





# The Orkney-Wide Energy Audit 2014

## Executive Summary

Report Number: P597 prepared by Aquatera Ltd. for OREF Ltd CES.

Release Date: January 2015

## Project Steering

Steering for this project was provided by Community Energy Scotland and OREF. The wider OREF membership and Orkney Islands Council provided comment on the draft report.



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## Citing

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## **The Commission**

CES worked with the Orkney Renewable Energy Forum (OREF) who commissioned local consultancy Aquatera to undertake an audit and propose elements of a switching strategy. Aquatera carried out the work in conjunction with Dr. Edward Owens from Heriot-Watt University, School of the Built Environment who provided Demand Side Management expertise.

Aquatera also gratefully acknowledge the input from the companies, individuals and organisations in Orkney who willingly contributed data and other assistance to help achieve a successful outcome to this study.

## **Aims**

The specific aims of the commission were:

- To quantify Orkney's existing energy sources and energy uses;
- To indicate the potential suitability and value of mechanisms for energy conversion and new energy uses which could lead to an increase in local electrical energy demand; and
- To seek energy adaptation strategies with both short and medium term benefits, but to focus upon solutions that could be delivered at an appropriate scale by 2017.

Alongside these primary aims it was desired that any energy adaptation strategies should:

- decrease energy costs;
- provide grid balancing by moving electrical demand to the outlying production zones; and
- reduce CO<sub>2</sub> emissions.

## **Background**

As a remote rural island community, with no gas network, Orkney has over recent decades had a high dependency on imported oil and coal as its main sources of energy. Due to the transportation costs involved in delivering such fossil fuels to Orkney they are more expensive in Orkney than in other parts of the UK. The higher costs of fuel together with the age and setting of the housing stock and the cool and windy climate means that Orkney suffers high rates of fuel poverty. Statistically Orkney is amongst the worst affected areas in the United Kingdom (UK) along with the Western Isles and Shetland.

The combination of harsh climate and high fuel costs make renewables a cost effective way of harvesting the energy needed.

Previous energy audits for Orkney have been undertaken, most recently in 2005 by the Northern and Western Isles Energy Efficiency Advice Centre a now defunct part of Orkney Islands Council (OIC). Since the last audits were undertaken the energy environment within Orkney has changed considerably due to the growth of renewables.

Orkney now boasts the highest proportion of electricity from renewables (mainly large wind), but also has the greatest number of micro-wind generators of any county in the UK. Homeowners and businesses within the county have installed renewable technologies, some with the support of government funded schemes. Orkney now has a number of community owned wind turbines, hundreds of micro-turbines and a world leading marine tidal and wave energy industry.

However, there is a limit to the amount of renewable energy that Orkney can accommodate without further grid upgrades and that limit has been reached. Therefore Orkney is faced with the need to find innovative solutions in order to continue producing, and increase the amount of, renewable energy generated within the county. Some of the problems are only limitations of capacity at particular pinch-points within the local electrical distribution network. Some limitations are due to the capacity limitations on the main cables linking Orkney to the national grid.

## **Report structure**

The report seeks to provide an overview of the energy status of the islands and proposes 'switching options' to alleviate curtailment challenges and to minimise fuel imports. The report is split into three main sections across two documents:

In the 'energy sources and uses' document

- The first section analyses the current energy sources in the county.
- The second section gives an overview of the energy usage on the islands and

In the 'switching options' document

- The third section outlines potential switching options.

The third section outlines potential 'Switching Options'. These options have the potential to alleviate some of the problems that are currently being faced, by: managing the existing grid; increasing electrical demand by switching from other fuels or creating new demand; storage or demand management. A number of these possible options arose from the work of the Orkney Grid Group, which was established by OIC and supported by OREF after the new connection moratorium imposed by Scottish and Southern Energy (SSE) in September 2012.

## **Overview of Energy Sources**

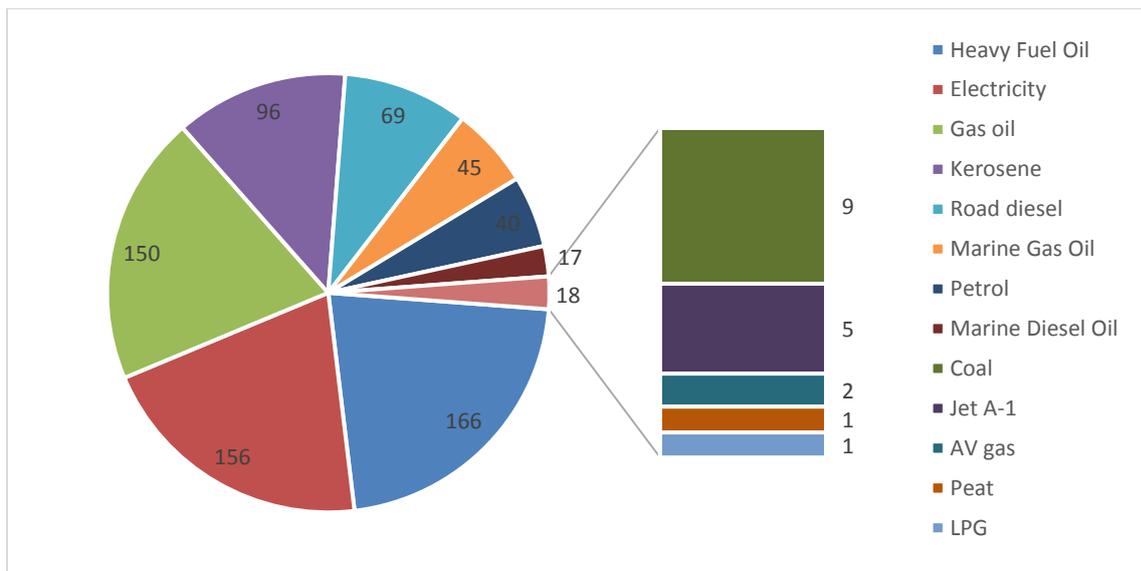
Included in this analysis is all the energy produced on the Orkney Islands and exported, as well as the fuel imported into the islands. The energy sources are categorised as follows:

- Imported fossil fuels
- Imported biomass
- Imported and exported electricity
- Indigenous biomass
- Local electricity generation

Most of the fossil fuels described below are imported into Orkney. The exception is the gas used at the Flotta Oil Terminal which is derived from the inward flow of oil and gas from the North Sea fields. This gas is used at the terminal for heating and electrical generation.

Electricity is imported/exported to and from Orkney via two 33kV (20MVA) submarine cables. In addition over the last decade or so Orkney has seen a large increase in the amount of renewable energy generations. Renewable energy production from wind in particular has increased dramatically. Renewables are now the predominant source of electricity in Orkney.

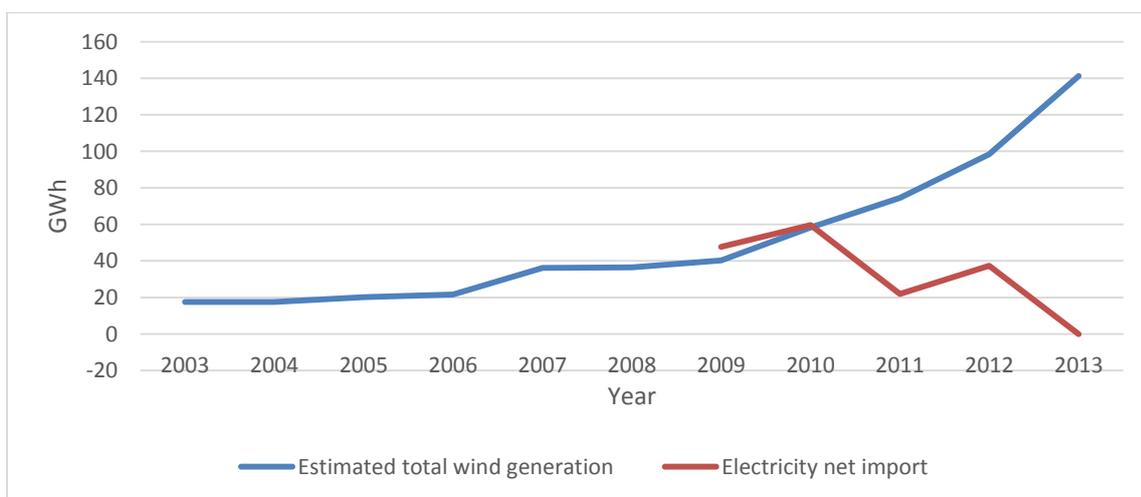
The following pie chart (Figure 1) shows an average of annual use of electricity, fossil fuels and peat used (2009 - 2013).



**Figure 1 Average fuel use 2009 - present (GWh)**

The audit showed that where data is available the use of fossil fuels that their consumption looks to have stayed fairly stable over the last decade, with the exception of coal for which the use has more than halved in the last decade.

Figure 2 shows that renewable energy generation, on the other hand, has increased significantly over the last 10 years from around 17GWh in 2003 to about 140GWh in 2013. At the same time the net amount of electricity imported has fallen from around 50GWh in 2009 to almost zero in 2013.



**Figure 2 Estimated total wind generation and net import of electricity**

In 2009 an Active Network Management (ANM) system, which monitors the electrical network and controls the grid, was set up in Orkney to allow additional generation on the system without expensive grid upgrades. However even with this system in place the growth of the wind (and other renewables) has meant that in September 2012, Scottish and Southern Energy Power

Distribution (SSEPD) imposed a moratorium on all new generation, except the very smallest generators.

The Audit shows over 48MW of wind energy generators are currently operational in Orkney. These turbines range in size from less than a kW to several MWs. The total energy generated from wind is now estimated to be around 140GWh per year (as shown in Figure 2). Photovoltaic systems have also become increasingly common but to a lesser extent than wind generators with a total of 1.2MW of photovoltaic panels now installed.

A growing wave and tidal energy industry in Orkney is set to contribute substantially to the overall renewable energy generation picture in the future. In 2011, the Crown Estate held a leasing round for commercial and demonstration marine energy project in the Pentland Firth and Orkney waters. There are currently leases held for 550MW of wave energy projects and 530MW of tidal projects in Orkney waters. Currently these technologies are still at an early stage of development and therefore the number of GWh is small day-to-day, but this is expected to rise in the future as the testing periods increase and the industry moves towards commercial projects.

## Data Gaps

In terms of data collection for these first two sections, there were limitations to the data collected for several reasons:

- The length of time to obtain data;
- Format of data;
- Confidentiality of data relating to areas such as grid; and
- Concern in the business community as to whether the overall approach to moving away from existing fuel types and behaviours would impact upon their current business.

Consequently certain assumptions were made in estimating the energy sources and uses were necessary. Where assumptions have been made they are highlighted in the body of the report.

Important data gaps to note are:

- Modelled data (from Department of Energy and Climate Change (DECC)) was used for most of the fossil fuel analysis due to lack of real world data. It may be important in the future to verify this modelled data.
- Crude oil, of which the majority of the energy embodied simply passes through Orkney's Flotta Oil Terminal and was not considered in this audit.
- Of the crude oil, passing through the Flotta Oil Terminal a small fraction is used at the oil terminal for heating and electrical generation. The oil terminal uses gas extracted from the crude oil on site for heating and to produce electricity. The total energy used in this way is equivalent to 0.49GWh but it is not clear how much energy is used for heating, electricity generation or flared as data from Talisman was unavailable.
- Kirkwall Power Station ceased regular operation in the late 1990's after the second cable to the mainland was commissioned. It still runs monthly for test purposes and covers faults and system outages on mainland links. This small contribution to the overall electricity supply was not considered in this audit.
- Indigenous biomass in the form of peat is used at Highland Park as part of the whisky making process in addition peat is still used as a fuel source in Orkney for domestic heating however it is difficult to estimate the extent of peat cutting for domestic use as no records are kept.
- Short rotation wood crops and fuel produced from anaerobic digesters have also been on Orkney but on a trial basis. No assessment was made of the uptake.
- Imported biomass comes into Orkney as logs, wood pellets, eco-logs, peat and waste wood. This was not possible to quantify but is likely to increase in the future due to the Renewable Heat Incentive (RHI), a government financial support programme, which pays participants of the scheme that generate and use renewable energy to heat their buildings.
- Marine fuel was analysed using a bottom up approach. Many of the major energy users are included in the study but it is understood that the larger fishing vessels and a number of dive boats have direct contracts with the main fuel suppliers. Therefore the data presented in this report is not a complete picture of fuel use by boats operating in Orkney.
- Air transport data only includes any fuel imported into Orkney. A significant portion of the fuel used on routes to and from the County will come in on planes refuelling at other airports and could not be accounted for in this report.

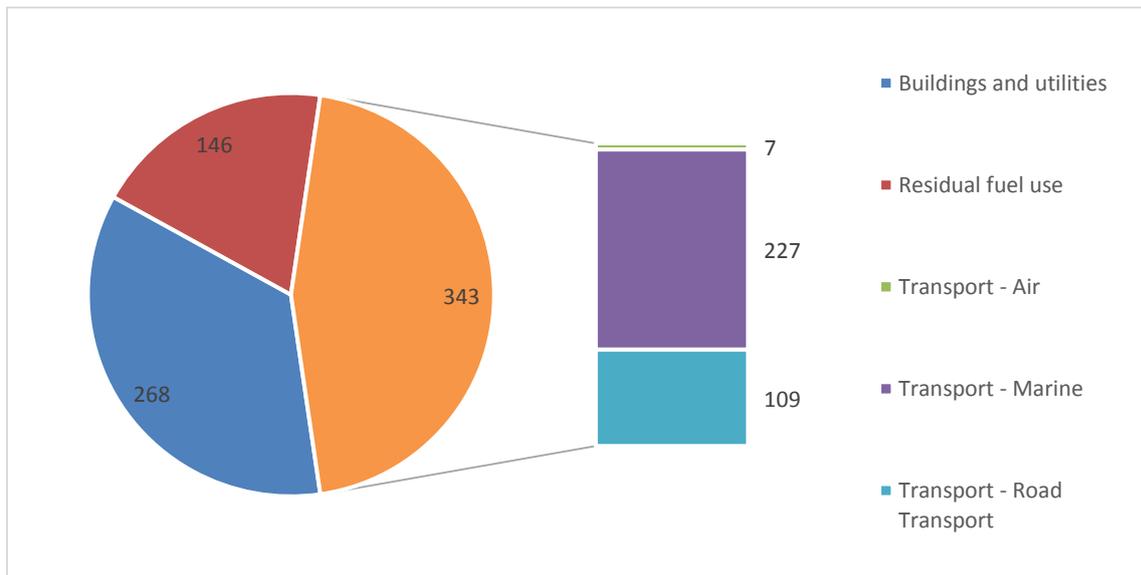
**Recommendation 1.** The data gaps identified should be proactively filled on a continuous basis. The necessary data flows be identified, managed, commissioned and the audit should therefore be maintained as a decision informing device.

### Overview of Energy Uses

Energy use in Orkney can be broadly categorised into three main energy uses and further broken down by sector as follows:

1. Buildings and Utilities:
  - Domestic;
  - Commercial/industrial;
  - Public administration
2. Transport:
  - Road ;
  - Marine;
  - Air
3. Residual fuel use, which encompasses all other terrestrial energy i.e. the use of red diesel (gas oil) for non-road transport and other static powered machinery in the following sectors:
  - Industrial;
  - Agriculture;
  - Public administration

Figure 3 shows transport is the major energy use (343GWh) followed by buildings and utilities (268GWh). Note that air transport figures included here is likely to be significantly underestimated for routes to and from Orkney due to refuelling elsewhere.

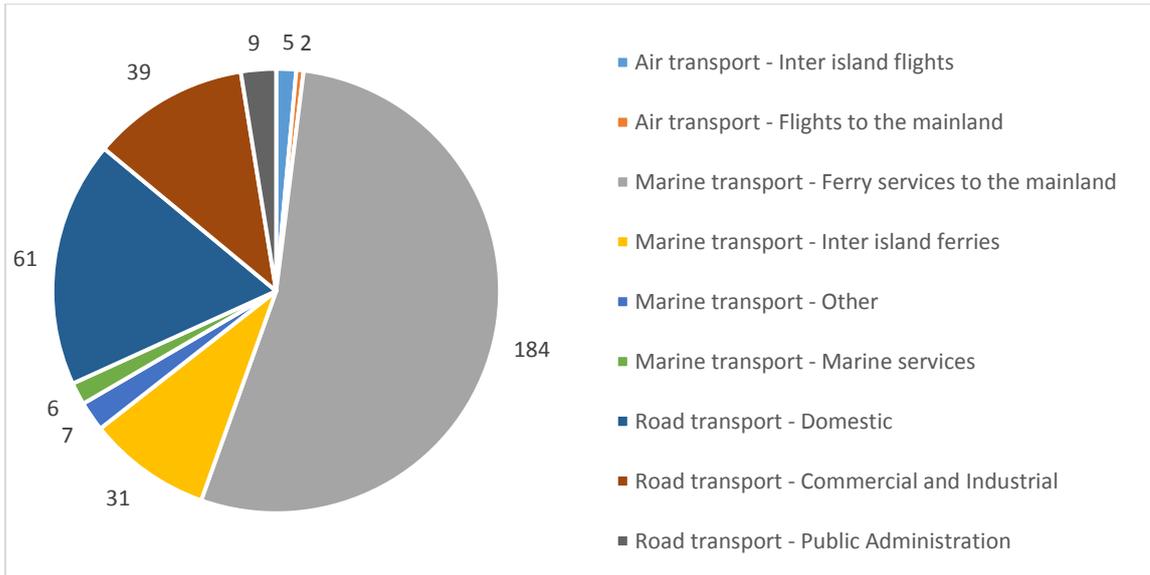


**Figure 3 Energy use by end use**

The following charts further break down Figure 3.

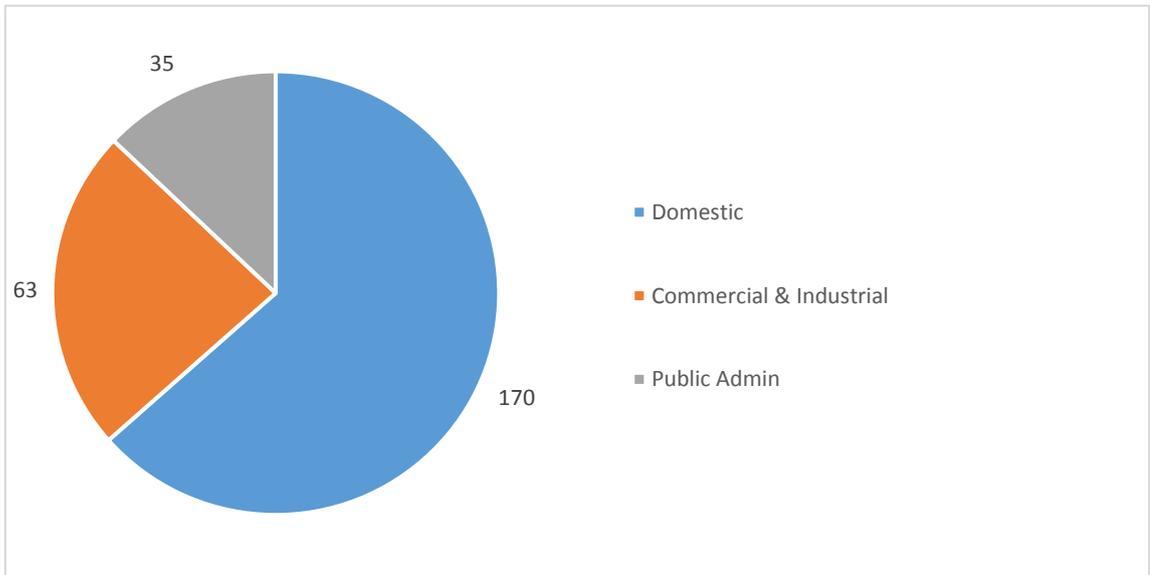
The transport section of the Figure 3 is broken down further by sector in Figure 4a and shows that the largest energy use in the transport sector is for ferry services to the mainland (184GWh) followed by domestic road transport (61GWh).

As explained above air transport is included but is likely to be significantly underestimated.

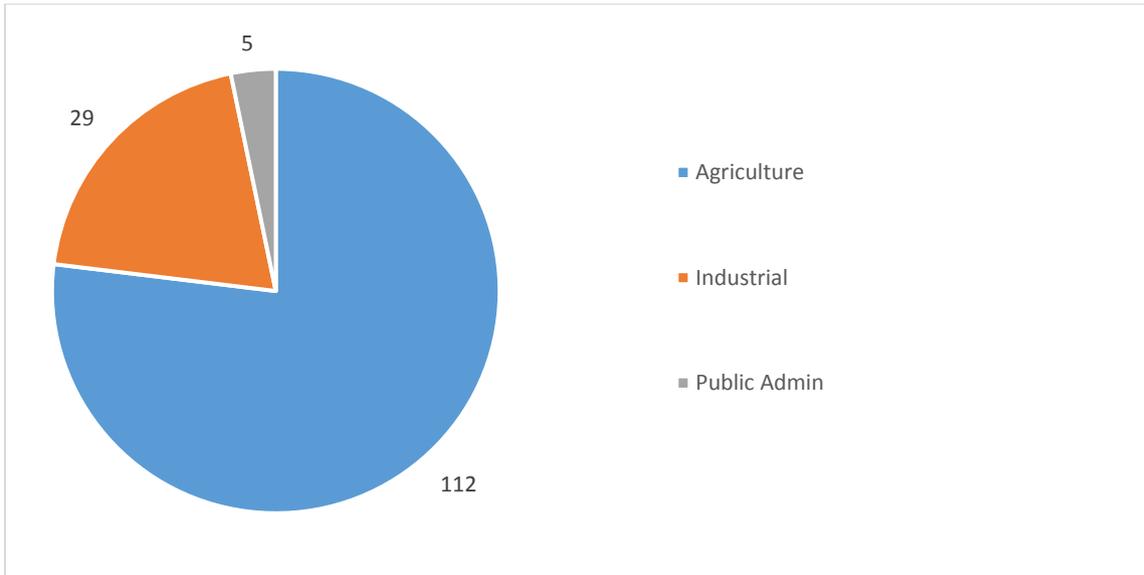


**Figure 4a Energy use by sector - Breakdown of energy use in the transport sector**

Figure 4b shows that the largest energy use in buildings and utilities is for domestic energy use (170GWh) and Figure 4c shows that for 'residual fuel' is mostly for agricultural uses (112GWh).

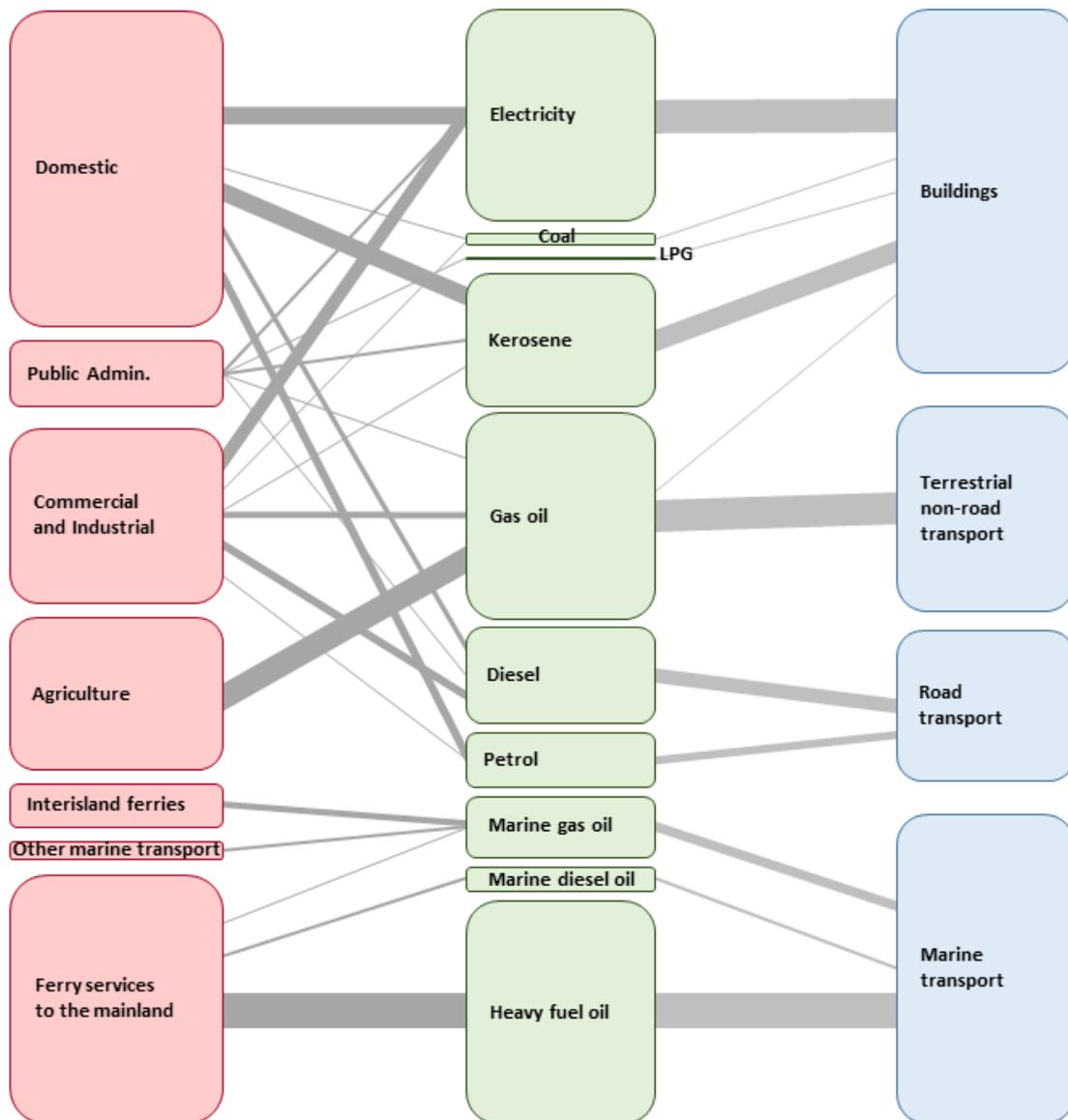


**Figure 4b Energy use by sector - Breakdown of energy use by buildings and utilities by sector**



**Figure 4c Energy use by sector - Breakdown of residual fuel use by sector**

The Sankey diagram (Figure 5) below shows the different fuels in the middle and who uses them on the left and the purpose on the right. The size of each of the blocks is proportional to the total amount of energy. The width of the lines is proportional to the energy flow.



**Figure 5 Sankey diagram (excluding air transport and peat)**

Note: This diagram only considers present fuel uses. It does not represent imported commodities which have a high embodied energy and which could feasibly be produced in Orkney. The diagram only shows what is happening, not what could happen.

## Potential Energy Strategies

Any energy strategy adopted will need to consider the options available. The ‘Switching Options’ section of the report considers a wide range of ideas and will seek to inform the strategy to be developed. Systematic examination seeks to quantify the benefits and costs of each proposal.

In the project brief it was made clear that options should aim to:

- decrease the target market’s annual spend on fuel;
- provide grid balancing by moving electrical demand to the outlying production zones; and
- reduce CO<sub>2</sub> emissions.

The energy switching options considered have been grouped into four broad categories: grid management, time-switching strategies, fuel switching and demand increase strategies as shown in Figure 6. The colours indicated the suitability of each option where dark green shows the most promising options and dark red the least promising.

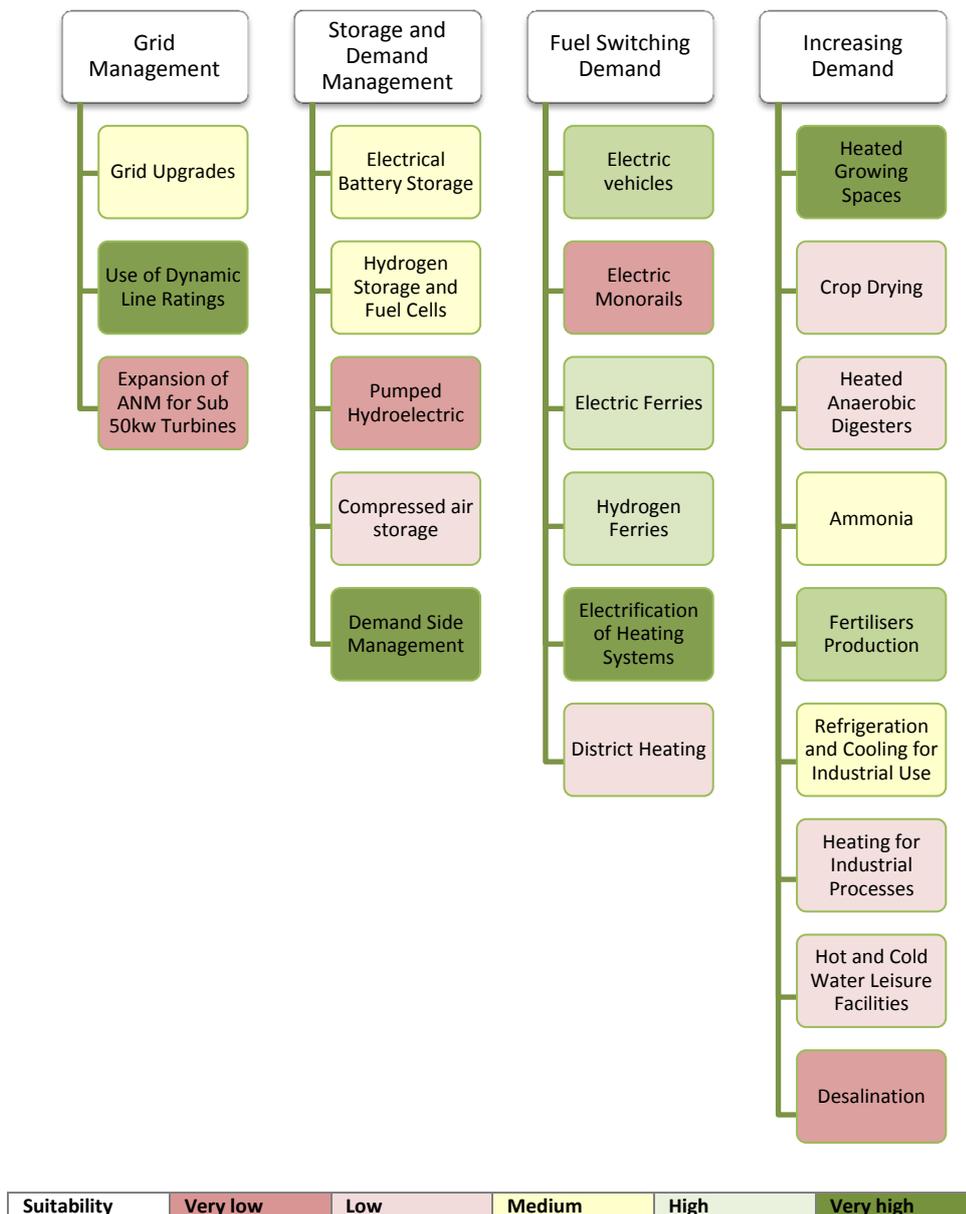


Figure 6 Summary of switching options

The options that have been deemed to be most promising are those that are at an appropriate stage of development and appropriate for the nature, scale and culture of Orkney. Initial investigations show that business cases should be developed to take forward the preferred options.

**The most promising options are listed below:**

- Use of dynamic line ratings
- Demand side management
- Electric vehicles
- Electric ferries
- Hydrogen ferries
- Electrification of heating systems
- Heated growing spaces
- Fertiliser production

Note: This is not an order of priority.

In order for any of these options to be adopted a number of specific actions will need to be taken, these are outlined in the following table:

Strategy	Action
Use of dynamic line ratings	<ul style="list-style-type: none"> <li>• Further engagement with the network operator to explore the potential to role this out further.</li> </ul>
Demand side management	<ul style="list-style-type: none"> <li>• Further engagement with Heriot-Watt University to maximise outcomes and opportunity for transferring outcomes from Findhorn to Orkney.</li> <li>• Further investigation, if data is available, to look at the scale of the grid balancing benefit on the individual DNO zones.</li> </ul>
Electric vehicles	<ul style="list-style-type: none"> <li>• The installation of 'Rapid chargers' at key locations to support the use of EVs.</li> <li>• Extensive installation of 'Fast Charge' points throughout the county.</li> <li>• Direct engagement with constrained turbine owners to encourage a shift to EVs.</li> <li>• Engagement with national grant awarding bodies to support a shift towards procurement of EVs.</li> </ul>
Electric ferries	<ul style="list-style-type: none"> <li>• Undertake a feasibility study into the potential of replacing existing diesel ferries which are at the end of their commissioning periods with electric ferries or hybrid electric ferries.</li> <li>• Engagement with other relevant stakeholders that have experience with electric ferries (e.g. Caledonian Maritime Assets Ltd.) to learn from their experiences.</li> <li>• Engagement with battery technology developers to match the demand of the vessels for longer routes.</li> <li>• Exploration of the potential for 'cold ironing' should be explored with the ferry operators.</li> </ul>
Hydrogen ferries	<ul style="list-style-type: none"> <li>• Undertake a feasibility study into the potential of replacing existing diesel ferries which are at the end of their commissioning periods with hydrogen ferries or hybrid hydrogen ferries.</li> <li>• Engagement with other relevant stakeholders that have experience with electric ferries (e.g. Caledonian Maritime Assets Ltd.) to learn from their experiences.</li> <li>• Engagement with fuel cell technology developers to match the demand of the vessels for longer routes.</li> <li>• Exploration of the potential of conversion of engines to directly burn hydrogen.</li> </ul>
Electrification of Heating Systems	<ul style="list-style-type: none"> <li>• Analysis of EST home analytics data to look at the heating systems used in the current housing stock to give a better estimate of the market.</li> <li>• Determine and publicise impact on customers looking at installation costs versus running costs of different heating systems including RHI payments for applicable technologies.</li> <li>• Investigate the likely demand created by switching fuels for small turbine owners</li> </ul>

	<p>who are currently using non electrical heating for hot water and space heating.</p> <ul style="list-style-type: none"> <li>• Economic analysis cost of wind to heat versus selling to the grid and electric heating.</li> <li>• Engage with national and local grant awarding bodies to establish grant for local residents encouraging shift from fossil fuel to electric for installation costs</li> <li>• Engagement with SSE or other operator to establish opportunity for Orkney specific tariff to encourage a shift from fossil fuel to electric.</li> </ul>
Heated growing spaces	<ul style="list-style-type: none"> <li>• Discussions with Eday and Benbecula projects to discuss opportunities and pitfalls.</li> <li>• Engagement with grant awarding organisations i.e. Rural Payments and Inspectorate Directorate in relation to agricultural land.</li> <li>• Engage with local shops to establish demand and willingness to participate and purchase locally grown produce.</li> <li>• Research cooperative style food supply business to support number of small farms supplying local shops.</li> </ul>
Fertiliser production	<ul style="list-style-type: none"> <li>• Undertake a feasibility study into the cost effective production of locally produced ammonia fertilisers.</li> <li>• Identification of applicable locations to determine possible sites of operation that minimise impact.</li> <li>• Determining the seasonal demand for ammonia based fertilisers could highlight the level of production and storage that would be required.</li> <li>• Gathering data on the use of ammonia based fertilisers of neighbouring regions to Orkney.</li> <li>• Data on the variety of fertilisers used within Orkney.</li> </ul>

**Recommendation 2.** The actions above need to be allocated to specific organisations following review and agreement.

In addition to the above there is also a need to consider the following:

- How Orkney as a whole (i.e. different organisations) will approach the strategic delivery of such projects(s) in order that the Orkney communities benefit from the decisions and actions taken, by working together and supporting each other;
- Who the key organisations are within Orkney to take forward the outcomes? Will it be a number of existing organisations, is it a single organisation, is it a new organisation?
- What relationships need to be established and/ or strengthened outwith Orkney to maximise opportunities within Orkney;
- How can Orkney businesses be provided with/secure the support (skills, knowledge) to maximise the opportunities for new business streams (i.e. shifting away from fossil fuels); and
- Understanding and calculating the risks associated with individual projects or the wider ambition based on different future scenarios (helping alleviate concerns or identifying previously unknown risk factors).

## **Conclusions**

The 'Energy Audit' and the 'Switching Options' reports together provide the most comprehensive baseline of energy information for Orkney to date. They should now be used as a benchmark to help determine energy related policy and decision making within and outwith Orkney.

This study has shown what Orkney has achieved so far. Over the last 15 years Orkney has installed enough capacity to generate 103% of its electricity demand in 2013. The islands have now reached the point where further increases in generation capacity are limited by the grid.

There is however still a desire and a need to develop more renewables energy projects on Orkney in order to decrease our dependence on fossil fuels and to further increase the economic and social contribution made by renewable energy to the Orkney Islands.

The proposed options provide highlight where potential is most likely to be found as well as indicating the actions that need to be taken to deliver in these areas. The benefits to Orkney as a whole for investigating and strategically switching the way it sees and used energy can enhance its reputation as an energy laboratory as well as achieve the direct financial and environmental benefits associated with increased electrification.

Further initiatives and work is now required to turn this list of options into real 'on the ground' activities and projects. It is hoped that these documents will help focus discussions in order that the next level of decision making can take place and action to address the energy issues facing Orkney can be taken.

The Options show that delivery will be a community wide activity. It will need to be delivered by different agencies working together. Undertaking such actions in the Orkney community will take a considerable effort and need strong co-ordination to be successful.

However the potential of the options to give communities real energy security and a range of income generating projects is clear.



# Orkney-Wide Energy Audit 2014

