is put in place to combat climate change or to create a low carbon economy are much greater than those of the implementation of hydrogen technologies and other means of combatting climate change. The results of the inability to plan, utilise resources and create sufficient energy capacity can lead to parts of Orkney being underwater before the next generation of innovators begin to work. Hydrogen fuel cell technology plays a significant role in what is needed to combat these serious threats. It is a strong obligation to acquire new knowledge and skills, thus stimulating the economic growth in Orkney.

### Industrial Competitiveness

With the project being a world first pilot project, it already places Orkney firmly on the map as a demonstration for other isolated territories and as a replicable technology that can essentially be replicated anywhere. This is putting Orkney well ahead of other places beginning to come to terms with the ideas of hydrogen as a means of combating fuel poverty, climate change and other environmental threats to the planet. This strengthens the competitive position as it is an early hydrogen market entrant.

### Quality of Water & Soil Resources

The hydrogen technology has a potential positive impact arising from a reduction in the use of traditional fossil fuels in the road transport industry. This contributes to a reduction in pollutants in rainfall and runoff waters, thus preventing groundwater contamination and pollution. With this, a decrease in shipments of crude oil reduces the risk of mass oil pollution incidents in seawater.

Little knowledge is known regarding the uptake of hydrogen in the soil, or the potential effect hydrogen may have on the quality of soil, requiring further study. However, there is no foreseeable adverse impact projected on soil resources.

## ████████ Sustainable Development & Transport

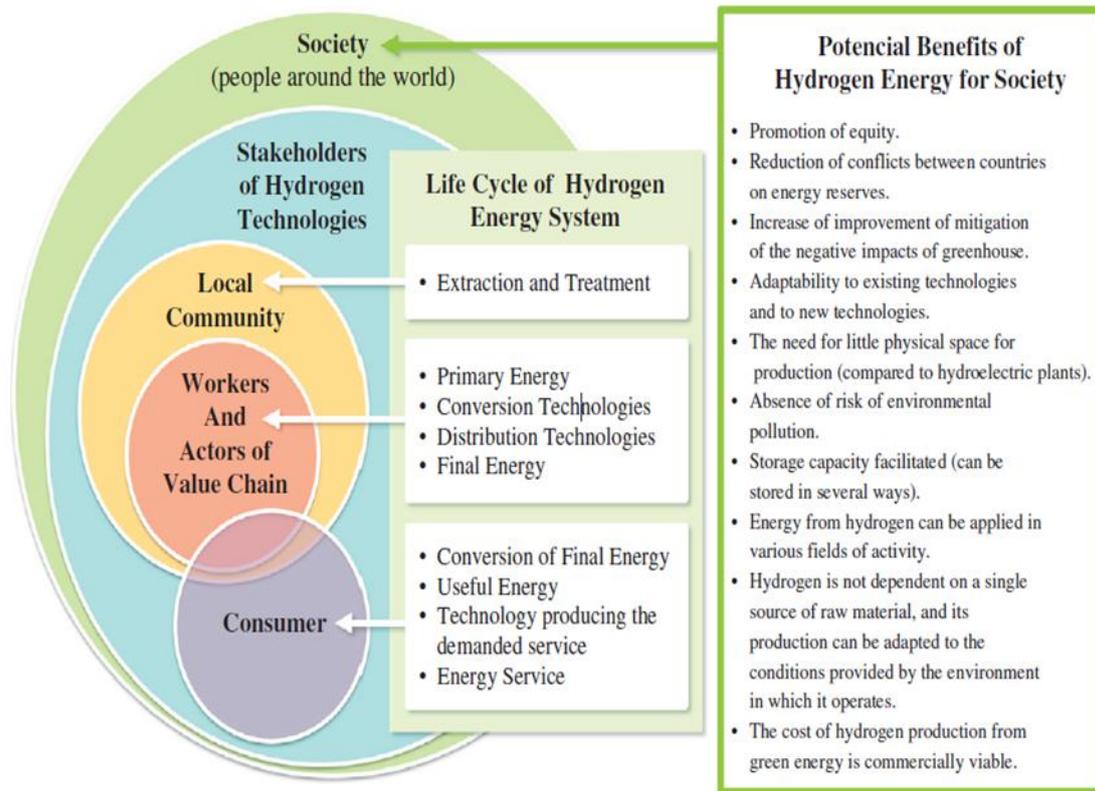
The BIG HIT project aids Orkney in contributing to Scotland's national sustainable development targets and the reduction in greenhouse gas emissions targets. In the transport sector, hydrogen fuel cell vehicles have been on the horizon, and for Orkney, the Orkney Islands Council will obtain the benefits of utilising the fleet of Renault Kangoo vans for the healthcare sector in Orkney.

Regarding the project impacts on commercialisation of HFC electric vehicles, the BIG HIT project fleet of vans has provided critical areas of emission free mobility, efficient heat and power applications and energy storage through electrolysis, increasing the penetration of Renewable Energy Systems in Orkney's energy sector.

The demonstration of the utilisation of such vehicles sets the stage for the emerging hydrogen economy. The demonstration project will portray that hydrogen technologies can effectively compete with the traditional combustion engine vehicle due to their advantages of having low carbon emissions, less noise pollution and lower costs.

This demonstration project also gives rise to the application of hydrogen in other areas of the transport sector. After seeing the successful implementation of hydrogen technologies in isolated territories shows that the application of hydrogen technologies is extremely possible and has the potential to provide huge benefits.

Figure 10. S-LCA of Hydrogen Technologies



## 7.2 Identification & Addressing of Negative Impacts

### Safety Concerns

If mishandled, or if there is an accidental release of hydrogen and it was to become ignited, it can be a hazardous substance. However, this is not any different from many fuels that are in use globally at this time. Many properties distinguish hydrogen from other fuels which also require specific consideration. (HIE, 2006)

1. Hydrogen mixtures released in the air are highly flammable over a wide range of compositions
2. Energy required to ignite such a hydrogen mixture can be low in comparison to its potential consequences

3. Hydrogen burns with an invisible flame during the hours of daylight-which in the summer months in Orkney is slightly more concerning due to its northerly geographical positioning
4. Hydrogen is a small molecule which has the capability to leak easily
5. A 'jet flame' is a rapidly moving hydrogen flame if hydrogen is released from a high-pressure storage unit

### █ Inefficient Transportation

The transportation of hydrogen is a hugely significant part of the cost of the delivered product. The network design of the infrastructure for the carriage of the produced hydrogen is an integral component of the delivery system. The main challenge or barrier to achieving the optimum system of delivery is matching the hydrogen inputs and delivery system, selecting the optimum site for the production of hydrogen and to establish a viable transportation network.

The projects network of transportation is highly inefficient. Reasons for this are the way in which it is to be transported via passenger ferries from Shapinsay and Eday to Mainland Orkney (Kirkwall) where it will power moored ferries overnight and provide fuel for the refuelling station in Hatston. This is inefficient for multiple reasons:

1. Take up a large amount of space of passenger ferries due to its labelling as a 'dangerous good'. "With respect to transport by road; the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG 2009) amended to implement the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)" and "With respect to transport by sea, the Merchant Shipping (Dangerous Goods and Maritime Pollutants) Regulations 1997 implement the International Maritime Dangerous Goods (IMDG) Code. The current version of IMDG is 2010." Only one vehicle carrying dangerous goods may travel via passenger ferry at a time. (Health Facilities Scotland, 2013)
2. More vehicles on existing infrastructure, leading to road damage, increased levels of traffic and emissions
3. Safety Concerns regarding its transportation leave community members unsettled

4. Clean source of energy being transported by one of the main sources of pollution in Orkney, it is passenger ferries are 'old and dirty', thus polluting the sea resources as they travel multiple times per day
5. The cost of transportation (qualified drivers and handlers, hours on the ferry must be considered, fuel for the tube trailers)
6. Hydrogen Fuel could be used much more efficiently, for example, in the future to power Shapinsay's 'out of hours' ferry

#### Expensive

Hydrogen is less expensive than most ESSs on the market at this time, however, it is still rather expensive. Lowering the price of hydrogen requires extreme improvements throughout the embryonic hydrogen economy. The production, process, transportation, storage and distribution, improvements in fuel cell technologies require 'revolutionary breakthroughs' and 'evolving improvements' within the supply chain (Myers et al., 2002)

#### Slow Market Diffusion

The transition to a hydrogen economy requires the design and implementation of an economic incentive regime that will encourage the building of hydrogen specific infrastructure as well as developing a market for hydrogen applications such as fuel cell technologies. Niche markets are currently being developed where hydrogen technologies and their potential applications have the ability to penetrate the hydrogen market. (Klett, et al., 2002) Hydrogen technologies will evolve and expand as knowledge and economies of scale begin to drive the costs of technology and fuel down.

#### Renewable Energy Resources

Renewable energy sources are naturally intermittent throughout their cycles and are not aligned with current patterns of human energy consumption demand. Mass value is placed upon the capability of renewable energy technologies to provide energy forms that can be stored with ease as the grid is not flexible and doesn't hold the ability to take such great amounts of generated electricity (Eberle et al., 2012).

The hydrogen technology processes the required density of energy for the storage of large amounts of excess energy, in small volume tube tanks in isolated territories. The power-to-

hydrogen may reduce the predicament of an excess supply of energy through the conversion of electricity into energy that is chemically stored in the form of hydrogen and transported. This in itself lessens the risk of overloading the grid (Multin et al., 2012).

### 7.3 Mitigating Factors

#### ████████ Safety Concerns

Hydrogen is quite buoyant. Leakages of hydrogen would disperse quickly into the air, rather than accumulating nearer to the ground. Escaped hydrogen has a low density of energy, and it is non-toxic. Regarding the use of hydrogen in an industrial setting, various safety codes and standards are in existence. However, with the use of hydrogen becoming more ubiquitous and in use by the general public, new standards are required. Much work has been done in Europe over the past number of years on the development of new standards, considering the safety aspects of all constituents of hydrogen infrastructure. (HIE, 2006) Some of which include:

- Safety Distances
- Design of Housing Hydrogen Equipment
- Protection of Earthing and Lighting
- Materials used in Hydrogen Systems
- Standardization of Nozzles do Hydrogen Dispensers

#### ████████ Inefficient Transportation

The transportation of the hydrogen tube trailers will be well managed to ensure that the community members who travel on the Orkney ferries often will not be displaced. In depth studies have been conducted over the past year and a half, discovering the most viable options, days and times of ferry operation for the tube trailers to travel with ease and without disruption. The hydrogen tube trailers will travel to and from the islands during off-peak hours and ensure that the utmost safety is considered throughout the entire process of transportation.

#### ████████ Expensive

Over the past number of years, intensive research and development in the hydrogen economy, technology and applications of hydrogen has been made. Initially, similar to many

demonstration projects, it can be expensive. However, as the project evolves and the delivery of the project becomes more efficient, costs will begin to lower. As the hydrogen economy emerges from its current embryonic state, the expense of hydrogen will lessen.

#### ■ Slow Market Diffusion

The demonstration project has goals and aspirations to encourage other isolated territories similar to the Orkney Islands and other places to involve themselves in the development of such energy storage systems, granting independence from the national grid and other great prospects. In turn, the demonstration project hopes to stimulate the market, thus, speeding up the process of market diffusion.

#### ■ Renewable Energy Sources

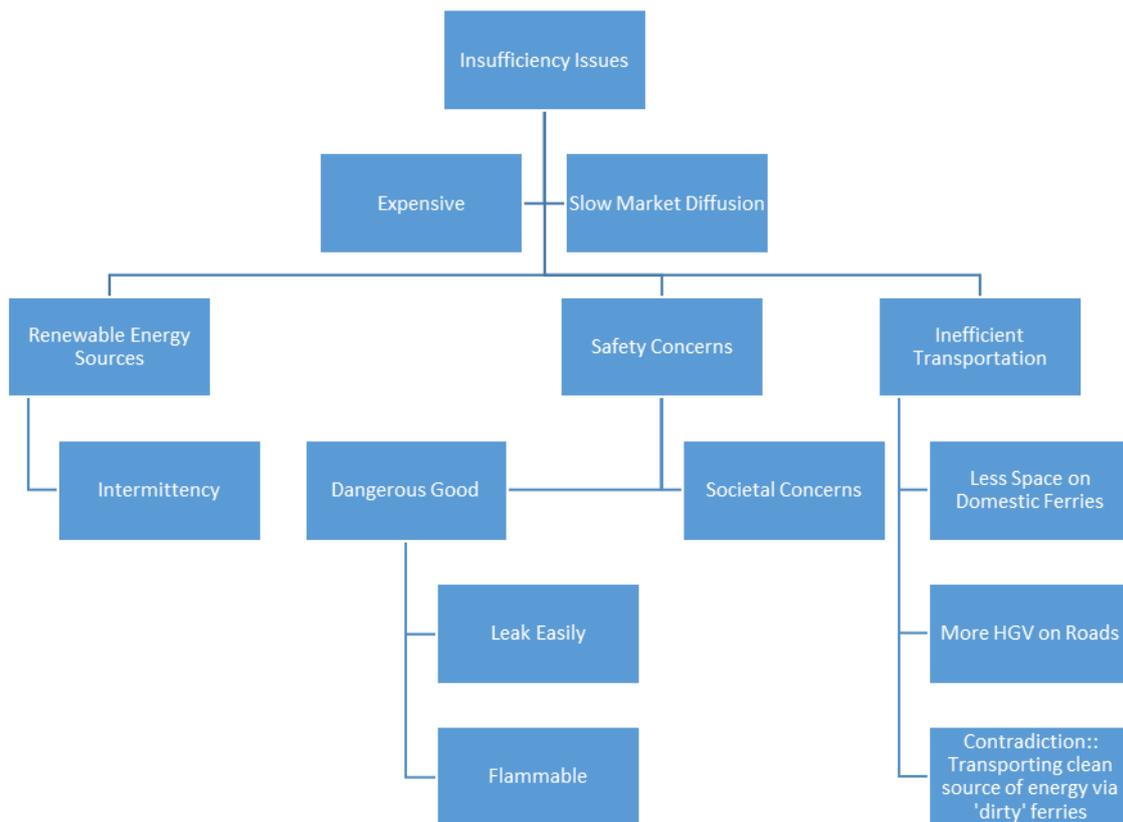
Using renewable energy sources allows communities such as Eday and Shapinsay to curb current curtailment issues and begin to generate energy once again while showcasing innovative energy storage systems that can potentially sustain the isolated territories. The use of renewables allows a full cycle of clean, green energy – obtaining significant benefits for both the environment and society.

## 8 Theory-Based Monitoring & Evaluation Framework through Logical Framework Development

### 8.1 Problem Analysis

This section identifies the issues and problems regarding the implementation of the project. These issues were chosen as the focal point for the 5-year duration of the project, and a fault tree was constructed.

Figure 11. Fault-Tree



## 8.2 Stakeholder Analysis

The stakeholder analysis identified those who are responsible for the addressing of the problems previously identified in the above section and who will be affected the most. They have been categorised and linked in the table below. Further identification and analysis can be found in appendix C.

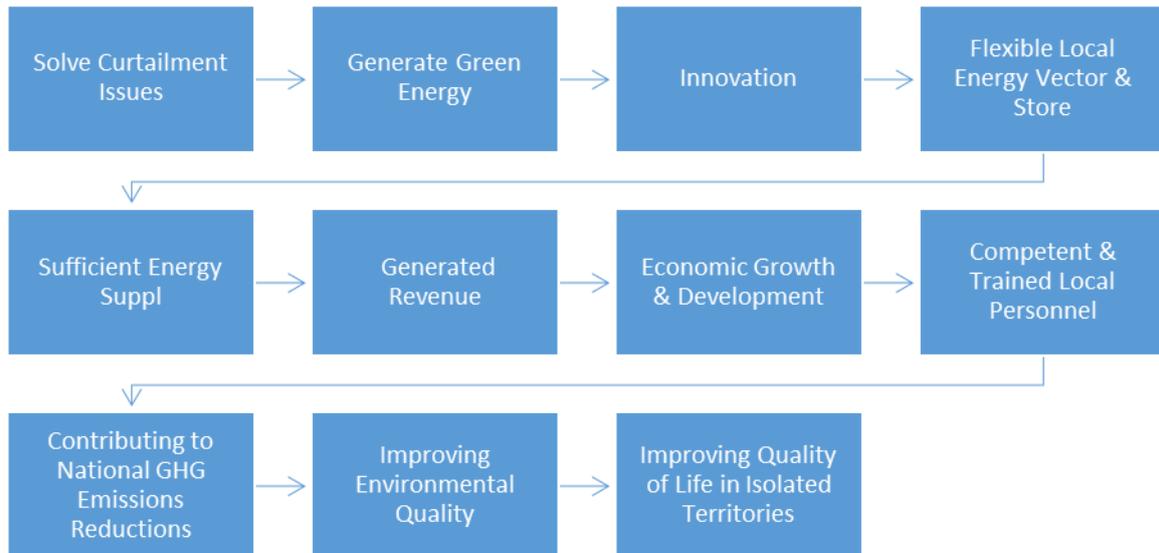
Table 3. Stakeholder Identification & Analysis

<b>Hydrogen Production</b>	<b>Transport &amp; Storage</b>	<b>Utilization</b>	<b>Demonstration</b>	<b>Affected</b>
ITM Power	Calvera	CES	ITM Power	Shapinsay Community
Rendall Electrical Ltd.	SymbioFCCell	Giacomini	Orkney Islands Council	Eday Community
EMEC		OIC	DTU	Kirkwall Community & Industry
SHFCA		SDT	EMEC	
Ha		Shapinsay Community	CES	
Shapinsay Community			Ministry of Transport & Infrastructure	
Eday Community				

### 8.3 Objective Analysis

The objective analysis is formed through the earlier scoped objectives. They are formulated into a similar tree. The objective tree can be seen below.

Figure 12. Objectives Tree



### 8.4 Theory-Based Logical Framework

The main elements of the project for the input, activities, output, objectives, means of verification and risks/assumptions are essential components of the logical framework matrix. The analytical results will fill up the matrix table, formulating the logical framework that can be referred back to and replicated quarterly for reports.

Table 4. Logical Framework for Theory-Based Monitoring & Evaluation Framework

	<b>Project Description</b>	<b>Indicators</b>	<b>Verification</b>	<b>Risks/Assumptions</b>	<b>Frequency</b>	<b>Responsibility</b>
<b>Goals</b>	Building Green Hydrogen Systems in Isolated Territories	Demonstration project Hydrogen as a means of energy storage	Baseline Studies Qualitative & Quantitative Data Collection	Safety Concerns/local communities require & accept support to strengthen indigenous energy	6-8 months	Project Manager
<b>Purpose</b>	Solution to curtailment issues	Lack of Energy Generation due to Curtailment Lack of Income Generation	Up to 60% Curtailment at Present Monitoring	Inefficient transportation/Strengthen capacity of communities to produce green energy	Annually	Project Manager/Officials
<b>Outcomes</b>	Knowledge & Skills dissemination	Safety Concerns Local Communities Require & Accept support to strengthen indigenous energy	Policy Regulations Standards	Renewable Energy Sources Intermittency	Annually	Project Manager/ On the Ground / Site Project Partners
<b>Outputs</b>	Flexible local energy store and vector	Grid Constraints/Restrictions	Valuable energy for local applications Replicable Hydrogen Systems	Delays Transportation Issues	Annually	Project Manager
<b>Activities</b>	Electricity Generation Energy Conversion via Electrolysis Energy Stored in H2 form H2 Transported & Utilized	Community Engagement Managing conflicting interests within the community	Interview Operators Check figures Regular checks Coordinate regular meetings Report	Expensive Dangerous/Hazardous Goods Trained Personnel	Post each activity	Project Manager/ On the Ground / Site Project Partners
<b>Inputs</b>	Local Community Innovation	Renewable Resources & Community Development	Hydrogen will be used near to the point of production on Eday & Shapinsay	More information sharing required as project develops	6-8 months	Project Manager/ Communications & Social Project Manager

## 9 Discussion

This discussion reflects upon the process of a theory-based monitoring and evaluation framework. A critical evaluation of the assessment and limitations of implemented systems are entailed throughout this discussion. The purpose of this study has been to evaluate the benefits and adverse impacts of the BIG HIT Project. To answer this, a wide range of social impacts were integrated within a conceptual framework. The goal of this dissertation was to bring out the most important factors that will affect the delivery of the 5-year demonstration project.

This research presents a methodology developed through an inaugural and prerequisite process. It takes on the complexity of island dynamics, using inklings and signs pieced together to produce well-rounded data. Qualitative and quantitative data was conducted through the means of interviews and questionnaire surveys. These proved beneficial in reaching an in-depth study. The development of social indicators is much more complex than others as their nature disallows them to form a straightforward categorization and predetermined prescription. Pushing boundaries to overcome a façade of challenges that social research proposes, with the lack of clarity between communities and industry, the coping and results prove gratifying to the researcher.

With Social Life-Cycle Assessment, Social welfare is a high priority goal of modern society. Understanding and considering improvements well-being is a paramount component of public policy. The assessment evaluation of social impacts and benefits can be difficult and often controversial (Luigia Petti et al., 2014). This is due to cultural elements, differences in values and lifestyles. S-LCA integrates the traditional life cycle assessment method with social impacts being the focal point of the study to be carried out. Improving the quality of life in isolated territories remains paramount to the scope of the project. Each social aspect was carefully considered and studied to a great extent. This was to ensure that each value was carefully considered, and will continue to be throughout the 5-year demonstration project.

Assembling a theory-based monitoring and evaluation framework was formulated through a logic model, which aided the ease to acquire a mosaic of impact pathways, interdependencies and the means to achieve results through them. The logic model

represents the goal, scope, outcome, outputs, inputs, activities. It entails whose responsibility it is to overcome adverse aspects and when to do so to develop the project promptly, including all social considerations. As in-depth as the model intends to be, it is no measure for completely capturing the full extent of social reality.

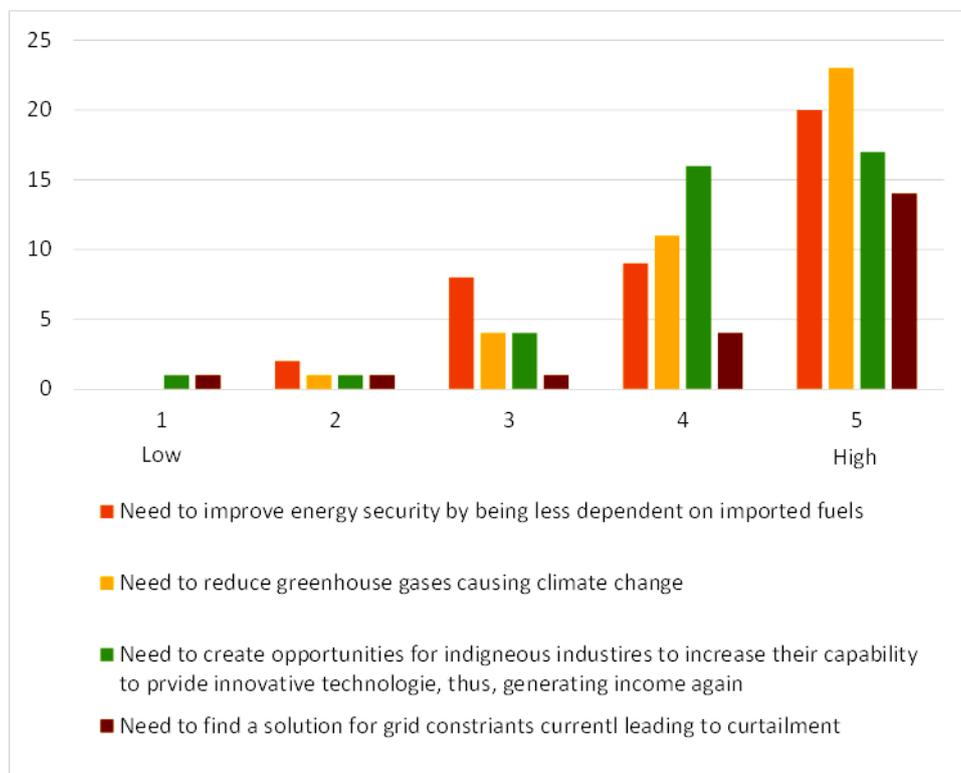
An analysis of the impact pathways followed a foundational approach to the scoping and discovery of the risks originating in these impacts. This included the need to make choices and selections, altogether refining and emphasising the focus of the SLCA. Regardless of this, limitations at the stage of developing the logic model are inevitable as it is not always possible to address impact in great detail.

Global markets often pass isolated territories by, creating detrimental limitations regarding socioeconomic, functional and spatial evolution. The isolated location is related to a lack of accessibility to economic activities, according to literature “determines the locational advantage or disadvantage of an area relative to all other areas considered”. The low population density creates a highly dispersed and widespread population densities throughout the islands. This makes it difficult to implement effective and affordable efficiency increasing strategies. Although there has been an increase in population in some areas over the past number of years, the age of labour force has declined. This often contributes to adverse demographic dependency ratios. With low connectivity, adverse demographics and general higher living costs, isolated territories usually show lower employment levels, contributing to weakened economic structures. However, with the advantages aiming to balance these adverse characteristics, the regular model of development allows peripheries to move economic stagnation once again by recurring to local natural resources, leading to a renewable resource recovery path. Throughout the scoping, it is these limitations that have contributed to the mitigation strategies.

Questionnaires were made available for the general public of Orkney and the stakeholders involved in the BIG HIT project. A full analysis of these can be found in appendix E. The participants of the questionnaire were asked to rate a series of problems regarding importance in their regions. The challenges were based on energy security, greenhouse gases & climate change, curtailment and generating income from indigenous innovation. The results are broadly consistent with the overall attitude of the local communities in Orkney as well as those in the industry. This observation is reflected in the diagram below.

It is interesting but expected that the problem with the highest level of concern regards to climate change. This is not unexpected as climate change is now largely linked to the renewable industry. Similarly, the need to improve energy security is a subject of real concern. Unexpectedly, some participants indicated the current curtailment issue and needed to generate income through indigenous industries as matters of low priorities. This can be seen below and is interesting because of the negative knock-on effects that these issues have had on the Orcadian communities over the past number of years.

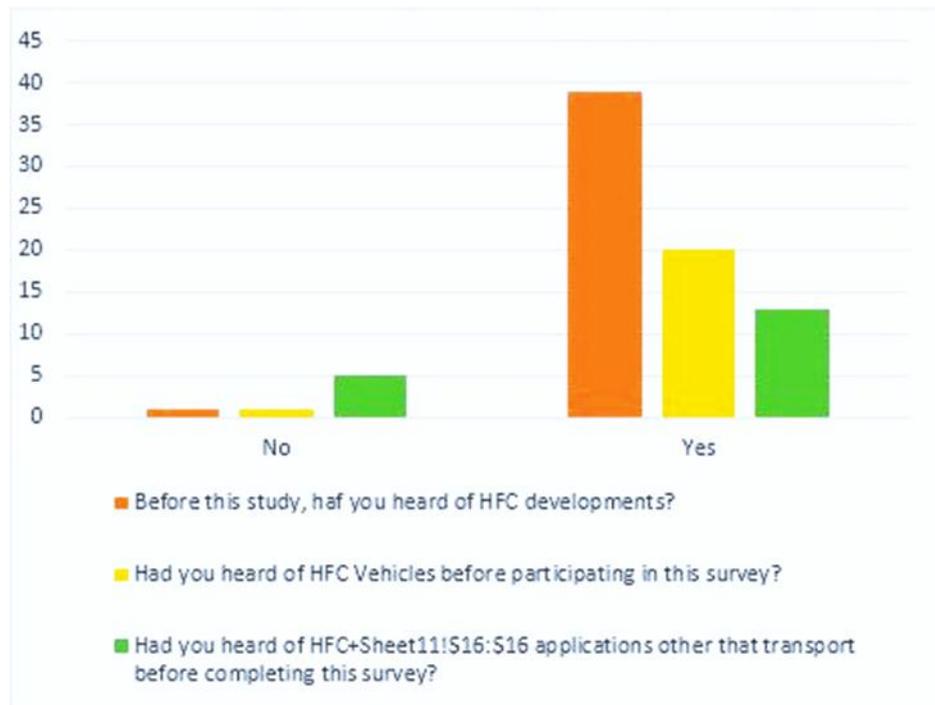
Figure 13. Rating Problems in Importance for Region



This study demonstrates the level of familiarity with Hydrogen Fuel Cell developments (vehicles, heat & power) in Orkney, particularly in the areas most likely to be affected by this BIG HIT project development. As Orcadian communities are generally small and news travels rapidly, the level of awareness and familiarity was to be expected. However, very few of the participants had not heard of hydrogen developments before participating in this social study. This is portrayed below through the means of a graph. Following on from this, further study was undertaken regarding the levels of awareness in particular regions. As previously mentioned, the dispersal of information throughout the communities has been

varied. Even within the communities themselves, the level of awareness has varied. This required further examination.

Figure 14. Level of Familiarity with Hydrogen Developments in Orkney



The stakeholders of the BIG HIT project were asked about the responsibility of the sharing of information. Below are the direct answers from the survey analysis. The comments are left anonymous for privacy reasons. The varied answers suggest that communication has not been fully coherent or considered. This could not be the fault of the project partners. However, this study reinforces the recommendation for the introduction of additional programmes, dispersing information further.

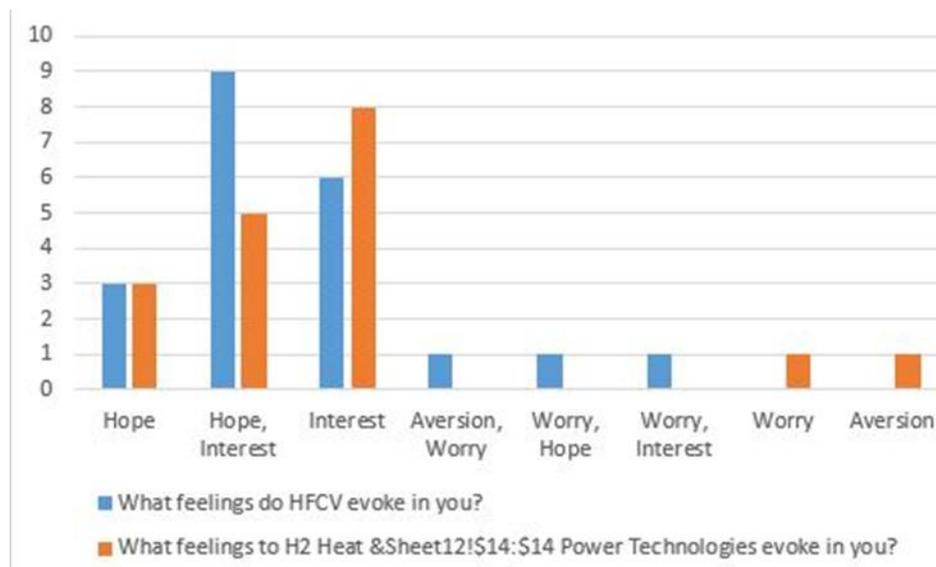
Table 5. Stakeholder Responses to Responsibility of Information Share

“A variety, mainly those who are involved in the projects who have sufficient information with which to communicate.”
“Nigel, the WP leader of the dissemination activities”
“All!”
“Local Companies and Associations”
“I do not know”

“Everybody”

The participants who took part in the public surveys were asked about the feelings that hydrogen fuel cell developments, particularly those directly relating to this occurring BIG HIT project evoked in them. These findings concur with other studies that show the attitudes of the public towards new technologies. It was integral to the dissertation to ensure that the personal feelings of those who took part in the study were portrayed as valuable information that would aid the implementation and decommissioning of the BIG HIT project for the community as well as the project partners. As portrayed in the graph below, ‘interest and ‘hope’ were amongst the most consistent feelings. ‘Interest’ and ‘hope together also proved apparent here. However, some participants felt ‘worry’ and ‘aversion’. This was to be expected as many people still carry a slight stigma towards hydrogen due its previous uses. These findings can contribute considerably to the development of the project, considering the voices and opinions of the communities most likely to be affected can assist decision- makers in the way in which an activity is to be executed in a sensitive, safe and responsible manner.

Figure 15. Feelings Evoked by Hydrogen Technology Applications



The stakeholders were asked whether or not this is the best solution for curtailment in Orkney at this present time. The answers were taken directly from the survey analysis and

are provided below. The consensus was that yes, it is the best solution for Orkney's curtailment issues at this moment. However, it is evident that there are alternative solutions. With this, these other solutions are largely expensive in comparison to hydrogen technology. The inefficiency of the delivery of the project regarding transport suggests that with time, the project activities will evolve and become more efficient. The project aspires to be a demonstration of what could be while solving a problem that has disabled communities from receiving the FIT that the community wind projects once promised and delivered.

*Figure 16. Stakeholder Opinions of Hydrogen as Solution to Orkney's Curtailment Issues*

The technology is sufficient at present to resolve the issue of curtailment while the grid connection to expand capacity is delayed. The government of this country and others are showing interest in backing, at least in part, a hydrogen transition.

Other solutions such as EV charging and heat could have more obvious community benefit (energy poverty etc)

At the same time that curtailment is reduced, hydrogen is helping to distribute the energy among the islands, and helping as well local consumption of the RES.

The overall efficiency of transporting energy from Eday to Kirkwall is ridiculously low. Possibly as low as 20%. Included are other energy inputs, such as diesel to transport the hydrogen, and additional ferry congestion. It would have been cheaper to uproot the Eday turbine and rebuild it on the Scottish mainland.

It seems to be. Anyway there could be other possible technical solutions.

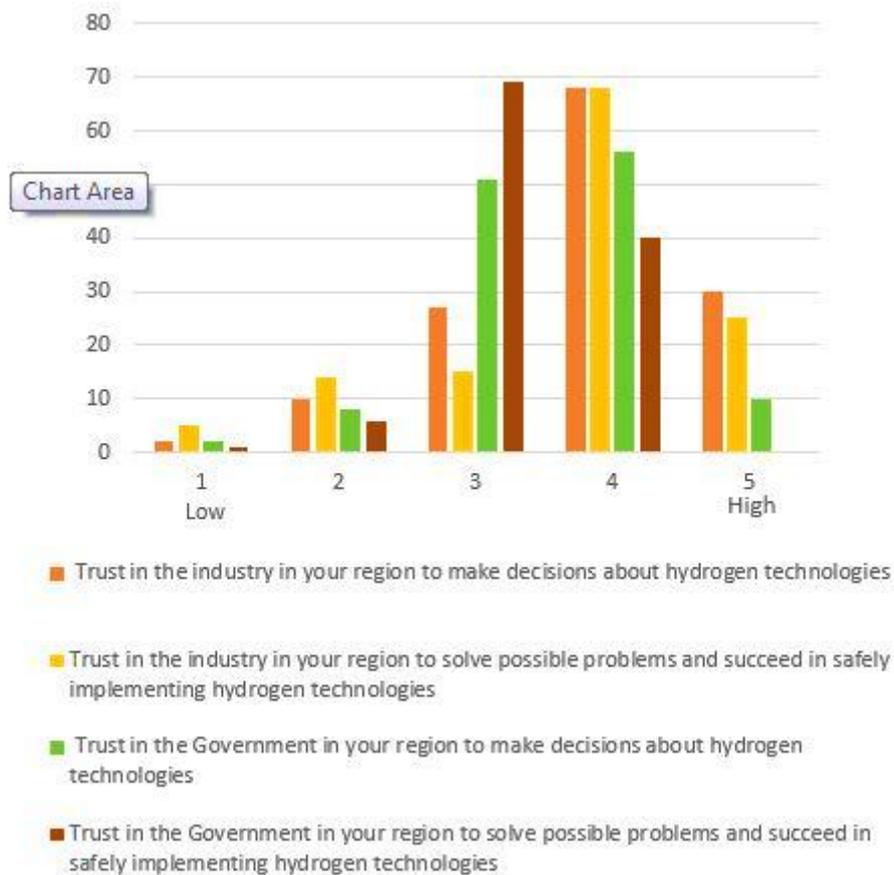
Use renewable energies like wind turbine to generate new energy.

After 10 years of failing to make any progress with the grid, this remains a possibility.

The participants of the public surveys were asked to state their level of trust towards the government, industry and local organisations about the safe and responsible implementation of the project and decisions made regarding hydrogen technologies. The graph below depicts the array of results. The results show that the industry is relatively highly trusted with regards to these activities which was to be expected. The level of trust in the government was higher than anticipated after further research was pursued regarding this kind of information through meetings and interviews with local council representatives, local organisation representative and members of the local community where the government seemed to have little admiration due to the previously discussed deplorable efforts. However, it could be due to the efforts made by the Orkney Islands Council in recent

years. It is their belief that many events that they have organised have been poorly attended due to the stigma held towards them as a governing body.

Figure 17. Level of community Trust



Earlier on in the study, before the fieldwork took place, presumptions and assumptions were made to begin the scoping ng process initially. This process entailed a detailed study in previous literature written regarding similar projects and technologies as well as in similar areas. This scope provided a basis for the data collection. However, this data was not sufficient enough to build a logic framework, thus the need to undertake extensive fieldwork. These results describe the impacts emanating from the BIG HIT project.

This study shows that The Orkney Islands have the opportunity to demonstrate the refusal to relinquish the environmental and societal challenges and consequences of climate change, while at the same time, create rich and innovative economic opportunities. With Orkney’s geographical location and experience over the past number of implementing renewable energy projects as a way of targeting the combating fuel poverty, instigating innovation in isolated territories on the path to becoming self-sustainable and promoting

economic growth. The archipelago has opportunities to create synergies between research institutes, the private sector and local political authorities.

Orkney is becoming an international platform for testing and demonstrating renewable energy technologies, aiding the islands to create and optimise economic spinoffs from already existing projects. With this, comes researchers and educational activity in the local areas.

The methodological research design was chosen to ensure an in-depth collection of data on impact pathways. Central to this study was gaining the insights of the residents of Shapinsay, Eday and the Mainland areas that were most likely to be affected by the impacts of the project.

This study demonstrates that the logical framework for the theory-based monitoring and evaluation system was structured around goal, scope, activities, outcomes, outputs and inputs. This is to ensure the future success of assessing these deliverables throughout the 5-year demonstration project. Community members and stakeholders were asked to identify and specify the extent of the outputs affects and how they feel about it. Creating this structure ensured precision throughout the assessment and showed the conciseness of how the evaluation was carried out. Each component contributing the model is included as key data as, without its inclusion, the model would be incomplete. This emphasized the importance of its contribution.

Analysing the pathways of all impacts emanating from the project proved to be of particular relevance and use. This ensured the delivery of the methodology to stay focused on its original aims and objectives. It also aided the continuous thought process relating to the concepts of the impact analysis ensuring the challenge of framing and categorising or impacts was overcome.

The main finding of this dissertation is the social impacts, both positive and negative impacts have emerged. The properties of renewable energy development have already brought benefits to the region and the communities. It has brought employment opportunities through working directly for the BIG HIT Projects and indirectly through knock-on effects and initiatives. Over the life-cycle of the project, there would undoubtedly be increased job opportunities, energy security, and innovation, development of skills and

transfer of knowledge along with much more as previously discussed. However, there have also been some unintentional negative impacts. Whether a decrease in community and cohesion has been occurring without the presence of the project or not, it is still occurring. Further studies could be taken into the healing and harmonisation once more for these community issues through innovative process and learning. Some deterioration of health and the environment or at least perceived degradation of these.

Some unfulfilled promises such as the secondary heating system promised in Eday Primary School, have resulted in distrust and disillusionment of the community members towards their community trust/partnership. This finding was unexpected and suggests that this could be no fault of the BIG Hit project, they had no choice but to shut this down as there is limited funds/capital at this stage to invest in such a system.

At the community level, what is primarily an issue is whether local communities will receive an appropriate balance of benefits to compensate for the costs associated with negative impacts on their livelihoods. For example, the road in Eday leading to the test site is in need of rejuvenation as the HGVs travelling to and from the centre, place immense pressure on the existing island infrastructure. While the communities are bearing most of the environmental and social costs of the project, most profits flow elsewhere. This has led to growing demands that a sufficient portion of the benefits should flow to the communities to ensure adequate compensation. In Eday, residents are currently worried and infuriated with the management of profits arising from renewable energy developments on their island at present. This could not be the fault of the project partners but possibly falls upon the community voice/body/representative. This seems to be the case in Eday and seems less than this in Shapinsay. However, recent tensions have emerged suggesting that the community has not been receiving the level of information previously alluded.

Project partners and companies involved that were interviewed as part of the field research for this study have mentioned the importance of improving the implementation and contribution of activities such as outsourcing to support local business development, establishing community investment initiatives, increasing human capital, encouraging synergies and more. Economically, some benefits extend from local to a national level as well as contributing to national greenhouse gas emissions targets which are a value heavily embedded in the Orcadian Community.



## Limitations

Although the research has achieved its aims, there were some unavoidable, inevitable limitations. Firstly, due to the time limit, this research was conducted on a small portion of the population who had the time to express their opinions, fill out the survey and speak about any concerns regarding the implementation of the project. It is also noteworthy that some members of the island communities were happy with expressing themselves and that others were reluctant to involve themselves in anything related to the BIG HIT project. Secondly, it was difficult to contact all of the stakeholders. Many stakeholders were keen to talk about their feelings and opinions. However, some did not respond. Within the project, there was 'wiggle-room' for lack of information like this, so it did not skew the project in any shape or form.

S-LCA is a relatively new process with few studies undertaken to this date. S-LCA studies that have previously been conducted often lack or have been limited in goals and scope. There is no single approach or methodology, a range of different approaches have been used in S-LCA studies in the past. A set of guidelines were published in 2009 and still require significant future work methodologically. Limitations due to the nature of society and effects, the values of humans are heavily involved, making the quantification aspect of the assessment rather difficult. With this, the aggregation of social data can be difficult to understand for qualitative data. Regarding the evaluation of the usability, replicability and the level of satisfaction, it is potentially better assessed through the use of other tools (UNEP, 2009, p.78)

Another limitation was the absence of focus groups as local tensions did not allow for them to happen. Delayed and no responses from the trusts to allow the community to participate in the survey as they didn't feel it was a good idea, although shortly after a questionnaire based on housing conditions was distributed on Shapinsay. The lack of intent to help implement the social impact analysis reflects on the lack of communication between the communities and their officials. This could be down to the recent emergence of tensions within the trust. This is a good place to begin with for further research as the AGM took

place there on the 24<sup>th</sup> of August 2017, where new members (whose names were not disclosed) came into action.

## 10 Conclusion

Over the course of this research, the main social impacts and change processes emanating from the BIG HIT project actions have been assessed, presented and discussed. Both positive and negative impacts will occur as a result of the BIG HIT Project. One of the issues that were repeatedly present throughout the study is that there are risks involved with this project. If any contamination were to occur it would be in an ecologically and socially sensitive area given the small nature of the island regions. Mitigation measures are to be implemented and the theory-based framework will assist the monitoring and evaluation of any arising negative impacts.

The development of a theory-based monitoring and evaluation framework has proven successful in assessing the social impacts on an island community level about the conversion and storage of hydrogen through electrolysis. It has captured the complexity of local social dynamics and presented them in a fashion that is easy to assess and replicate. Strategies and actions have been informed and designed throughout the study of this dissertation. All emanating risks arising from the project itself have been identified and presented. This includes the actions of the project itself, the supplier, customers and all relevant stakeholders.

The testing of this theoretical framework has determined the level of user-friendliness and its effectiveness in capturing the identified social impacts. The theoretical framework has been of great use and can be replicated throughout the 5-year demonstration project to monitor and evaluate social impacts arising from the activities of the project in an orderly manner. The tools adapted for the specific impacts are user-friendly in a way that they can be replicated with ease, especially with blank figures presented in appendix D.

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## 12 Appendices

### 12.1 Appendix A. The Process of SIA

#### Public Participation

The development of a public participation programme is key to beginning the first stage. It intends to involve all interested and affected parties. This stage involves identifying stakeholders and community members that will either benefit or be adversely affected by the project. This would include, those who live close by may be displaced, and those who have an interest in the project but may not necessarily live in the proximity. Others affected include residents affected by an influx of workers, creating the ripple effect. For example, more people are frequently utilising infrastructure, compromising the availability of public services for the communities due to the excess amount of personnel. Participation technique is used to collect data regarding public response towards the proposed project. This first step is necessary to further the process throughout the implementation, including monitoring and evaluation.

#### Identification of Alternatives

The next step involves the description of the proposed project and any alternatives available. The project is described in detail, identifying data requirements necessary for a preliminary assessment. This would include any new construction in the area, its size and requirements for the local work force. This provides the larger extent of the project including its stakeholder profile

#### Baseline Conditions

The relevant location/area of influence that the project is in should be documented. The baseline should identify the distribution of people potentially at risk due to the nature of the project. The description should involve the historical socio-economic culture of the potentially affected group.

#### Social Issues

The impact assessment should provide an overview of the social issues that are associated with the project. This should include demographic, socioeconomic, social organisation, socio-political, needs and values as factors to derive from

## Scoping of Impacts

This section intends to present the prioritisation of likely social impacts. This suggests extensive open discussions regarding the project or interviews concerning it, with those likely to be affected by the project. Existing literature written by experts, along with questionnaires and public scoping is popular amongst social scientists. Workshop based methods such as collaborative decision-making processes are necessary, along with the participatory assessment methods through multiple field visits to local communities and available stakeholders (Rietbergen-McCracken and Narayan 1998). Consultations are including participatory rural appraisal (PRA), or other kinds of beneficiary assessment methodologies. Scoping the impacts essentially provide collaboration tools between local people in analysis and planning. They can significantly benefit the development of action plans and participation frameworks.

## Identification & Analysis of Potential Effects

This is section essentially sews the SIA together. It is a process of analyzations and predictions of potential impacts, comparing those against the baseline conditions. This entails an investigation of likely impacts:

- Predicted Outcome without any Action
- Predicted Outcomes with Actions and the Predicted Impacts

The investigation of the probable impacts involve paramount sources of information:

- Data on proposed action
- Secondary sources
- Fieldwork
- Surveys to the General Population

Methods to predict future impacts are paramount in the process of an SIA. The finished report should be of sufficient quality and transparent, thus providing a critical review. Some methods that have been adapted from Taylor et al., 1998 and Impact Assessment and Project Appraisal, 2003 include:

- The Comparative Method: Examining how a community has responded to previous changes, similar impacts on other communities and their chosen action. It compares the present to the future proposed action. It bases itself on previous research and experiences.
- Expert Consultation: This includes meeting and speaking with researchers, local authorities, knowledgeable citizens and others who are familiar with the area of study.

### ■ Prediction & Evaluation of Impact Responses

This section is useful in determining the significance and extent of the previously identified social implications. It involves the projection of impacts through analysis. After direct analysis of the impacts, an estimation of how the affected communities would respond regarding attitudes/actions towards the given project must be made.

### ■ Indirect & Cumulative Impacts

These often include knock-on effects, including secondary to tertiary impacts which have been added to other past, present and future activities related to the initial project. Secondary and indirect impacts are those that arise because of direct impacts. They often occur later in down the project line. Cumulative impacts refer to the build of impacts without action.

### ■ Impact Mitigation & Monitoring the Development

Mitigation measures must be put in place for minimal impact. This can take the form of specific modification, redesign of the policy or project practices. It may also include compensation by providing substitutional facilities, employment opportunities and resources. Monitoring the development involves a step-by-step process and implementation of a monitoring strategy, aiming to identify aberrations from the project action the strategy intends to track project development, picking up on any adverse properties and compare present impacts with forecasted impacts.

## 12.2 Appendix B. Analysis of Interviews

██████ Nic Thake (Managing Director of Shapinsay Development Trust)

12th May 2017

### *12.2.1.1 Background, Involvement, Overall Perspectives/Consensus*

Nic Thake has a background in tourism and cruise ships and has lived on Shapinsay for over 13 years. The Shapinsay Development Trust is a community run trust that was formed in 2002. Nic Thake described it as ‘a vehicle that collectively helps maintain and improve lives. The current NET migration has been inward over the past several years. This is due to the ‘excellent’ amenities and resources. The quality of the primary school is excellent. Shapinsay is geographically ‘lucky’. Secondary school children can go to school on mainland Orkney in the morning and return home in the evening. Citizens of Shapinsay have the opportunity can work on the mainland with ease, particularly with the use of the ‘Out of Hours Boat’ which is driven by a local man called Harvey Groat. This allows the residents of Shapinsay to have ‘a more comfortable standard of living’.

Employment is traditionally embedded in agriculture. ‘The number of individually owned turbine has been increasing over the past number of years’. There is an incentive for outsiders to erect a turbine on an individual’s land. The individual is provided with free electricity, and the outsider reaps the income generated.

The school building is also the doctor’s surgery practice, the leisure facility and also has an open community room where lunches and community social events are often held. This is the building that will directly benefit from the BIG HIT project where a catalyst boiler system will be located. The compound storage system will act as a secondary heating system, allowing the temperature to reach a certain point and the already existing heating system will take over from there. The boilers are 5KW each, and the deliveries of H<sub>2</sub> will occur during off-peak hours when the building is not in use.

### *12.2.1.2 Beginning of alternative energy*

Aquatera ran a survey on ‘low carbon transport’ in the past which aided the gravitation towards hydrogen. ITM engaged in a project that was to use an electrolyser for the CO<sub>2</sub> from distilleries, producing synthetic processes. The appropriate solution being red diesel, phase 1 was fully funded. After one year of the developing project, the phase 2 application

fell through as the BIG HIT project evolved which in turn superseded the energy project on the horizon. Shapinsay signed the BIG HIT agreement. BIG HIT was set to absorb all curtailed energy from the community owned wind turbine 'Whirly'. Nic raised the concern for the need for a 'hydrogen market' here. The turbine was paid by a feed in tariff (FIT) to encourage which is based on p/KW produced. Thus, with curtailment, no energy is being generated, no electricity is being produced, and therefore, no income is being generated and put back into the community.

This challenge has multiple solutions. Hydrogen is a new opportunity to create an innovative, new value to the economy based on hydrogen as new renewable energy applications for the future. BIG HIT sets the stage for what is to come in the future. Hydrogen technology can be applied to the shipping industry in the future.

#### *12.2.1.3 Community Engagement and Attitude of the Public*

The community is in broad support of the BIG HIT project. Citizens were written to, informing them of the project. The priority concern is based on the safety of hydrogen itself. Safety and how it is managed were explained and noted as ever evolving. 'Transporting hydrogen has no regulatory framework'. 'Surf n Turf' project hold the responsibility for implementing a safety strategy. The project provides the opportunity for local people to train to become a handler of hydrogen on board vessels and at the Kirkwall Pier.

There are hopes and aspirations of the community of the BIG HIT project. It is anticipated to provide the basis for a future solution to target fuel poverty. The level of acceptance is unknown. It is estimated to be broadly accepted for domesticated use of hydrogen to provide heating systems to homes. Nic also addressed the issue of 'dirty ferries'. His aspirations are for the out of hour's boat to be run on hydrogen.

Orkney Islands Council (Adele Liderdale & Gavin Cameron)

17th May 2017

#### *12.2.2.1 What is the council's view on the implementation of the h2 economy in Orkney?*

RE potential large/domestic turbines. Resources 'Saudi Arabia of the North' in a small scale 'isolated territory'. Funding- ferries £millions, - test take, -generation of income, -perception on-board Eday and Shapinsay (understanding for themselves) with limited with what to do with resources and opportunities.

#### *12.2.2.2 Do different opinions exist within the council?*

Different opinions do exist within the council. However, these views are drawn together to come to a consensus. With 11 new councillors, the previous council were 'keen' to go forward with green energy projects in Orkney and "it looks as though the decisions remain unanimous". The chair of the development committee gives consistent positive support.

#### *12.2.2.3 Does the Council prescribe any community engagement for the BIG HIT project?*

"There are organic policies for community engagement". The local newspaper and radio station have a heavy influence in Orkney and are a vehicle for spreading news. The Council helped organizes public meetings which they mentioned it is rare to see a "new face" attending, "it is the usual folk who attend these organised meetings". It was mentioned that the council are not 'politically official'. The loudest voices are usually those that are not in favour. An example of this was the townscape development project, where the council issued a 'clean up/tidy-up' project to rejuvenate the facades of the Kirkwall buildings. The buildings were to hold their historic features. However, the public opinion was lost due to changes made by the council.

#### *12.2.2.4 What are the mitigation measures being developed?*

In relation to transport, hydrogen at sea has strict guidelines and policies, such as the dangerous goods act. The pier will be fully equipped to exact specification for training personnel. 'Mark Shiner' trains individuals under Orkney College. The open systems pass on extensive practical skills and knowledge, linking with the out with job role.

██████████ Becky Ford (PHD STUDENT)

15th May 2017

General discussion

Help each other

The way renewable, narrative shapes, way stories emerge

██████████ John Skuse, EMEC, Test site in Eday

22nd May 2017

The interview was held at the test site. It began a series of probing questions regarding the hopes and aspirations, the best solution to curtailment. It was conducted in an informal matter to ensure that opinions could be expressed fully and without interruption. John expressed his concerns regarding the benefits for Eday. However, without contradiction, he reinforced the concerns with the speaking about the benefits. Safety concerns were not an issue as John, and his team are well-trained and understand the technology to the extent that any adverse events will be prevented rather than dealt with after.

John conducted a tour of the site and its technology, giving a running commentary, explaining the details of how it is to be operated, stored and transported off-site. John explained that the Eday school secondary heating system had been pulled from the project earlier in the month. This news was both shocking and intriguing. When asked if he had known the reasons for this he said that he was not sure, but it is most likely down to funding.

#### ██████████ Group of Women in Heritage Centre Crafts afternoon, Eday

22nd May 2017

An arts and crafts afternoon takes place each Monday at the Heritage Centre in Eday. This is where a group of local women congregate for a creative afternoon and to have a general chat. With permission, this was the perfect opportunity to discuss the BIG HIT project and their feelings/opinions towards it.

One woman did not wish to speak, and a slightly hostile atmosphere lingered there. However, other women did want to talk about their thoughts on the process, and one lady said: "There is no point". She mentioned that it would be to 'deaf ears'. She then went on to say "we should not let the island get like this". When asked what she meant by this statement, she mentioned that it is many of the islanders who would rather say nothing when it comes to conflict. It was apparent that the community can see a disparity yet are not willing to pry.

Some names were mentioned in a slightly derogatory way. However, for the sake of privacy, they will not be disclosed in this dialogue like section.

Another woman was horrified by the lack of will to repair the turbine. “It has been four years since we have seen it going around”. When asked more about the development of hydrogen, one lady said that she “couldn’t stand the smell, it has been awful since they started”. This suggested a stigma towards the use of hydrogen as a solution to their curtailment issues due to previous uses of hydrogen in the past. Another said; “I do not care to talk about that”. Another said: “Oh, we walk to the pier and we watch and think, Oh! There is another green container, and that is it we go back to our lives”. The women had mentioned EMEC as a sponsor to the heritage centre and that they had held a meeting there. The women said that they had not been invited. It was a bit consuming as the women each said slightly different things on this matter. Some women stated that they had had the chance to meet Neil Kermod and others stated that they were not given that opportunity.

██████████ Adrian Bird, Turbine Manager, Shapinsay

29th May 2017

This interview/meeting was conducted by another student working on his dissertation. The meeting was openly conducted, allowing scope for Adrian to speak his mind and provide information regarding the turbine, his opinions.

Adrian firstly talked about the maintenance of the turbine, health and safety, the fact that they are willing to pay a small sum to keep the turning rotating daily and his role. Adrian is the turbine manager. He is the point of contact in charge of coding, analysis, forecasting, software updating and the turbine technological properties. He also mentioned the replacement of the G59, which acts as the “brain”. The cost of replacement exceeded £100’000 to replace. It covered under the maintenance contract. He spoke about the difficulty of maintenance due to the geographical location of Shapinsay.

The conversation then drifted towards curtailment. He mentioned the ‘stepped agreement’, ‘last up first off’. Adrian monitors the turbine carefully. He said with passion that it is essentially “stealing 35% of power from Shapinsay on an annual basis. When speaking about the turbine operators, he mentioned that they work in two weeks on, two weeks off pattern. It is of Adrian’s belief that grid replacement activities will take place in September of this year. (Speaking to other sources: “maybe reinforcement or some work being done but definitely no replacing until at least 2022” –Bryan Rendall)

The voluntary enforced curtailment means that the income generated and gift aided to the Trust which is then distributed to the community is lessened. Shapinsay Renewables and Shapinsay Development Trust run the turbine. The board makes decisions. The Trust is responsible for the community decisions.

When steered towards the question of trust, the level of community trust, in particular, Adrian said, "Some people never wanted the turbine". He mentioned that there was a 50/50 attitude towards the construction of the turbine in Shapinsay. However, a number of community members who are benefitting from this income are huge.

When asked about other uses or alternatives means of hydrogen production, Adrian was keen to mention the production of hydrogen could contribute to private home-care, and future agricultural fuel, as it is one of the traditional livelihoods on the island. Adrian said that the electricity poles in 1953 attracted both positive and negative responses and reactions. One man allegedly refused to get on board with the innovation and didn't receive electricity in his home until 1986 due to his strong beliefs and reluctance. This is natural in isolated communities. Change can often be scary, but sometimes it is needed to ensure nothing gets left behind.

 Abbey, 17 years old, The Smithy

29th May 2017

Abbey was very excited to speak about the BIG HIT project. She had been well informed and did her reading up about it following on from that. Before having asked any questions, Abby began discussing why she was so excited and had a keen interest in the project. She mentioned that it is "a good idea as the turbine has been losing energy and money for a long-time now". Abby said that there is an interactive reading on the school wall to see when the turbine is rotating and when it is not. "This is a good feature because it gets us all involved".

Abby aspires to work offshore. She has gained certificates from various maritime related courses, one of which the 'Maritime Skills for Work' in Stromness, to prepare her for her journey on a career at sea, to which she claimed it is going to be 'awesome'. When asked about the sharing of information, Abby said; "I have been informed well, and I can just go to the boathouse if I have any questions or want to know there, they will help me".

████████ Fiona, the Smithy & Mid-Wife at Balfour Hospital in Kirkwall

29th May 2017

Fiona, Abby's mother, took a few moments to express her opinions. Fiona had explained that she was delighted to sit and chat about the topic as she had arrived home from a night shift at the hospital at 10 am that morning and at this time (1:30 pm) she was already back to work, running the café. This is traditional in Orkney to have multiple jobs. Hard-work is very real in isolated territories 'everybody does it, I am no different'. She mentioned that it is always a good thing to have new developments on the island as long as they are not "too big" and "benefit our Community". She is proud of her daughter and thinks that living in Shapinsay has much to do with the career her daughter wishes to pursue. She feels that having renewable energy on the island can be seen as an "inspiration to the youth".

████████ Stephen Vegan, Eday Partnership

31st May 2017

#### *12.2.9.1 What kind of involvement as the Partnership got with the current hydrogen systems?*

"Eday Partnership has not any involvement", "we're the third point of call when it comes to hydrogen, and it goes over our heads". Eday Partnership would like to generate income once again. The Partnership has involvement with the hydrogen system implemented into the current 'Surf n Turf' project, utilising the same electrolyser.

#### *12.2.9.2 Is this the best solution for the current curtailment issues in Orkney?*

Stephen said that there are minimal benefits for Eday regarding this project regarding its development. Stephen had a considerable resentment towards the use of the hydrogen as he believes it will put a significant amount of stress on the current transport. "The road is in a poor state as it is, with a 20-ton limit".

#### *12.2.9.3 Goals, hopes and expectations of the project:*

Stephen mentioned that the indirect benefits are not quite enough to suffice. /he mentioned that the turnover from the 'Surf n Turf' project is hoping to bring things such as a swimming pool to the island or some spa development, creating a health and well-being destination. Stephen expects that many of the proposed benefits will not benefit Eday.

“Differences in expectations between the Partnership and the subsidiary have resulted in trust issues and conflict”.

#### *12.2.9.4 Overall Outcome of meeting*

Stephen felt that Eday community has been supplied adequate information on a need to know basis. He spoke about the health and safety concerns as he felt that the island required some degree of balance between the two. He talked about the income generated when the turbine is rotating. He mentioned that they had a problem with the switch gear. Although Stephen was not well informed, he spoke about the need for this kind of projects to reduce fuel poverty in Eday.

Stephen, on behalf of the partnership, has expressed scepticism towards the outcome of the project and hostility towards the local conflicts, suggesting that “local politics are the islands biggest handicap”. With this constraint removed, he feels that they could sustain the island and provide better social care, facilitating community well-being through affordable housing, the provision of leisure facilities and training opportunities.

With 15 years left of the turbine guarantee, the partnership is enthusiastic about upskilling of local individuals as well as other possibilities. The partnership has been involved in multiple community development projects such as the island’s ‘cooperative’ food store and the lotteries ‘non-fit’ direct outcomes. Stephen fears that the lack of direct impacts that BIG HIT has to offer Eday results in no guarantees, leaving the partnership worried.

██████████ Ailsa Skudos, Community Energy Scotland

2nd June 2017

This meeting was a joint meeting with Michael Westrom, another MSc student. Community Energy Scotland is involved in the day-to-day operations viewing the levels of hydrogen. CES is responsible for the advisement of the Western Isles.

Ailsa mentioned that they deal with the members of the development trust and the community. They provide supporting roles for the community as well as a ‘Local Energy Challenge Fund’. They aid the implementation of innovative projects within communities to increase the value of local benefits as well as meeting local demand.

Ailsa expressed that CES's hopes and aspirations of the project will tackle fuel poverty, increase community resilience, boost employment & knowledge and underpin the local community development plan.

The SMILE project in Orkney is a £14 project similarly "demonstrate a set of both technological and non-technological solutions adapted to local conditions targeting the distribution grid enabling response to demands, smart grid functionalities, storage, and energy system integration".

████████ Cathryn Townsend, Community Member

5th June 2017

This phone call meeting was beneficial as it gave an insight from a community level. Cathryn lives near the EMEC testing site, where the hydrogen technologies are currently housed. Cathryn was slightly upset over the "false hope, and expectations promised" by the project, the school heating systems being one of the main upsets.

Cathryn was confident in the plan to bring innovation to the island for the island's survival and sustainability. However, she felt that the information regarding the project was not very well publicised to the Islanders. The community has supported the development from what they know about it". She feels that the community did not have the opportunity to engage. When asked should there be more information shared at each stage of the projects her response was "Yes, we need concrete, not just dribs and drabs, here and there".

"The community fear expression". The lack of community engagement is a weakness in the community. Cathryn expressed that a member of the Partnership has 'ideas'. However, "those ideas are not to benefit the community..." the assumption was made here that there is much more than meets the eye in the world of politics and financial unrest in Eday.

The trading subsidiary wishes to maximise profit "but we never see a penny". "Our only option is to trust EMEC". "We will put our trust in EMEC and Orkney Islands Council, but we have our reserves that Eday's best interest is not at heart".

████████ Bryan Rendall (BJRE)

14th June 2017

Bryan Rendall contacted after hearing about the project on BBC Radio Orkney. The meeting took place shortly afterwards and was conducted openly, allowing Bryan to do most of the talking to cover the topics and aspects of his choice.

Overview of Main Points

Electricity constraint- hours, research for turbines

Commercially it is not the best solution

Relocate turbine? Wrong place

Cost efficient v. h2

£1.3m electrolyser (Expensive)

Other infrastructure

Capacity building/demonstration

Better than another curtailment

More energy wasted-more pay out

Hope excess energy can be used

Northern Ireland demonstration-worthy of exploration –more uses for h2

Multiple uses of h2 statistic installation

Micro-turbine moratorium

On-site-use-realistic

The margin of safety 5m either side, in front and behind.

Eday public space on passenger ferries

Spare Capacity

Transport product

“Margin of safety.”

Empty deck space on ferry (dangerous good)

Refit timetable

Potential social impact-

SSE renewing cables 2022 12 MVA-24MVA

Benefits for Stronsay

Split views-money

Work in Eday in MREs

10-12 years feasibility with EMEC

How people deal with new up comings and impacts

Tomatoes-electrolyser ERE 2014-2015

EMEC (end) Design interface with design

Construct system

ITM (prep work)

Input to changes 'Orkney Proof' vs Sheffield proof

Busy design period and work 2016

Social benefits

On site since 5th December 2016

2-3 years/procurement June

Employees lived in hostel over seven months generating over £14000 Community Association Hostel

Away from their families/civil contractors

Local folk employed

Negative Impacts

Damage to road

Infrastructure

Negligible

Andy Sennett-schools, let people, pass on roads

Maintenance and upgrades

Safety

ITM manage h2

Standard work-high voltage electricity

Steps put in place for operation

Lightning rods (6m high)

Electrolyser -earthing system

Design to be safe at beginning rather than wait to fix it

Mitigation

Unload trailers

“Mr Tweedy: What is it? Mrs Tweedy: It is a pie machine, you idiot. Chickens go in; pies come out. Mr Tweedy: Ooh. What kind of pies? Mrs Tweedy: Apple. Mr Tweedy: My favourite! Mrs Tweedy: Chicken pies, you great lummox! Imagine. In less than a fortnight, every grocers' in the county will be stocked with box upon box of Mrs Tweedy's Homemade Chicken Pies. “

No concerns regarding safety -awareness and well-managed

Commissioning tests

Start process

Safety conventional

“Mushroom cloud.”

Minimal impact on the shop

Civil shop in Shapinsay pass contractors

Bringing employment

Knowledge and experience

Supply and demand (production and consumption)

Duray (shipments of radioactive substances)

Snags

Ships

Too conservative in thoughts

#### *12.2.12.1 Other perspectives*

Breaking off catch 22

H2 demand must meet supply

Range-recharge 1 hour/30 mins

Pier FC plan to be charge switches

Estimations

Outcome uncertain

Trying time/hurdle to overcome

Early days stimulate production and demand

Bottleneck to break down

Measurement point

Interesting/challenging

 Horizon 2020 Conference Bergen, Norway

8th June 2017

This project was mainly related to the funding opportunities under Horizon 2020. The presentations at the conference touched on societal challenges such as health; the

demographic change and well-being of society and the provision of a clean source of efficient energy and transportation. In relation to climate, it touched on the actions necessary to mitigate its effects on the planet and its inhabitants. Inclusive innovation that is reflective of societies is needed to provide security to societies, which is a common EU challenge in need of combatting. Low carbon-energy was stressed as a priority (smart citizen-centred energy system). The research unit project focuses on society. The conference also touched on the 'technology readiness level', which has stages to ensure innovative actions can be taken on an evolutionary basis.

██████████ [Trond Stromsgen, GCE Subsea, Florø, Norway](#)

12th June 2017

This interview was conducted at the GCE Subsea School casually. He spoke about the Hydrogen Ferry 2021 project. He expects to cut emissions in this industry by 55%, to begin with. The hydrogen adds value to the local value-chain, with the addition of knowledge there, they wish to "export knowledge to New Zealand". "There is a hydrogen economy being built and an Oxygen economy too". The oxygen will be used to provide instant heat to the fish farming industry.

When asked about his perception of the hydrogen applications in Orkney as a solution to the current curtailment issues being experienced, Trond expressed that it is a fantastic idea to introduce hydrogen energy storage applications into isolated territories and that it has a big future with a globally expanding market it is good to be on board with such a technology in such early stages of its evolution.

██████████ [Andrew Stennett \(Managing Director Eday Renewable Energy Ltd.\)](#)

14th June 2017

Examples of Community Engagement: Meet at the school where hydrogen students got children involved in hydrogen power using motorised models. 'Surf n Turf' Community Meeting where Neil Kermode from EMEC talked to the public about 'Surf n Turf'. Posters advertising the hydrogen trailer on the ferries and at the Eday community shop, anticipated Mail out to all Eday Residents highlighting a summary of the 'Surf n Turf' project (for those

who missed the community meeting) by use of the pamphlet, and update of where we are with the project, jargon busters explaining the differences between 'Surf n Turf' and BIG HIT, and how the community is likely to benefit,

#### *12.2.15.1 Socio- Economic Benefits*

Socio

Increased income from the community turbine, means it will meet it is more able to meet its social outcomes

#### *12.2.15.2 Economic*

Reclaimed curtailed electricity for community-owned wind turbine should create increased revenue for the Partnership

Increased income earned by the community turbine, will ensure increased business resilience against challenges, now and in the future

'Surf n Turf' was the prerequisite before BIG HIT could go ahead and while we are not a BIG HIT partner there is potential opportunity (and therefore, increased reclamation) from new loads including Hatston Hydrogen Vehicle charging Fuel point

Contrary to the thrust of the article this morning, there is still plenty of potential for further reclamation, and with us having an HV switching unit in place, one could argue we are in pole position\* for finding and developing a new plug and play opportunities when the right fit is found.

ERE, being one part of a hydrogen supply chain, may create new learning, teaching and trading opportunities in the future.

\*Shapinsay have less curtailment than us and more hydrogen capacity than us and so it would be harder for them to argue the case for new expenditure to divert to additional non-electrolyser loads.

We think that having priority access to the three point loads at Kirkwall Pier gives the Eday community wind turbine good opportunities for energy reclamation. While ERE has invested

money in return for access to switching assets and pier loads, the payback period based on the only moderately optimistic scenario is just over two years.

The priority loads for 'Surf n Turf' appear to more substantial than the priority loads for BIG HIT.

While the incremental revenue does not include export and embedded benefits (GSuoS, BSuoS, RCRC, Triads) such as with the Demand Side Management System developed by Rousay, the latter project suits a generator that is much higher in the stacking order than Eday Renewable Energy. There, may, however, be opportunities in the future, for Eday to partner with Rousay to supply local grid side demand.

We think that having priority access to the three point loads at Kirkwall Pier gives the Eday

 Kris Hyde (ITM Power)

19th June 2017

#### *12.2.16.1 Overview of Involvement*

UK Experts-drafted EMEC's tender for electrolyser, supplied electrolyser

ITM Local Energy Challenge

Application-find a use for hydrogen

Merge project with phase 1 application CES 'Surf'n'turf' project

BIG-HIT Opportunity 'FOUNDATION'

Hyde wrote BIG-HIT

ARAGAN work packages

Match funding 'pitchus' – 30% from UK government

Capacity of wind energy feasibility studies (multiple), e.g.: 'isolated.'

#### *12.2.16.2 Why?*

Profit making company

'Showcase in Orkney'

70% of cost back- "hardly cover your costs."

“Not a money making project, hoping for a roll out of future sales.”

High concentration –critical mass’, -not linked’, -don't build up expertise in one area’, -  
'demonstration of self-sustaining ecosystem’, -seed point for future projects.’

Concerning Societal Impacts

No real concerns

Aware

#### *12.2.16.3 Other Solutions Explored? Are there any?*

‘Right now, no other solution.’

Lithium-ion MW battery (½ hour storage £2M-not suitable)

Business bolt on to the bottom of the turbine- what sort of company can run on  
intermittent power?

H2 Relatively cheap in comparison to any other options

CAPTURE & STORE ENERGY

Hot water storage? How can't physically move it?

Main Safety Concerns

Extreme lengths to ensure safety

Large and extensive studies to identify and manage safety

Guidelines, acceptability

NO CONCERNS-AWARE AND MANAGING

Safety Devices-switch off/SHUT DOWN

#### *12.2.16.4 Level of Community Engagement –Enough? –Who is responsible?*

Attended 415 community engagement events

Open evenings offering knowledge about technology and applications

Leaflet in Orcadian (Island Newspaper)

Yes, Neil was involved

Spoke to communities on visits

Get 'on-ground' + full operation

Efforts

Studied 'off-peak' travelling times

Tried to mitigate design before rather than after implementation

██████ Neil Kermode (Managing Director of EMEC)

21st June 2017

BIG-HIT best solution for curtailment issues in Orkney

"No. Surely there is something better out there". –mixed answer

Best manageable at this time, costs, given current circumstances

Inefficiencies: Hauling things by ferry

Other things for local use is Shapinsay

H2 better use

'Foundation'

'Enabler'

'Power of Demonstration'

'Spectrum of Opinions'

Balance recruiting people

Cultural differences

Group willing to move a bit with general 'concerns.'

Won't move completely against the grain

Goals/Aspirations/Hopes of Project

Two-fold

H2 economy will not be based on two projects (needs dozens)

Enabler for getting things away

No guarantee to get better funding

A way to get critical mass

Connection to mainland, interconnection between islands and replacement cables (12MVA to 24MVA)

Not strategic

Energy flows change fractionally

Government Energy Strategy

'Scotland Leading'

'Going with the hydrogen grain.'

Starts to propagate ideas

Societal Impacts of Greatest concern

H2 critical mass

Other transfers going on (at night)

Pipeline if needs be

It will be dealt with; it will go away

Time-board-most important

Innovation Culture of Orkney does well (Useful and productive work)

Communities facing other challenges

MRE 350 new jobs, chunk to come

Make you own Power 98p per £ RECYCLE YOUR CAPITAL

Not having to haemorrhage income

Decarbonisation of fuel system

Passing 400ppm-450ppm= 2 degrees temperature increase= 6m sea rise (KIRKWALL AND SHAP partly gone)

Oregon State University Accelerating

WE ARE UNPREPARED FOR THIS-HIGH COSTS IF ACTION IS NOT TAKEN

H2 terrifies

Segregation

Change dynamic for places like Eday-CONNECTIONS

Help SEA 'RENAISSANCE'

O2 market, post h2market

Transitional ferries -synthetic fuels not fossil fuels

Level of Community Engagement- is there enough? Where does the responsibility fall?

No, it is not enough

Needs to be more

You can never do enough

Want to see more community engagement-ERE

Reach out

Responsibility?

Depends on who wants to push on and get things done

Stakeholders should be enabler

Different Things, times, reasons

OIC-Adele Liderdale

Islands have needs and opportunities

Can't be having something

Showing

Doing, done, want to do

Can anybody help?

Nothing succeeds like success

Huge, where do you start?

Build it, and they will come

Well-earned stigma OIC

Not accepting of outside opinions

Challenges-won't accept

Council engagement can be brilliant (Dave Hibbitt Orkney ferries)

Vision of h2 ferries

Manoeuvring/driving things

Margaret Meade

Small group of individuals

M.Hull, D.Hibbitt, N.Kermode

Good people

Culture is driven by historical progress-innovation-success

Sets a backdrop of success

Orkney is incredibly Energy literate

Projects stand on generational shoulders of giants

Construction

Power, expertise

██████ Nigel Holmes, Scottish Hydrogen Fuel Cell Association

27th June 2017

*12.2.18.1 1 Overview of your organisational involvement:*

Dissemination and Exploration

Not to prove technology works, business model= goal

Coordination of events (12 partners, finding opportunities, raising awareness, information regarding awareness)

*12.2.18.2 Goals, hopes and inspirations of the project:*

Goal= provide compelling business model, easy for other island communities to replicate

*12.2.18.3 Main concerns regarding the safety of the implementation and delivery of the project*

No real safety concerns as the project are being heavily managed and have had extensive safety processes in place should an adversarial event occur.

*12.2.18.4 Is this the best solution for the current curtailment issues being experienced in Orkney?*

At the moment-various options, hydrogen benefit

Increasing Revenue (Shapinsay mentioned not Eday)

Direct benefit

Raising profile

Green Tourism

Safety- no real concerns

Dangerous good –compressed gas- risk is well understood and well managed

Community Engagement Activities, workshops (May/June 2016)

Kirkwall evening event

‘Surf n Turf’ – operational phase

‘Very good attendance.’

NEGATIVE: removing h2 by ferry inefficient, crowd out ferries

Model 'rush hour.'

Make sure 'off-peak.'

3-6 months to engage with community – July & August

██████████ Cécile Ratinet, Export Manager, Calvera

7th July 2017

#### *12.2.19.1      1Overview of your organisational involvement:*

For this project, all departments of our company have been involved because it was necessary to make a specific design for the storage and transport of hydrogen from Island to Mainland.

We have designed a special solution to optimise the transport capacity of hydrogen respecting the requirements of road and maritime regulations in Scotland. Technical, production and quality departments have been the most implicated.

#### *12.2.19.2      Overview of your specific role within the project:*

We have participated in this project developing the storage and transport solution to link Island and Mainland. We have taken part in logistic phase to allow the hydrogen transport is coming from the electrolysis to be used for heating and power generation end uses.

#### *12.2.19.3      Goals, hopes and inspirations of the project:*

Support Community in its energy project, the first project for us in this country.

Know expectations and needs of the Community to offer them our technology and expertise.

Participate in European Project, to collaborate and share knowledge with international companies.

Challenge for our company to design the best solution respecting specific requirements

Introduce our company to participate in more projects in the Country, not only through European project.

Meet people, learn about them, their way of living .....

*12.2.19.4 Main concerns regarding the safety of the implementation and delivery of the project:*

The most difficult point for us was to get the approval of the equipment according to the European norms and Scottish Regulations for the transport by road and sea of the storage systems.

*12.2.19.5 What is the highest priority societal impact concerning you?*

The criterion of decision is not only economic and profitable but also it is necessary the consent and the acceptance of all the population to have real success. Moreover, the project must allow social use for everyone's benefit.

*12.2.19.6 Level of Community Engagement is it enough?*

We think that Community is very conscious of the need for this project to be self-sufficient at the energy level.

*12.2.19.7 Who does the responsibility fall on to fulfil community engagement?*

The involvement must be Global, not only people directly committed in the project but also all people of Orkney Islands.

*12.2.19.8 Is this the best solution for the current curtailment issues in Orkney?*

We do not have enough knowledge to answer, but we are sure that Community has previously studied all opportunities before taking the decision.

Samuele Molina, Product Manager, Giacomini

7th July 2017

*12.2.20.1 Overview of your organisational involvement:*

Giacomini developed years ago hydrogen boiler. It is an R&D project that is going on, but the product is not on the market. Giacomini normally produces components for heating systems and the boiler could be an opportunity for a new type of business in the next future.

*12.2.20.2 Overview of your specific role within the project:*

I'm the project manager. I was involved in all Giacomini hydrogen projects of the last eight years.

*12.2.20.3 Goals, hopes and inspirations of the project*

Our objective is to take this technology to the market. This project is an opportunity in this way because it is an example of the application of this technology.

*12.2.20.4 Key concerns regarding the safety of the implementation and delivery of the project:*

This a new technology but there are some years that we are testing this, so we are confident about it.

*12.2.20.5 What is the highest priority societal impact concerning you?*

Our hope is that people could accept this technology. Normally there is an afraid against hydrogen, and it is difficult to convince people that this technology is not more dangerous than others that are usually accepted.

*12.2.20.6 Level of Community Engagement is it enough?*

I think that in this case, Giacomini should give the technical support to the local players to convince people of this technology. Giacomini is not so strong locally and is responsible only for a part of the equipment, so it should be a local player that takes in charge of this duty.

*12.2.20.7 In your opinion, is this the best solution for the current curtailment issues in Orkney?*

This is for sure a valid solution. I could not be sure it is the best because of there a lot of possibilities, and in my thoughts, there are some positive and negative aspects of every possible solution.

*12.2.20.7.1 Why?*

Hydrogen is a way to store energy. I think that for the quantity we have in the project hydrogen is the best solution. Giacomini boilers use hydrogen as a fuel; the advantage is that the efficiency is high and it's not influenced by the external temperature. In the other hand the temperature of the system could not be too high, so the heating system should be low-temperature types such as radiant floor or fan coil units.

Other possibilities could be the use of the heat pumps that are very efficient, but you have to take care of the external temperatures. Also, the heating system type is very important such as for Giacomini boiler. Another opportunity could be to have an electric system with some electrical heaters in the floor for example.

████████ Jesús Simon, Hydrogen Aragon (Ha)

21st July 2017

*12.2.21.1 Overview of your organisational involvement*

The government launched the organisation over 15 years ago for research and development and the implementation of hydrogen systems in Aragon.

*12.2.21.2 Overview of your specific role within the project*

Ha is responsible for coordinating the deployment of the project under work package 2. Their task is to create a demonstration model producing transportation and minimising local restraints.

*12.2.21.3 Goals, hopes and aspirations of the project*

The main ideas are to reduce the curtailment levels in Orkney. To provide energy efficiency and aid the local communities to become independent.

*12.2.21.4 Main concerns regarding the safety of the implementation and delivery of the project*

The main safety concern is the lack of skilled people. Training can be provided to those who are willing to learn new skills. It is a great opportunity for the transfer of knowledge into smaller communities that have not had the opportunity to train in Orkney before this.

*12.2.21.5 In your opinion, what is the highest priority societal impact concerning you?*

The highest priority is to inform people about the safety procedures of hydrogen technologies and handling. The project has been deeply researched into the possibilities of adverse effects, and trained personnel will be able to mitigate such effects.

*12.2.21.6 Level of Community Engagement- Is it enough? –Who does the responsibility fall on to fulfil community engagement?*

After the update of the SIA, Jesús feels that more engagement is necessary and that the responsibility falls on all of the project partners.

*12.2.21.7 In your opinion, is this the best solution for the current curtailment issues in Orkney?*

Jesús feels that there are other options, but it is the most effective and affordable at his present time.

*12.2.21.7.1 Why?*

He feels it brings much more than a solution to the curtailment being experienced at the moment.

**Other Students**

*12.2.22.1 Becky Ford*

A general discussion was held, regarding communication within renewable energy development. Becky's PhD focuses on research surrounding the narrative shapes of renewable energy within society and how stories energy.

*12.2.22.2 Michael Westrom*

Mike Westrom requested a meeting as he was writing a similar dissertation. After an exchange of information and informal discussion about renewable energy, intermittency

and communities in isolated territories, joint meetings with stakeholders and local workers were organised.

### 12.3 Appendix C. Stakeholder Analysis

The figure below represents the identification and clarification of the main actors within the hydrogen production, transport & storage, utilisation and demonstration supply chain.

Table 6. Actors within the Project

<b>Project Actors</b>	<b>Likely Impacted/Beneficiaries</b>
Industry	Incentive and courage to embark on other technologies in a similar embryonic stage Incentive to go further with Hydrogen as a means of combatting climate change and the need for dirty fossil fuels Theory tested and put into practice, acting as a real-life example-helping society understand the possibilities the future and benefits of energy storage
Producer	Stimulation of future projects International Success International Recognition Actively contributing to finding new means of producing clean, green energy-eliminating the need for dirty fossil fuels
Supplier	Successful recognition of installed products & technologies Incentive to embark on other projects with similar goals and aspirations Actively contributing to a renewable future
Community	The local community reaps immense benefits and positive impacts. Some of which include international recognition as a world's first in this type of technology and energy source combined, an influx of people having a knock on effects such as spending within the community, living in the island hostels
Government	Incentives for other knock on projects, e.g., beginning of hydrogen economy, future oxygen economy, contributing to national, European and Global carbon and clean energy targets
Stakeholder	Chase product flow Shows Value at each stage Actor Orientated

University	ICIT, Heriot-Watt University, DTU
Consumer	OIC The Scottish Government Industry (Aquatera, EMEC etc.) Future Hydrogen Economy
Society	Demonstration project stimulate growth in energy storage sector as a means of combatting curtailment issues, climate change, contributing towards national low carbon targets Stimulation of new ideas of how this can be done elsewhere as well as the means of managing and physically pulling a project like this through in other isolated territories worldwide

*Table 7. Project Partners*

<b>Project Partners</b>	<b>Properties</b>
Ha	Private non-profit organisation promoted by the Aragon government, public and private companies Specialises in Research & Development Projects and consultancy projects, in cooperation with national and international companies. Foundation supports the regional strategy for the uptake of fuel cell & hydrogen technologies
Calvera	Developing new products for compressed hydrogen storage and transport Manufacture compressed gas trailers for hydrogen The deployment of 8-10 tube trailers in the Orkney islands to store and transport the hydrogen between the renewable production sites and the end user locations
CES	Provides practical help for communities on green energy development and energy conservation Working with community groups, electricity network operators, agencies, research bodies and technology companies to drive innovation in

	local power generation, local supply, domestic demand and local financing
DTU	Ranked as one of the foremost technical universities in Europe, and DTU Energy specialises in energy conversion and storage Energy works on FCs, electrolysis, solar cells, batteries, magnetic refrigeration and other sustainable energy technologies
EMEC	The first and only centre of its kind in the world to provide developers of both wave and tidal energy converters Technologies that generate electricity by harnessing the power of waves and tidal streams – with purpose-built, accredited open-sea testing facilities
Giacomini	Ranks among the world leaders in the production of components and systems for heating, cooling and water distribution in homes, offices, commercial & industrial buildings Developed h2ydrogem, a catalytic combustor boiler based on an innovative catalytic hydrogen burner The catalytic combustor allows the hydrogen and oxygen to combine spontaneously into a water molecule, in a clean and flameless process, which at the same time releases heat
ITM Power	Manufactures integrated hydrogen energy solutions to enhance the utilisation of renewables that would otherwise be wasted Manufactures integrated hydrogen energy solutions that are rapid response and high pressure, meeting the requirements for grid balancing and energy storage services Production of clean fuel for transport, renewable heat and chemicals
Ministry of Transport & Infrastructure	Aims to promote and develop the transport sector in Malta using proper regulation and by the promotion and development of related services, businesses and other interests, both locally and internationally Enable the effective implementation of programmes and capital infrastructural projects
OIC	Britain's smallest local authority - lead the way in Scotland in providing all the council services used by the people of the county Activities touch the lives of everyone living in our island community, from schools to the care of the elderly, from rubbish collection to maintaining the county's roads and from caring for burial grounds to handling planning applications
SDT	Formed by the residents of Shapinsay Vehicle through which the islanders can collectively help to maintain and improve their lives on the beautiful, peaceful island of Shapinsay

	<p>Shapinsay Renewables Ltd (SRL) is the trading company for the 0.9MW wind turbine which is wholly owned by Shapinsay Development Trust</p> <p>SRL operates the turbine with the purpose of passing the profit generated to SDT for the benefit of the community of Shapinsay</p>
SHFCA	<p>Industry sector body representing member interests for the development and deployment of hydrogen and fuel cell technologies in Scotland</p> <p>Over 75 members, mostly based in Scotland but with an increasing number of members based overseas</p> <p>Hydrogen and Fuel Cell technologies are playing an increasingly important role in helping businesses to reduce their overall carbon footprint</p> <p>Projects like BIG HIT will contribute to delivering Scotland's ambitions to generate 100% of annual electricity demand from Renewables</p> <p>Deploy 1GW of locally-owned Renewables by 2020</p>
SymbioFCcell	<p>Pioneering company in fuel cell technology and inventors of the first range extender for hybrid (combined electricity and hydrogen) vehicles</p> <p>The Symbio vans for BIG HIT are based on the Renault Kangoo ZE Maxi, retaining a 22 kWh Li-Ion battery but with the addition of a 5 kW hydrogen fuel cell range extender system which doubles the operational range</p> <p>No impact from using the cabin heating on the range</p>

## 12.4 Appendix D. Theory-Based Monitoring & Evaluation Framework

1. Fault Tree
2. Stakeholder Analysis Table
3. Objectives Tree
4. Continued Logical Framework (See template created for use below)

## 12.5 Appendix E. Results of Opinion Surveys

Three questionnaires were created, two of which were for the general public of the Orcadian communities. One referred to the heating and power of buildings; the other referred to the fuel cell vehicles. Both began with a demographic section to set the scene, a general knowledge/familiarity of hydrogen technology section. They then broke down into the two topics. Both surveys consisted of the same relevant and other variables sections to gather a general and variable perspective. The third survey was sent out to the stakeholders via email and consisted of economic/market, technical and other questions driving the opinions of the stakeholders of the potential impacts on society that would be created by the project.

The questionnaires were answered electronically, through the use of google forms. This allowed a broad range of people to access and complete the surveys on the different islands. Various groups were able to access these surveys as they were sent on social media platforms such as the 'Orkney Merkit Place' and through private email to the people who were interviewed as part of the research.

### General Public Survey Analysis

The results from the demographic, general, relevant and other variables sections were merged in order to paint a clear picture for the background of the analysis. This section begins with the demographic section, moving to the general and relevant sections before splitting into each 'general public' survey results; one based on hydrogen fuel cell vehicles and the other based on local community use of hydrogen as a source of energy. Both surveys have been written with sensitivity and with encouragement for the participants to express themselves, gathering well-rounded freely, and whole analytical data to aid the

representation of social impacts potentially arising from the application of hydrogen technologies as a solution to the curtailment issues being experienced at present.

### 12.5.1.1 Demographic

The demographic section asked questions related to sex, age, their current status, the participant's current residency, and where they were raised. Each of the participants had heard of hydrogen technology applications before undertaking the surveys.

Figure 18. Sex of Participants

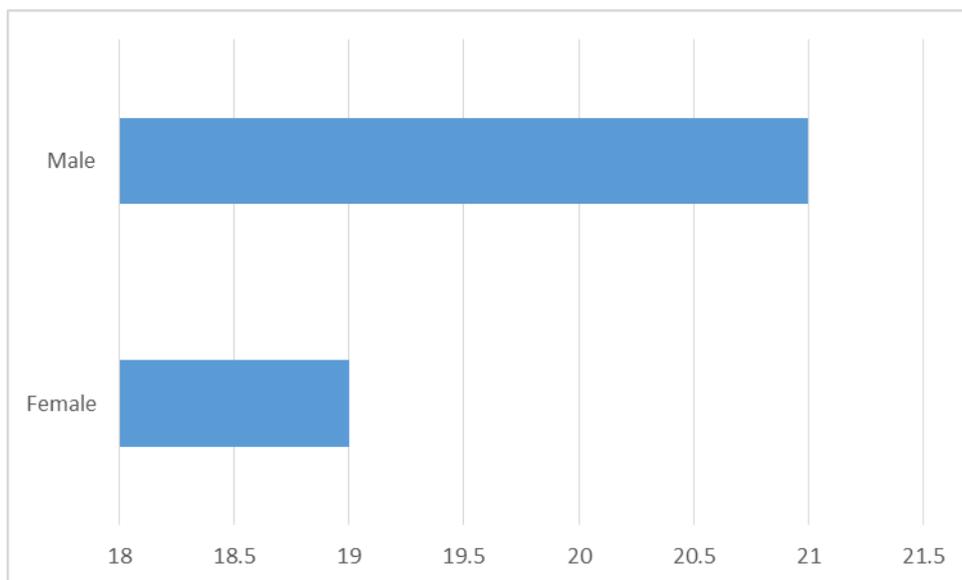
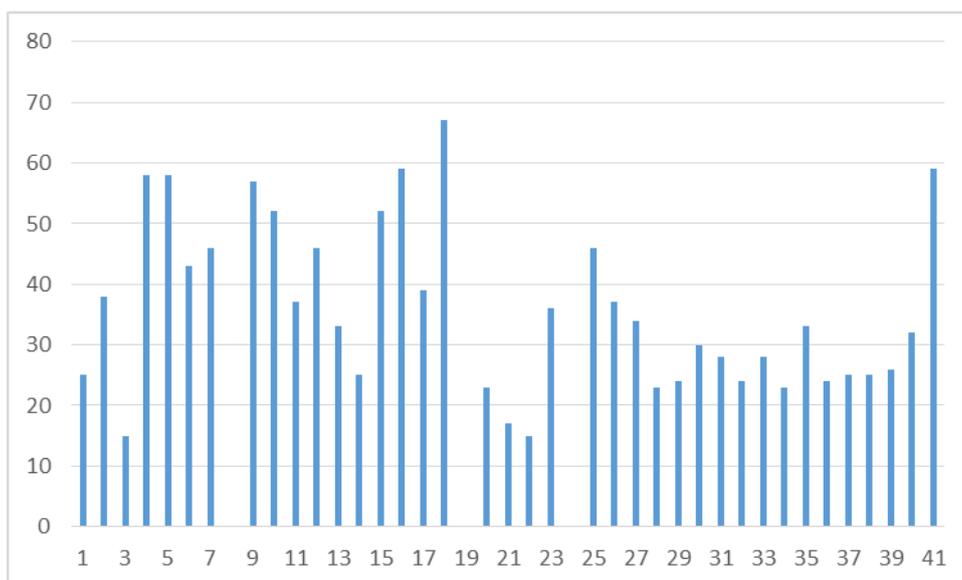


Figure 19. Age Distribution of Participants



The distribution of age groups was interesting. From secondary school goers to retirees. It is important to note the wide audience that participated in these surveys. As seen in the pie chart below, 52% of the participants are employed.

Figure 20. Current Status of Participants

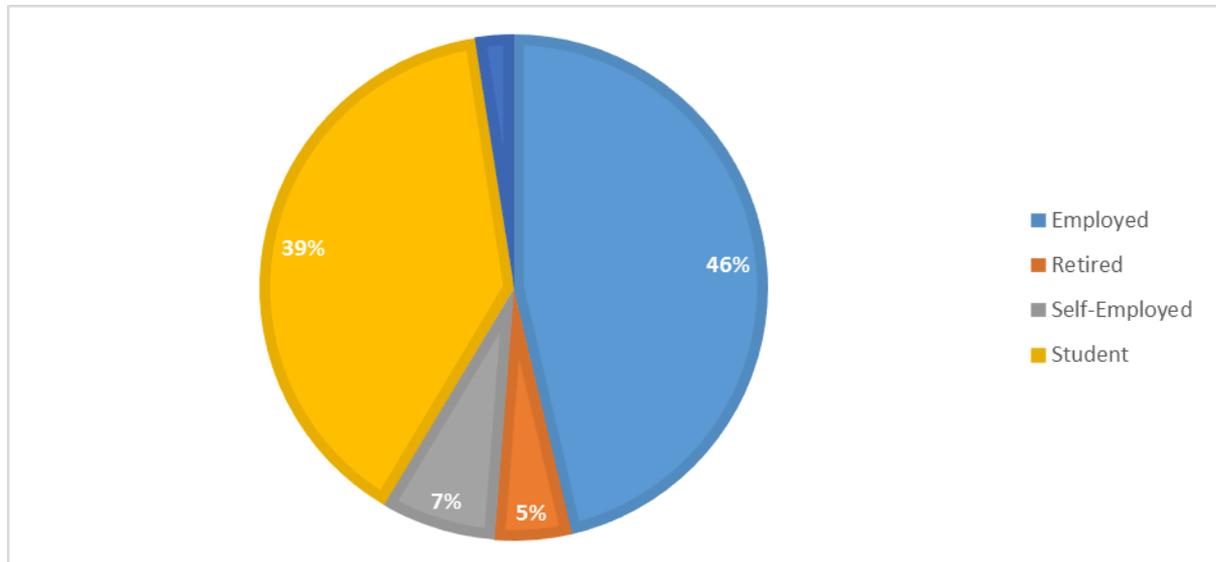
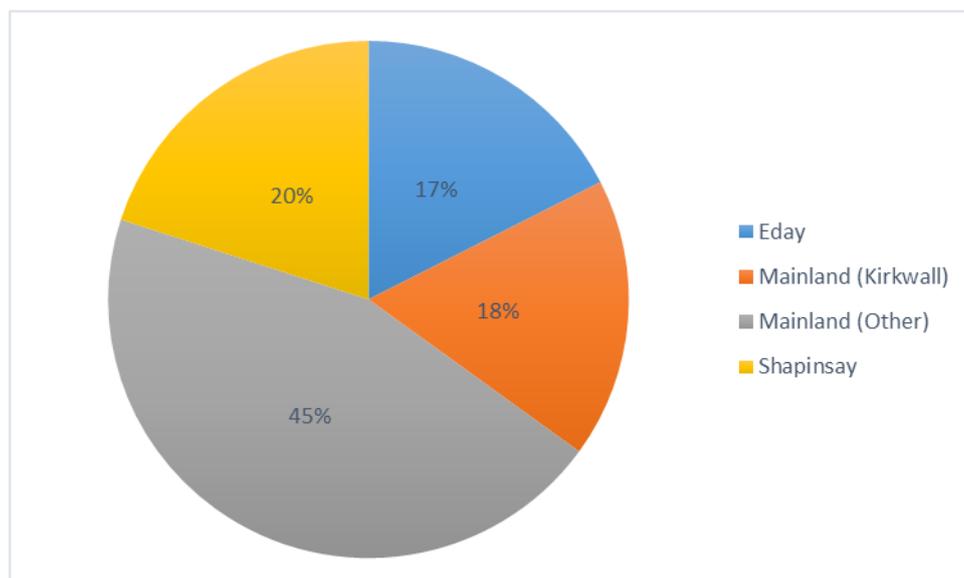
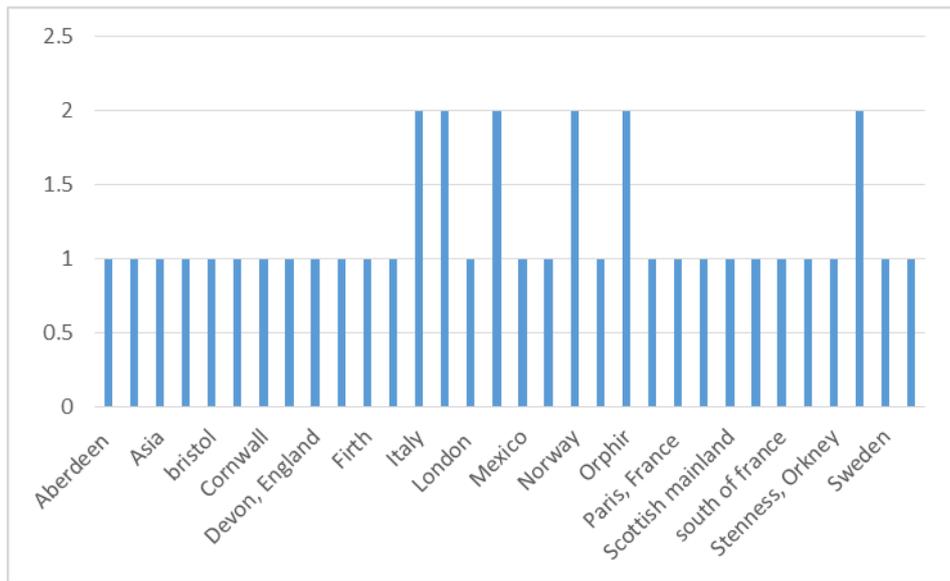


Figure 21. Current Residence of Participants



The pie chart above portrays the majority of people who participated in these surveys live on Mainland Orkney. Below, the figure represents where the participants were initially raised but whom now call Orkney home. It is interesting to note the relatively high number of participants who have migrated to Orkney.

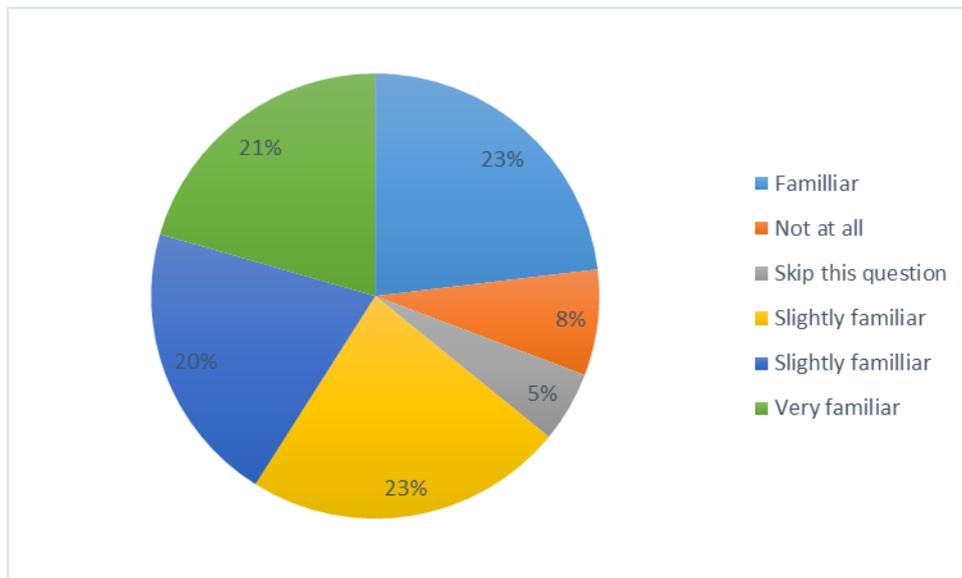
Figure 22. Where Participants were originally raised



### 12.5.1.2 General

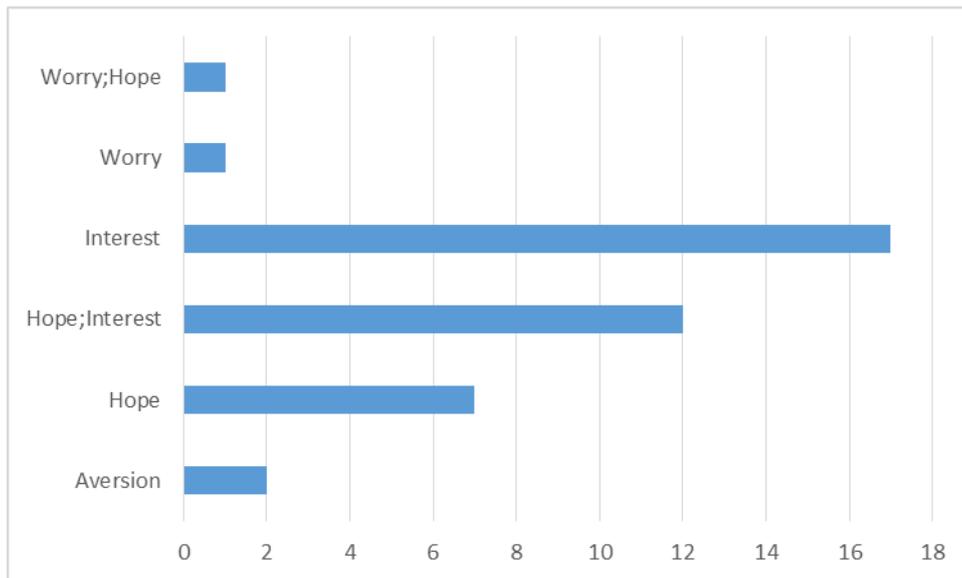
This section intended to acquire a general set of opinions and scope out the attitude of the Orcadian public towards hydrogen technologies as a solution for their curtailment. The participants were asked to rate a series of questions relating to their familiarity and feelings with the technology.

Figure 23. Familiarity Rating of HFC Developments



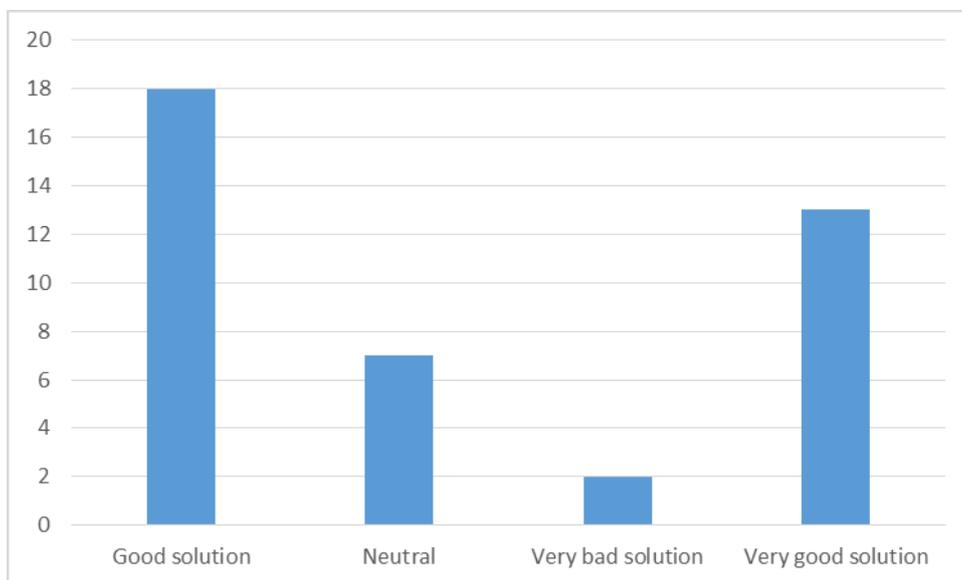
The feelings evoked by the technology was interesting. The results show that more people were hopeful and interested in the prospect of hydrogen developments and fewer people appeared worried.

Figure 24. Evoked Feelings



When asked whether the hydrogen scheme was a good or bad solution to the current curtailment issues being experienced, it became apparent that many of the participants were in favour of the project as a good solution.

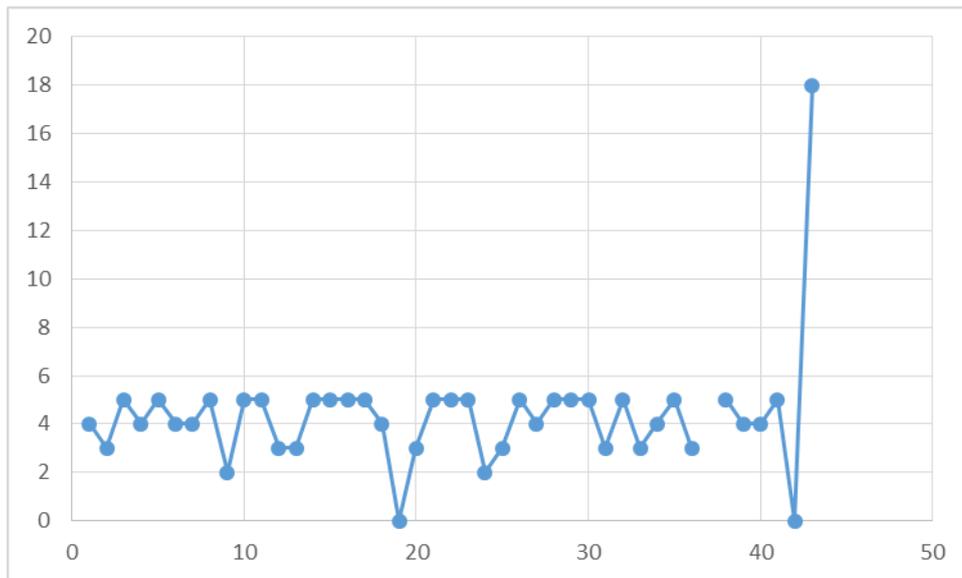
Figure 25. Rating of Hydrogen as a Curtailment Solution



### 12.5.1.3 Relevant

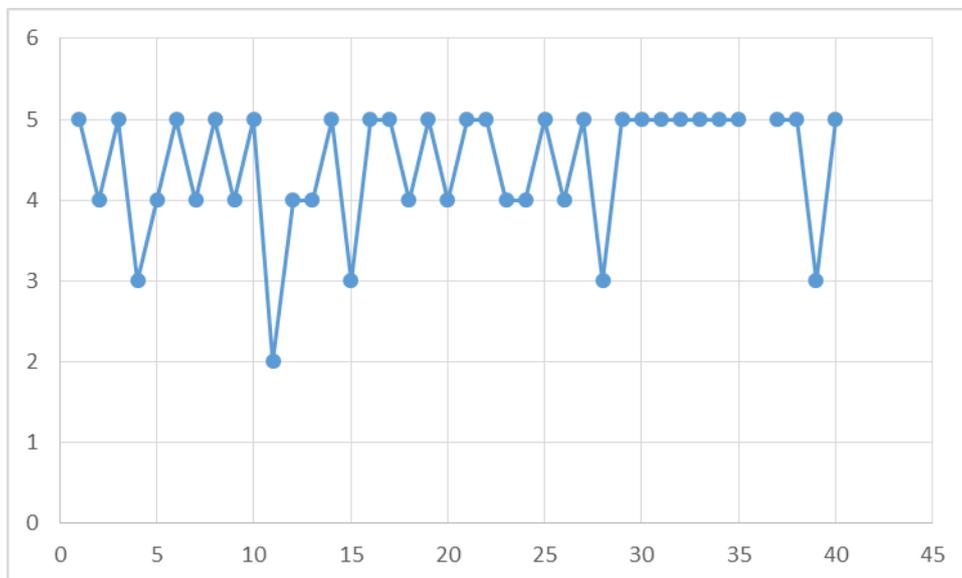
This section was based on a series of ratings. The ratings were thought of to determine the level of importance of certain improvements and the willingness to contribute to these.

Figure 26. Need to Improve Energy Security by being less dependent of Imported Fuels



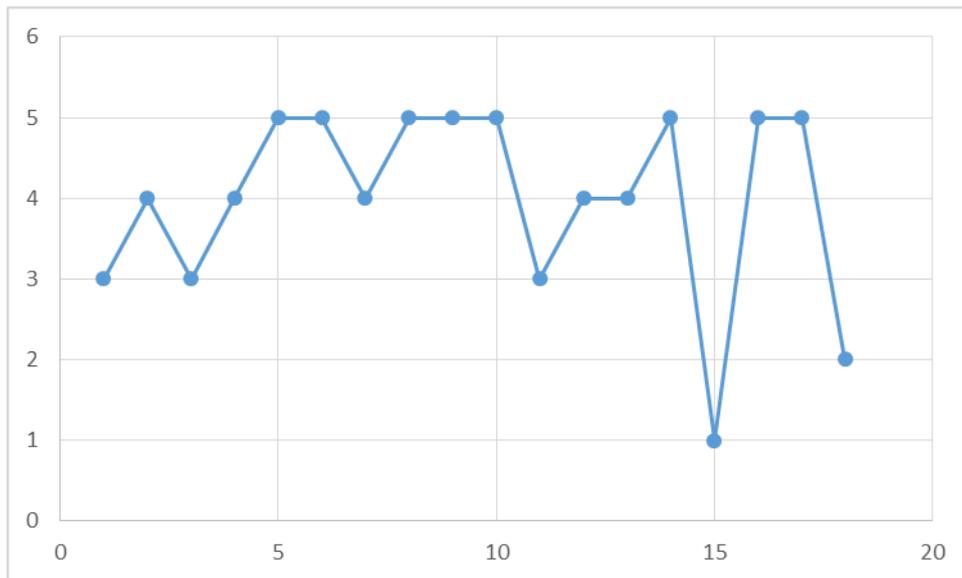
When asked to rate problems regarding the importance for their region on scales of 1-5 where 1 represents the lowest option, and 5 accounts for the highest choice, the results appeared varied. However, strong intuition took place when asked about the need to become less dependent on imported fuel, the lessening of greenhouse gas emissions.

Figure 27. Need to Reduce GHG Emissions



When asked about the need to create opportunities for indigenous industries to increase their capabilities to provide innovative technologies that would generate income, the results appeared to be staggering; the majority felt that there is a need to create opportunities. This can be seen in the figure below.

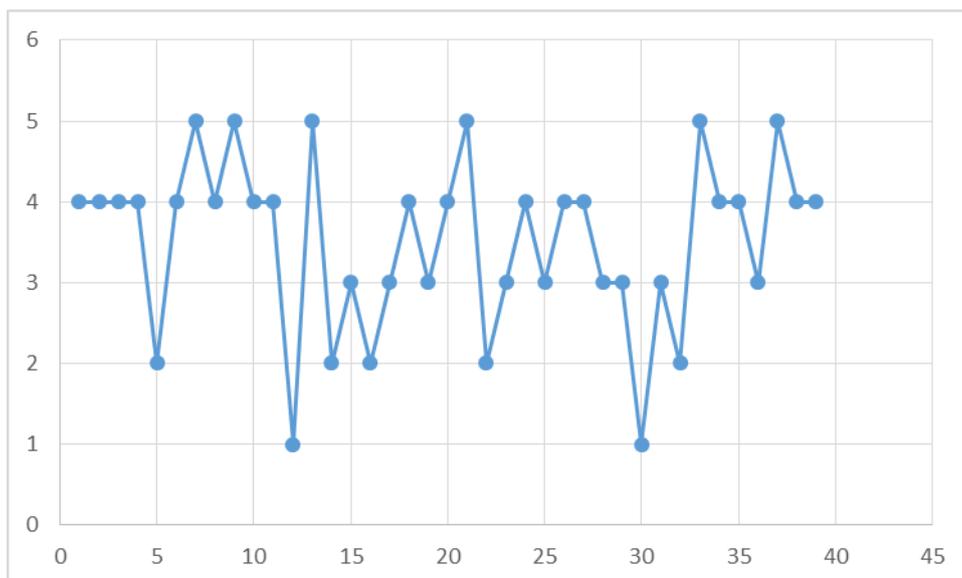
Figure 28. Need to Create Opportunities for Indigenous Industries



#### 12.5.1.4 Other Variables

This section relies heavily on trust. It sets out to determine the levels of trust that the communities have in the industry, the government and the general process of the project. It also sets out to scope out the degree of community engagement, whether residents have been happy to date with the standard of communication from officials throughout the project process thus far.

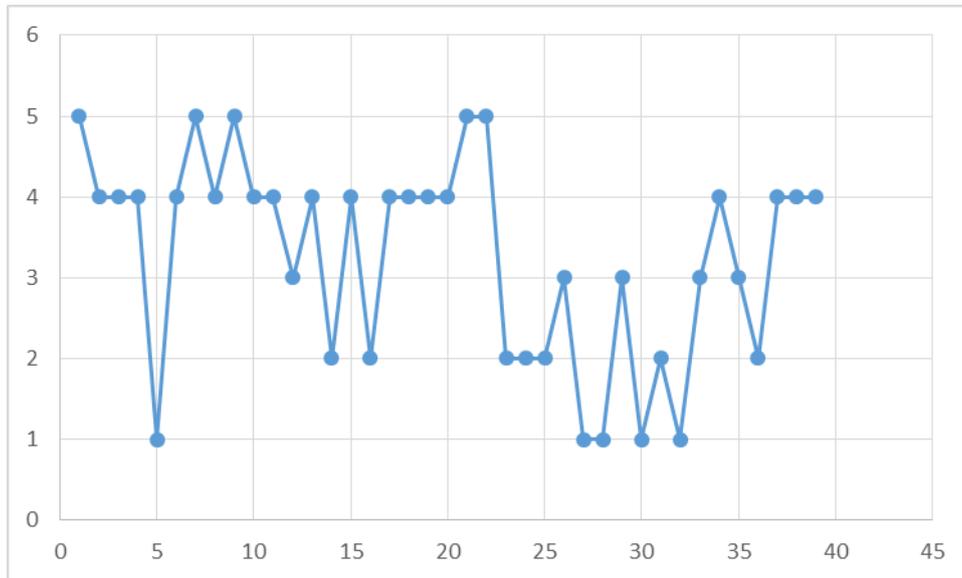
Figure 29. Trust in Industry to make H2 Decisions



The above figure represents the level of trust the communities have in the industry to make decisions about hydrogen technologies in their areas. The results are varied, yet state a

good level of trust in the industry. The figure below represents the level of trust in the industry to solve problems and succeed in the safe and responsible implementation of hydrogen technologies. This was also varied. The public has less faith in the industry in this sense.

Figure 30. Trust in Industry to Safely & Responsibly Implement H2 Development



The figures below represent trust in the government. This varied response reflects the varied nature of government priorities in Orkney. In some senses, the public relies on the government to implement projects that are for the benefit of the public. Much of the time, a source from the council has expressed that local authority engagement is often overlooked as necessary or beneficial to the public, thus, generating a slight stigma from some members of the public towards local authority intervention.

Figure 31. Trust in Government to make H2 Decisions

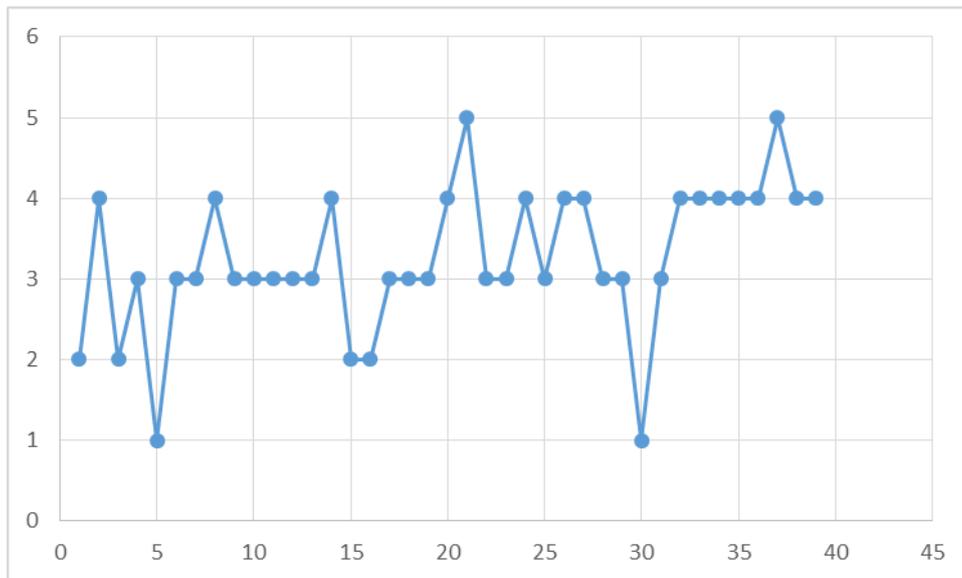
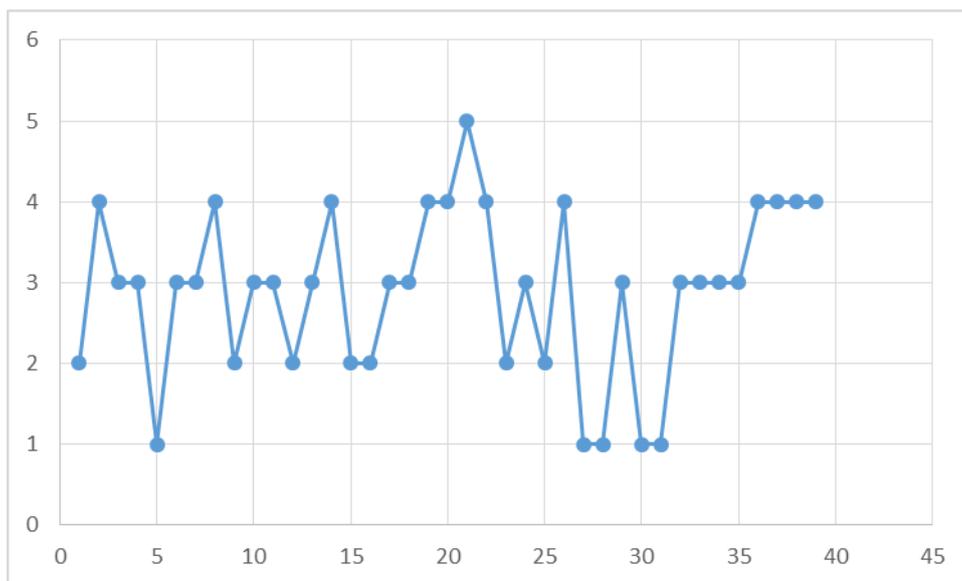
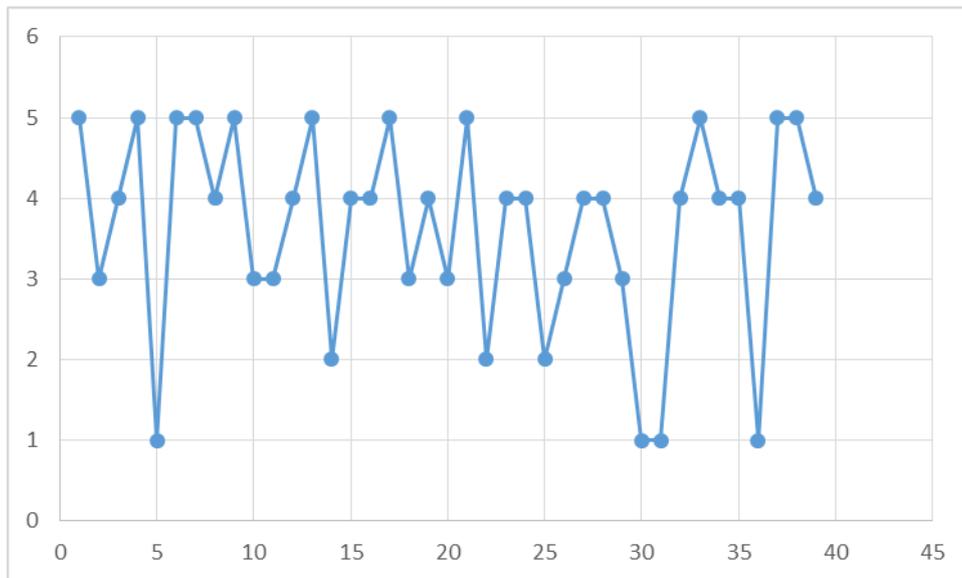


Figure 32. Trust in Government to problem solve and successfully implement H2 Technologies



The involvement of local organisations such as the Shapinsay Development Trust gives local community members slightly more confidence in believing the benefits generated from such projects will be direct and local. It can be seen in the graph below that most individuals have faith in their local organisations to see a project through safely and responsibly.

Figure 33. Trust in Local Organisations (SDT & Eday Partnership)



The graph below is based on the participant's perspective on how environmentally friendly they feel life they lead is. Most participants felt that they live a relatively mediocre green lifestyle. This gives scope to determine why. From further studies, the level of 'green living' is hard to reach as isolated locations have a harder time with reaching these standards. For example, the use of bicycles are only useful to a local point, many members of the Shapinsay community usually travel via ferry. The members of the Eday community are very spread out regarding proximity to neighbours and amenities. A member of the Eday community suggested the use of the community electric vehicle could be used to transport elderly inhabitants to the shopping facility and home again as the number of retirees, with limited mobility, have a hard time doing these activities alone.

Figure 34. Level of Environmentally Friendly Living

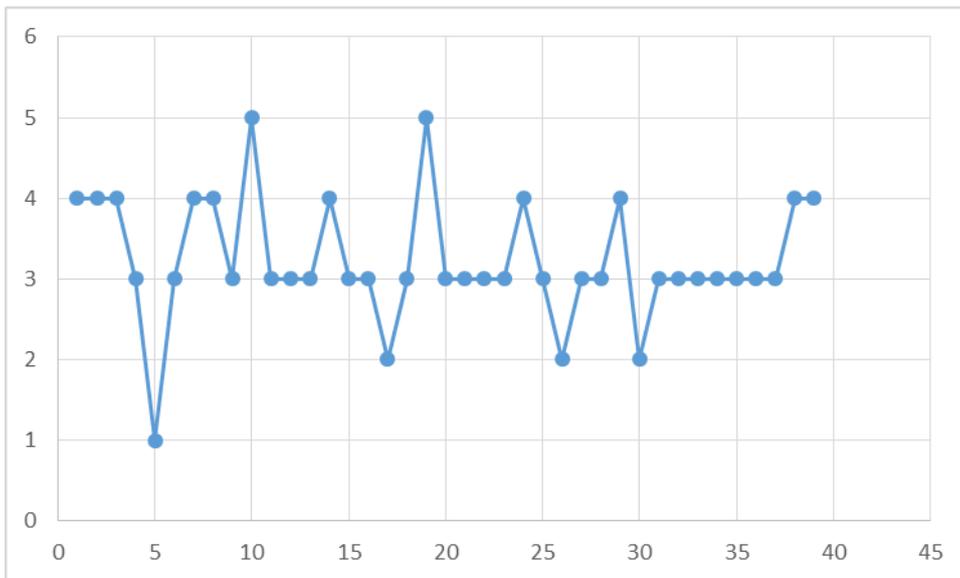
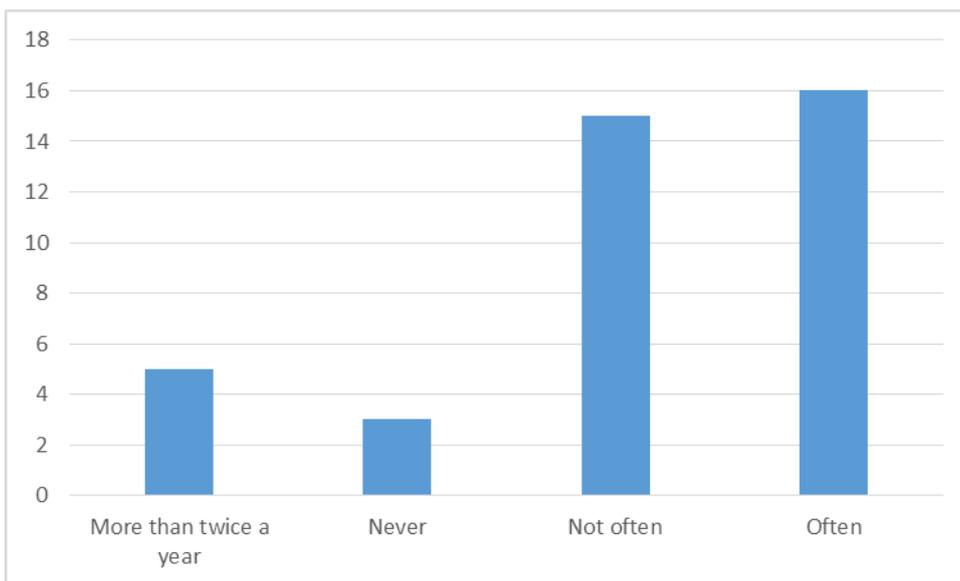
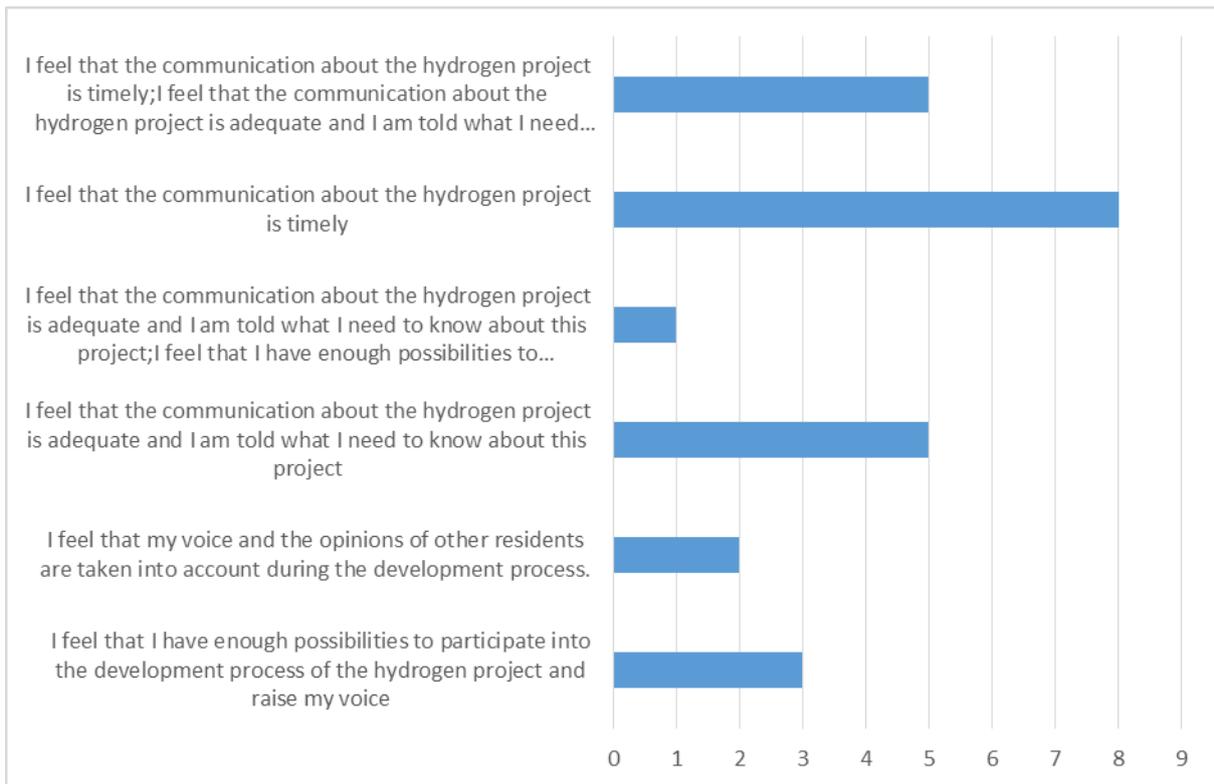


Figure 35. Level Community involvement & Engagement



The participants were asked how often they are involved in community events. Most participants suggested that they 'often' took part in these developments and few suggested that they never participated in these events. The results from the below figure, representing the level of community engagement was interesting. The mix of results suggests that in some areas, improvement is necessary and in other regions, communication has been sufficient and efficient.

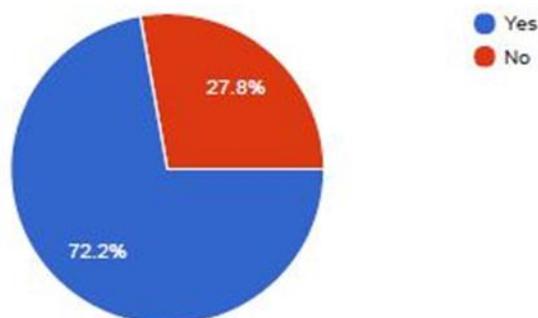
Figure 36. Level of Communication



#### 12.5.1.5 Hydrogen Fuel Cell Technology: Community Heat & Power

This section of the survey related solely to HFC applications in community buildings. The types of questions asked are related to the level of awareness, expectations and feelings towards the domestication of HFC applications in community building and close proximity to neighbourhoods.

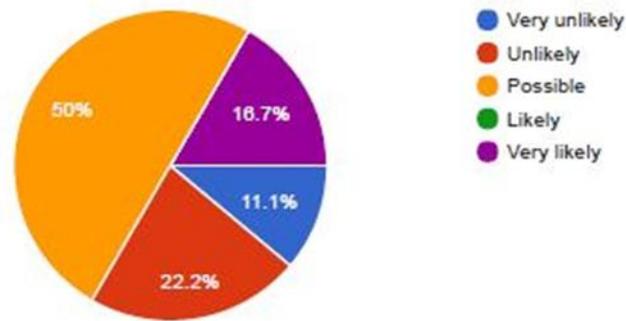
Figure 37. Level of Awareness



The level of awareness of HFC applications other than in transport was high. After a series of ratings of traditional conventional and other means of domestic heating and power sources

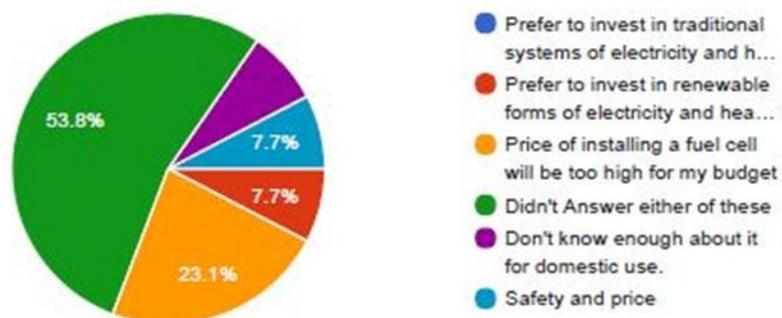
were completed. Following on from this was a question related to the likelihood of community members to install HFC systems in their own homes as a source of heat and power. 33.3% of participants said it was unlikely that they would install such a system.

Figure 38. Likelihood of Residents to Install Domestic HFC systems in the home



Those who answered unlikely or very unlikely were then asked why they would not invest in such a system. The price of such a system would be too high for many of the community member's current budgets. With further research and development, innovation and willingness of the government to further the applications of hydrogen, the price of installing domesticated HFC technologies in the homes of community members would allow efficient, inexpensive means of producing heat and power.

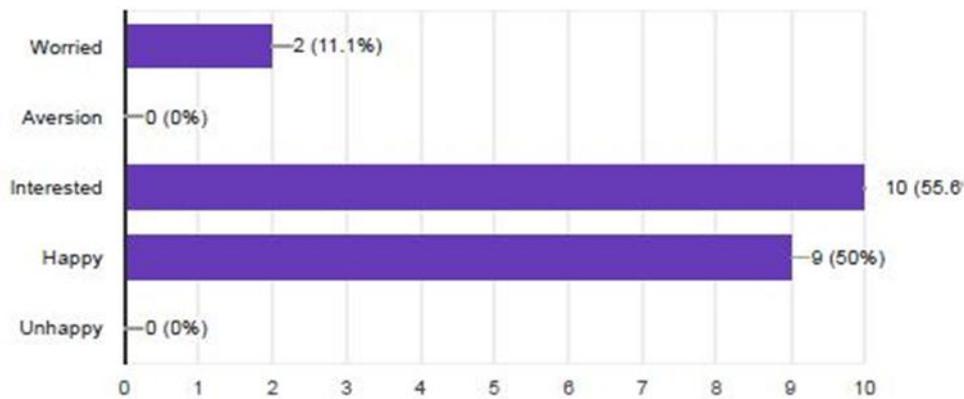
Figure 39. Reasons for above answer



The participants were then asked about their feelings towards domesticated HFC technologies in local community buildings. The majority of people felt happy about the

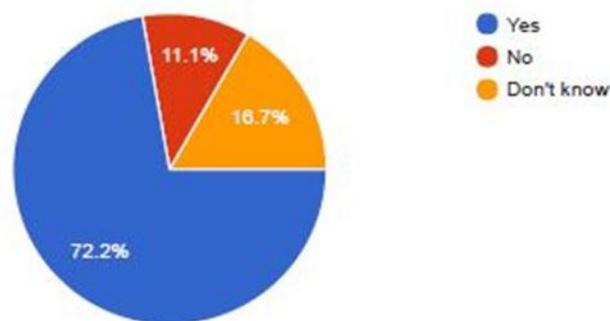
innovative technology and interested in the progression of such a technology. Few participants felt worried.

Figure 40. Feelings evoked by domestic HFC Technologies in Local Community Buildings



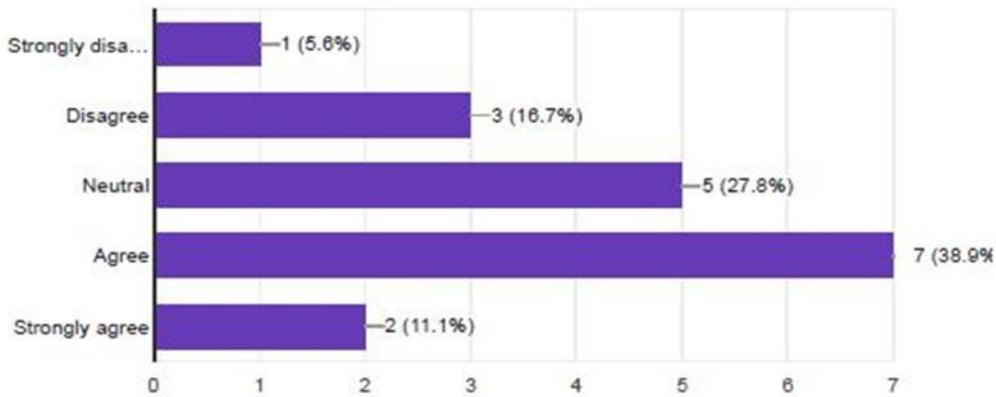
After this, a hypothetical voting question was asked regarding the placements of a hydrogen fuel station near community buildings. The majority voted 'yes' they would be in favour of this. Few voted 'no', and others were unsure whether they would be in favour.

Figure 41. Hypothetical Voting results, placing of HFC refuelling station close to community buildings



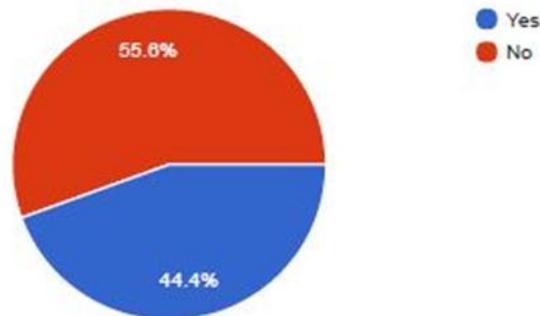
Another hypothetical but very possible question was raised in the survey. The participants were asked to express their level of agreeance to allocate public funding to subsidise the purchase price of a fuel cell system. AS seen in the bar chart below, the majority of participants are in agreeance, many are neutral, and only a small portion of the participants do not agree.

Figure 42. Public Funding to Subsidise Purchase Price of Fuel Cell System



The level of awareness of specific installations of HFC technologies in their local region was interesting. It can be seen that over half of the participants are aware of specific facilities. Although under half, the percentage of participants who are unaware of such installations is concerning, considering the smallness and level of community engagement displayed throughout the survey results.

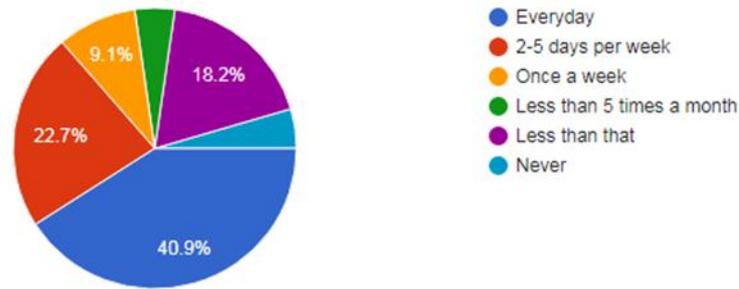
Figure 43. Awareness of Specific Installations in Orkney



#### 12.5.1.6 Hydrogen Fuel Cell Vehicles

This section of the survey related solely to HFC applications in community buildings. The types of questions asked are related to the level of awareness, expectations and feelings towards the domestication of HFC applications in vehicles.

Figure 44. Frequency of Travelling by car



The above and below pie charts represent the frequency that the participants travel via car and ferry. The figures are relatively similar to that of other isolated territories globally. The frequency of participants travelling via ferry often is surprising considering the connections between the islands of Orkney. The participants were then asked when travelling on ferries in Orkney, do they book in advance to ensure space is available and reserved for them. The majority of people book ahead of the journey. This is relevant as with the tube trailers taking up much space; it is important to acquire a depiction of the significance space on the ferry has to the communities.

Figure 45. Frequency of Travelling by Ferry

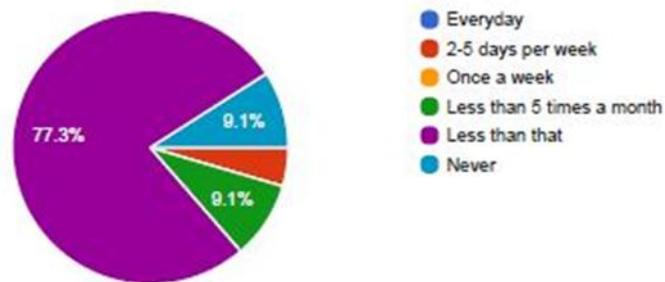


Figure 46. Tendency to book ferry in advance

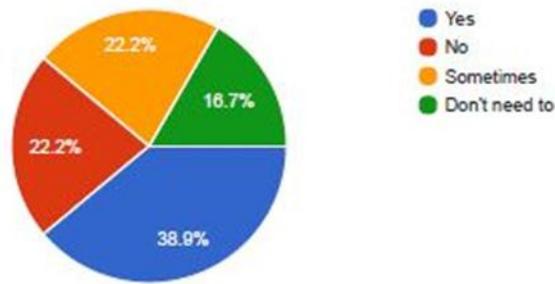
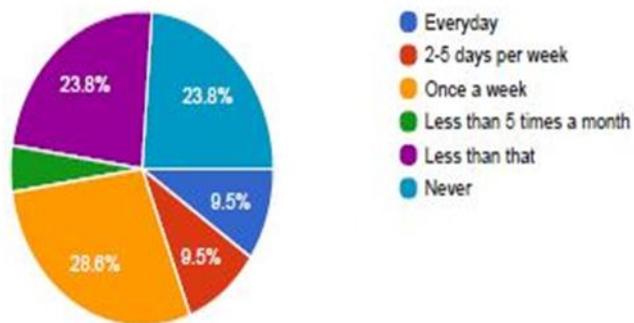


Figure 47. Frequency of Traveling by bicycle



The majority of participants often leave Orkney; this can be seen in the diagram below. When asked which mode of transport most frequently used to leave Orkney, the participants chose via aeroplane. This is surprising as the ferries frequently travelling to and from Orkney.

Figure 48. Frequency of Leaving Orkney

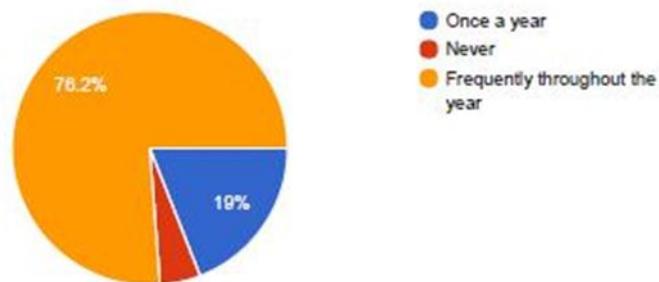


Figure 49. Ferry vs. Aeroplane

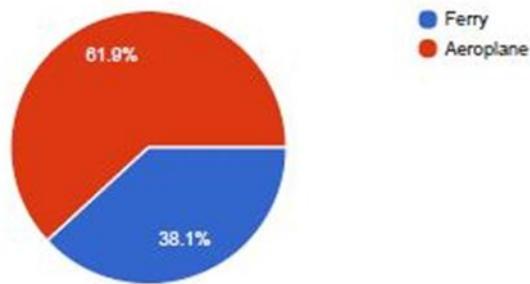
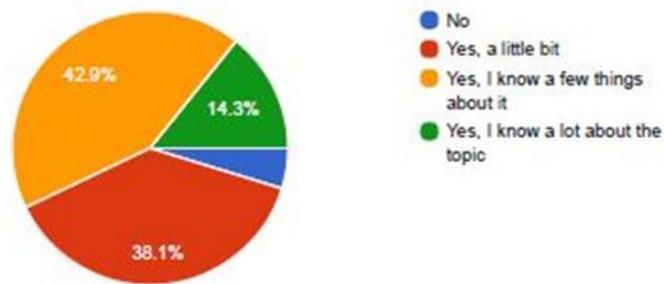


Figure 50. Level of Awareness of HFCV



The majority of participants were more interested than worried about the technology. The technology has proved hopeful in the eyes and thoughts of the participants. However, aversion was selected by one of the participants which raise concerns regarding sufficient communication and sharing of knowledge.

Figure 51. Feelings Evoked

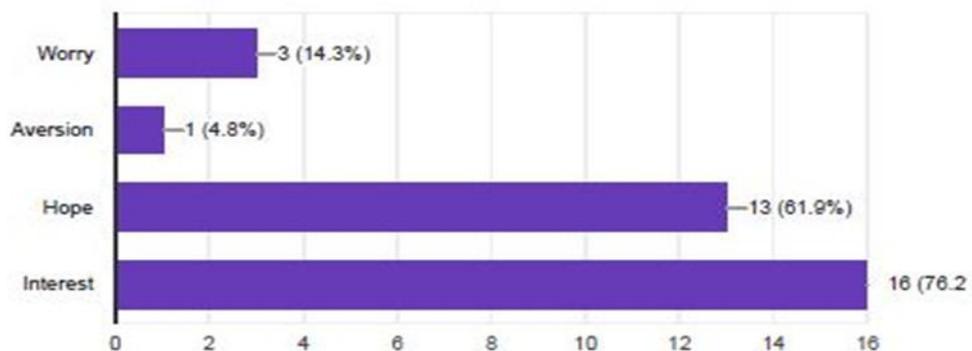
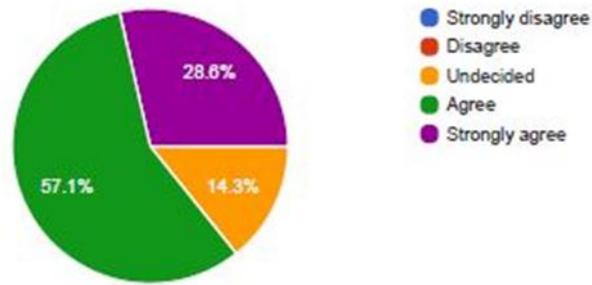
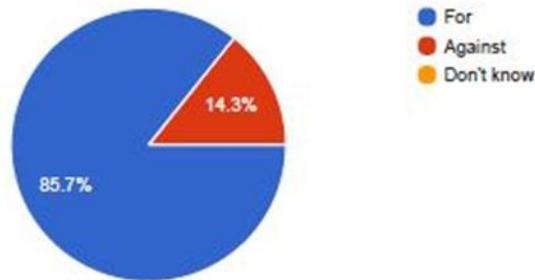


Figure 52. Local Communities should promote substitution of conventional public transport for hydrogen fuel cell transport  
extent of agreeance



The expectations of the technology proved beneficial. This suggests that the participant's expectations of the technology are positive. However, few participants answered negatively. This suggests that more traditional vehicle is seen to be safer. This again comes down to the level of information being shared with regards to the technology that will be used in the local healthcare system, by the council.

Figure 53. Hypothetical Vote to have Station in close proximity to Community Buildings



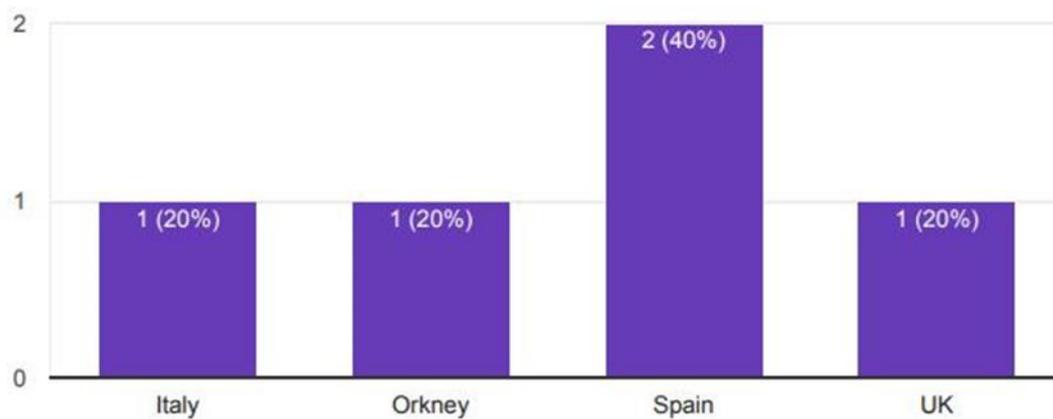
## Stakeholder Survey Analysis

The purpose of this survey was specifically designed to represent the data collection instruments with the primary aim to assess and develop an understanding of stakeholder's views of the demonstration of hydrogen and fuel cell technologies that will replicate current hydrogen production elsewhere using curtailed community energy. The Survey was spilt into sections to grasp an understanding of the different aspects of stakeholder involvement in hydrogen technologies and developments at this time.

### 12.5.2.1 Profile

The first sections provide a background to build the profile of stakeholders who participate in this survey. It gives a clear understanding of their interest and opinions regarding hydrogen solutions.

Figure 54. Country of Residence



The below chart represents the different types of organisations that make up the stakeholders. Following this, the next question asked was related to their feelings towards hydrogen as a potential solution to environmental and energy challenges to which the majority answered a 'very good solution'. The stakeholders were then asked to discuss why they feel this way.

Figure 55. Type of Organisation

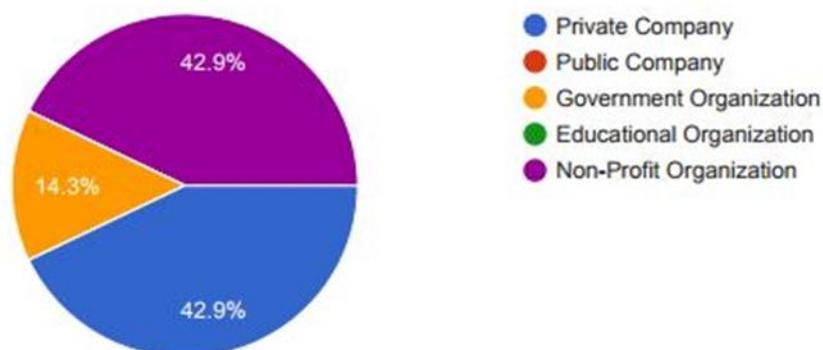


Figure 56. Feelings towards H2 as Curtailment Solution

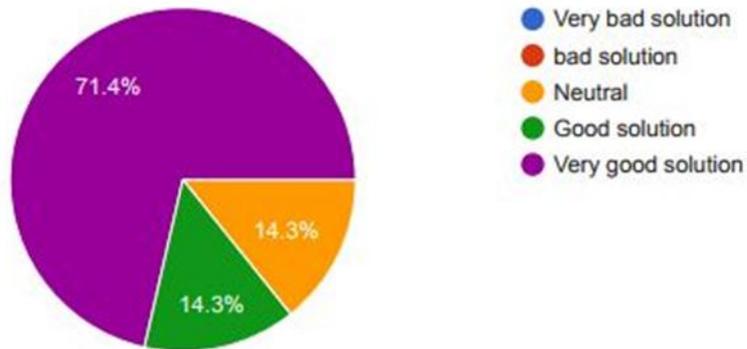


Figure 57. Opinions stated in relation to best application of h2 at this time

Resolving the issue of curtailment for community development groups

Transportation (ferries, cars, buses)

Transport sector

Balancing power grids with high penetration of renewable energy sources

Road vehicles

Storage for electricity and backup. Mobile solutions.

Use hydrogen for power generation

Transport - Road, agriculture and ferries

Following on from this, the stakeholders were asked about their expectations regarding the medium-term market implementation of the BIG HIT project. The majority of the stakeholders have been professionally involved in the industry for approximately five years with a significant portion over 20 years.

Figure 58. Expectations of the medium-term H2 market (5-10 years)

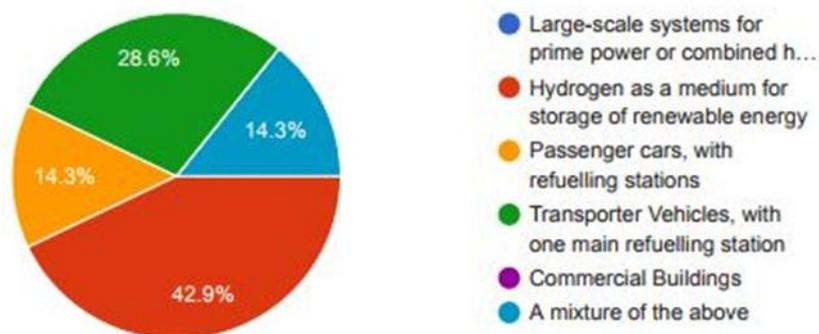
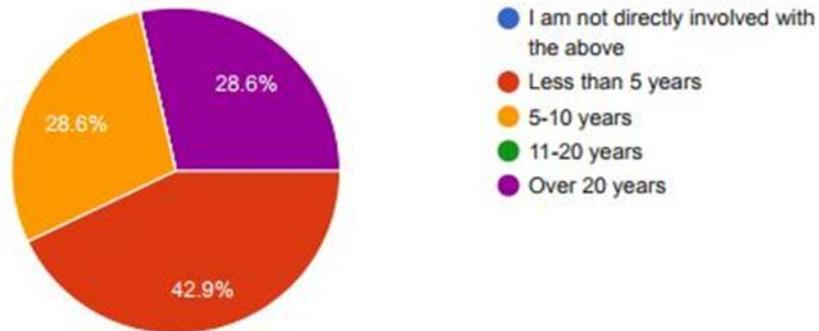


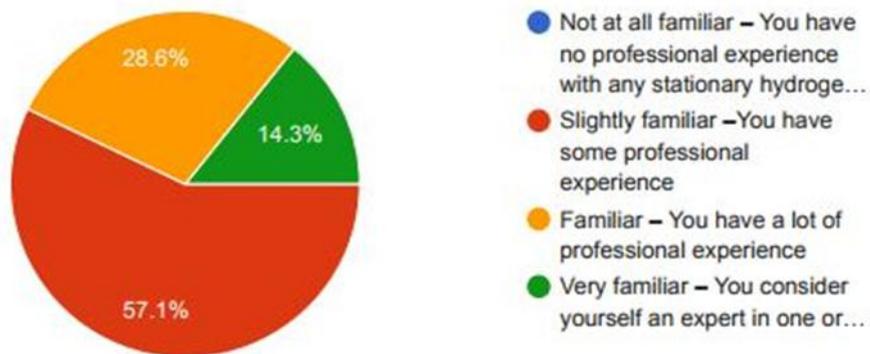
Figure 59. Professional Involvement-How Long?



### 12.5.2.2 General

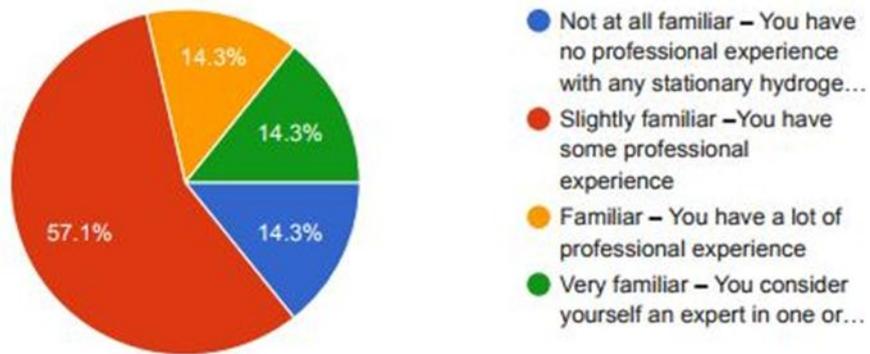
This section gives an insight into the level of familiarity, expectations, and feelings towards market diffusion and potential roll-out progressions on from the demonstration project from the perspective of those directly involved in the makings of the BIG HIT project.

Figure 60. Level of Professional Familiarity with HFCV



The above chart suggests that the majority of stakeholders were 'slightly familiar' with vehicle applications and the below chart for hydrogen boiler applications was the same. This suggests that the relatively new phenomenon has had a lot of research and development conducted over the past number of years. However, it also suggests room for more.

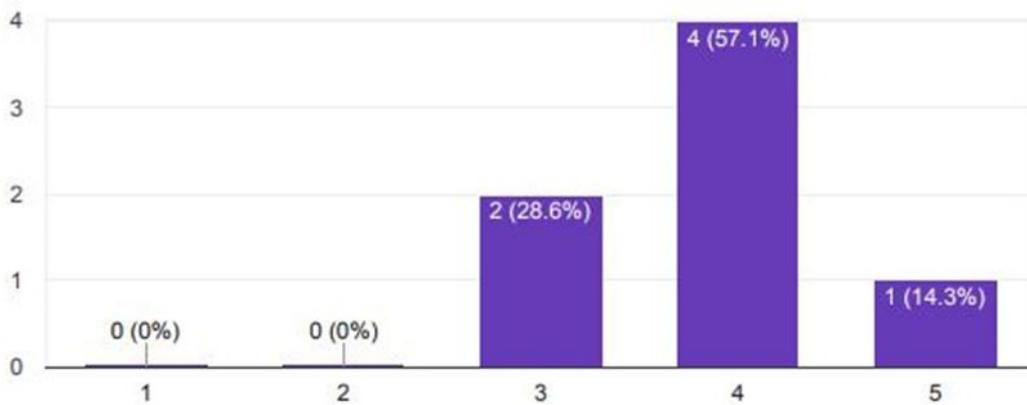
Figure 61. Level of Professional Familiarity with HFCV



### 12.5.2.3 Expectations Regarding Market Success

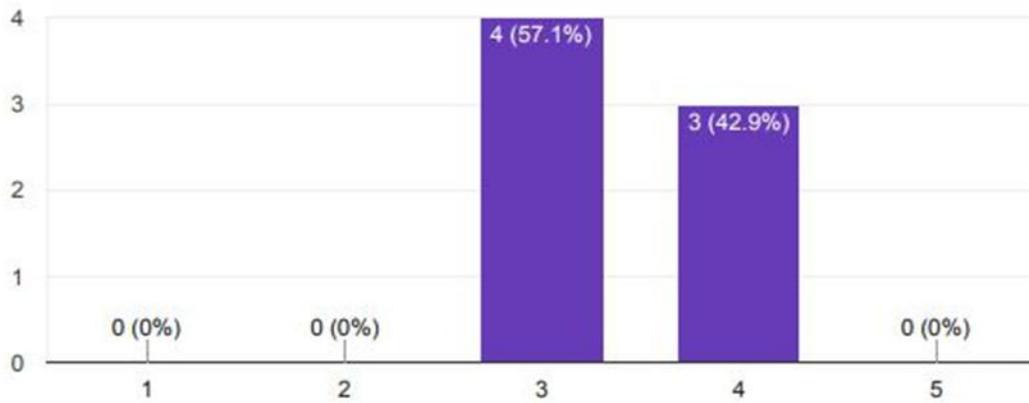
A series of questions related to the stakeholder's expectations were asked relating to the success of the market implementation for different types of hydrogen applications. The below bar chart portrays the majority of interested parties are relatively confident in using hydrogen as a means of storing energy.

Figure 62. Hydrogen as a medium for energy storage -Renewables



When asked about portable power applications the stakeholders were less confident than that of energy storage applications. This can be seen in the diagram below.

Figure 63. Portable Power Applications



The following questions were related to passenger cars and refuelling stations, heating & power systems in buildings, and inter-island ferries & shipping as this is where the economy intends to be steered towards.

Figure 64. Passenger, refuelling stations

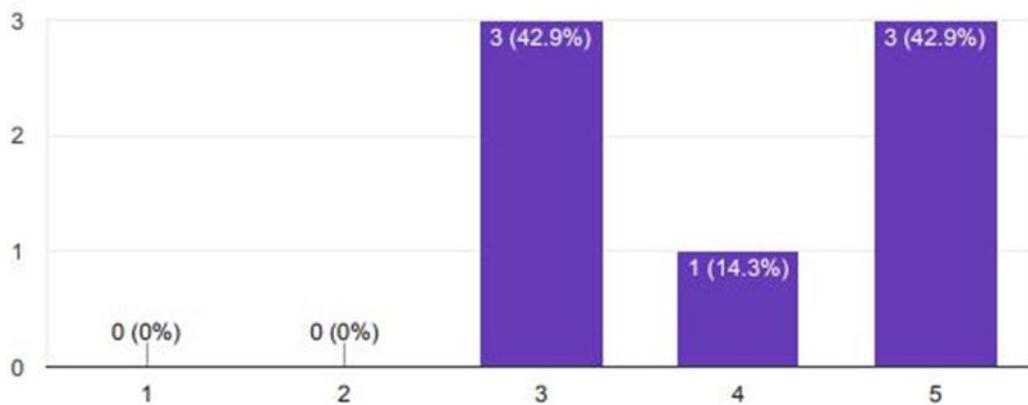


Figure 65. HFC Applications in Buildings

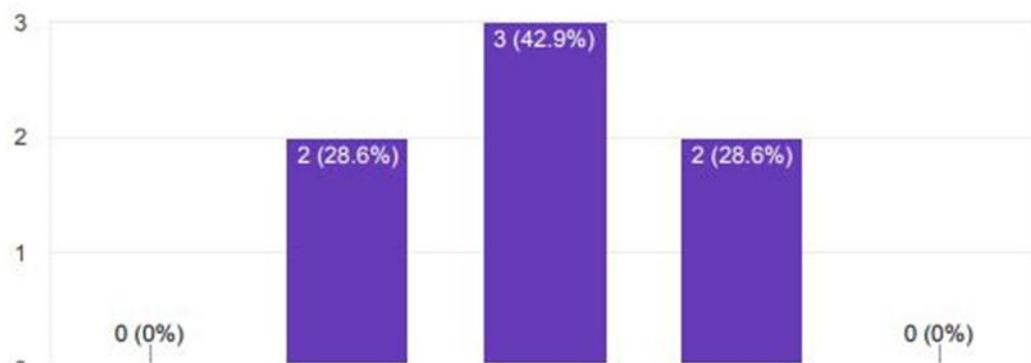
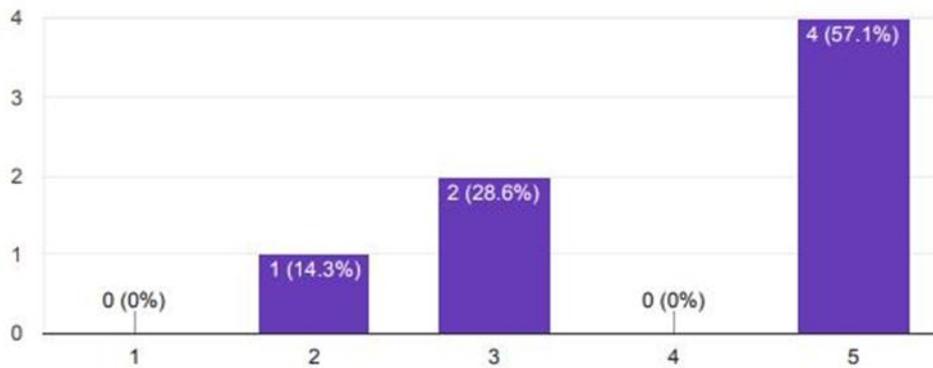


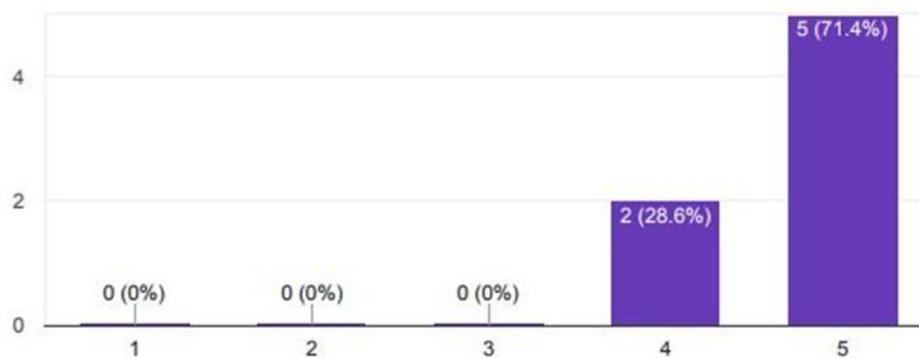
Figure 66. HFC Applications in Inter-Island Ferries & Public Transport



#### 12.5.2.4 Familiarity of Hydrogen Fuel Cell Technology Applications

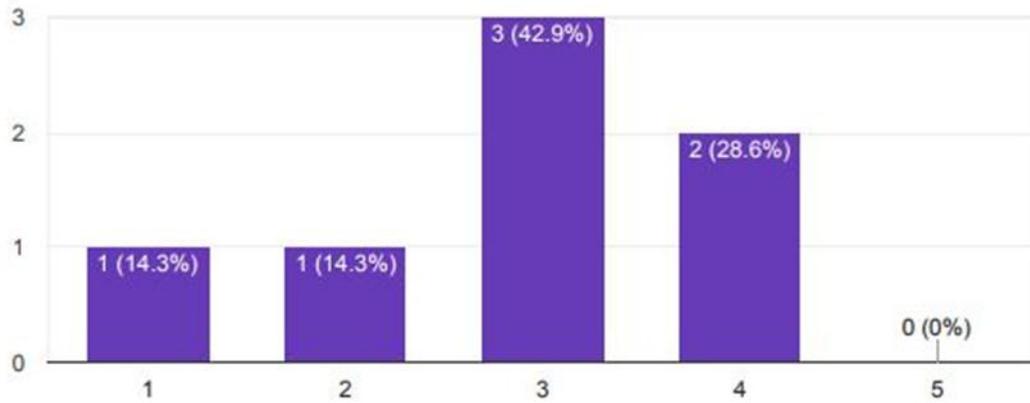
The next set of questions were steered towards the support of the hydrogen economy, and the level of assistance that the stakeholders feel should be in place to support the transition to a hydrogen economy.

Figure 67. Government & Companies should support the transition to H2 Technologies



Stakeholders were in agreement that government and businesses should support the transition to hydrogen. The diagram below shows that there was a varied response to the encouragement of a shift to natural gas for electricity and heating, aiding the development of hydrogen infrastructure.

Figure 68. Encourage shift towards natural gas for electricity & development of h2 infrastructure



The stakeholders view towards the specific fuel used for the hydrogen supply having a probable influence on the public's perception of HFC vehicles. A mixed response arose relating to the allocation of public funding. However, the use of public funding for hydrogen technology applications was accepted which can be seen below.

Figure 69. Specific fuel having significant influence over public perceptions of HFCV

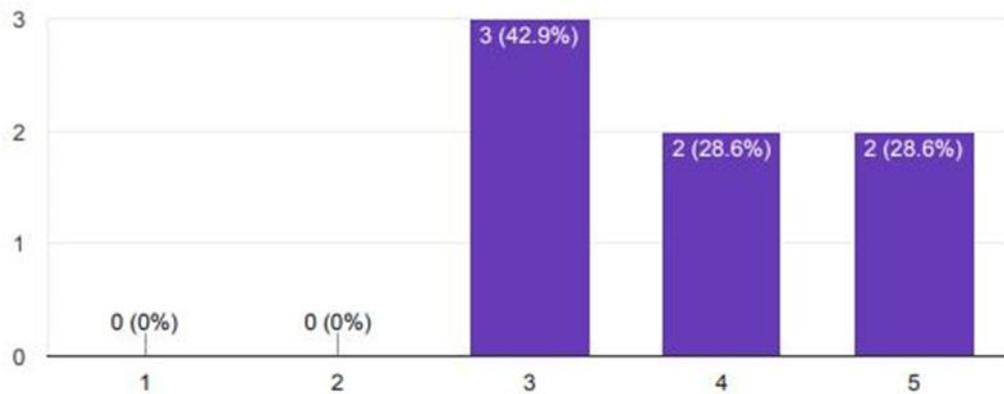


Figure 70. Public Funding should subsidise Purchase Price of Hydrogen

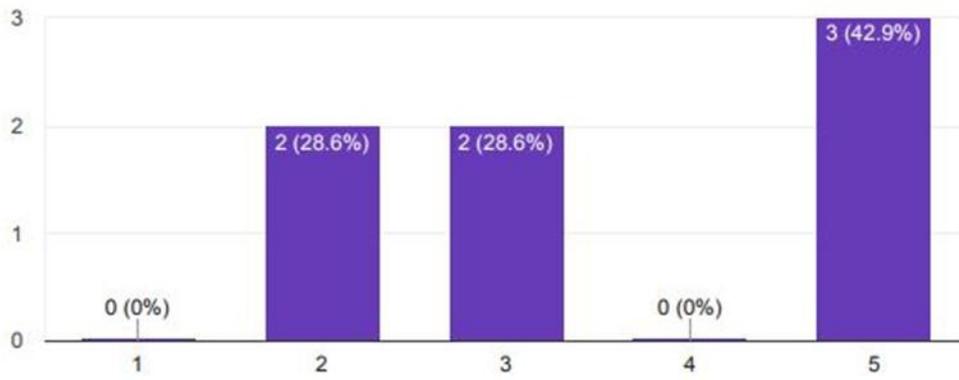


Figure 71. Public Funding should fund demonstration projects with h2 technologies

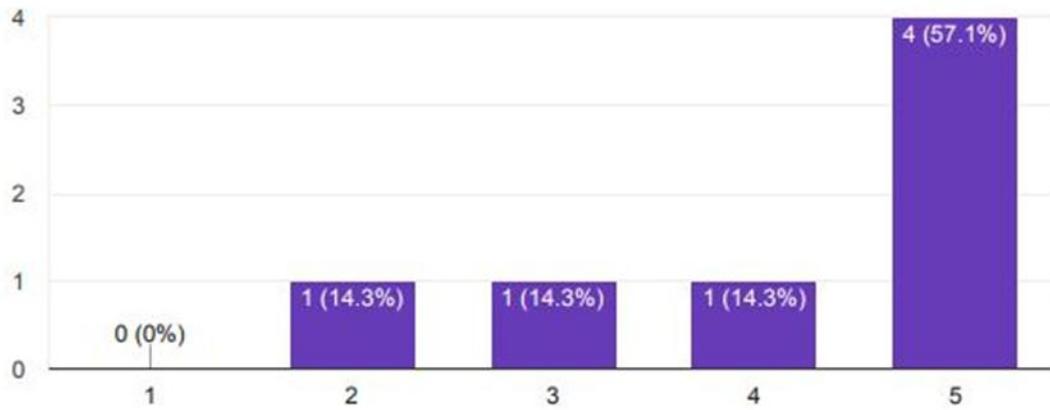
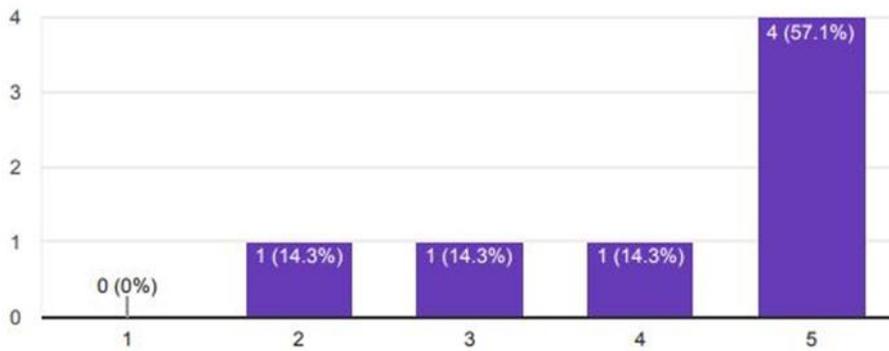
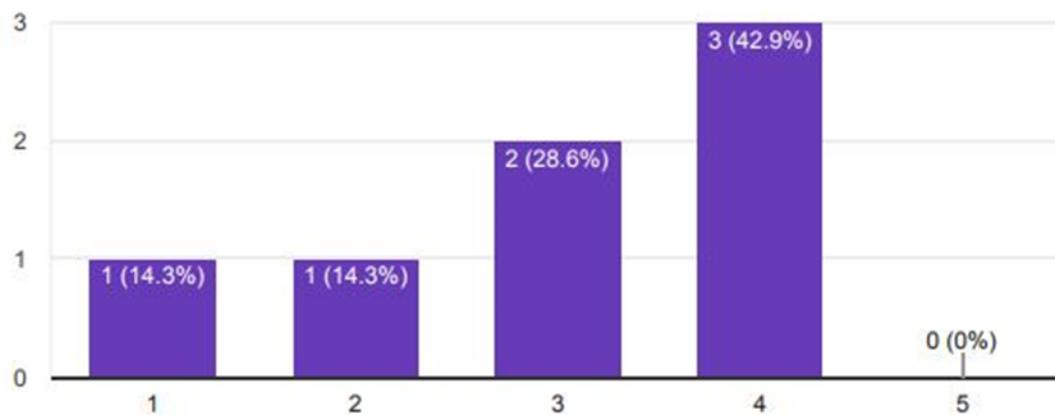


Figure 72. Public funding should be used for R&D



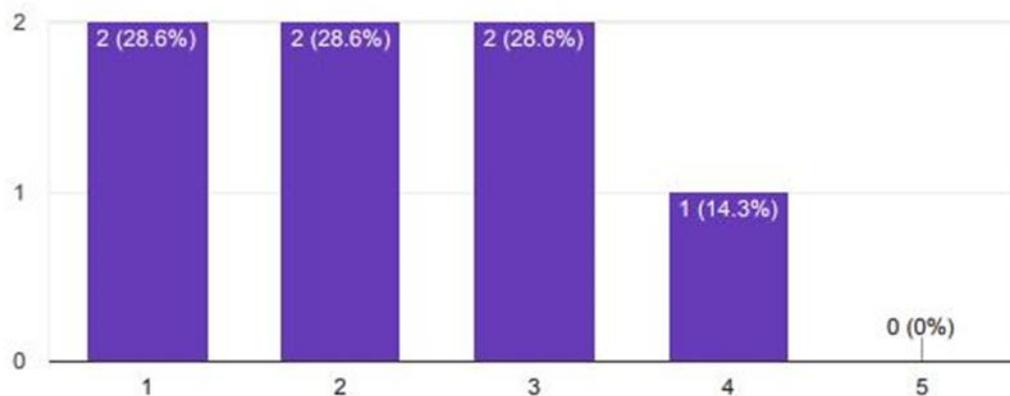
### 12.5.2.5 Rating of Level of Familiarity

Figure 73. Level of familiarity with HFC in same sector



The standard of familiarity with HFC electric vehicles was interesting and varied which can be seen in the above diagram. The stakeholders appear to feel that politicians and regulators are relatively unfamiliar with HFC electric vehicles.

Figure 74. Level of familiarity of Politicians & Regulators



Similar to that of politicians and regulators, the stakeholders appear to feel that the general public are slightly familiar with such applications. It is important to note here that different regions where different technological applications are being implemented, will have varying levels of awareness towards these technologies.

Figure 75. Level of familiarity of General Public

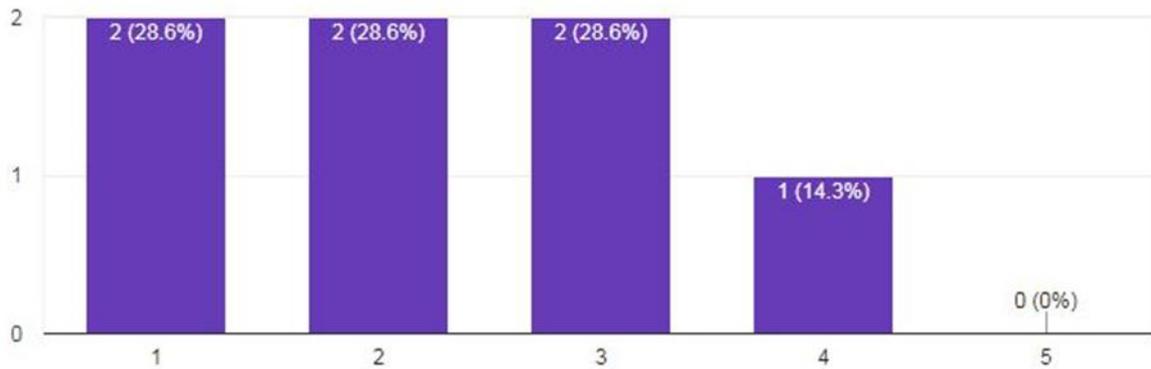
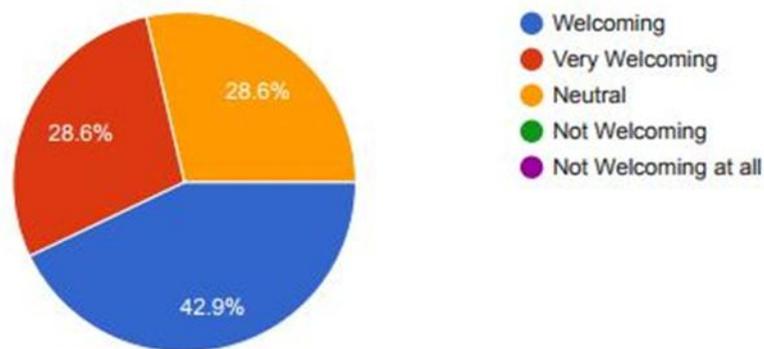


Figure 76. Attitudes of these sectors towards H2 Applications



### 12.5.2.6 Orkney

The final section of the survey is related to Orkney. This section asks the stakeholders their views on Orkney's current problems, potential and solutions. The results are as follows.

The stakeholders were asked whether or not hydrogen is the best solution for the current curtailment issues being experienced in Orkney. The majority answered 'yes'. Those who answered maybe and no, perhaps see other means of providing a solution for curtailment in Orkney. However, it has been made apparent that at this current time, it is the most optimum solution.

Figure 77. Is this the best solution to the curtailment issues in Orkney?

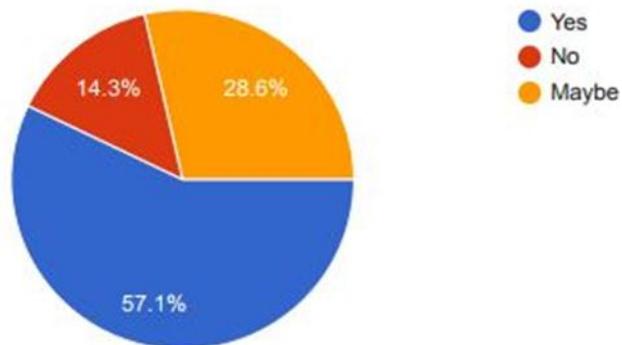


Figure 78. Reasons for answers

The technology is sufficient at present to resolve the issue of curtailment while the grid connection to expand capacity is delayed. The government of this country and others are showing interest in backing, at least in part, a hydrogen transition.

Other solutions such as EV charging and heat could have more obvious community benefit (energy poverty etc)

At the same time that curtailment is reduced, hydrogen is helping to distribute the energy among the islands, and helping as well local consumption of the RES.

The overall efficiency of transporting energy from Eday to Kirkwall is ridiculously low. Possibly as low as 20%. Included are other energy inputs, such as diesel to transport the hydrogen, and additional ferry congestion. It would have been cheaper to uproot the Eday turbine and rebuild it on the Scottish mainland.

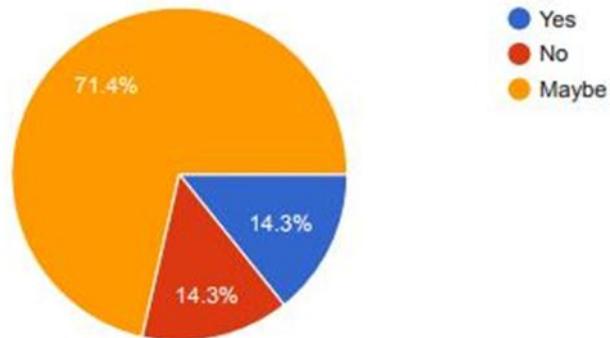
It seems to be. Anyway there could be other possible technical solutions.

Use renewable energies like wind turbine to generate new energy.

After 10 years of failing to make any progress with the grid, this remains a possibility.

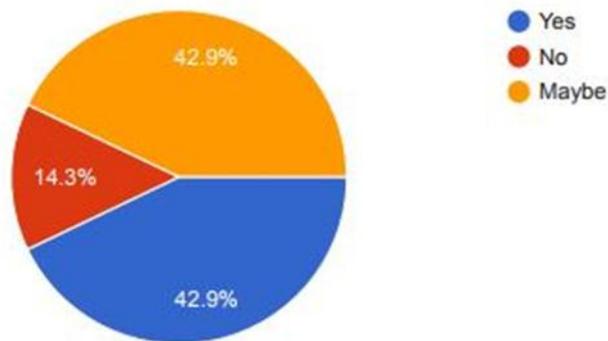
When asked about the level of community appraisal or engagement, most answered 'maybe'. This suggests that many of the stakeholders are unaware or unsure about the degree of information are being passed along to the members of these communities that are most likely to be affected.

Figure 79. Level of Community Engagement



They were then asked whether or not there should be more. Again, many said 'maybe' pointing in a similar direction to that above. However, those who have said no possibly understand the complex nature of an island community and the level of difficulty it is to deliver information to ALL. Another question was about the responsibility of the sharing of information. The variety of comments relating to this issue can be seen below.

Figure 80. Should there be more?

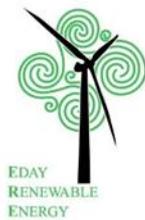


## 12.6 Appendix F. Policy Context

Table 8. Policy Objectives adapted from OIITS-Economic Baseline & Future Planning Horizon 2016

<b>Policy, Plan, Strategy</b>	<b>Purpose</b>	<b>Objectives</b>
Orkney Local Development Plan	Vision and Spatial Strategy for development of lands in the Orkney Islands for next 10-20 years	Consolidating strong position of island archipelago Nationally significant training and investment opportunities Tourism targets Small applications supported, subject to conforming with other areas of LDP No anticipated step change in development
Orkney Community Plan 2015-2018	Brings together public, private and third sectors with view to developing plan to support delivery of local authority's Single Outcome Agreement (SOA) Vision statement 'Working together for a better Orkney'	Orkney partnership set strategic priorities –positive ageing, vibrant economic environment, healthy and sustainable communities Inter-island transport of critical importance Essential Investment in Orkney's internal ferry fleet and potentially new management model
Eday Partnership	Create economically prosperous self-reliant community widely connected to the world, remaining a safe and clean environment	Economic development-agriculture critical New Opportunities- investment into Eday Renewables Ltd. Potential use of surplus electricity from community turbine to generate hydrogen
Shapinsay Development Plan (currently being revised)	Island Development Plan-sets out community's future ambitions	Meet challenges of future, building on current staple industries Potential use of surplus electricity from community turbine to generate hydrogen (similar to Eday's scheme) Current transport connectivity-community using proceeds from turbine to charter extra sailings
Zetland County Act 1974	Conservancy, development and harbour duties	Enable Council to exercise harbour jurisdiction and powers Powers to construct works and to acquire lands
Unitary Local Authority Areas	Political Integrity	Autonomous entities Representation in Parliament
Our Islands Our Future	Alignment of purpose between 3 authorities	Prosperous Islands Empowered Island Connected Island Powerhouse Island Special-Status Island Autonomous Island

## 12.7 Appendix G. ERE Public Notification Post Visits



Hello from Eday Renewable Energy!



Fig 1. The Surf 'n' Turf Team

We're writing to everyone on Eday to update you on the Surf 'n' Turf hydrogen project, in which ERE is a partner.

The installation and commissioning phase of the project is still under way – there's no Eday hydrogen just yet.

But we're getting close, so we'd like to tell you about progress and how the island is set to benefit. You can also look out for update posters on the ferries and in the shop, or go online to [www.surfnurf.org.uk](http://www.surfnurf.org.uk)

Our core aim throughout is to increase the productivity of the ERE wind turbine, keeping it turning when it might otherwise be off because of grid capacity limits. This grid curtailment is significantly reducing the production of the turbine and how much it earns. When we help it earn more, we can then pass the net surpluses on to Eday Partnership, so the community gets direct benefit.

A lot of progress has been made over at the wind turbine site, as well as at EMEC and on the Kirkwall Pier. Unless there are further delays, we hope to be operational in September.

### **What will happen to the Surf 'n' Turf hydrogen?**

Fig 2. The Fuel Cell



The fuel made on Eday will be transported to Kirkwall Harbour where it will be used to make electricity and heat in a fuel cell at the Pier.

The harbour has significant energy demand for its pier facilities and also to power the ferries when they are tied up overnight.

### **Getting ready for deliveries**

You may have seen the hydrogen delivery truck when it came here (empty) on test runs in April and May. Those visits helped the team check how best to load it on the ferry, drive over to the EMEC site and fill it with hydrogen. We also made time for the Eday fire fighters to familiarise themselves with the lorry, its equipment and the built-in fire safety systems. Kate, Adam, Hamish and Mick had a climb around the truck and the trailer storage unit.

Fig. 3. The hydrogen trailer



Once the equipment at EMEC starts making hydrogen, the truck will collect the gas a few times a week. It will arrive at EMEC, drop off an empty trailer and head off – perhaps the following morning – with a full one.

Surf 'n' Turf will make ferry bookings, just like all other users, but everyone involved recognises regular loads could have an impact on deck space, so the project has done what it can to minimise disruption:

- We've looked into how we can choose less busy sailings.
- Orkney Ferries have added extra lashing points on the North Isles boats so the truck uses as little deck space as possible.

**What about other hydrogen projects?** It's a bit confusing at the moment as Eday and the county are lucky to have three different hydrogen projects getting going. Here's how they interlink:

1. Our Surf 'n' Turf project on Eday and at the Kirkwall Harbour is led by our project partner, Community Energy Scotland, and is mostly funded by the Scottish Government.
2. Surf 'n' Turf builds on and works with EMEC's electrolyser and their hydrogen activities at the tidal energy site. Activity inside the EMEC compound is separate to Surf 'n' Turf and wholly managed by EMEC.
3. You also may have heard about a second electrolyser on Shapinsay, some hydrogen vans, and about places on Eday and Shapinsay benefitting from hydrogen heating.

These are all part of BIG HIT – a separate and EU-funded project. Whilst Eday Renewable Energy have not been directly involved with BIG HIT to date, there may be opportunities to become more involved with BIG HIT, in the future.

If BIG HIT does install heating for a building in Eday, that's more hydrogen we can use, more gas that needs to be made here, more electricity generation for the community wind turbine and more money for Eday Partnership to invest (oh and some useful low-carbon heat).



All that remains to say is “watch this space” and to express our sincere thanks to the Community Energy Scotland (Orkney) team for their input on this newsletter.

Kind Regards,

Andy Clive Sue Kate Tony and Mike  
The Eday Renewable Energy Team.  
July 2017

Any questions please feel free to drop us a line at:  
[astennett@hotmail.co.uk](mailto:astennett@hotmail.co.uk)  
[clivefromeday@btinternet.com](mailto:clivefromeday@btinternet.com)  
or phone andy on 01857 622313

*All Images courtesy of Community Energy Scotland 2017*

## 12.8 Appendix H. Blank Surveys

### HFCV General Public Blank Survey

#### Hydrogen Fuel Cell Vehicles

Author: Rebecca Kavanagh

Contact: [rk30@hw.ac.uk](mailto:rk30@hw.ac.uk)

Nature: Report

Status: Draft

Disclaimer: Dissertation Project, reflects view of author. Author taken any available measure for content to be accurate, consistent and lawful.

Executive Summary: Report represents data collection instruments with its primary aim to assess awareness and develop an understanding, acceptance and the impact of hydrogen and fuel cell technologies. This questionnaire was specifically designed for this purpose and aim.

#### Overview of BIG-HIT Project



#### Demographic

This section is created for the sole purposes of defining different categories and areas.

1. Are you male/female/Other

Mark only one oval.

- Male  
 Female  
 Other

2. What age are you?

\_\_\_\_\_

## Hydrogen Fuel Cell Technology in the Local Community Heat and Power

Author: Rebecca Kavanagh

Contact: [rk30@hw.ac.uk](mailto:rk30@hw.ac.uk)

Nature: Report

Status: Draft

Disclaimer: Dissertation Project, reflects view of author. Author taken available measures for content to be accurate, consistent and lawful.

Executive Summary: Report represents data collection instruments with its primary aim to assess awareness and develop an understanding, acceptance and the impact of hydrogen and fuel cell technologies. This questionnaire was specifically designed for this purpose and aim. Please feel free to skip questions you feel are not relevant to you.

### Overview of BIG-HIT Project



### Demographic

This section is created for the sole purposes of defining different categories and areas.

**1. Sex**

Mark only one oval.

- Male
- Female
- Other

**2. What age are you?**

\_\_\_\_\_

## Stakeholder Blank Survey

### Hydrogen Fuel Cell Technologies

Author: Rebecca Kavanagh

Contact: [rk30@hw.ac.uk](mailto:rk30@hw.ac.uk)

Nature: Report

Status: Draft

Disclaimer: Dissertation Project, reflects view of author. Author taken available measures for content to be accurate, consistent and lawful.

Executive Summary: Report represents data collection instruments with its primary aim to assess and develop an understanding of stakeholder's views of the demonstration of hydrogen and fuel cell technologies that will replicate current hydrogen production elsewhere using curtailed community energy . This questionnaire was specifically designed for this purpose and aim.

### Overview of BIG-HIT Implementation



### Profile

For the scales of 1-5, 1=lowest and 5=highest

1. Please indicate your country of residence

\_\_\_\_\_

2. Please indicate the kind of Organisation you work for

Mark only one oval.

- Private Company  
 Public Company  
 Government Organization  
 Educational Organization  
 Non-Profit Organization  
 Other: \_\_\_\_\_

3. How do you feel about hydrogen technologies as a potential solution for energy and environmental challenges?

Mark only one oval.

- Very bad solution  
 bad solution  
 Neutral  
 Good solution  
 Very good solution