Orkney Energy Audit 2019

Version 3

Report for ReFLEX Orkney

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Audit Summary

Introduction

This Energy Audit ("2019 Audit" or "Audit") has been produced to quantify Orkney's energy sources, forms of energy storage and energy uses. It builds on a previous audit (Orkney-wide Energy Audit 2014[1] (Aquatera Ltd, 2015)), and has been produced as part of the ReFLEX Project ("Project"). The Project aims to create a 'smart energy island', demonstrating the energy system of the future, which will reduce and eventually eliminate the need for fossil fuels. It is part funded by United Kingdom Research & Innovation ("UKRI") through the Industrial Strategy Challenge Fund. This Audit also provides details on Orkney's carbon emissions and includes a separate section on socio-economics. It is also a tool to inform the design of the overall Project, a baseline to measure its success against in future, and to inform and support other energy related activities in Orkney and further afield.

The Audit Summary follows the order of the full Audit and is intended to be read alone or in conjunction with the full Audit where reference to further details is required. Data sources on energy are provided in a wide range of units including by volume (e.g. litres), by weight (e.g. tonnes or kg), or by energy (e.g. Joules or kWh) often driven by international conventions and/or historical reasons. Therefore, in addition to the original units of measurement, Giga-watt hours (GWh)[2] are used throughout the Audit to aid clear comparison of relative sources and uses of energy.

ReFLEX Orkney is very grateful to the organisations and businesses who provided data for this Audit. There are however a number of incomplete datasets and limiting factors requiring certain assumptions to be made on the energy sources and uses and the resulting carbon emissions. Further details on these are provided in the relevant sections of the full report. The findings of the Audit should therefore be treated with this in mind.

Whilst this Audit is referred to as the 2019 Audit it has not always been possible to get the most up to date data and therefore actual data used may be from before 2019.

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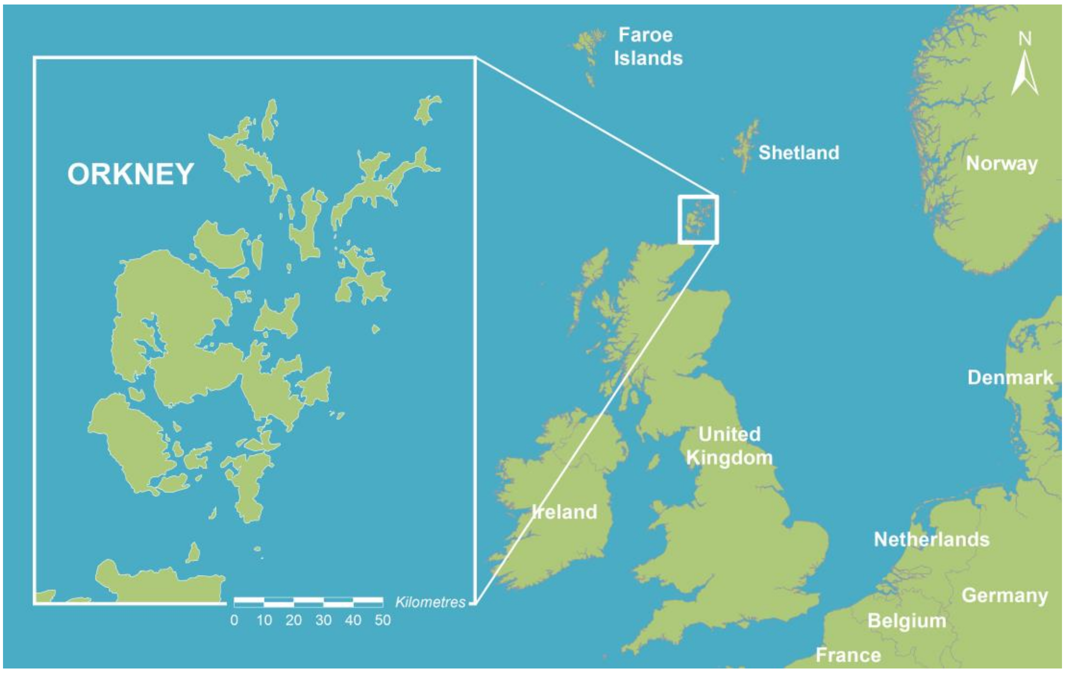
[1] The purpose of the Orkney-wide Energy Audit 2014 was twofold. Firstly, to provide a baseline of information relating to energy sources and uses within Orkney in order to understand fully the pattern of fuel use within the islands and to help identify fuel uses that could be replaced with energy produced from renewable resources. Secondly to present options that could help alleviate some of the problems and maximise the socio-economic and environmental benefits for Orkney. The data was collected in 2014 and Aquatera published the report in 2015.

[2] One GWh is equal to one million kWh and a thousand MWh. Approximately, one kWh is the energy needed to run a single bar electric fire for an hour. In Orkney each household uses around 8,000 kWh per year of electricity.

Orkney Overview

Orkney is located off the north coast of Scotland, comprising 20 inhabited islands with a population of around 22,000 people, which has seen an increase of 13.3% between 1998 and 2018.



Orkney has a long association with energy and innovation, including the development of North Sea oil and gas, testing of wind turbines, the building of European marine energy test facilities, and more recent work on hydrogen, energy storage and smart energy systems. It is more than self-sufficient in the use of electricity from renewable energy but not being connected to the mains gas network relies heavily on the use of oil-based products for the majority of its energy supplies.

Orkney is home to some of the highest rates of fuel poverty and extreme fuel poverty in Scotland and ranks as the local authority with the fifth highest carbon footprint per person in Scotland.

Energy Sources

This Audit considers all forms of energy in Orkney including the importing of fuels, indigenous fuels, and local renewable electricity generation.

Imported Fossil Fuels

Coal and coal-based products were imported by bulk carrier prior to 2015. They are now imported as freight using the island ferry services. It was not possible to get data from the two main coal merchants and more recent modelled data from BEIS gives a much higher total than historical averages. The most recent historical data shows imports of 8.2 GWh (or 981 tonnes), representing just over 1% of Orkney's energy.

There is no mains (natural) gas in Orkney and liquified petroleum gas (LPG), comprising propane and/or butane is imported either as bottled gas or via road tankers. It has not been possible to get all data sources, only from one of the largest users, and from this it is estimated that 0.8 GWh, representing just 0.1% of Orkney's energy is imported.

Kerosene is imported in bulk and accurate data has been provided by Orkney Islands Council (OIC) Marine Services, showing imports of 117.3 GWh (or 9,139 tonnes), representing 15.5% of Orkney's energy.

Similarly, petrol, representing 43.6 GWh (3,330 tonnes) or approximately 5.8%, and diesel (also known as white diesel or Diesel Engine Road Vehicle (DERV) or ultra-low sulphur diesel (ULSD)) and representing 86.1 GWh (6,780 tonnes) or approximately 11.4% of Orkney's energy are imported in bulk.

Gas oil (also known as 35-second oil or red diesel) and sulphur free gas oil (SFGO) are also imported for use in marine transport, industry and agriculture and represents an estimated 236.0 GWh (just over 22 million litres) or 31.3% of Orkney's energy. An estimate has also been made for Orkney's share of gas oil used in ferries to the mainland, one of which is shared with Shetland, and this adds a further 101.5 GWh (just under 9.5 million litres) or 13.4%.

Finally, of the imported fossil fuels, an estimate has been made of that associated with both flights to the mainland and inter-island flights within Orkney. This comprises Jet A-1 at 22.4 GWh and AV Gas at 1.3 GWh, representing almost 3% and just under 0.2% of Orkney's energy respectively.

Indigenous Fuels

Peat has been used as a fuel for centuries and a limited amount is still cut in Orkney, estimated to be in the order of 0.47 GWh (99 tonnes) per year, or equivalent to less than 0.1% of Orkney's energy.

There are no known short rotation or other biomass crops in Orkney and at present no energy sourced from anaerobic digesters.

Imported Biomass

A number of biomass products (such as wood, wood pellets, Eco-logs) are imported into Orkney but it has not been possible to obtain data in order to calculate the equivalent energy supplied.

Electricity

Orkney is currently connected to the national grid via two 33kV (~20MW) submarine cables, which allow for the import, and export, of electricity with the Scottish mainland, depending on the level of local demand and generation. Within Orkney, the electricity network operates at 33kV and 11kV, and covers all the inhabited islands.

After the year 2000, when the first modern large wind turbines were installed, there was a steady increase in installed wind capacity until 2012. In 2009, as more generation wanted to connect, the grid operator, Scottish Hydro Electric Power Distribution (SHEPD) introduced an innovative Active Network Management (ANM) system to allow generation to connect to the grid without substantial upgrades being necessary but at the operators own risk of their generation being limited due to network constraints. However, in 2012, SHEPD imposed a moratorium on all new generation due to increasing constraints. Despite this, Orkney is more than self-sufficient in electricity from renewable sources, and on average, over a year and depending on the output of the generators operating in any year, is estimated to export up to about 30% more electricity than it consumes.

The largest contribution to Orkney's decrease in emissions associated with electricity generation is from wind turbines. Figure 1 shows the growth in wind turbine installed capacity, split by large (above 50 kilowatt (kW)) and small scale (below 50kW). Orkney has more small-scale wind turbines than any other local authority area in the UK accounting for 11% of the UK's installed capacity of this size (Ofgem, 2019b).

It is estimated that the annual energy generation from large scale wind turbines is 161.33 GWh (from the current installed capacity of 44.7 MW). A further 19.7 GWh is estimated to come from the current installed capacity of 5.92 MW small wind turbines.

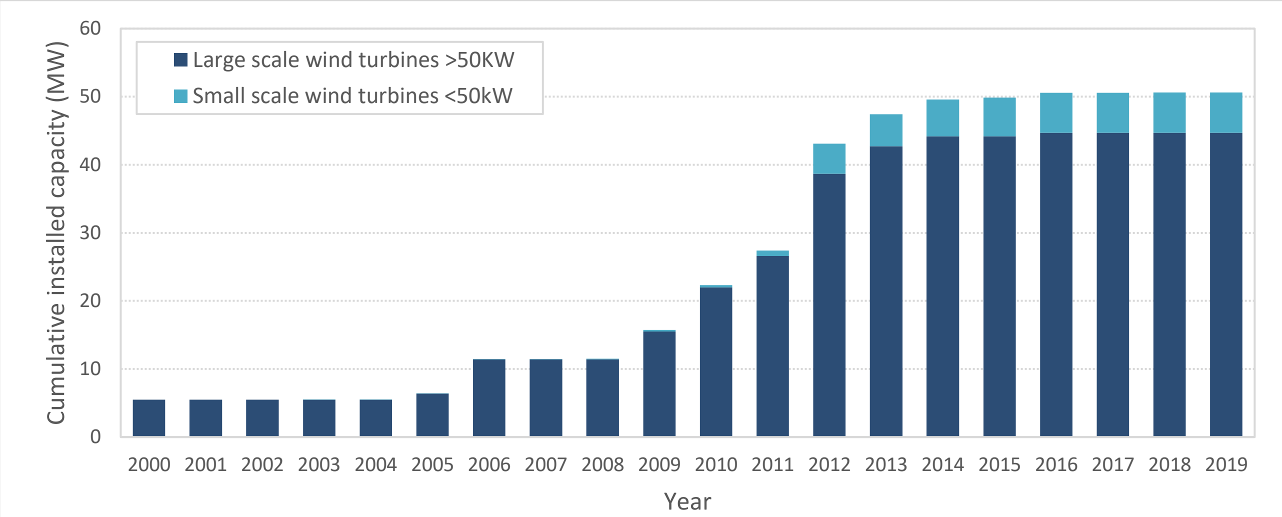


Figure 1 Cumulative installed capacity of wind turbines in Orkney

In addition to wind energy, there is also renewable energy generation from solar photovoltaic (PV), hydro and from wave and tidal technologies being tested at the European Marine Energy Centre ("EMEC") testing facilities. As a test centre the output in any year can be very variable, but also significant. For example, in September 2017 the Orbital Marine Power's (OMP, and formerly Scotrenewables) 2 MW prototype SR2000 tidal turbine generated over 116 MWh (0.116 GWh) in less than a week, providing around 7% of Orkney's electricity consumption over that time (EMEC, 2020).

Solar PV installations amount to about 1.4 MW of installed capacity (Ofgem, 2019b), with an estimated annual energy generation of 1.19 GWh of Orkney's energy.

There is one hydro scheme in Orkney with a total installed capacity of 11 kW, located at Woodwick Mill, and generating electricity since 2015. The estimated annual energy generation is 0.03 GWh.

There are two non-renewable power sources that feed into the Orkney electricity grid. Kirkwall Power Station ceased regular operation of its diesel generators in the late 1990's and now provides a back-up source of electricity.

Flotta Oil Terminal has the capacity to use gas extracted from the crude oil as well as diesel for on-site heat and power generation. As the terminal has its own grid connection it is able to export electricity during periods of high gas availability. In 2019 it exported about 16.1 GWh of electricity.

In total, it is estimated that 138.1 GWh or 18.3% of Orkney's energy comes from electricity.

Table 1.1 Orkney's energy use by fuel

Fuel	GWh	% of total GWh	Tonnes of CO_2	% of total tonnes of CO_2
Road diesel	86.1	11.4%	21,452	11.1%
Petrol	43.6	5.8%	10,440	5.4%
Kerosene	117.3	15.5%	28,788	14.9%

Fuel	GWh	% of total GWh	Tonnes of CO_2	% of total tonnes of CO_2
Electricity	138.1	18.3%	38,188	19.8%
Coal and Coal-Based Products	8.2	1.1%	2,579	1.3%
LPG	0.8	0.1%	174	0.1%
Peat	0.5	0.1%	178	0.1%
Jet A-1	22.4	3.0%	5,494	2.8%
AV gas	1.3	0.2%	312	0.2%
Gas Oil	197.4	26.1%	50,030	25.9%
Gas oil and sulphur free gas oil	140.1	18.5%	35,526	18.4%
Grand Total	**755.7**	**100.0%**	**193,160**	**100.0%**

Energy Storage

Energy may be stored in number of ways such as electro-chemically (e.g. batteries) in pure chemical form (e.g. hydrogen) or thermally (e.g. hot water tanks or storage heaters). There has been rapid development in battery technologies in recent years with variants in the lithium-ion (or Li-Ion) concept becoming widely available from small/domestic scale, through their use in electric vehicles to larger, utility scale applications.

In December 2018 Solo Energy launched a first of its kind housing project in Kirkwall, where 30 homes were built with either solar photovoltaic (PV) plus in-home battery storage assets (16 homes) or solar PV plus smart immersion controllers (14 homes). The houses with battery assets allow residents to make use of renewable energy throughout the day not only restricted to when the sun is shining. Whereas the houses with smart immersion controllers can divert excess energy produced by the solar PV into their hot water tanks. The batteries can also import, via the connection to the grid, and store, some electricity from Orkney's wind resources.

As a response to the limitations of insufficient grid capacity innovative hydrogen projects are also under development in Orkney including Surf 'n' Turf and BiGHIT (Building Innovative Green Hydrogen Systems in an Isolated Territory) which aim to produce, store and transport hydrogen from curtailed electricity. The Surf 'n' Turf project uses electricity produced from tidal turbines connected to EMEC's Caldale site on Eday, and the community-owned 900kW wind turbine to produce hydrogen via an electrolyser. After transportation to Kirkwall harbour, using a fleet of mobile storage units (MSU), the hydrogen is used to provide shoreside power (via a fuel cell) to some of the inter-island ferries that dock overnight. The BiGHIT project builds on the Surf 'n' Turf project. It introduces further elements including hydrogen use in heating and transport, along with additional production of hydrogen from an electrolyser powered by electricity from Shapinsay's 900kW wind turbine.

Energy Uses

The main uses of energy in Orkney are buildings, road transport, marine transport including ferries, industry and agriculture and flights both inter-island and to the mainland, summarised as follows:

Buildings

Buildings account for the largest share of Orkney's energy use at an estimated 264.3 GWh, or almost 35%. The bulk of this is electricity at 138.1 GWh, or 54% and Kerosene at 117.3 GWh, 46%. Kerosene is mainly used for heating, with the vast majority (over 90%) used in the domestic sector, followed by the commercial and public administration sectors. Data has been collated from the UK Government department for Business Energy and Industrial Strategy (BEIS) sources.

Buildings also use a small amount of coal and coal-based products, peat and LPG, mainly for heating. Highland Park use peat in the whisky making process.

The BEIS data shows that the electricity consumption across Orkney has generally remained constant with slight decreases over the last 12 years. Domestic electricity consumption accounts for around 59% of the use.

Road Transport

This accounts for approximately 130.2 GWh or just over 17% of Orkney's energy use, with the highest proportion used in diesel cars and light goods vehicles, followed by petrol cars. Again, BEIS data has been used to estimate local usage but does not cover the use of biofuels, liquified petroleum gas (LPG) or electricity. Over the last decade or so, there has been a steady increase in energy used for road transport, with a continued fall in fuel consumption by petrol cars and a trend towards diesel cars. Personal travel is estimated to account for the majority of the use, at about 63%. A very small amount (0.6 GWh or just under 0.5%) of road transport energy use is for electric vehicles but this has been steadily increasing and set to undergo rapid growth as electric vehicles increasingly replace diesel and petrol-powered vehicles, and the network of charging infrastructure becomes more widespread.

Marine Transport

Marine transport includes towage vessels and interisland ferries operated by Marine Services, a division of Orkney Islands Council (OIC), ferries to the Scottish mainland, together with other users such as fishing, aquaculture, marine renewables, oil and gas industry and cruise liners. It has not been possible to accurately establish fuel use for these other users, in part due to data being commercially sensitive and tracking where fuelling takes place and allocating an amount to Orkney. Also, the BEIS data does not provide a sufficient breakdown by sector and fuel use to calculate with accuracy the allocation across marine transport, industry and agriculture, so whilst the total amount of energy used in Orkney is considered an accurate estimate, an accurate allocation across these 3 sectors is not possible at present.

Of the marine gas oil used by Marine Services, 40.5 GWh, or just over 5% of Orkney's total energy use, the majority, around 78% is used in the ferries, followed by towage, at 17%, with the balance of 5% used in harbour craft.

The mainland ferries include three Northlink (vehicle) ferries, the Pentland (vehicle) ferry and the John O'Groats passenger ferry. Two of the Northlink ferries are shared services with Shetland, with Kirkwall being an intermediate call on this service. The energy usage allocated to Orkney from this service has therefore been amended to reflect this. Overall, it is estimated that around 13%, or 101.5 GWh, of Orkney's energy usage is in respect of ferries to the mainland of Scotland.

Air Transport

It is estimated that 23.7 GWh or just over 3% of Orkney's energy use is for air transport, both for flights off Orkney, to the Scottish mainland and for a small number of interisland flights. The vast majority, around 95%, is used for off-island flights. It has not been possible to get data on refuelling in Orkney or off-island, so an estimate of fuel use has been made from BEIS data on passenger emissions per km, using standard conversion factors.

Other Energy Uses

The vast majority of the remaining energy consumed in Orkney is estimated to be used in the agriculture sector, other marine transport users, industry and in crude oil processing, at the Flotta Oil Terminal. In total, this is estimated to amount to 195.5 GWh, or 25.8%, with the Flotta Oil Terminal accounting for 55.4 GWh or 28.3% of this. As noted above an accurate allocation beyond this is not possible.

Table 1.2 below gives a breakdown of the total GWh used, and tonnes of carbon, for each sector.

Table 1.2 Orkney's energy use and carbon emissions by sector

Sector	GWh	% of total GWh	Tonnes of CO_2	% of total tonnes of CO_2
Road transport	130.2	17.2%	32,045	16.6%
Buildings	264.3	35.0%	69,754	36.1%
Aviation	23.7	3.1%	5,805	3.0%
Marine transport	142.0	18.8%	35,991	18.6%
Industry	55.4	7.3%	14,039	7.3%
Industry, Agriculture & Marine transport	140.1	18.5%	35,526	18.4%
Total	**755.7**	**100.0%**	**193,160**	**100.0%**

Orkney Energy Flows & Carbon Emissions (Sankey diagrams)

The following Sankey diagram[3] (Figure 2) shows how each of the energy sources are used by sector and end use. The GWh values were then converted to carbon dioxide emissions using standard conversion factors[4] for each of the fuels represented to estimate the total annual carbon emissions for Orkney (Figure 3).

Note that for some of these energy sources the figures in the Sankey diagram do not represent a complete picture of the total energy usage in Orkney due to various limitations in collecting data. These figures should therefore be used with caution and are intended only as a broad scale estimate of the energy situation in Orkney. There are also energy flows not represented here due to lack of data[5]. Also, note that in in some instances the subcategories may not add up exactly to the category total due to rounding.

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[3] A Sankey diagram is a graphic illustration of flows - like energy, material, or money - where they can be combined, split and traced through a series of events or stages. The width of each stream represents the amount of material or energy in the flow.

[4] Standard conversion factors were taken from the Digest of United Kingdom Energy Statistics 2018 (BEIS, 2018c), except for Peat (Simmons, 2000) and electricity (BEIS, 2019b) and are as follows for each fuel in Tonnes CO_2 per GWh: Domestic coal - 315, LPG - 214, kerosene - 245, Jet A-1 - 245, AV Gas – 238, Petrol - 239, Road diesel - 244, Gas oil and sulphur free gas oil - 254, Peat – 379 and Electricity – 277. Note that carbon emissions are done from the raw sources rather that the rounded figures shown in the summary tables and Sankey diagram.

The UK emission factor for electricity (277 tCO2/GWh (BEIS, 2019b) is used in the following Sankey diagram to give an estimate of the carbon emissions associated with grid electricity consumed in Orkney. The rationale behind using the UK figure (as opposed to equivalent figure published for Scotland or estimates produced for Orkney), is that the services required to keep the grid running are procured from all over the UK, and also to allow comparison across different geographic areas of the UK on a consistent basis. Emission factors calculated for grid electricity in Scotland are much lower at 24 tCO2/GWh (Scottish Government, 2019) and estimates of Orkney grid electricity even lower at 17 tCO2/GWh (OREF estimate). Using these figures would reduce the total carbon emissions from 38,188 tCO2 to 3,313 and 2,347 tCO2 respectively.

[5] There are also energy flows not represented here due to lack of data, notably those associated with Kirkwall Power Station, curtailed energy, energy stored as hydrogen or in batteries, self-consumption of energy, energy produced by heat pumps, biomass/biofuels, fuel other than gas oil used at Flotta Oil Terminal, crude oil exported from Flotta Oil Terminal, and crude oil transferred during ship-to-ship transfers in Scapa Flow.

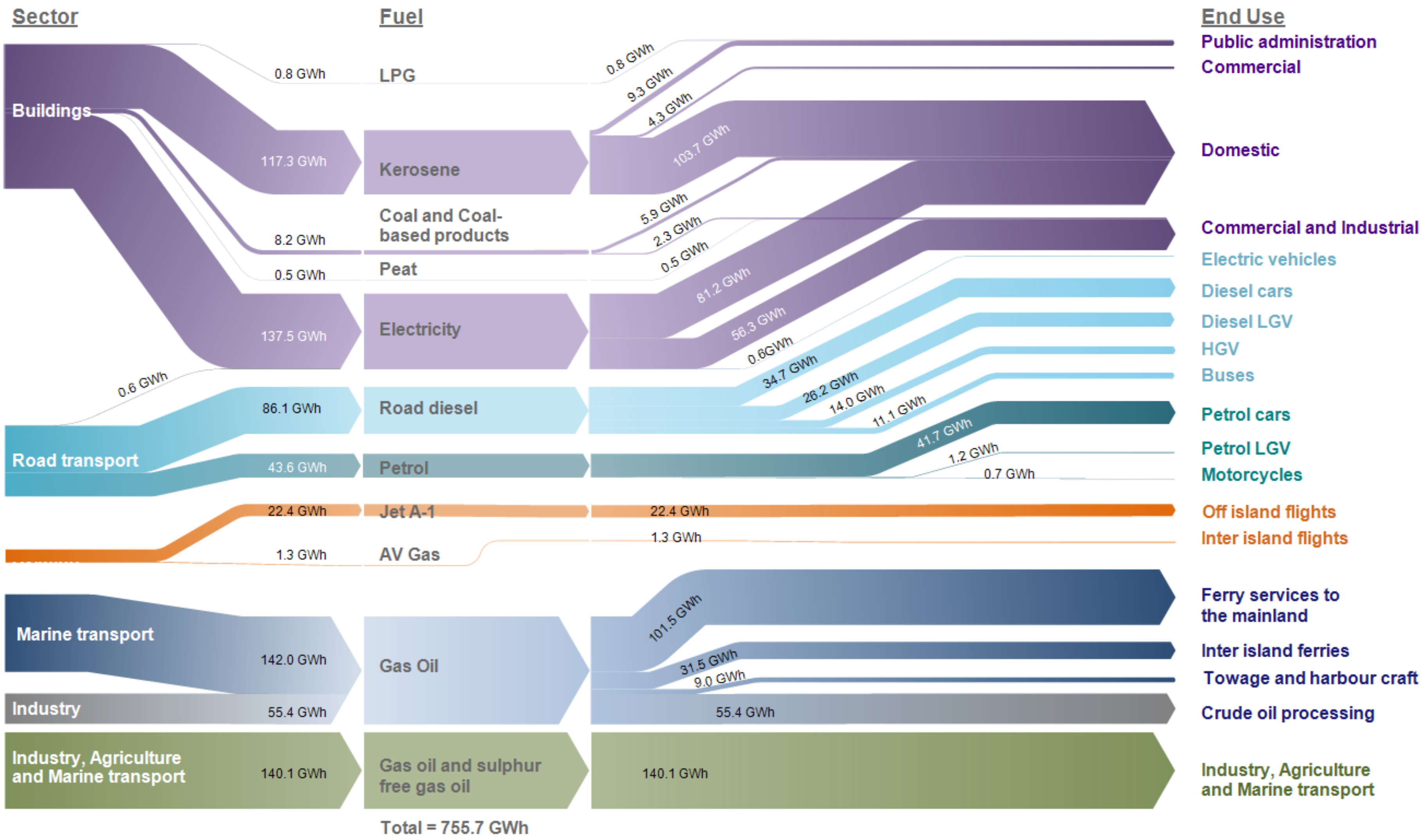

Figure 2 Sankey diagram showing Orkney's energy use by sector and end use (GWh)

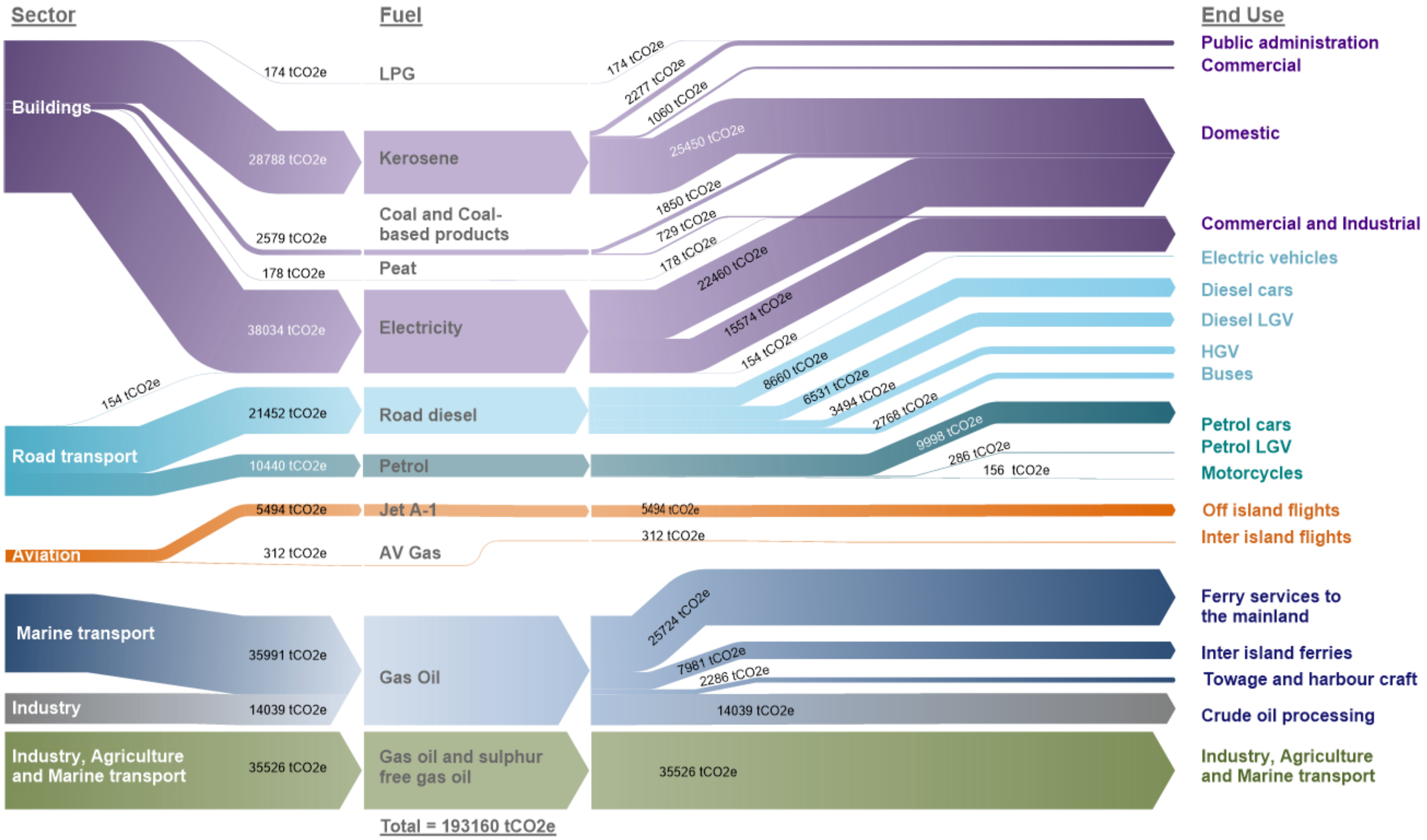

Figure 3 Sankey diagram showing Orkney's carbon emissions use by sector and end use (Tonnes of CO_2)

Socio-Economic

Within a separate section of the Audit selected indicators have been included to provide a socio-economic background for Orkney, as a reference against which any wider social, economic or environmental effects can be measured as the energy systems continue to develop.

The 2018 population estimate shows, at 22,190, that Orkney has the lowest population out of all 32 Scottish local authority areas, whilst experiencing a 13.3% increase in population since 1998, relative to a Scotland average change over that period of around 7%. The highest proportion of the population is in the 45 to 64 age group, with 9% being in the 16 to 24 age group. The number of households has increased by 26% between 2001 and 2018, compared to a Scottish wide increase of 12.9%, with 60% of dwellings being detached houses (21% for Scotland as a whole).

Orkney is home to some of the highest rates of fuel poverty and extreme fuel poverty in Scotland with 31% of households in fuel poverty and 22% of households in extreme fuel poverty. This compares with figures of 26% and 12% respectively for the Scottish average. There are particular circumstances that can increase the likelihood of living in fuel poverty which are accentuated in rural areas. Fuel poverty also disproportionately affects older households and rural areas generally have a greater percentage of 'older' households with one or more householder of pensionable age. This pattern applies to Orkney. Data from the Scottish Housing Condition Survey 2015-2017 reveals the housing stock in Orkney is generally less energy efficient than in the rest of Scotland. The absence of a mains (natural) gas connection, the additional costs associated with importing, and a restricted range of suppliers, all mean fuel costs are also a factor.

In terms of health, the proportion of the adult population in Orkney living with a long term physical or mental health condition is 29% for 2017, marginally higher than the equivalent figure for Scotland, at 28%.

In education, 43% of the female adult population in Orkney hold some form of Higher Education, including a degree, professional qualification, HNC/HND or equivalent, a very similar level to the Scottish average, at 42%. However, for males the respective figures are 33% and 43%, and with 21% of the male population holding no qualification, compared with the Scottish average of 15%. Similar trends are found in other rural areas, patterns possibly driven by the migration of people away from these communities after achieving qualifications.

In terms of economic indicators, Orkney has an economically active rate of 90.4%, compared with a Scottish average of 77.8%, with an unemployment rate of just 2%, just under half the Scottish average, at 4.1%. Average pay rates are around 10% higher than the Scottish average, with the most common income bracket being £30,001 to £40,000, at around 23% of incomes, compared to around 15% for Scotland as a whole. Approximately 10,000 full-time and part-time jobs are supported by the Orkney economy, with the two largest being Human Health and Social Work Activities (17.5%, compared with a Scotland average of 16.3%) and Public Administration and Defence; Compulsory Social Security (12.5% Orkney, 6.4% Scotland).

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1 INTRODUCTION

1.1 PURPOSE AND AIMS OF STUDY

This audit has been commissioned, under the project ReFLEX Orkney, to update a previous report, Orkney-wide Energy Audit 2014 (Aquatera Ltd, 2015) and quantify Orkney's existing energy sources and energy uses in 2019 ("2019 Audit"). ReFLEX is short for 'Responsive Flexibility', and the project aims to create a 'smart energy island' - developing a ground-breaking 'integrated energy system' in Orkney, across the electricity, heat and transport networks, which will monitor generation, grid constraints and energy demand and then use smart control of energy technologies to manage and improve the supply-demand balance. It is funded over 3 years by United Kingdom Research & Innovation ("UKRI") through the Industrial Strategy Challenge Fund. This Audit will help inform the design of the project ReFLEX Orkney and provide a baseline set of data for measuring its performance against over the longer term.

The idea of transforming Orkney into a 'smart energy island' will demonstrate smart local energy systems of the future, reducing and eventually eliminating the need for fossil fuel usage across the isles to help combat climate change. It should also allow for more energy to be produced locally, from renewable energy sources, and decrease local energy costs to help tackle fuel poverty in Orkney.

This audit was prepared by Aquatera in conjunction with Community Energy Scotland.

1.2 BACKGROUND

In the last decade Orkney has firmly established itself as a centre for innovation and development in the renewable energy sector.

By 2014 Orkney was generating 104% of its annual electrical demand, a feat unmatched by any region in the UK. However local grid infrastructure could not keep up with this growth in generation and inadequate grid capacity would threaten the financial viability of established community energy schemes and the potential to develop further generating capacity in the future.

In response, OREF and Community Energy Scotland commissioned the Orkney-wide Energy Audit 2014 (Aquatera Ltd, 2015), which was carried out by local consultancy firm, Aquatera.

Now in 2019 the future development of Orkney's physical grid capacity is based on SHEPD's project to construct a new 220kV subsea cable connection between Orkney and Scottish mainland, providing an additional 220MW grid capacity.

This 2019 Audit is to further understand Orkney's current energy situation and what needs to be done in order to meet and exceed the targets set out in project ReFLEX Orkney, and ultimately, completely decarbonise Orkney's energy system.

1.3 SCOPE

The scope of this 2019 Audit includes both the energy generated, and consumed, within Orkney. Energy used for transport to, and from, mainland Scotland is allocated entirely to Orkney's energy use, as travel is normally to, and from, Orkney, not via Orkney. In some cases, where services are a stop off on the way to Shetland, assumptions have been described clearly where applicable. It aims to include details on all forms of energy such as electricity, oil, coal etc.

This audit is intended as a snapshot of the current energy situation so where possible the most recent data has been used. It should however be noted that not all the data sets cover the same period of time. In some cases, data may be presented over a number of years to help with explaining trends and for comparison.

1.4 AUDIT STRUCTURE

This audit seeks to provide an overview of the energy status of the islands and is split into four main sections:

- The first section 'Energy Sources' examines the current energy sources in the region. This includes all the energy produced in Orkney and exported, as well as the energy sources (fuel and electricity) imported into Orkney.
- The second section 'Energy Storage' gives an overview of any large-scale energy storage projects.
- The third section 'Energy Uses' examines the energy usage on the islands and how this is split been the major sectors.
- The fourth section 'Socio-economic Overview' focuses on Orkney's socio-economic indicators, providing the context within which the islands' energy profile exists

Data presented is given in the appropriate units for the energy source and subsequently converted into GWh for consistency and ease of comparison. Separately, relevant conversion factors have then been applied to illustrate the equivalent in CO_2 emissions. Information on all these conversion factors is included in Appendix A.

1.5 PREVIOUS STUDIES

A number of previous energy audits have been undertaken for Orkney. The first by the Northern and Western Isles Energy Efficiency Advice Centre (NWEEAC), part of the Orkney Islands Council (OIC), published in 2005 (Northern and Western Isles Energy Efficiency Advice Centre, 2005), the focus of which was on the quantification of local energy production and the balance of energy supplies imported from outside Orkney. Before this, a further two audits were undertaken in years 1991 and 1996.

More recently Aquatera was commissioned to undertake an audit and propose elements of a switching strategy for Orkney Renewable Energy Forum (OREF) (Aquatera Ltd, 2015). The work was undertaken in conjunction with Dr. Edward Owens from Heriot–Watt University, School of the Built Environment who provided Demand Side Management expertise.

The previous audits from 2005 and 2015 are available at: http://www.oref.co.uk/resources/orkney-energy-audit/

1.6 LIMITING FACTORS

The following were deemed to be limiting factors in the completeness of this audit:

- Difficulty of obtaining data from individual suppliers either unwilling or unable to provide data, or unable to do so in a to do so within the timeframe [6]
- Concern in the business community as to whether the overall approach of moving away from existing fuel types and behaviours would impact upon their current business.
- In cases where there are only one or two suppliers, commercial sensitivity of the data may mean that businesses are unwilling to share or allow their data to be published if it cannot be anonymized.

[6] Future updates may be able to include these gaps

The data in this audit has received appropriate approvals for its inclusion and dissemination. In some cases, parties that were approached deemed the information that was requested to be commercially sensitive and as a result this has either not been included, or the data has been presented in a way that does not directly link it to an individual or organisation. Where information is available but not accessible it has been identified as a data gap.

Due to these limiting factors certain assumptions in estimating the energy sources and uses were necessary. These have been highlighted throughout the body of this audit.

2 ENERGY SOURCES

2.1 INTRODUCTION

This chapter of the audit covers the energy sources that are imported into Orkney for use on the island as well as fuels and energy generated on the island.

2.2 IMPORTED FOSSIL FUELS

2.2.1 Coal and coal-based products

In Orkney, coal products are used largely for domestic heating purposes. Prior to 2015 the majority was imported into Orkney by bulk carrier (as shown in Table 2.1). Since then, all coal is now arriving into Orkney as freight on one of the ferry services. The two main coal merchants were also contacted to obtain data on the amount of coal imported as freight but were unwilling to provide data or unable due to commercial sensitivity. Modelled data from BEIS gives a much higher total for Orkney and is discussed further in Section 4.2.1.

Table 2.1 Bulk coal imports

Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Tonnes	2,898	3,873	3,641	2,443	1,437	1,486	985	1,122	1,067	1,001	914	0	981
GWh	24.3	32.5	30.5	20.5	12.1	12.5	8.3	9.4	9.0	8.4	7.7	0	8.2
Tonnes of CO_2	7,625	10,190	9,579	6,428	3,781	3,910	2,592	2,952	2,807	2,634	2,405	0	2,581

Source: OIC Marine Services

2.2.2 LPG

LPG (Liquefied/liquid petroleum gas), also known as propane or butane is a flammable mixture of hydrocarbon gases used as fuel in heating appliances, cooking equipment and vehicles. These mixes can be either mixes that are mostly propane, mostly butane, or mixes including both propane and butane. There is no mains gas distribution system in Orkney, but LPG is used in the islands, either as bottled gas or supplied by road tankers. In the past, there was a fuel pump in Orkney, for vehicles running on LPG, located at North End Garage in Stromness, but this is no longer in use.

OIC use LPG in a number of their properties (as detailed in Section 4.2.2) which comes into Orkney via tankers. There may also be other large users having LPG delivered by tanker, but no data has been collected on these and therefore, they have not been accounted for. Although data was received from one of the mainland ferry companies on the total imports over the past number of years it has not been possible to publish it here because of commercial sensitivity and there may be imports of these fuels on the other mainland service. Therefore, there figures in Table 2.2 do not represent a complete picture of the total LPG fuel usage in Orkney.

Table 2.2 LPG estimates for OIC properties

Units	2014/15	2015/16	2016/17	2017/18	2018/19
Litres	136,770	53,573	117,601	153,927	116,748
GWh	1.0	0.4	0.8	1.1	0.8
Tonnes of CO_2	204	80	175	229	174

Source: OIC

Bottles gas is also sold in Orkney but the individual suppliers of these products have not been willing to provide data (or in one case provided some historical data but not want it published) making it impossible to calculate a total annual energy supply figure for this fuel.

2.2.3 Kerosene

Kerosene is commonly used for commercial and domestic heating purposes. Kerosene is also called 28-second oil, heating oil or burning oil. The bulk of this comes in shipments, therefore data is available from OIC Marine Services, who have a record of fuel shipments coming into OIC's piers (Table 2.3). A considerably smaller amount is also imported as freight, in road tankers, when necessary.

Table 2.3 Bulk kerosene imports

Year	2016	2017	2018
Tonnes of Kerosene	8,007	7,917	9,139
GWh	102.8	101.6	117.3
Tonnes of CO_2	25,222	24,939	28,788

Source: OIC Marine Services

2.2.4 Petrol

Petrol in British English (also known as motor spirit, gasoline or gas in American English) is a petroleum-derived flammable liquid that is used primarily as a fuel for road transport. The data for bulk petrol imports, shown in Table 2.4, was obtained from OIC Marine Services.

Table 2.4 Bulk petrol imports

Year	2016	2017	2018
Tonnes of unleaded petrol	3,097	3,135	3,330
GWh	40.5	41.0	43.6
Tonnes of CO2	9,709	9,828	10,440

Source: OIC Marine Services

2.2.5 Road diesel

Diesel (also known as white diesel or DERV which stands for Diesel Engine Road Vehicle) or ultra-low sulphur diesel (ULSD) is primarily used as a fuel for road transport. The data for bulk diesel imports, shown in Table 2.5, was obtained from OIC Marine Services.

Table 2.5 Bulk DERV imports

Year	2016	2017	2018
Tonnes of DERV	6,713	6,800	6,780
GWh	85.2	86.3	86.1
Tonnes of CO_2	21,240	21,515	21,452

Source: OIC Marine Services

2.2.6 Gas oil and sulphur free gas oil

Gas oil (also known as 35-second oil or red diesel) is a low-duty form of diesel fuel. Red diesel is dyed red and chemically marked in order to easily detect its use. It is used extensively throughout the construction, civil engineering, agricultural, marine, leisure and commercial industries. It is also used in static diesel-powered machinery such as generators, pumps and industrial heating and cooling systems. Older domestic heating systems may also use red diesel.

The data for bulk gas oil and sulphur free gas oil (SFGO) imports, shown in Table 2.6, was obtained from OIC Marine Services.

Table 2.6 Bulk gas oil and sulphur free gas oil imports

Year	2016	2017	2018
Tonnes of gas oil	7,115	8,096	7,972
Tonnes of SFGO	5,828	6,898	6,383
Total Tonnes	**12,943**	**14,994**	**14,355**
GWh of gas oil	89.5	101.9	100.3
GWh of SFGO	73.3	86.8	80.3
Total GWh	**162.8**	**188.7**	**180.6**
Tonnes of CO_2	**41,288**	**47,831**	**45,792**

Flotta Oil Terminal also uses gas oil (diesel). The bulk gas oil imports shown in Table 2.8 are supplied directly to the Oil Terminal via supply vessel. This usage is in addition to the bulk gas oil imports as shown in Table 2.7 as it is supplied directly to the Oil Terminal.

The Oil Terminal primarily uses gas extracted from the crude oil with gas oil as a back-up fuel for onsite heating and power generation. Normal operations do not require the use of gas oil but when the Terminal is gas deficient around 40 tonnes per day of gas oil can be used.

Table 2.7 Gas oil usage at Flotta Oil Terminal

Year	2017	2018	2019
Tonnes	1,842	4,139	4,401
GWh	23.2	52.1	55.4
Tonnes of CO_2	5,876	13,203	14,039

2.2.7 Aviation fuel

There are two types of aviation fuel used in Orkney, Jet A-1 and AV Gas. Jet A-1 (or aviation turbine fuel) is conventional kerosene-based jet fuel, whilst AV Gas (also known as aviation spirit) is a high-octane alternative used in lighter aircraft. The company providing aviation fuel at Kirkwall airport were contacted but were not willing to provide details of the aviation fuel provided to the airport. They did confirm however that for flights to and from mainland Scotland, most refuelling happens outside of Orkney. This is not to be the case for the inter-island flights (Table 2.8).

An estimate of the amount of aviation fuel used for all flights to and from Orkney has been made based on passenger numbers for domestic (CAA, 2018) and short haul flights and from information from Loganair for inter-island flights (as detailed in section 0).

Table 2.8 Estimated aviation fuel use for inter-island flights, domestic and short haul flights

	Orkney Inter-island Flights	Domestic and short haul flights
Units	**AV Gas**	**Jet A-1**
Litres	140,000	2,181,744
Tonnes	100	1,774
GWh	1.3	22.4
Tonnes of CO_2	312	5,494

2.2.8 Crude oil

Flotta oil terminal

The Flotta Terminal, commissioned in 1977, is a crude oil storage and processing facility. Crude oil is imported to Flotta Oil Terminal from several offshore installations through a subsea pipeline fed by the following North Sea oil fields: Sinopec Operated fields; Claymore, Scapa, Piper 'B', Tweedsmuir, Tartan, Highlander, Duart, Petronella, Galley and Nexen's operated Golden Eagle field.

The design maximum plant flow rate of the processing facility is 375,000 barrels per day (bbl/d) (REPSOL SINOPEC, 2017). The Flotta blend total production in 2012 was approximately 50,000 bbl/d (A Barrel Full, 2014a). The storage capacity of the facility is 3.5 million barrels (A Barrel Full, 2014b).

Since the mid-nineties there has been a decline in the volume of crude oil exported from Flotta up until 2013 as shown in Figure 2.1. There was an upturn in 2017 when 4.6 million tonnes of crude oil was exported, declining again to 3.1 million tonnes in 2018 (Fisher Associates, 2019).

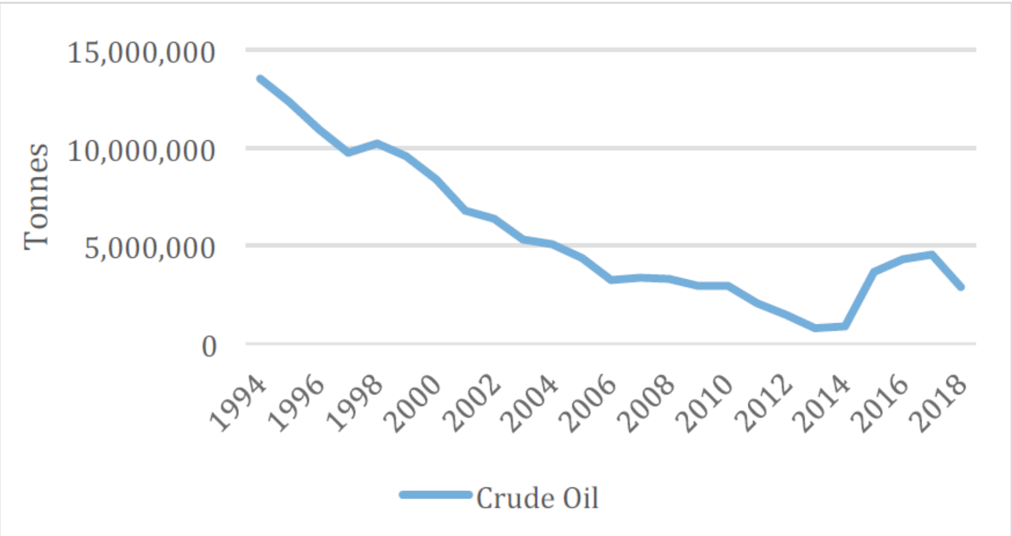


Figure 2.1 Volume of crude oil exported from Flotta

Ship-to-ship transfers

Ship-to-ship (STS) transfers of crude oil (as well as LNG and LPG) are carried out within Scapa Flow. The number of ship-to-ship operations and volume of crude oil transferred has fluctuated over the past two decades as shown in Figure 2.2. 2018 saw the highest number of transfers and volumes recorded since operations began – 66 operations involving the transfer of 4.8 million tonnes of oil (Fisher Associates, 2019).

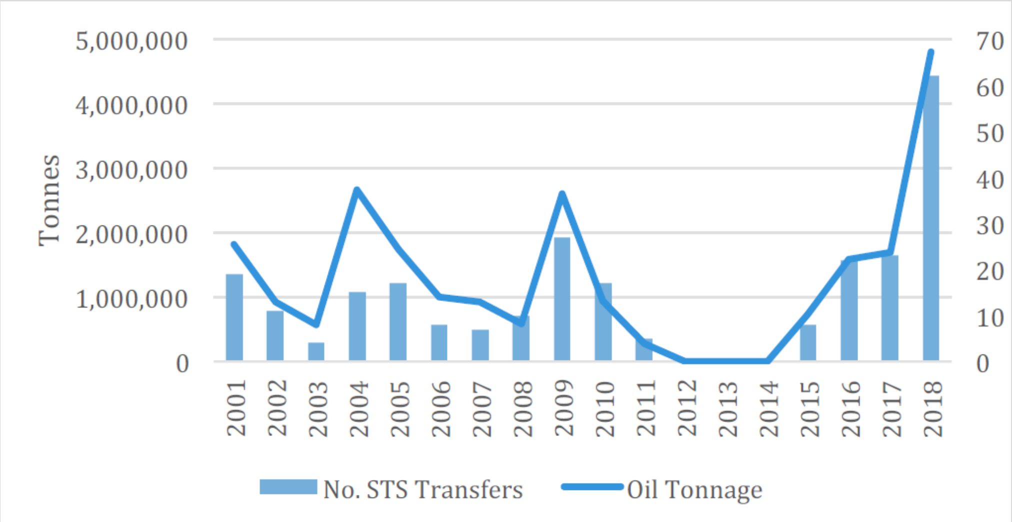


Figure 2.2 Ship-to-ship transfers and crude oil volumes transferred

2.3 INDIGENOUS FUELS

2.3.1 Peat

Peat has been used as a fuel for centuries and is still used as a fuel source in Orkney for some domestic heating, as well as in the whisky making process. The amount cut for domestic use is difficult to estimate as no records are kept but anecdotal evidence suggests that domestic use of peat has decreased to a low level.

Highland Park uses peat in the whisky making process and is licensed to cut a maximum of 300 tonnes of peat per year. Currently they cut considerably less peat than that amount following significant improvements to efficiency within the distillery. The amount of peat cut varies by year, depending on production levels. In 2018 (Table 2.9), 99 tonnes of peat were cut for use in Highland Park.

Table 2.9 Estimated peat in the whisky making process

Unit	2018
Tonnes	99
GWh	0.47
Tonnes of CO_2	178

Source: Highland Park

2.3.2 Short rotation wood crops

The Agronomy Institute at Orkney College (University of Highlands and Islands, UHI) has carried out experimental trials on short rotation coppice (SRC) willow as a biomass crop since 2002, following interest from Orkney Housing Association

Ltd (OHAL). These trials have showed that biomass yields of around six oven dry tonnes (ODTs) per hectare per year are achievable in Orkney. It is too labour intensive to harvest and process SRC willow manually, and the cost of specialist machinery makes it uneconomic on a small scale. As such, there are no known short rotation wood crops in Orkney.

2.3.3 Anaerobic digesters

There is currently no anaerobic digester device operating on Orkney, although the Westray Development Trust, with financial support from the Scottish Community and Householder Renewables Initiative (SCHRI), sought to establish a facility on Westray in 2015. However, the project was cancelled following receipt of tenders which showed it was no longer financially viable.

2.4 IMPORTED BIOMASS

2.4.1 Biomass imports

A number of biomass products such as wood, wood pellets, Eco-logs are imported into Orkney but the individual suppliers of these products have not been willing to provide data making it impossible to calculate a total annual energy supply figure for these fuels.

2.5 ELECTRICITY

2.5.1 Description of the Orkney network and the ANM system

Orkney is currently connected to the national grid via two 33kV (~20MW) submarine cables, which allow for the import, and export, of electricity with the Scottish mainland depending on the level of local demand and generation. Within Orkney, the electricity network operates at 33kV and 11kV, and covers all the inhabited islands (See Figure 2.3).

In 2009 an innovative Active Network Management (ANM) system was set up in Orkney in order to allow operators to connect generation to the grid without substantial upgrades being necessary but at their own risk of their generation being limited due to network constraints. Not all generation in Orkney is connected under this system.

2.5.2 Grid connections

When an operator wishes to install a renewable generation technology larger than 3.68kW per phase (16A per phase) and connect to the grid, there is a need to gain approval from the Distribution Network Operator (DNO). In Orkney the DNO is Scottish Hydro Energy Power Distribution ("SHEPD"). There are three different types of connections, which are described in more detail below (SSEN, 2007). These include:

- Firm Generation (FG)
- Non-Firm Generation (NFG)
- New Non-Firm Generation (NNFG)

Firm generation (FG)

Operators with a Firm Generation (FG) connection are able to operate without constraint in the event of the loss of either one of the two submarine cables to the mainland. The amount of generation that can be connected in this way is based on the capacity of the smaller mainland submarine cable circuit (20MW) plus the minimum demand on Orkney. This amounts to a maximum of 26MW (based on a previous minimum demand condition of 6MW) (SSEN, 2007).

Table 2.10 List of generators with a FG connection in Orkney

Generator	Type	kW
Kirkwall Diesel Power Station	Diesel	15,000
Flotta	Gas	10,500
EMEC	Wave	7,000
Thorfinn Wind Farm (Burgar Hill)	Wind	2,700
Thorfinn Wind Energy Project (Burgar Hill)	Wind	1,500
Sigurd (Burgar Hill)	Wind	1,300
Total (not including Kirkwall Power Station)[7]		**23,000**

Non-firm generation (NFG)

Additional generation connection capacity has been made available under "non-firm" arrangements. These arrangements allow operators with a Non-Firm Generation (NFG) connection to operate as long as both submarine circuits are operational. 21MW of additional generation capacity has been realised by this method and has been allocated to contracted generators (SSEN, 2007). The Non-Firm capacity group has already been contracted, some of which have connected.

Table 2.11 List of generators with a NFG connection in Orkney

Generator	Type	kW
Spurness Wind Farm II	Wind	7,500
Burgar Hill Wind Farm - A	Wind	5,000
EMEC (Eday)	Tidal	4,000
Flotta Wind Farm	Wind	2,000
Gallow Hill, Westray	Wind	900
Northfield Wind Energy Project, Burray	Wind	850
Total		**20,250**

New non-firm generation (NNFG)

NNFG is actively managed based on the capacity available on the Orkney network due to load variation and diversity in output from existing Firm and Non-Firm Generators. This active management is part of SSE's Active Network Management project that aimed at allowing operators to connect generation to the grid without substantial upgrades being necessary. The original ANM project, completed in 2004, suggested that Orkney could accommodate 25MW of NNFG capacity. As noted above the ANM system monitors set constraint points on the electrical network in real time and controls ANM connected distributed generation that is classed as New Non-Firm Generation.

The principle of access used in the Orkney ANM system is Last-In First-Off (LIFO). This means that the generators that first contracted with the Distribution Network Operator (DNO) are given priority over access to the grid. This is known

[7] Kirkwall power station not included as it only operates as a backup to cover faults and system outages on subsea cables to the Scottish mainland and for regular maintenance.

as the priority stack (discussed further in Section 2.5.3 below). Generators lower down in the stack are given less priority to access the grid.

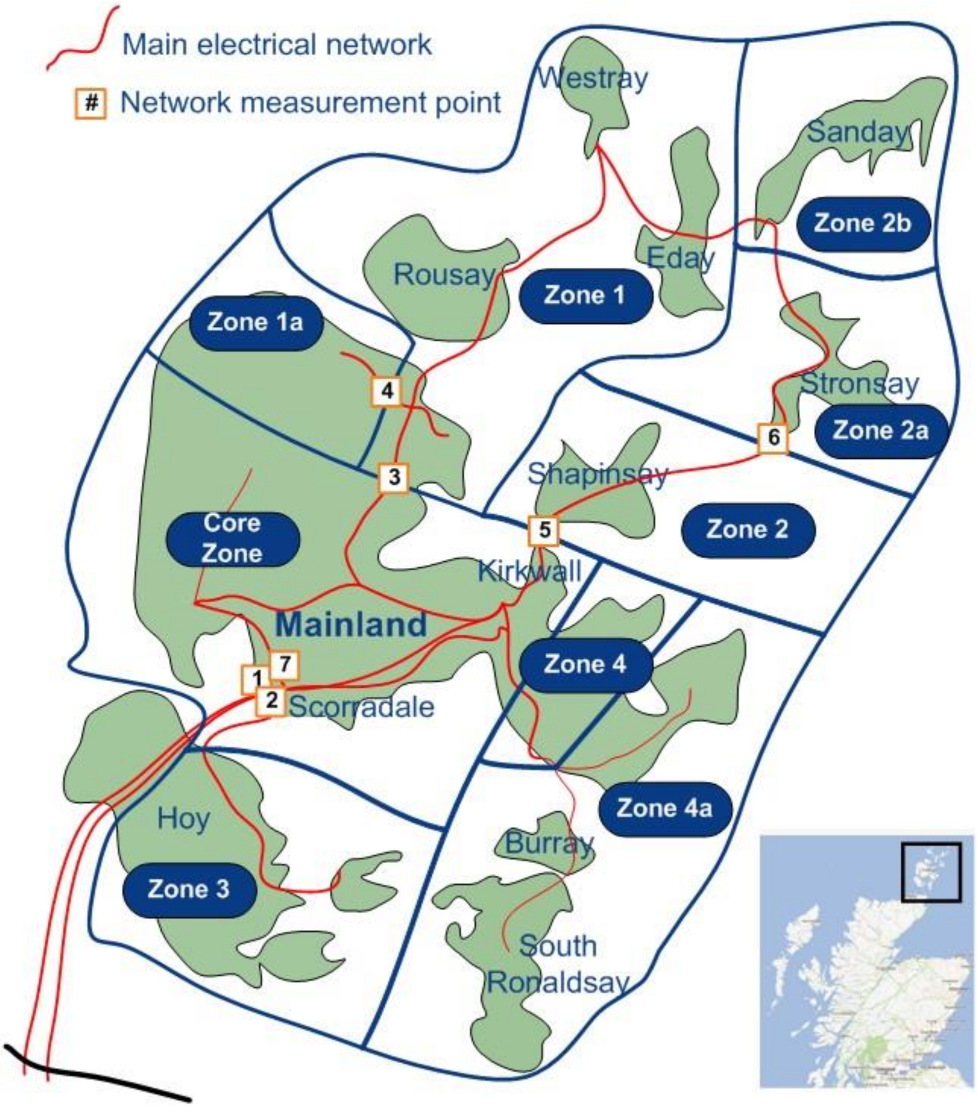


Figure 2.3 Orkney Distribution Network and ANM Zones

2.5.3 Curtailment

Curtailment estimation

Using wind data recorded at the location of some ANM wind turbine generators, and the power curves of the different NNFGs, the total un-curtailed generation of the ANM wind turbine generators was estimated. Comparing this estimation to the ANM NNFG actual generation data (obtained from SSEN[8] from 04/2017-12/2018), the shortfall, which represents the difference between the potential power output and the actual power output, was calculated:

$$\text{Shortfall} = \text{Potential Output} - \text{ANM Generation Output}$$

The shortfall between the potential and ANM output can be explained by the generators being curtailed due to grid constraint, as well as downtime for maintenance, or internal generator losses. Assuming that all NNFG are available to generate at all times, the curtailment can be calculated as follows:

$$\text{Curtailment } (\%) = \frac{\text{Shortfall}}{\text{Potential Output}} \, x \, 100$$

Table 2.12 shows the results obtained using the model for different periods of time. It can be observed that given the period, the results of the model vary significantly, with a range of curtailment from 14.7% in the financial year 2017/2018 to 16.9% for the calendar year 2018. This highlights the variation in the wind generation and the curtailment events from one period of time to another.

Table 2.12 Results of the curtailment estimation model over different periods of time

	Calendar year 2018	Financial year 2017/18	04/2017 to 12/2018
ANM generation (GWh)	70.184	78.873	126.722
NNFG Potential Energy generated (GWh)	84.480	92.417	151.269
Shortfall (GWh)	14.296	13.544	24.547
Curtailment (%)	16.9%	14.7%	16.2%

Considering that the ANM data used for this audit is limited, these figures can only be used as an order of curtailment in Orkney. Figure 2.4 represents the ANM total generation for the year 2018 as well as the shortfall between the potential energy output and the ANM output given by the model.

[8] Scottish and Southern Electricity Networks ("SSEN") is a trading name of Scottish Hydro Electric Power Distribution plc.

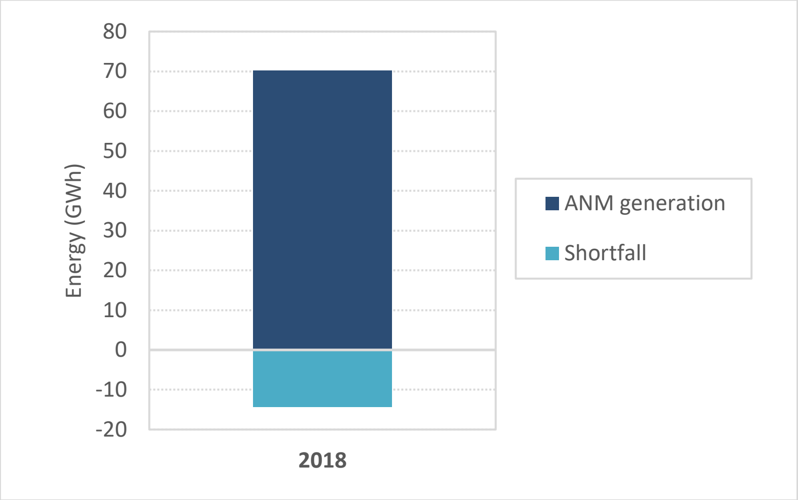


Figure 2.4 Total annual ANM generation and shortfall (2018)

Figure 2.5 shows the results of the model on the recorded ANM website data with monthly figures, the sum of shortfall representing the amount of electrical energy curtailed.

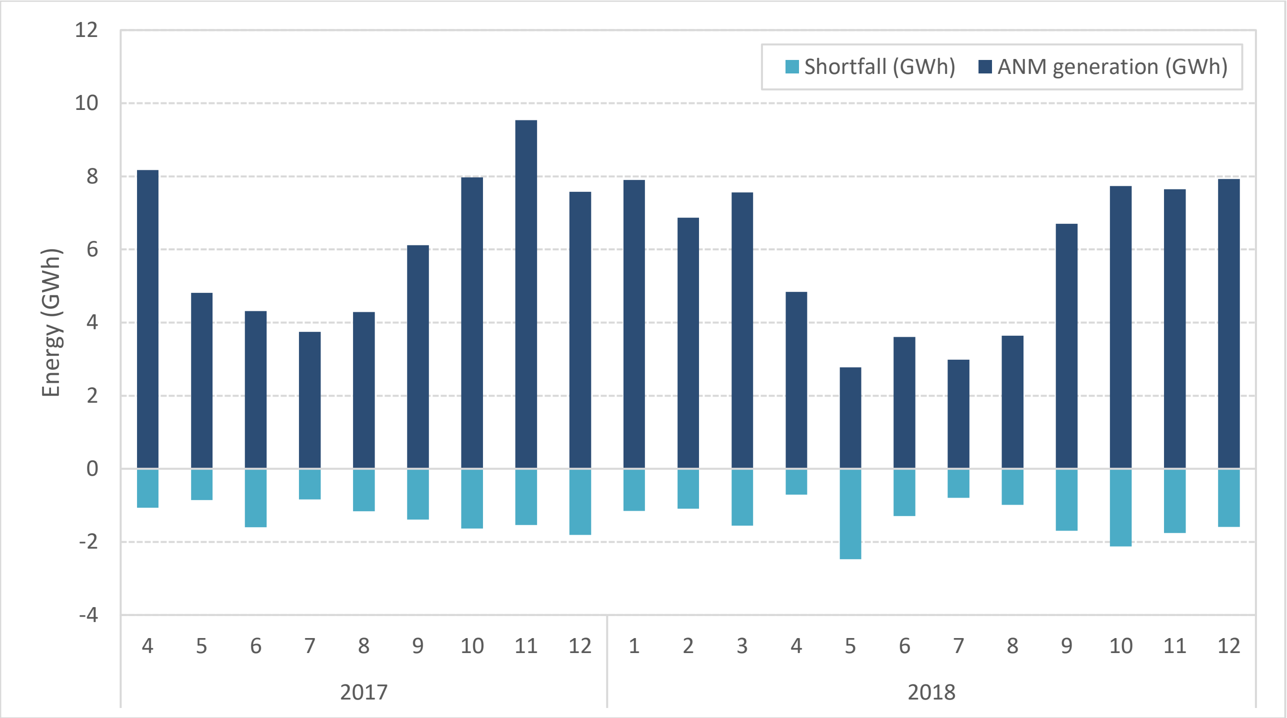


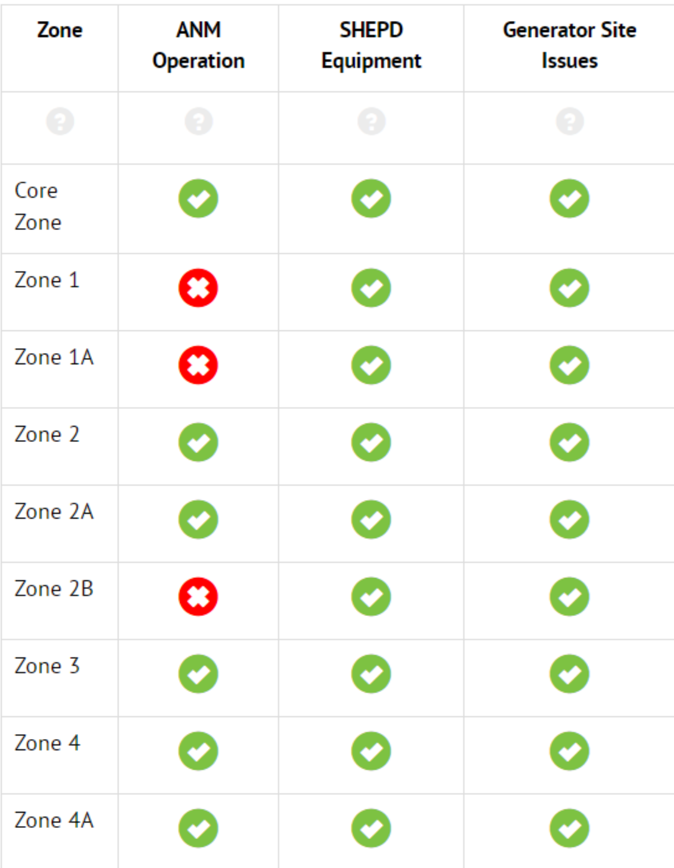
Figure 2.5 Total monthly ANM generation and shortfall (04/2017-12/2018)

Figure 2.5 also shows a seasonal trend over these two years of higher curtailment occurring in the autumn months when winds tend to be stronger but electricity demand is lower, than in the winter months when demand is higher.

Curtailment per zone

The estimate of curtailment in the previous section examines overall production for Orkney NNFG as a whole but, in reality, generators experience different levels of curtailment, as it is dependent on their position in the ANM stack and the zone in which they are installed. With the ANM stack applying to all NNFGs then overall the turbines at the bottom of the stack will be affected more than those at the top. In addition, curtailment is usually triggered by an alarm state at one of the 7 ANM measuring points associated with each ANM zone (See Figure 2.3) and the level of this activity varies between zones. As an example, generators installed in Zone 1 and 1a are more often subject to curtailment than generators in the core zone due to the capacity of the power lines.

To quantify the differences of occurrence in curtailment events across the zones, data collected from the ANM status webpage (SSEN, 2019) was used (Figure 2.6). The website gives the status of curtailment being "No Curtailment", "Marginal Curtailment" (one wind turbine generator is marginally curtailed) and "Full Curtailment" (at least one wind turbine generator is fully curtailed).



Zone	ANM Operation	SHEPD Equipment	Generator Site Issues
?	?	?	?
Core Zone	✔	✔	✔
Zone 1	✖	✔	✔
Zone 1A	✖	✔	✔
Zone 2	✔	✔	✔
Zone 2A	✔	✔	✔
Zone 2B	✖	✔	✔
Zone 3	✔	✔	✔
Zone 4	✔	✔	✔
Zone 4A	✔	✔	✔

Figure 2.6 ANM status webpage

Figure 2.7 shows the frequency of single and multiple turbine curtailment events in the different ANM zones from December 2018 until the end of August 2019. 'Multiple generator curtailment' events are events during which at least one generator is fully curtailed, meaning that potentially several other generators could either be fully or marginally curtailed. This data does not give an indication of the actual amount of power being curtailed, nor the number of generators involved.

It can be seen that over the recorded period, Zone 1, 1A and 2, 2A, 2B are most subject to "Multiple turbine curtailment" events, occurring more than 17.5% for Zone 1a and more than 19% of the time for Zone 2, 2A, 2B.

However, since one of the two 33kV export cables was out of service from early March 2019 until mid-July, the studied period is not representative of the normal levels of curtailment. The results show more curtailment occurring than normal, as well as a high number of curtailment events occurring in zones usually not subject to a high frequency of curtailment (Core Zone, Zone 3, Zone 4). This is clearly highlighted by comparing Figure 2.9, which excludes the period when the cable was out of service, with Figure 2.8; for example the 'Multiple generator curtailment' frequency for the Core Zone is reduced from around 15% (Figure 2.8) to 1% (Figure 2.9).

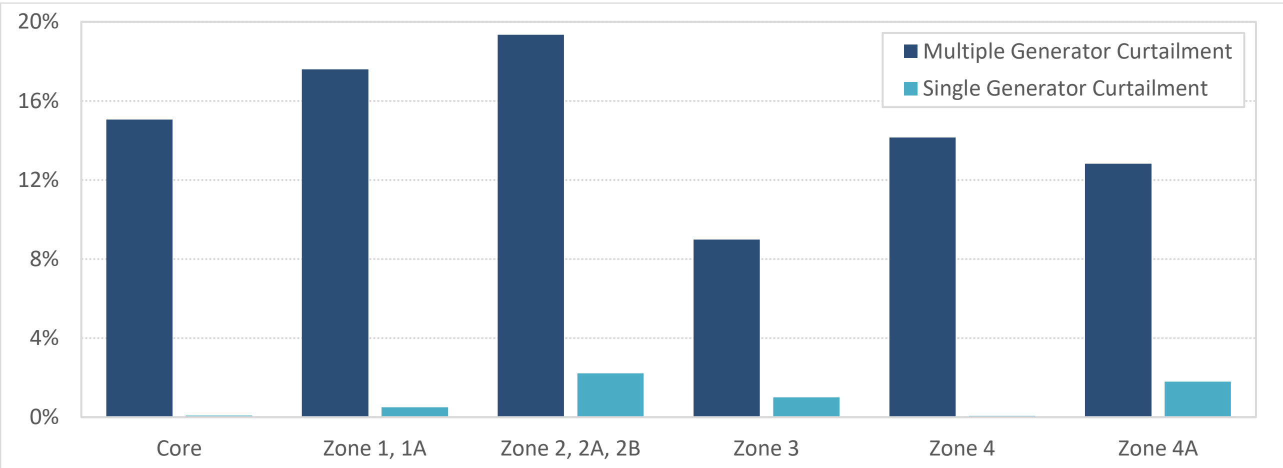


Figure 2.7 Frequency of curtailment events per ANM zone (01/12/2018-01/09/2019)

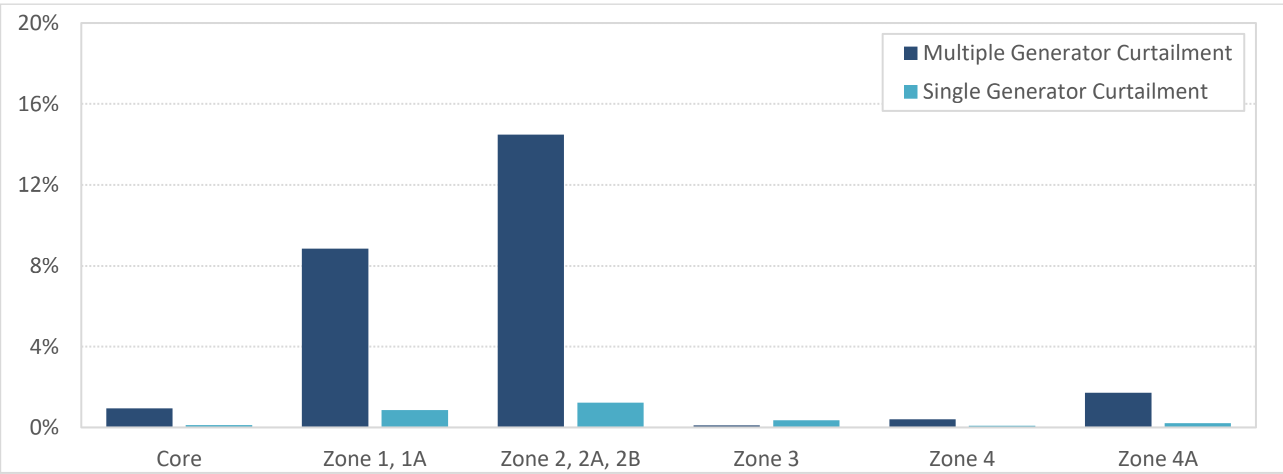


Figure 2.8 Frequency of curtailment events per ANM zone (01/12/2018-01/09/2019) excluding the period when the export cable out of service (03/2019-mid-07/2019)

Curtailment per generator

Data from individual turbines can be used to describe in more detail the patterns of curtailment experienced. This includes the level of occurrence of marginal and full curtailment, and the frequency and duration of curtailment events. The examples below have been taken from two actual turbines in Orkney that have been anonymised.

As an example, Figure 2.9 presents the duration of marginal and full curtailment events over a year for a turbine (named turbine A). The duration of the curtailment varies widely, from less than 2 minutes' events to between 5 and 12 hours' curtailment events. The marginal curtailment events of the wind turbine represent 25.9% of the total curtailment events for this year. Shorter curtailment events are more frequent than longer ones, but in terms of total duration of curtailment, longer events still account for most of the time the turbine is curtailed. Over the month of April, for example, the turbine has been curtailed (marginally and fully) for more than 100 hours in total.

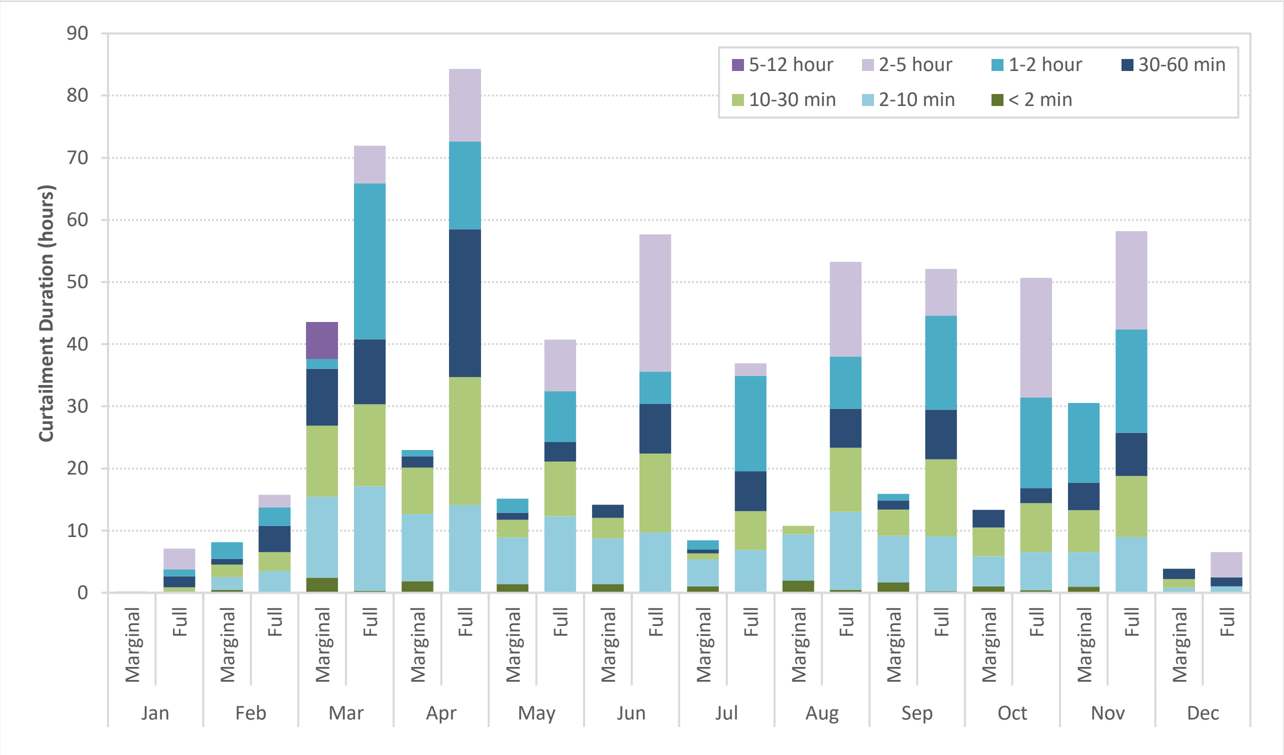


Figure 2.9 Annual marginal and full curtailment at turbine A during year 1

For the same year, the curtailment events' duration of another turbine (named turbine B), which is part of the same ANM zone, have been plotted in Figure 2.10. The marginal curtailment accounts for a bigger share of the overall curtailment events compared to turbine A, and the total curtailment duration for turbine B is less than for turbine A (around 61% of turbine A's total curtailment duration). From these observations, it is possible to conclude that turbine B is higher in the ANM stack than turbine A. This demonstrates the difference in curtailment that two wind turbines can experience within the same zone.

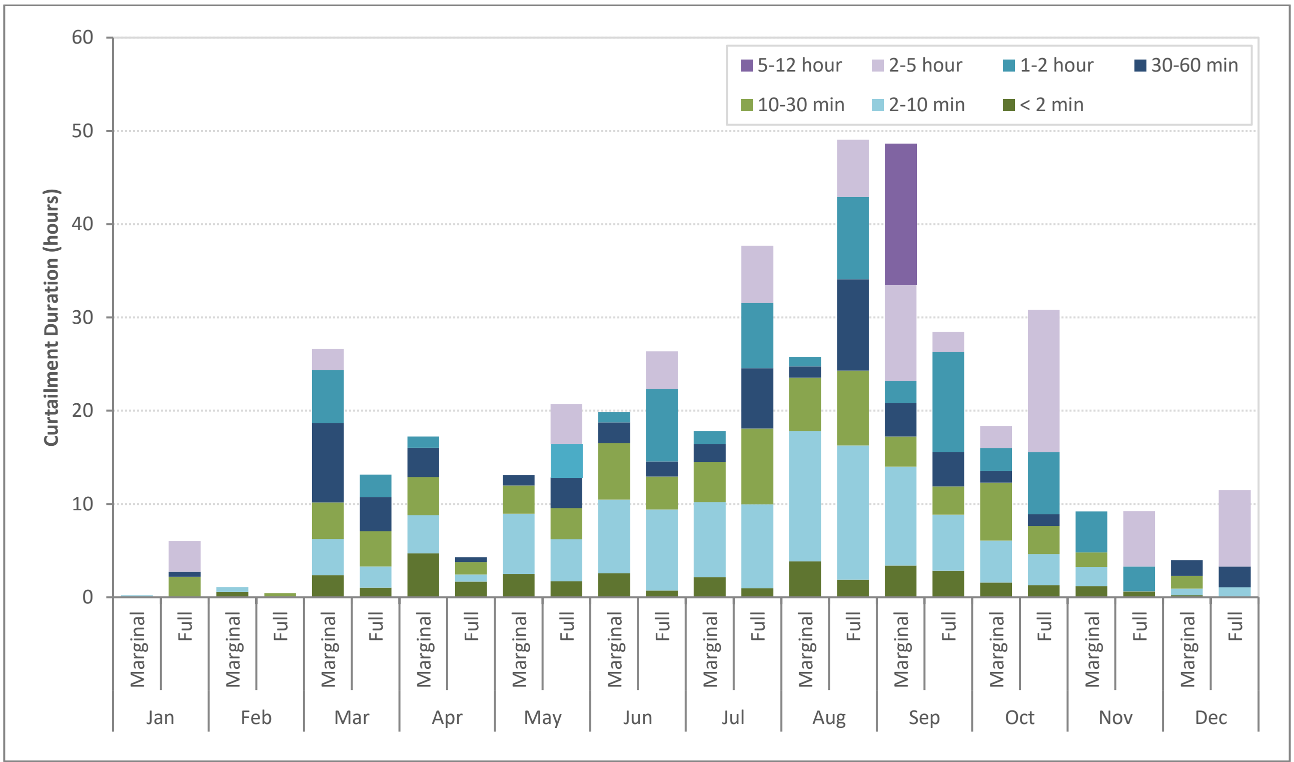


Figure 2.10 Annual marginal and full curtailment at turbine B during year 1

Figure 2.11 shows the monthly generation and shortfall generation of turbine A for the same year (year 1) as presented in Figure 2.9. Figure 2.12 shows monthly generation and shortfall generation of turbine A for another year (year 2), and that the overall level of generation has been lower in year 2.

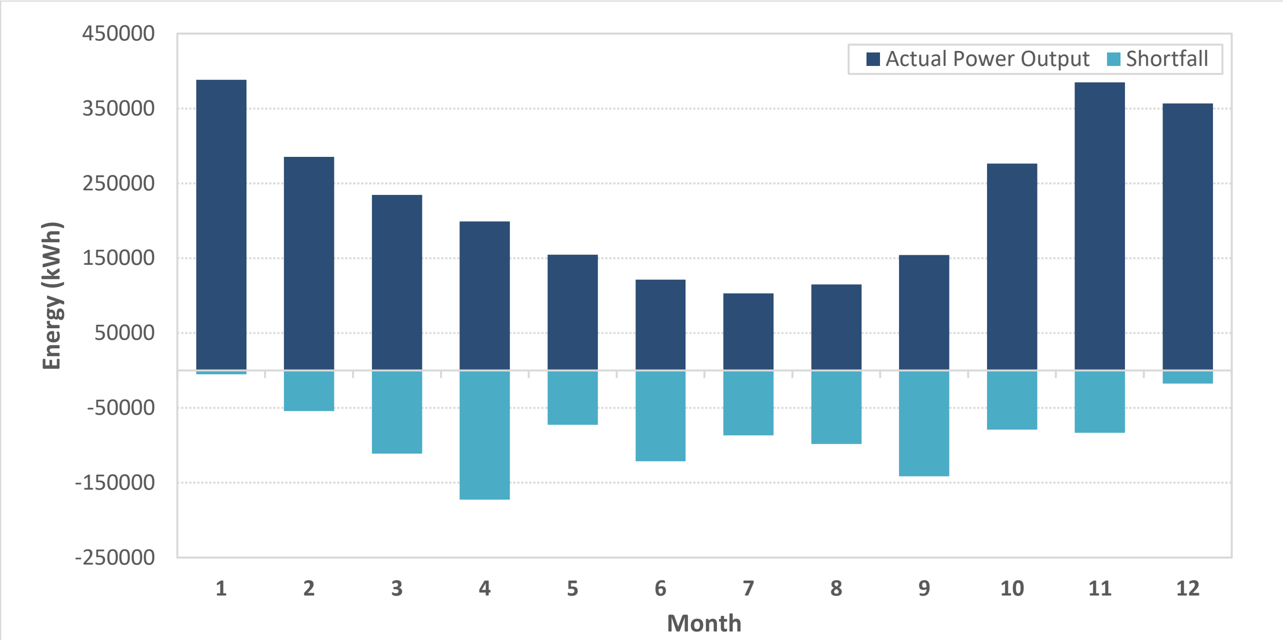


Figure 2.11 Monthly energy output and shortfall for wind turbine A during year 1

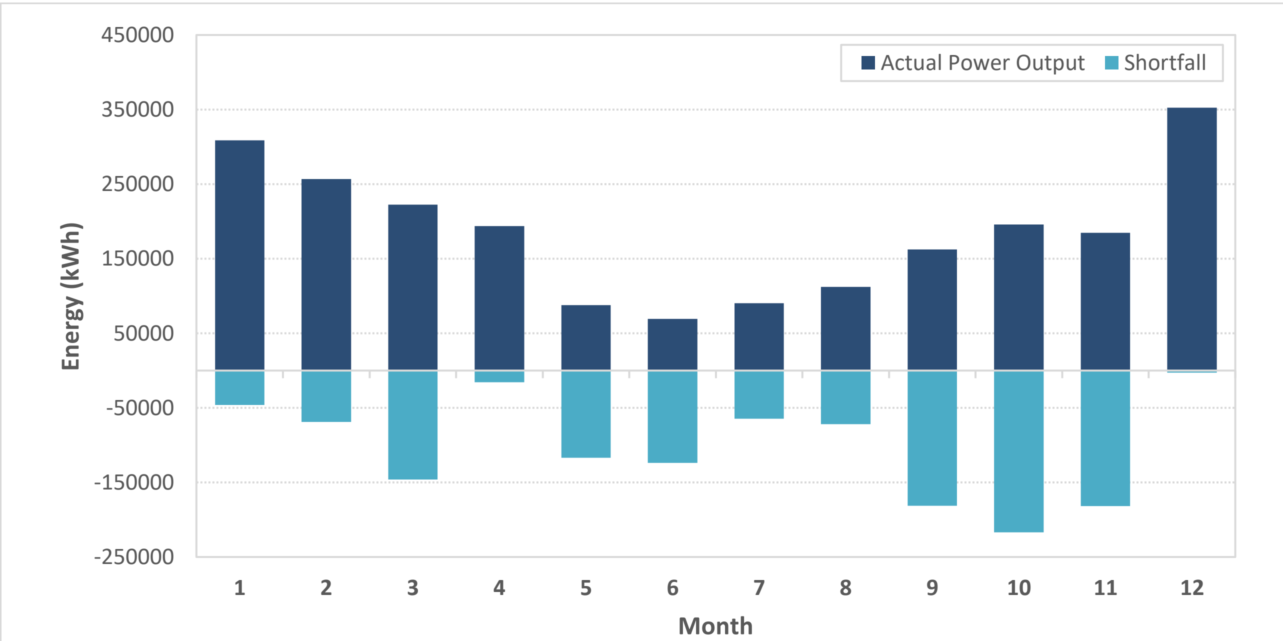


Figure 2.12 Monthly energy output and shortfall for wind turbine A during year 2

Figure 2.14 and Figure 2.13 present the annual energy output of wind turbine A and wind turbine B for three different years. Despite being in the same ANM zone, the shortfall of wind turbine wind turbine A is higher than wind turbine B, around 1GWh in each of the 3 years studied (Table 2.13).

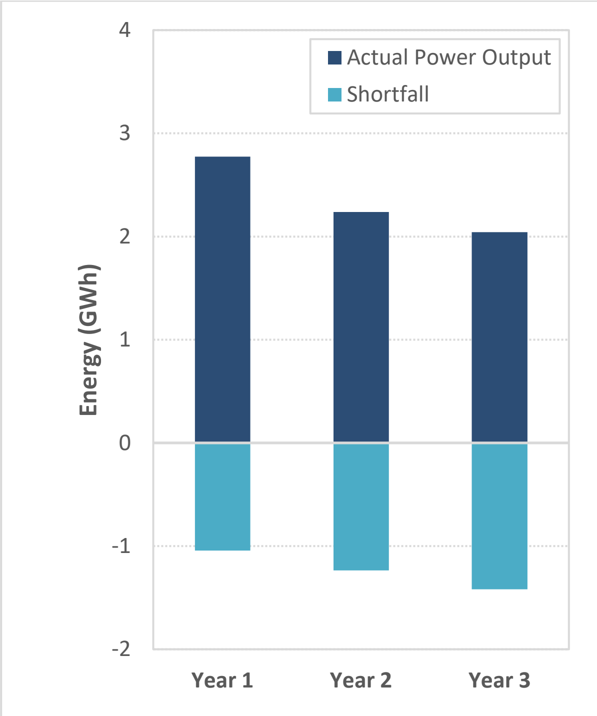


Figure 2.13 Yearly energy output and shortfall for wind turbine A

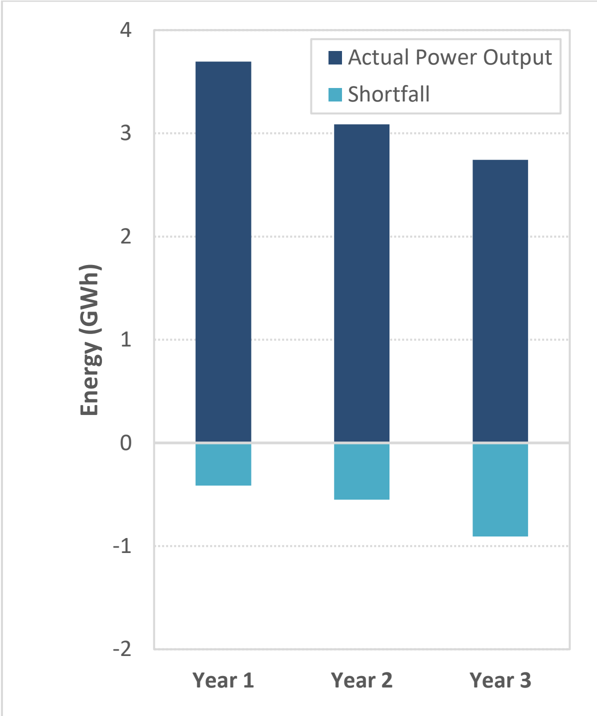


Figure 2.14 Yearly energy output and shortfall for wind turbine B

Table 2.13 Yearly percentage of shortfall for wind turbine A and B

	% Shortfall wind turbine A	% Shortfall wind turbine B
Year 1	27%	10%
Year 2	36%	15%
Year 3	41%	25%

2.5.4 Local renewable electricity generation

Large scale wind

As shown in Table 2.14 there is approximately 44.7MW of installed capacity (IC) from large wind turbines (of 50kW and above) in Orkney.

Table 2.14 Large scale wind turbines in Orkney

Location	ANM zone	Commissioned	IC (kW)
Thorfinn Wind Farm	1a	01/04/2000	2,700
Thorfinn Wind Energy Project (NM1500)	1a	01/04/2000	1,500
Burgar Hill	1a	01/11/2000	1,300
Northfield Wind Energy Project Burray- A,C	4a	01/02/2005	850
Burgar Hill Wind Farm - A	1a	01/12/2006	5,000
Birsay Energy	1a	01/09/2009	900
Gallow Hill, Westray	1	11/09/2009	900
Burgar Hill Renewables 1	1a	01/10/2009	2,300
Flotta Wind Farm	3	18/06/2010	2,000
Hammars Hill	1	23/08/2010	4,500
Trumland Farm, Rousay	1	18/02/2011	80
Ore Brae Wind Farm	3	21/09/2011	900
Kingarly Hill Wind Turbine	1	22/09/2011	900
Hatston Wind Turbine	Core	05/10/2011	900
Braefoot Wind Farm	2	21/10/2011	900
Rothiesholm Head Wind Farm	2a	17/11/2011	900
Thorkell Deerness	4a	09/03/2012	910
Cleat, Work Road, St. Ola	Core	17/09/2012	83
Spurness Wind Farm II	2b	22/10/2012	10,000
Fea, Holm	4	06/11/2012	83
Banks (Land Near), Rousay	1	26/11/2012	80
Sandybanks, Eday	1	27/11/2012	910
Wasbister, South Ronaldsay	4a	28/11/2012	55
Dalespot Hill	Core	29/01/2013	80
Hammer, Skelwick, Westray	1	27/02/2013	500
Barns of Ayre	4	03/07/2013	2,730
Scapa, St Ola	Core	26/09/2013	83
Mount Pleasant, Haybrake Road South Ronaldsay	4a	08/10/2013	65
Blackawall Cottage, Flotta	3	16/10/2013	83
DG Westray	1	17/10/2013	500
Towerhill, St Ola	Core	03/03/2014	83.3
East Hammer, Westray	1	24/03/2014	55
Rennibister, Firth	Core	28/03/2014	910
New Holland, Holm	4	20/11/2014	500
Ludenhill Farm (Land Near)	1a	27/09/2016	500
		TOTAL	**44,740 kW**
			44.7 MW

Sources: Ofgem, Renewable Energy Foundation, OIC

Another 47.3MW has planning permission but is not yet constructed (Table 2.15).

Table 2.15 Large turbines with planning approval but not yet constructed and/or operational

Address	Application No.	Decision date	Turbine size (MW)	Total (MW)
Gallow Hill, Westray	08/491/PPF	02/03/2009	2 x 0.9	1.8
Nearhouse, Rousay	11/329/TPP	02/11/2011	0.08	0.08
Berriedale, South Ronaldsay	11/060/TPP	29/11/2011	0.9	0.9
Herston Head, South Ronaldsay	11/691/TPP	24/02/2012	0.5	0.5
Southfield, Burray	12/058/TPP	05/07/2012	0.5	0.5
Orkney Auction Mart, Grainshore Road	12/091/TPP	24/08/2012	0.08	0.08
Orkney Auction Mart, Grainshore Road	12/097/TPP	24/08/2012	0.08	0.08
Land Near Hoy Community Turbine	11/728/TPP	08/11/2012	2 x 0.9	1.8
Gill Pier, Westray	12/230/TPP	29/11/2012	0.08	0.08
Akla, Orphir	10/631/PP	17/12/2012	0.9	0.9
Lochend, Westray	12/561/TPP	09/01/2013	0.06	0.06
Work Farm, St Ola	12/699/TPP	31/01/2013	2 x 0.9	1.8
Hunton, Stronsay	12/787/TPP	02/04/2013	0.06	0.06
New Holland, Stratheast Road, Holm	13/261/TPP	06/11/2013	2 x 0.5	1
Skerryvoe, Evie	12/766/TPP	04/06/2014	0.06	0.06
Burgar Hill, Evie	09/045/PPF	12/01/2015	2.3	2.3
Swanbister, Orphir	16/369/TPP	25/10/2016	0.5	0.5
Costa Head, Swanney	16/580/TPPMAJ	21/09/2018	4 x (unspecified)	14.4
Hesta Head, South Ronaldsay	17/083/TPPMAJ	21/09/2018	5 x (unspecified)	20.4
			TOTAL	**47.3 MW**

Source: OIC planning portal

As seen in Figure 2.15, showing the percentage of installed capacity for each of the ANM Zones, Zone 1a has the highest installed capacity of large-scale wind generators, with 31.7% of the total installed capacity, followed by Zone 2b with 22.4% and Zone 1 with 18.8%.

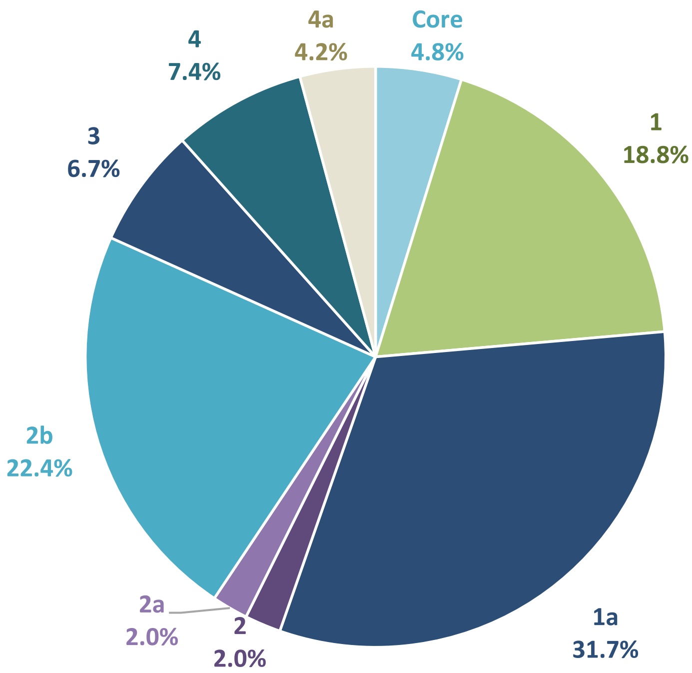


Figure 2.15 Orkney's current large scale wind capacity percentage distribution within the ANM Zones

From Figure 2.16, there has been a steady increase in the total installed capacity between 2005 and 2012 with a peak in 2012 mainly due to the 10MW wind farm at Spurness, in Sanday.

Furthermore, the moratorium on all new generation imposed by SHEPD in September 2012 is the main reason for reduction in turbines being installed after 2012. As shown in Figure 2.16, no large-scale turbines (50kW and above) have been installed since 2016.

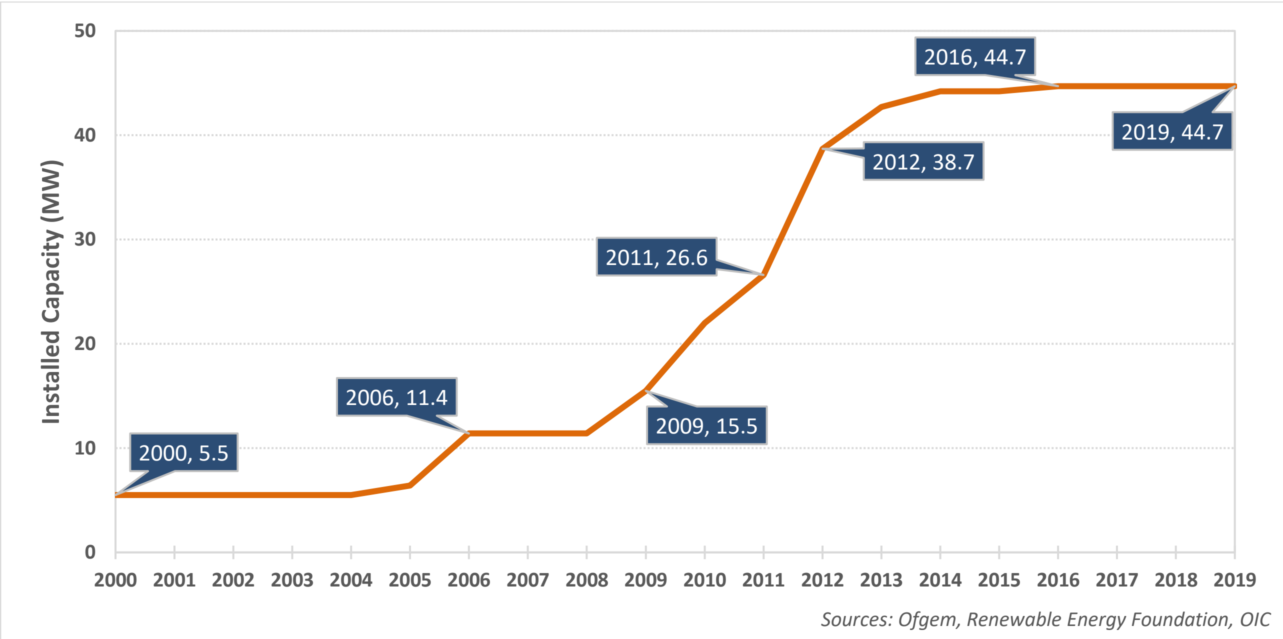


Figure 2.16 Cumulative installed capacity for large scale wind (>50kW) between 2000 and 2019

Based on the data in Table 2.16 a weighted average load factor was calculated as 41.2%, which results in an estimated annual energy generation of 161.33 GWh from the current installed capacity. This can be compared to the average load factor for onshore wind in the UK of 26.6% (RenenableUK, 2020).

It should be noted that curtailment, or long periods of wind turbine downtime, impact load factors.

Table 2.16 Load factors declared by some Large scale wind turbines in Orkney

Location	IC (kW)	Latest Data	Declared Load Factor
Spurness Wind Farm II	10,000	Sep-18	44.9%
Burgar Hill Wind Farm - A	5,000	Sep-18	40.4%
Hammars Hill	4,500	Aug-18	44.8%
Barns of Ayre	2,730	Oct-18	39.8%
Burgar Hill Renewables 1	2,300	Oct-18	50.9%
Thorfinn Wind Farm	2,700	Jul-18	34.7%
Flotta Wind Farm	2,000	Oct-18	45.9%
Thorfinn Wind Energy Project (NM1500)	1,500	Jul-18	46.7%
Burgar Hill	1,300	Aug-18	28.9%
Northfield Wind Energy Project Burray- A,C	850	Aug-18	47.1%
Birsay Energy	900	Jun-18	38.9%
Kingarly Hill Wind Turbine	900	Oct-18	40.8%
Hatston Wind Turbine	900	Sep-18	36.3%
Thorkell Deerness	910	Jun-18	39.8%
Braefoot Wind Farm	900	Sep-18	34.1%
Ore Brae Wind Farm	900	Oct-18	33.8%
Rothiesholm Head Wind Farm	900	Aug-18	16.8%
DG Westray	500	Mar-18	19.6%
Dalespot Hill	80	May-18	23.1%

Source: Renewable Energy Foundation

47.3MW has planning permission but is either yet to be constructed or constructed but not yet operational, and a further 183.5MW of installed capacity is proposed by wind farm developers (including Orkney Islands Council), as per Table 2.17. For this generation to connect, substantial network reinforcement is required. Scottish Hydro Electric Transmission's (SHE-T) have conditional approval from Ofgem for a 220MW transmission cable, subject to 135MW of generation meeting certain criteria by December 2021 (Ofgem, 2019a). As of the end of 2019 there are a number of large-scale wind farms in development (see Table 2.17).

Table 2.17 Orkney's future large scale wind farms in development

Name	Current planning status	Submission date	IC (kW)
Hoy Community Wind Farm	Scoping Opinion report produced and assessments in progress	02/05/2018	28,000
Rothiesholm Wind Farm (Stronsay)	Scoping Opinion Request (Decided)	18/06/2018	28,000
Hammars Hill Wind Farm (extension)	Scoping Opinion Request (Decided)	18/06/2018	11,500
Rennibister Wind Farm (extension)	Scoping Opinion Request (Unknown)	28/01/2019	20,000
Faray Community Wind Farm (Faray)	Scoping Opinion report produced and assessments in progress	26/04/2019	32,000
Quanterness Community Wind Farm (St Ola)	Scoping Opinion report produced and assessments in progress	26/04/2019	24,000
Rennibister Wind Farm (extension – St Ola)	Scoping Opinion Request (Unknown)	28/01/2019	20,000
Nevan Head Wind Farm (Eday)	Scoping Opinion Request (Awaiting decision)	18/12/2019	40,000
		TOTAL	**183,500 kW**
			183.5 MW

Small scale wind

Data on planning permissions, and further information about the turbine size and type extracted from the OIC planning portal (OIC, 2019) show a total capacity of 6569.1 kW for small turbines (under 50kW)[9]. The majority of these turbines are between 5 and 20kW as shown in (Figure 2.17).

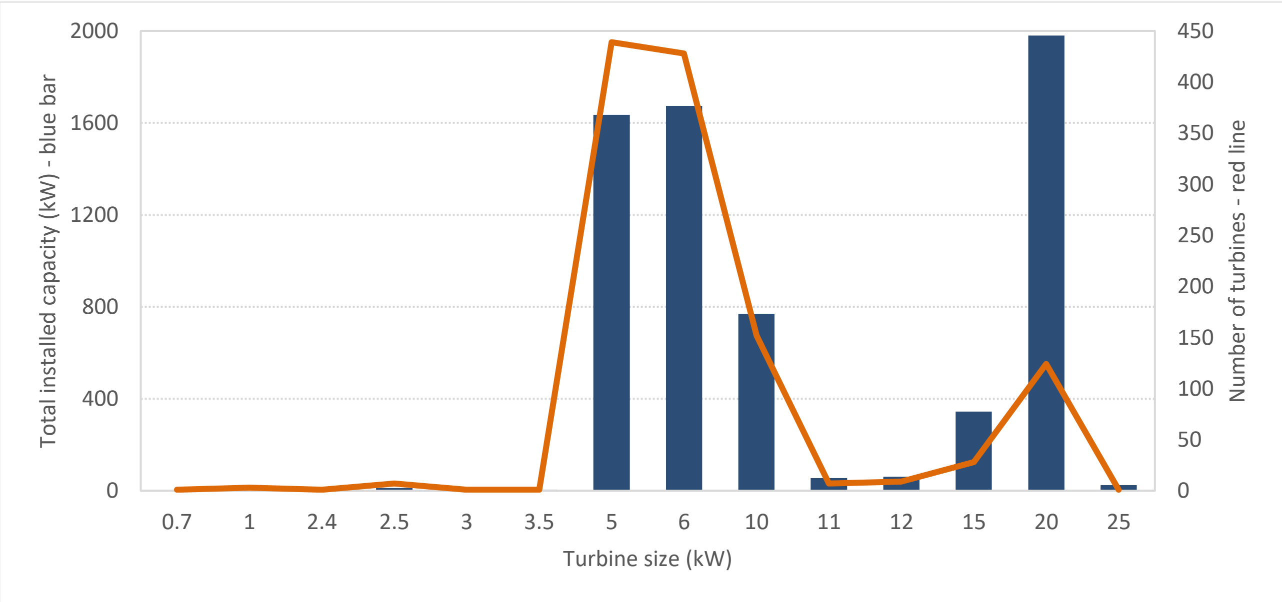


Figure 2.17 Planning permissions granted - Total capacity granted by turbine size

[9] All turbines with a decision date of 20 August 2019 or before.

The number of turbines granted planning permission peaked sharply in 2012 (as shown in Figure 2.18), prior to a reduction in the Feed-in Tariff (FIT)[10] and SHEPD imposing a moratorium on all new generation, except the very smallest generators which are limited to 16A per phase (3.6kW per phase).

It is unknown which of the turbines granted planning permission, shown in Figure 2.18, have actually been installed.

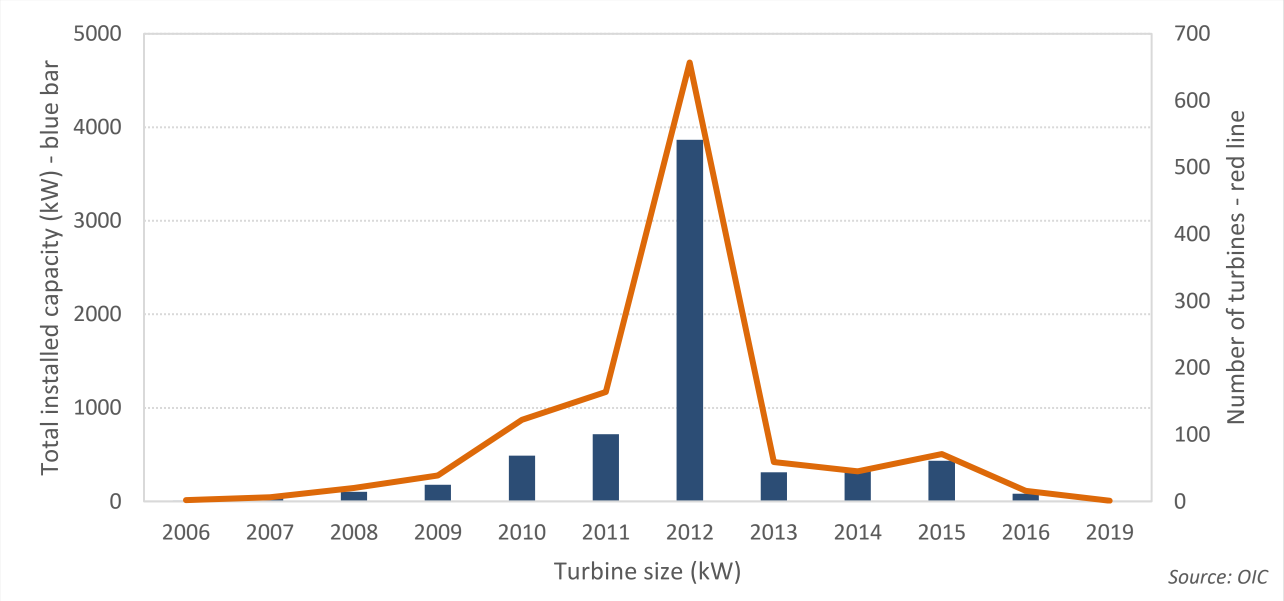


Figure 2.18 Installed capacity and number of small turbines (up to 50kW) granted planning permission by year

Data published by Ofgem (Ofgem, 2019b) on wind turbine which have registered for the FIT scheme shows that (for wind turbines under 50kW) a total of 5,918.9 kW are registered in Orkney. Orkney accounts for 11% of the installed capacity in the UK (and 13% of the turbines) for turbines less than 50kW.

Domestic turbines are especially prevalent in Orkney and account for 13% of installed capacity (15% of the turbines) of the UK total as shown in Table 2.18. The majority of these being commissioned in 2012 (Figure 2.20).

[10] The FIT scheme is a UK Government programme introduced on 1 April 2010 and replaced UK Government grants as the main financial incentive. It was designed to promote the uptake of renewable and low carbon electricity generation technologies. The FIT scheme was closed in April 2019.

Table 2.18 Small wind by type of installation in Orkney compared to the UK total

Type of installation[11]	Total number of installations in Orkney	Total number of installations as a percentage of UK total	Total installed capacity in Orkney (kW)	Total installed capacity as a percentage of UK total
Domestic	651	15%	4,947	13%
Community	9	7%	55	5%
Non-Domestic (Commercial)	75	8%	857	7%
Non-Domestic (Industrial)	2	4%	60	7%
Total	**737**	**14%**	**5,919**	**11%**

Source: Ofgem

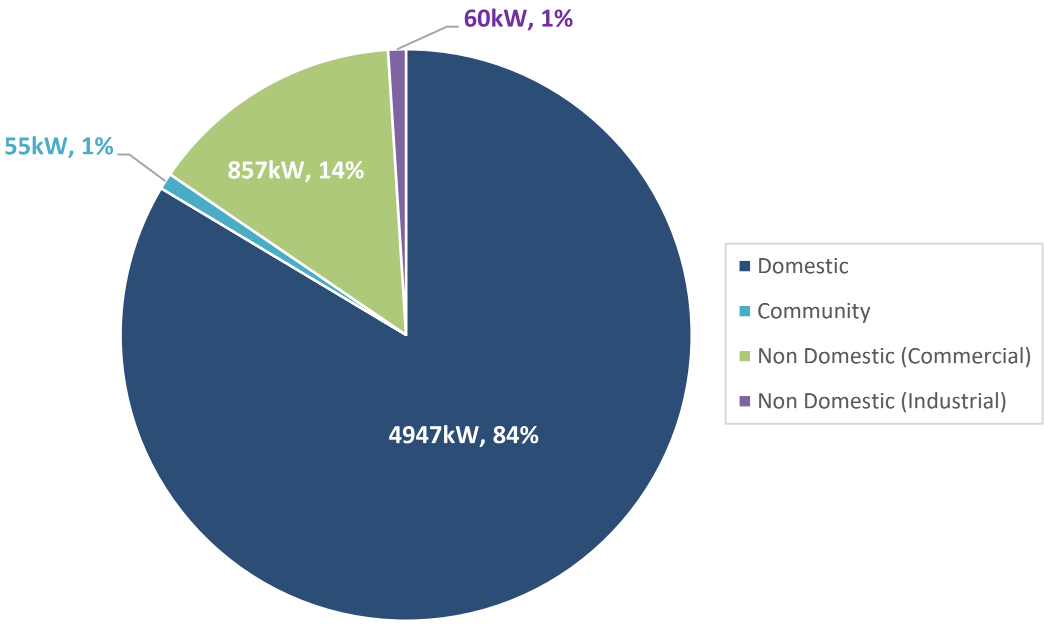


Figure 2.19 Percentages of Orkney's total installed small wind capacity by installation type

[11] The Installation Type is an indicator to assist in the reporting and statistical analysis of installations within the FIT scheme and is selected by the generator owner at the time of application.

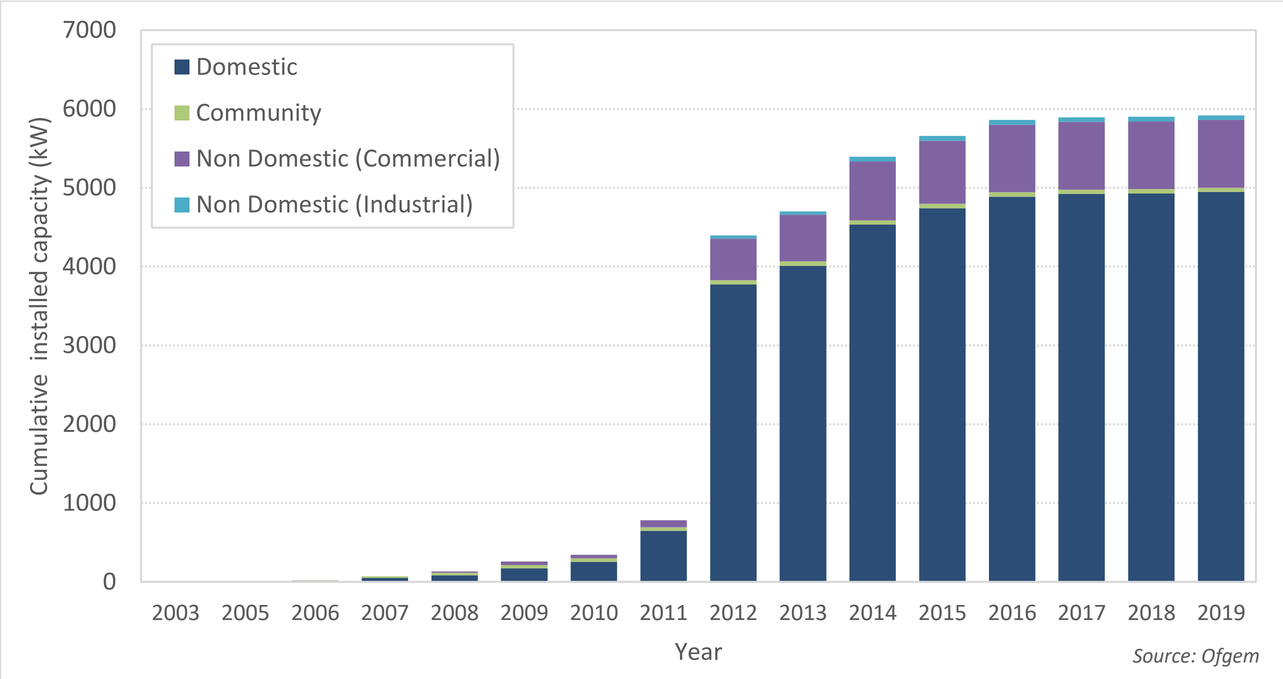


Figure 2.20 Cumulative installed capacity by commissioning date (small turbines up to 50kW)

The difference between the Ofgem and planning permissions data can be explained by the fact that some turbines with planning permission have not yet been built, and also permission being granted for turbines that are larger than those actually installed.

Figure 2.21 below shows that 56% of the total installed capacity (5,919kW) is in the 3 to 10kW category, followed by installations between 20 to 30kW, which account for 24% (1,434kW).

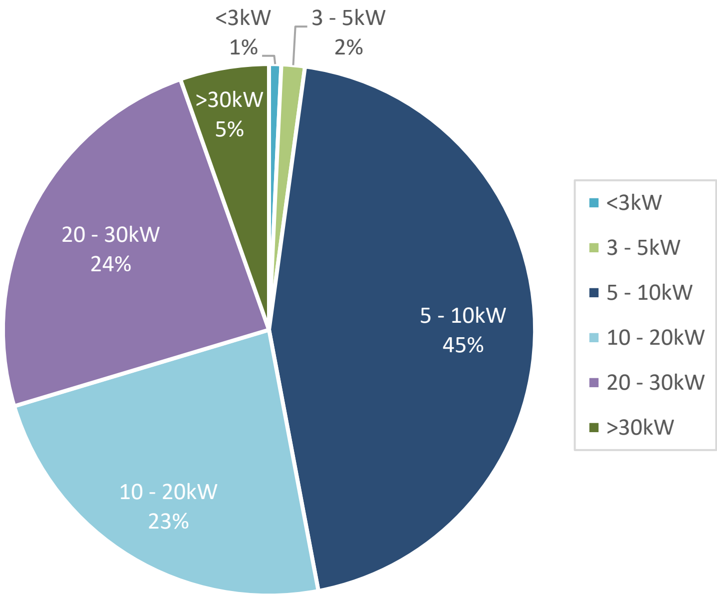


Figure 2.21 Percentages of Orkney's total installed small scale wind capacity by installation size

OREF has set up a database of micro wind generators in order to track the long-term performance of the different turbines in different locations and detect any patterns or problems by allowing users to submit their performance readings every month. Analysis of the readings in this database shows an average load factor of 38%. Applying this load factor to the total installed capacity in Orkney gives around 19.7GWh per annum from the current installed capacity.

Solar

Photovoltaic systems were eligible for the FIT scheme, which closed in April 2019, and have become increasingly common in Orkney with a total of 1,429 kW now installed (Figure 2.23). The tariff payment rates varied depending on factors such as whether the units are stand alone, mounted on a new building, retrofitted to a building, the energy efficiency of the building and the installed capacity.

Orkney currently has about 0.5% of all PV installed capacity in Scotland and 0.03% in the UK (Ofgem, 2019b). As seen in

Table 2.19 the majority of the PV installed capacity is domestic installations which total 1,369kW.

Table 2.19 Total photovoltaic installed capacity by type of installation

Type of installation	Total number of installations in Orkney	Total number of installations as a percentage of UK total	Total installed capacity in Orkney (kW)	Total installed capacity as a percentage of UK total
Domestic	368	0.04%	1,369	0.05%
Community	1	0.03%	26	0.01%
Commercial	5	0.02%	35	0.002%
Total	**374**	**0.04%**	**1,429**	**0.03%**

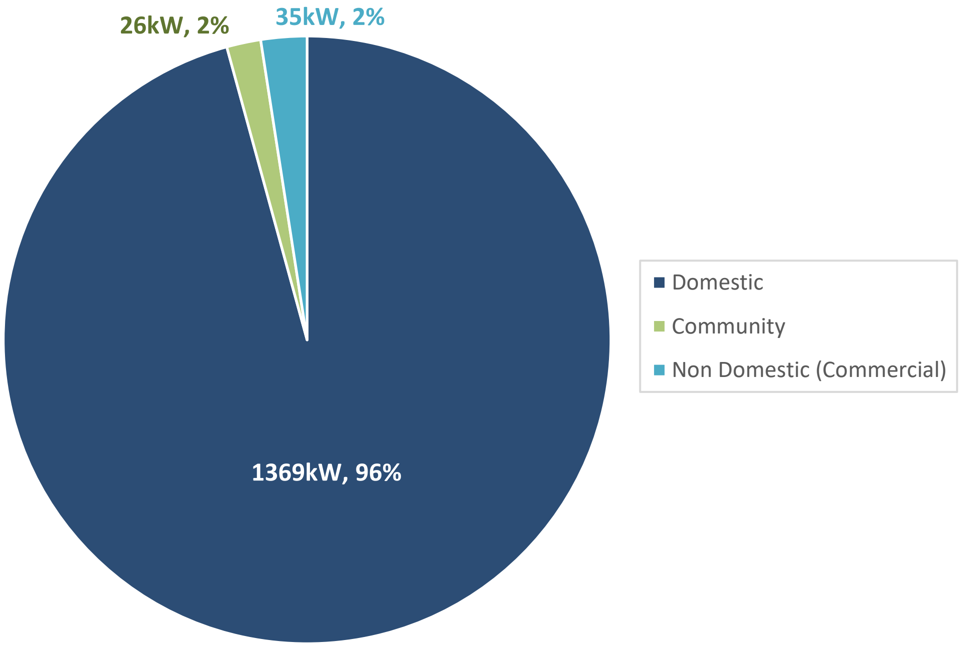


Figure 2.22 Percentages of Orkney's total installed photovoltaic capacity by installation type

In Orkney installations of PV systems peaked in 2012 and have tailed off since, as seen in Figure 2.23, probably due to the decreasing tariffs being offered as well as the moratorium on all new generation, above 3.6kW installed capacity, imposed by SHEPD in September 2012.

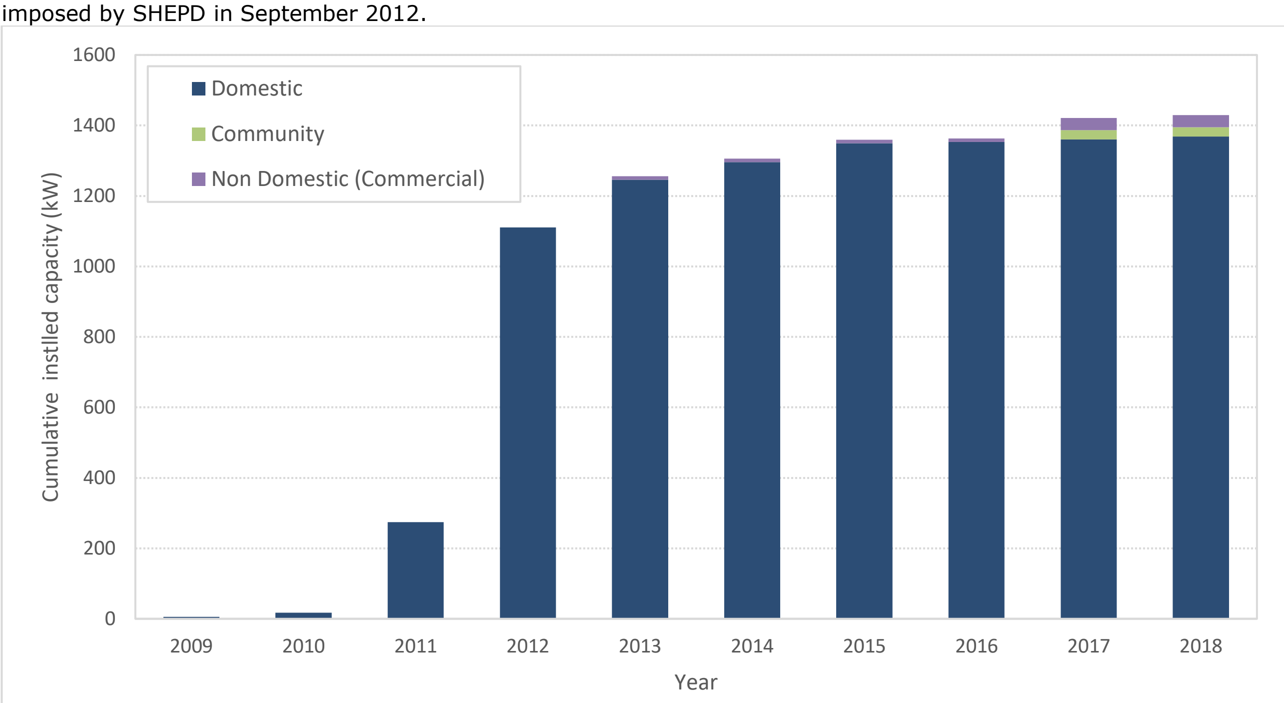
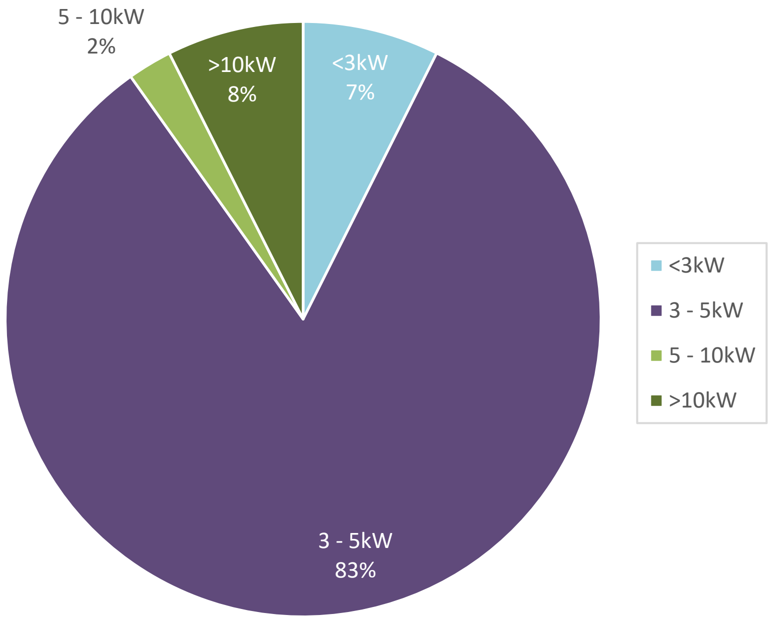


Figure 2.23 Cumulative installed capacity by commissioning date for photovoltaic panels

Figure 2.24 shows that 83% (1183kW) the total installed capacity is 3 to 5kW installations.



Source: Ofgem

Figure 2.24 Percentages of Orkney's total installed photovoltaic capacity based on individual installation sizes

Using data collected by OREF, where owners of PV installations voluntarily submit their PV system's monthly generation meter readings, it is possible to estimate an average load factor of approximately 9.5%, which results in an estimated annual energy generation of 1.19 GWh from the current installed capacity. The variation in load factor over an average year is shown in Figure 2.25.

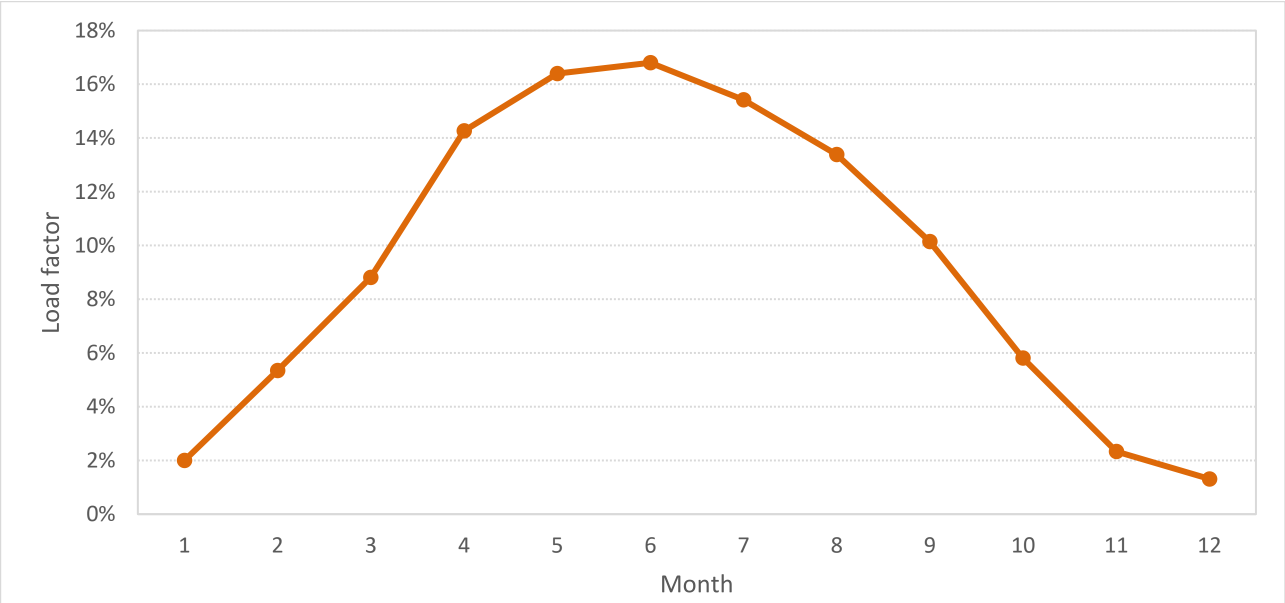


Figure 2.25 Load factor over an average year for PV panels in Orkney

Hydro

There is one hydro scheme in Orkney with a total installed capacity of 11 kW, located at Woodwick Mill, and generating electricity since 2015. The data provided by the owner gives an annual energy generation is 0.03 GWh.

Wave and tidal

Orkney holds a prominent position in the wave and tidal industry with the EMEC testing facility and the world's first leasing round for commercial wave and tidal projects was launched in 2010.

EMEC testing facility

Since its establishment in 2003 EMEC has attracted many developers to its purpose-built, accredited, open-sea wave and tidal testing facilities, located at Billia Croo and the Fall of Warness respectively. With 13 grid-connected test berths, there have been more marine energy converters deployed at EMEC than at any other location in the world, with developers attracted from around the globe to see what is achievable in some of the harshest marine environments. EMEC also operate two scale non-grid connected test sites where smaller scale devices, or those at an earlier stage in their development, can be tested in less challenging conditions.

The technology remains under development and therefore the number of GWh generated varies significantly from year to year. Some data is available, and for example, Orkney based Orbital Marine Power's ("OMP", and formerly Scotrenewables) 2MW prototype SR2000 tidal turbine generated 3.25GWh of electricity at the EMEC Fall of Warness test site in 12 months of continuous deployment, from the summer of 2017 to the summer of 2018. In September 2017, the turbine generated over 116MWh (0.116GWh) in less than a week, providing around 7% of Orkney's electricity consumption over that time (EMEC, 2020).

Commercial and demonstration projects

In 2010, the Crown Estate held a leasing round for commercial and demonstration marine energy projects in the Pentland Firth and Orkney waters. Of the leases awarded, the first phase (6MW) of the MeyGen project, on the southern side of the Pentland Firth near Gills Bay, is the only one to have been built and has now been operational since November 2016 (SIMEC Atlantis Energy, 2019). However as this is located on the Caithness side of the Pentland Firth it is not considered as part of this 2019 Audit.

ANM data

The SSEN Orkney ANM Live website (SSEN, 2019) shows the renewable generation[12] and demand for Orkney at one-minute intervals. This live data has been collected since 2012 and has been supplemented by data obtained from SSEN for 2018 (half hourly averages) to cover a period when no data was collected from the live stream[13].

Figure 2.26 shows monthly averages for renewable generation (and demand for comparison), over the last 7 years, and confirming a general pattern of more generation (and demand) in the winter. However, these are monthly averages and, over shorter timescales, generation and demand are more variable.

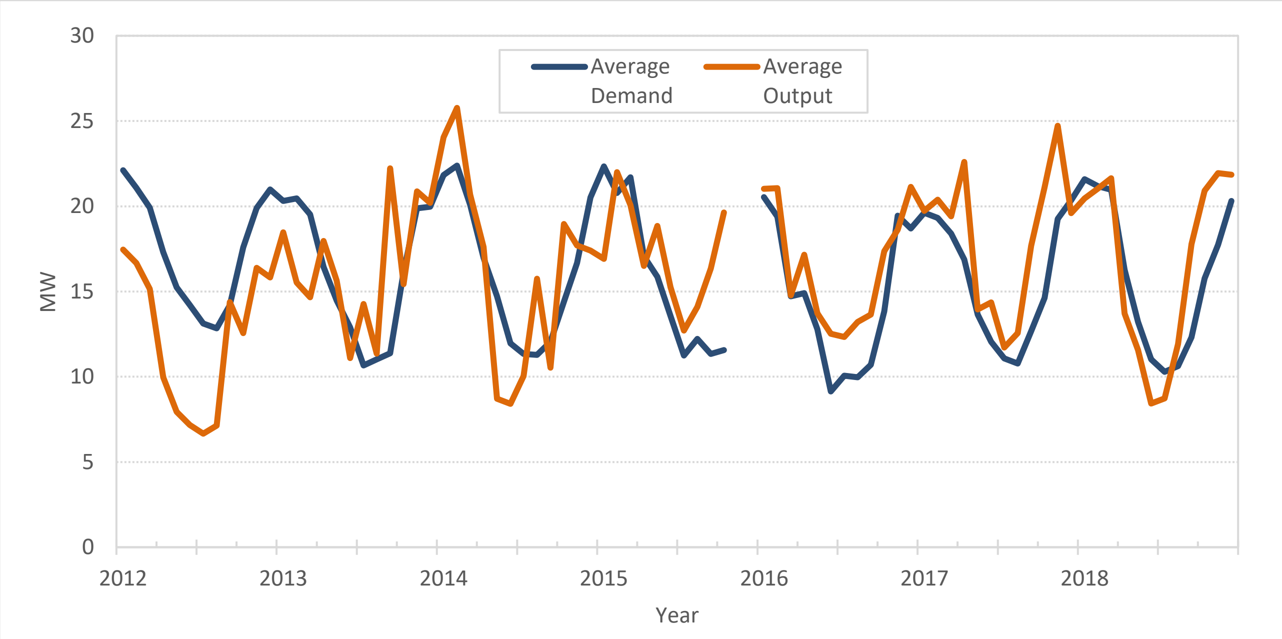


Figure 2.26 Monthly averages for renewable generation and demand (2012-2018 time series)

[12] The live feed data is assumed to be all grid connected renewable generation above 50kW which will mostly represent large scale wind generators with a very small contribution from EMECs wave and tidal generators.

[13] This was due to a change in SSE's website which meant that the system set up to record that data was unable to pick the data up.

2.5.5 Electricity import and exports with the Scottish mainland

As mentioned in Section 2.5.1, Orkney is connected to the UK national electricity grid by two subsea cables. By studying the flow of electricity in those cables over time it is possible to determine when electricity is imported to meet the local demand and also when local generation was higher than local demand and therefore electricity was exported to mainland Scotland. The graphs below (Figure 2.27 to Figure 2.32) show the monthly electricity imports and exports via the subsea cables from 2009 to 2014[14] and for the year 2018/2019. Positive values show exports from Orkney to the mainland and negative values show imports into Orkney.

It can be seen that, until 2012, Orkney was clearly importing more electricity than it was exporting, with months where up to around 10 GWh of electricity was imported (December 2010, Figure 2.28) compared to significantly smaller amounts of electricity exported. It is difficult to directly compare the years between 2009 and 2014 as there was a large increase in wind generation installed over this time. Demand is generally greater in the winter as shown in the ANM data above (see Section 2.5.4) and this is reflected in the higher imports in winter months in earlier years when there was less generation capacity.

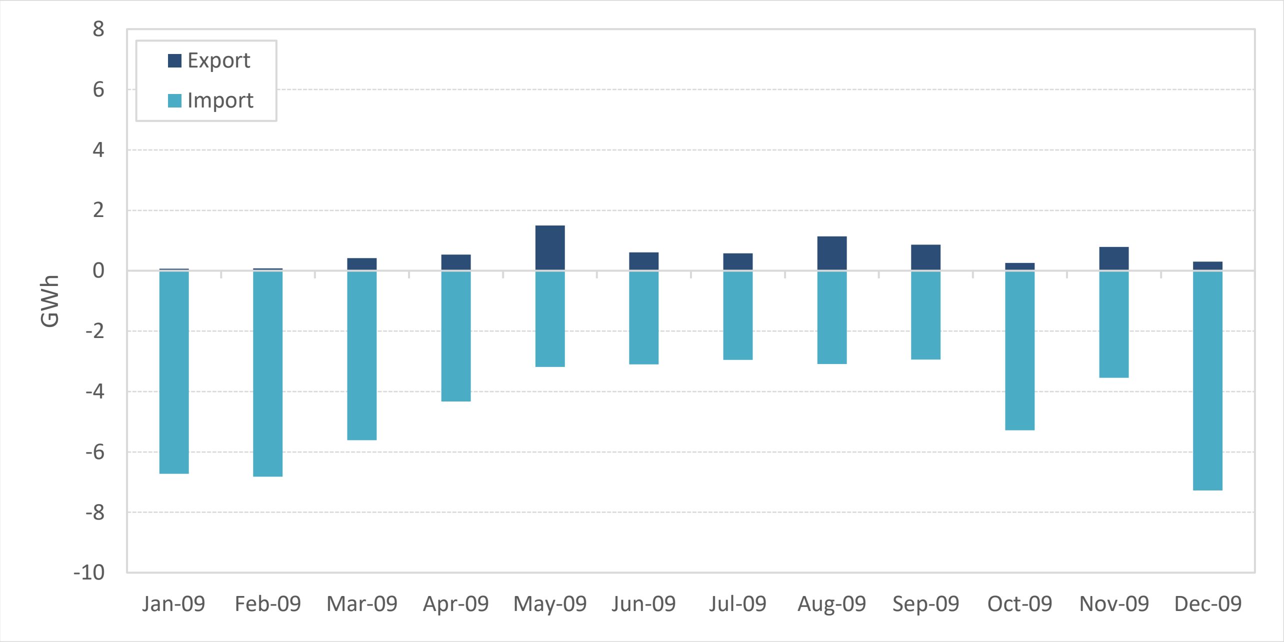


Figure 2.27 Monthly total electricity import and export (GWh) calculated from half hourly average values (January 2009 – December 2009)

[14] Data provided by SSEN for 2015-2018 has not been cleaned and validated by SSEN therefore permission was granted to use the data for those years to look at annual total but not for monthly analysis.

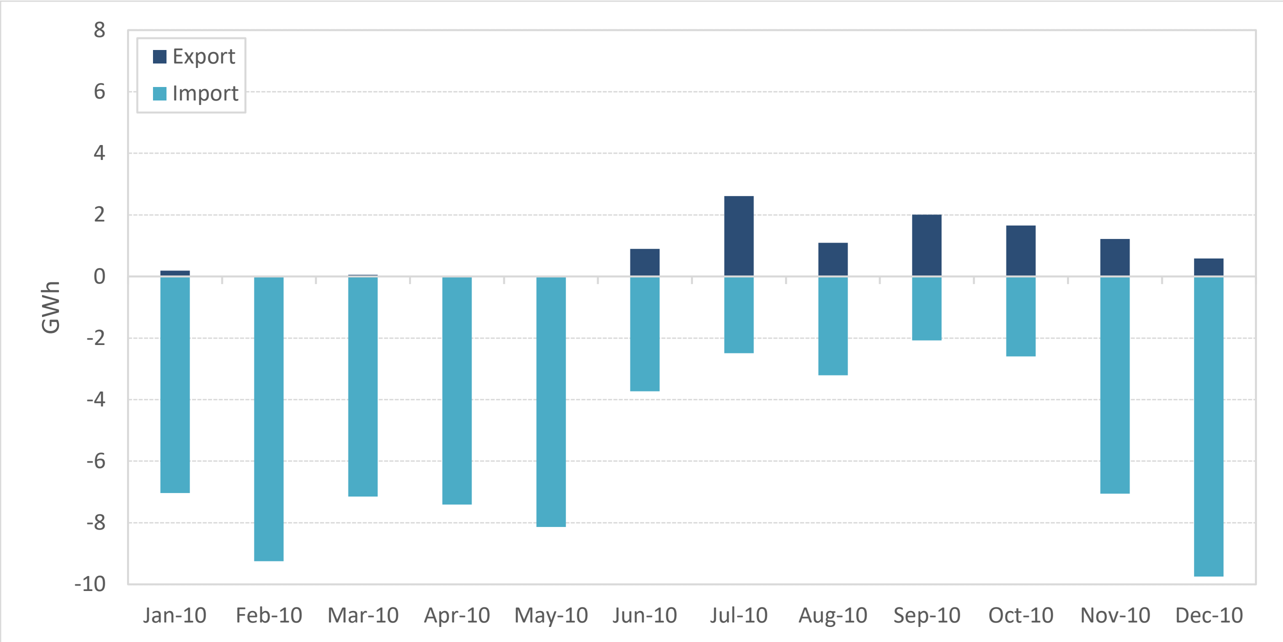


Figure 2.28 Monthly total electricity import and export (GWh) calculated from half hourly average values (January 2010 – December 2010)

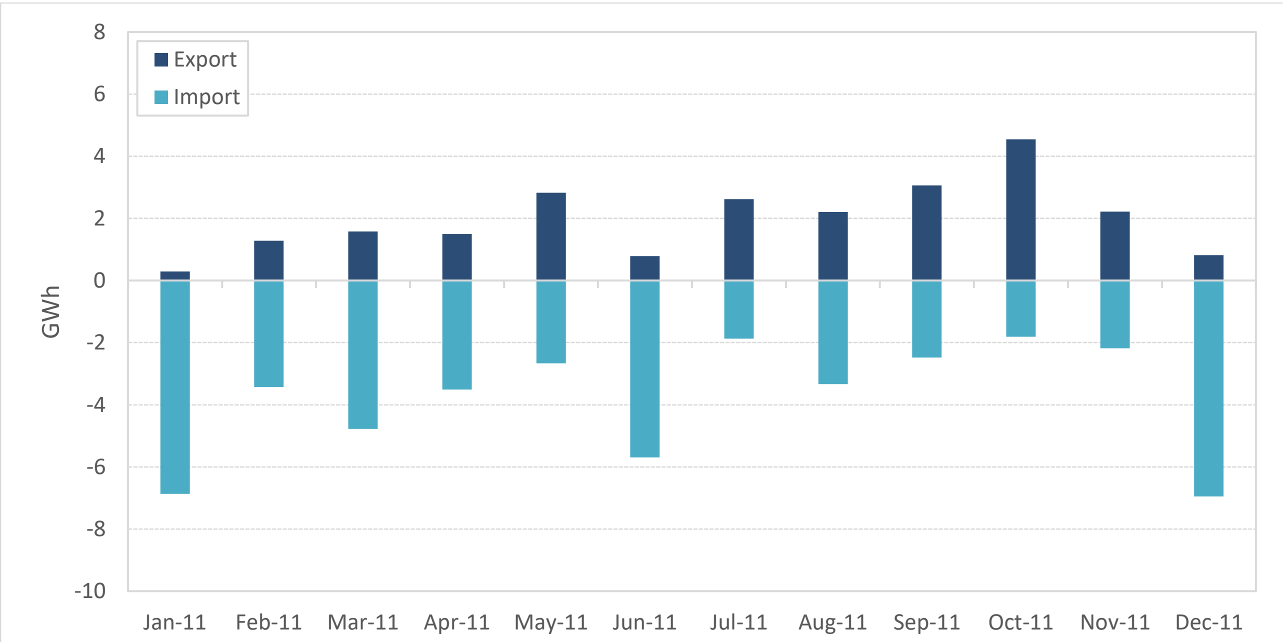


Figure 2.29 Monthly total electricity import and export (GWh) calculated from half hourly average values (January 2011 – December 2011)

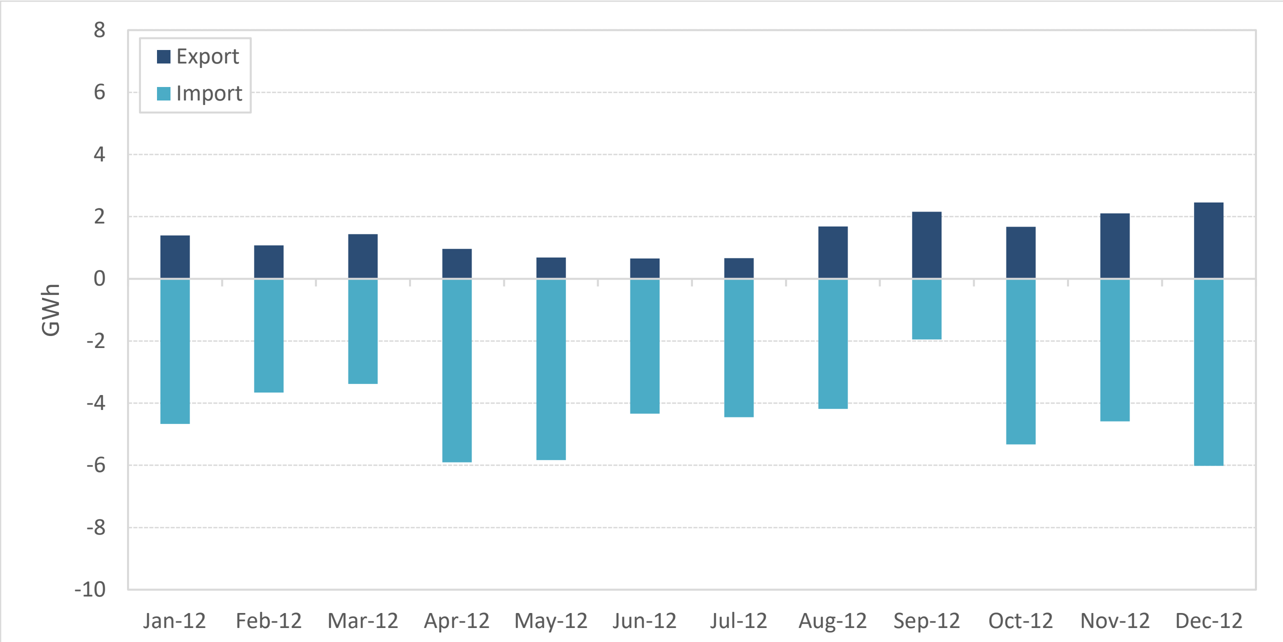


Figure 2.30 Monthly total electricity import and export (GWh) calculated from half hourly average values (January 2012 – December 2012)

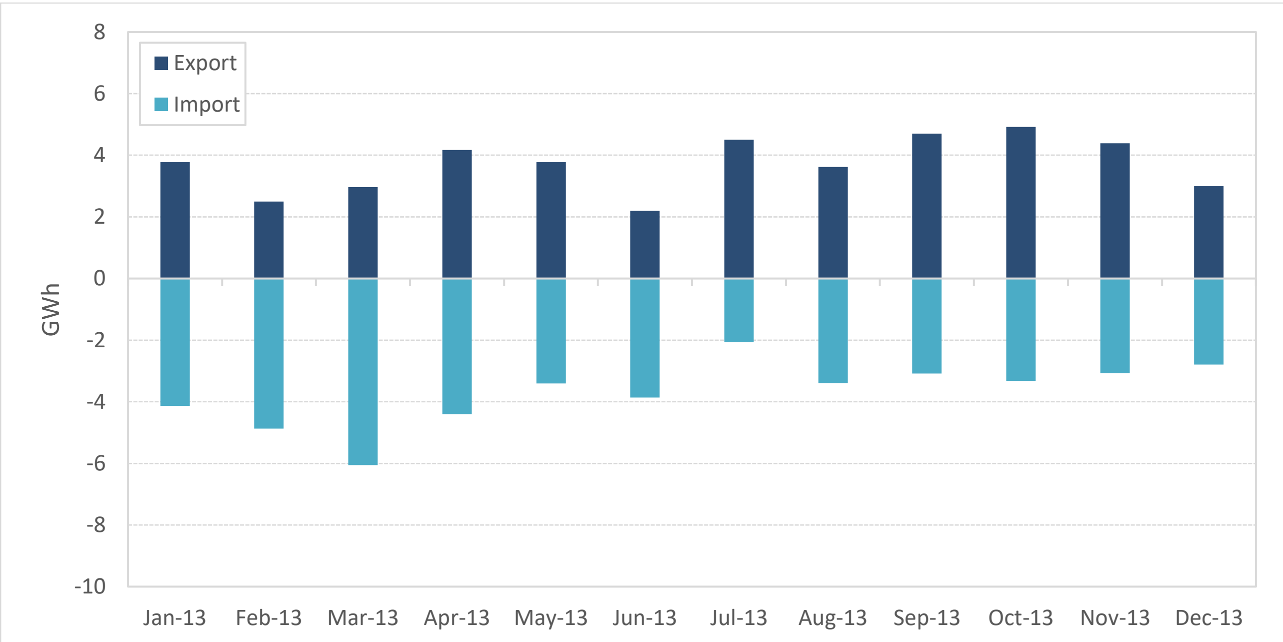


Figure 2.31 Monthly total electricity import and export (GWh) calculated from half hourly average values (January 2013 – December 2013)

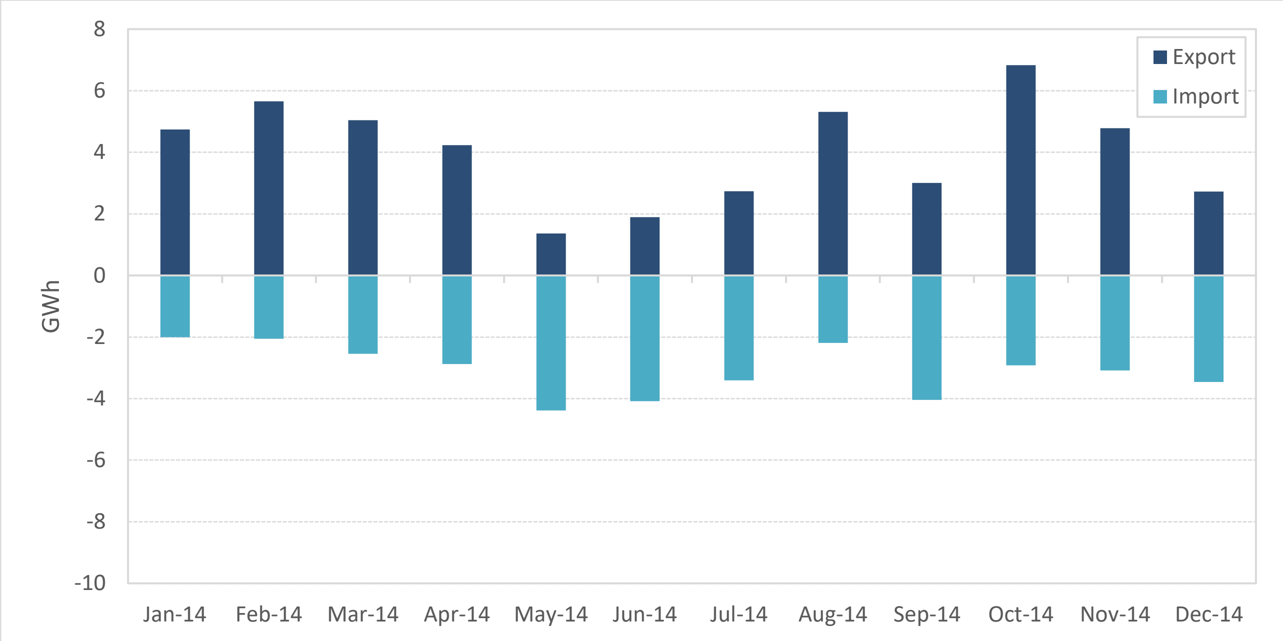


Figure 2.32 Monthly total electricity import and export (GWh) calculated from half hourly average values (January 2014 – December 2014)

The yearly import and export totals shown in (Figure 2.33) show the general trend over the last decade has been towards higher export as increasing amounts of renewable energy was installed in Orkney and over the last decade Orkney has gone from being a net importer to a net exporter of electricity.

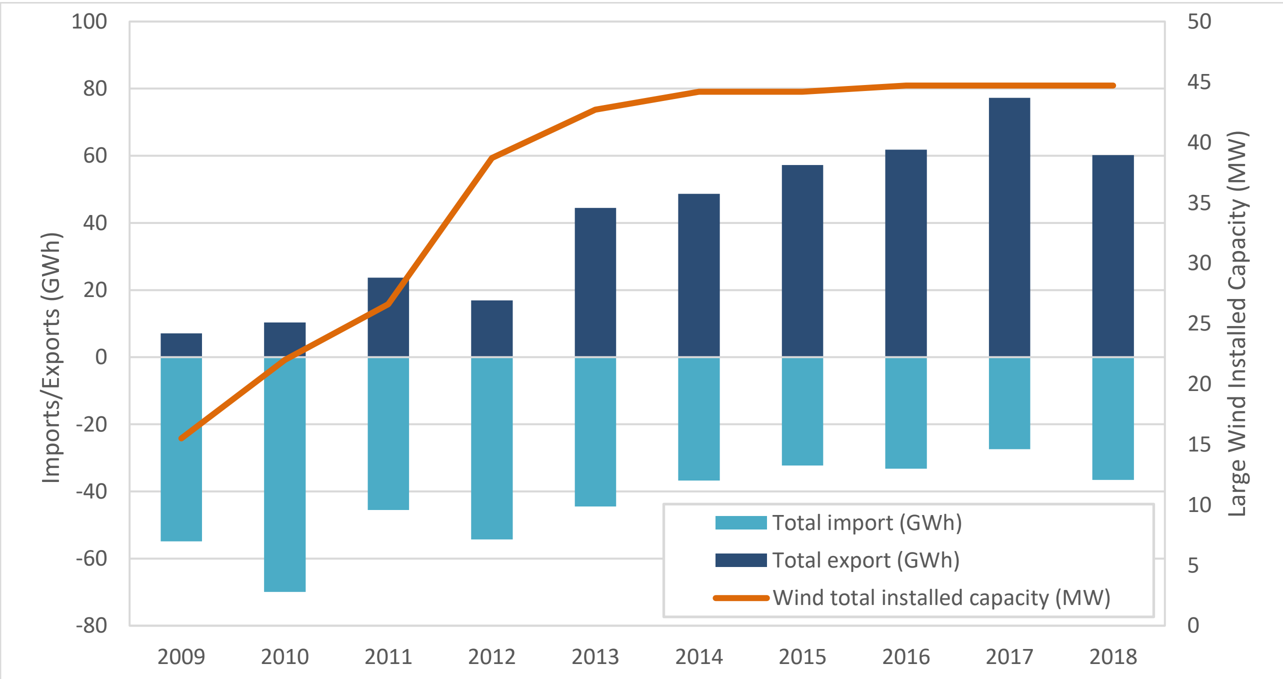


Figure 2.33 Total yearly electricity import and export (MWh) over the 2009-2018 period versus the total large wind capacity installed

The graph below (Figure 2.34) shows the bulk monthly amounts of energy imports and exports through the subsea cables between August 2018 and July 2019. One of the two cables was inactive due to failure and subsequent repair works during two distinct periods spanning 27 January - 10 February and 3 March -16 July.

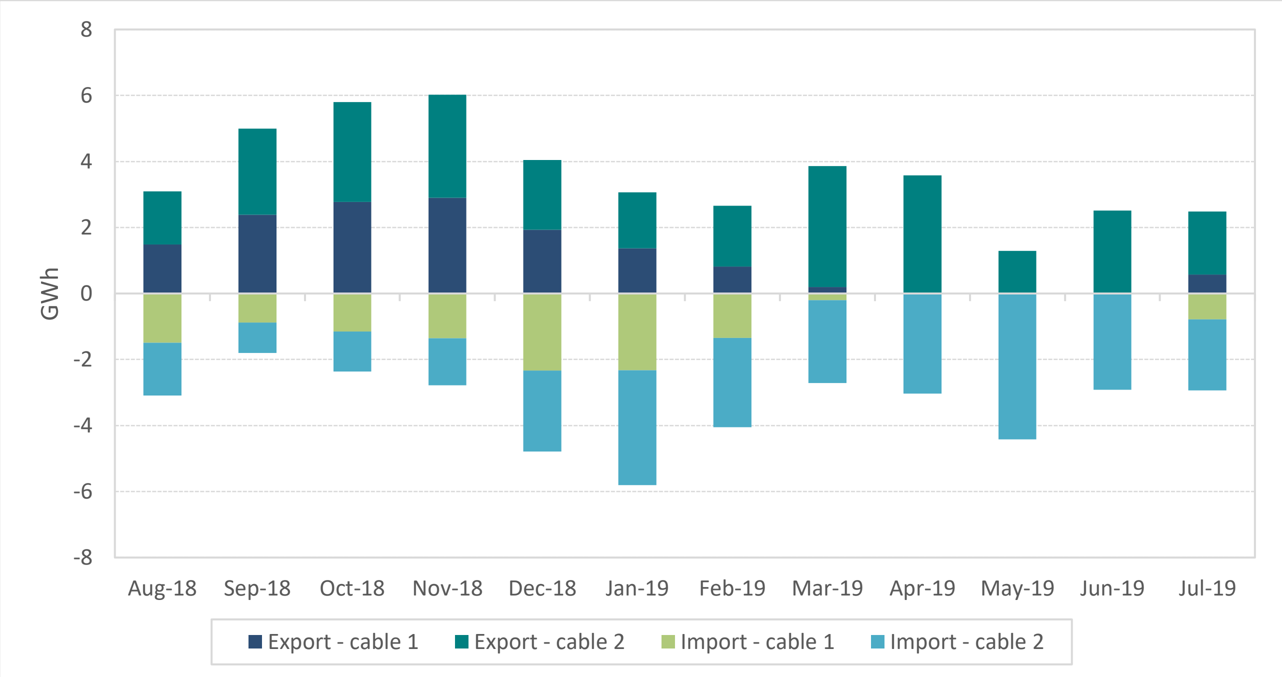


Figure 2.34 Electricity import and export (MWh) through the two subsea cables

2.5.6 Local non-renewable electricity generation

Kirkwall power station

The diesel fuelled Kirkwall Power Station currently contributes very little to Orkney's electricity generation. It ceased regular operation in the late 1990's after the second subsea cable to the mainland was commissioned, now running monthly for test purposes and to cover faults and system outages on subsea cables to the Scottish mainland. In 2019, it operated for two distinct periods, when one of the 33kV cables to mainland Scotland was out of operation but it has not been possible to get details on the amount of diesel used during these periods.

Flotta gas turbine

As discussed in Section 2.2.6, a large amount of crude oil comes ashore at the Flotta Oil Terminal. It primarily uses gas extracted from the crude oil, with gas oil as a back-up fuel, for onsite heating and power generation. Normal operations do not require the use of gas oil except when the terminal is gas deficient.

As the Terminal has its own grid connection it is able to export electricity during periods of high gas availability as shown in Table 2.7 for 2018 and 2019.

Table 2.20 Electricity exported from Flotta Oil Terminal

Year	2018	2019
MWh	12,625.1	16,098.3
GWh	12.63	16.1

3 ENERGY STORAGE

Electrical energy unlike some other forms of energy cannot be stored in its raw form and needs to be converted to another form of energy e.g. chemical as in a batteries or hydrogen, potential as in pumped hydro, or heat (i.e. hot water tanks). As we move away from using fossil fuels and towards more intermittent forms of renewable electricity generation, storage of electrical energy is becoming increasingly important.

3.1 GRID CONNECTED BATTERY STORAGE

In 2013 SHEPD connected the UK's first large scale battery, at 2MW, to the local electricity distribution network at Kirkwall Power Station but it is no longer active and has been decommissioned (SSEPD, 2015). However, further developments of this type can be expected in the coming years as the technology develops.

3.2 DOMESTIC BATTERY STORAGE

3.2.1 Stationary storage devices

In December 2018 Solo Energy launched a first of its kind housing project in Kirkwall, a pilot to help demonstrate Solo's business model and how new technologies can revolutionise the future of the traditional energy system using their proprietary software platform, FlexiGrid. This connects renewable generation with in-home battery storage to allow residents to make use of renewable energy throughout the day not only restricted to when the sun is shining. Furthermore, by being connected to the grid, via the electrical supply to the household, the battery can also be used to store some energy from Orkney's wind resources, which could, in time, alleviate some of the curtailment on existing wind generation schemes in Orkney.

Sixteen homes at Grainbank were built with solar PV and in-home battery storage assets, comprising a total of 4 Tesla Powerwalls (6.4kWh each) together with 12 Sonnen Eco (2.5kWh) units to give a total electrical storage capacity of 55.6kWh's. An additional 14 properties have PV + smart immersion controllers installed to divert excess PV into hot water.

3.2.2 Mobile storage: EVs and vehicle to grid

The charging of the battery in an EV provides a means of energy storage, although most systems are designed for the energy to flow one way, into the battery, and it cannot then be fed back into the electricity grid. However, 'Vehicle to grid' technology (also referred to as V2G) is a system which allows two-way flow of energy. This means that the energy stored the battery of the EV could be fed back onto the electricity grid at times of high electricity demand. There are no such schemes currently running in Orkney but this is expected to change in the near future as the technology develops.

3.3 HYDROGEN STORAGE

3.3.1 EMEC and the Surf 'n' Turf project

Production of hydrogen has taken place on Eday at EMEC's Caldale site using electricity from tidal turbines to power a 500kW ITM Power Proton Exchange Membrane electrolyser. The Surf 'n' Turf project also connected the Eday Renewable Energy Enercon 900kW community owned wind turbine to the scheme.

The hydrogen fuel is then stored as a pressurised gas within EMEC's 500kg static hydrogen storage on site, with a fleet of mobile storage units (MSU) to transport the gas to the Orkney mainland via road and ferry. The MSUs each contain 59 individual gas cylinders together holding 250kg of hydrogen gas at a pressure of 200Bar. The hydrogen is used in a

75kW (electrical output) fuel cell at Kirkwall harbour, with the electricity produced used to provide shoreside power to some of the inter-island ferries that dock overnight.

3.3.2 BiGHIT

The BiGHIT (Building Innovative Green Hydrogen Systems in an Isolated Territory) project builds on the Surf 'n' Turf project with additional hydrogen production and introducing further elements including heating and transport applications. When operational, an electrolyser is powered exclusively from the island of Shapinsay's 900kW wind turbine which suffers constrained output under the ANM scheme. The hydrogen will be used in the Shapinsay School for heating, where there is a 30kg store and also in the hydrogen refuelling station in Hatston, which has a 110kG store, for five converted Renault EVs with hydrogen powered range extender units to double their range. Both stores are balance filled from one of the two MSUs provided through the BiGHIT project.

Due to a number of technical and logistical issues the projects have taken longer to commission than planned. However, the projects have led to other exciting opportunities to prove further concepts in shipping, heating and aviation.

4 ENERGY USES

4.1 INTRODUCTION

This chapter of the audit covers how energy is used in Orkney. This can be broadly categorized into 5 main sectors as follows:

- Buildings
- Terrestrial non-road transport, industry, and agriculture
- Road transport
- Marine transport
- Air transport

In some places there will be overlap between the data shown here and in the 'Energy Sources' chapter where the data for a specific fuel has only been collected from one source for one specific use (e.g. the sue of peat at the highland park distillery) or where there is insufficient data to be able to attribute to specific end uses.

4.2 BUILDINGS

4.2.1 BEIS energy consumption statistics

BEIS (Department for Business, Energy and Industrial Strategy) publish energy consumption statistics at regional and local authority level. These sub-national energy consumption estimates are based on consumption statistics from the following four datasets:

- Sub-national electricity consumption data
- Sub-national gas consumption data[15]
- Sub-national road transport consumption data
- Sub-national residual fuel consumption data

Residual fuels are defined as non-gas, non-electric and non-road transport fuels and cover consumption of coal, petroleum, manufactured solid fuels and bioenergy and waste, not used for the generation of electricity or road transport. Fuel consumption from aviation, shipping and power stations are not included in the BEIS dataset. Where possible, fuels used for fuel transformation are excluded (e.g. fuel used in power stations).

BEIS advises users to recognise the limitations of the information contained in the datasets as they are based on modelled rather than real data, and as such are subject to potential modelling error (BEIS, 2018a). Each year, the GHGI (Greenhouse Gases Inventory) data, which underpin these fuel consumption estimates are updated and extended. Updates, particularly involving revised methodologies, may affect the whole time-series, so estimates for a given year may differ from estimates for the same year reported previously (BEIS, 2018b).

[15] Not examined here as there is no mains gas network on Orkney.

Coal

Table 4.1 below shows the estimated fuel consumption for coal and manufactured solid fuels for Orkney by sector from the BEIS data (BEIS, 2018).[16]

Table 4.1 Modelled residual fuel use in Orkney - coal and manufactured solid fuels (GWh)

Fuel (sector)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Coal (industrial and commercial use)	7.7	7.4	6.8	7.4	9.4	9.3	9.6	8.8	10.4	10.8	8.7	8.9
Coal (domestic use)	17.2	15.5	17.8	18.8	18.8	19.6	19.4	18.5	17.8	15.2	15.3	15.1
Manufactured Solid Fuels (domestic use)	9.0	8.6	7.8	9.5	8.1	9.2	8.1	7.7	9.1	7.7	7.2	7.2
Total	**33.9**	**31.6**	**32.3**	**35.6**	**36.3**	**38.2**	**37.1**	**35.1**	**37.2**	**33.7**	**31.2**	**31.3**

These estimates are much higher than the figures over the same years for bulk imports given in Section 2.2.1. Although these bulk imports (given in Section 2.2.1) do not represent the total imports into Orkney as the two coal merchants are likely to have had additional deliveries by freight especially in recent years when bulk imports were absent, the most likely explanation is that imports have fallen below the level that makes importing in bulk necessary. The BEIS data is therefore likely to be an overestimation and the totals given in the BEIS data have been disregarded, and only the split between the sectors used as an estimate of usage in Orkney. Taking the GWhs given in Table 4.1 and applying the same ratio of domestic use vs industrial and commercial use (22.3GWh : 8.9 GWh) to the bulk import figures from 2015 gives an estimation of the coal use by sector (see Table 4.2).

Table 4.2 Estimated fuel consumption by sector in Orkney based on 2015 bulk imports - coal

Fuel (sector)	Estimated fuel usage by sector from BEIS data 2012-2016	Estimated fuel consumption by sector (GWh)
Coal (industrial and commercial use)	28%	2.32
Coal and Manufactured Solid Fuels (domestic use)	72%	5.90
Total	**100.0%**	**8.23**

Kerosene

The BEIS data, shown in Table 4.3 (BEIS, 2018), does not break the petroleum products down into different fuel types. Non-gas, non-electricity and non-road transport petroleum use is broken down by sector. As kerosene is mainly used for heating it is assumed that this is in the domestic, commercial, and public admin sectors. Gas oil is also used in some instances for heating but less common as it is more expensive.

[16] It should be noted that these figures vary considerably from those reported by BEIS previously and referenced in the 2014 Orkney-wide Energy Audit (Aquatera Ltd, 2015) however this is likely due to a revision in their modelling methodology.

Table 4.3 BEIS modelled residual fuel use in Orkney - petroleum products (GWh)

Sector	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Domestic use	102.2	108.9	94.6	97.4	95.3	106.2	82.1	81.4	84.3	76.8	77.4	77.1
Public administration use	12.1	7.5	6.6	5.1	2.6	1.7	4.5	1.8	0.7	1.2	1.6	1.7
Commercial use	5.7	4.4	4.1	3.8	2.6	2.9	2.9	2.4	2.6	3.0	3.6	3.3
Total	**120.0**	**120.7**	**105.3**	**106.3**	**100.5**	**110.8**	**89.5**	**85.6**	**87.6**	**80.9**	**82.6**	**82.0**

Data obtained from OIC (shown in Table 4.4) for their kerosene use gives a much higher value than the BEIS modelled estimates for petroleum products in public admin and have, therefore, been used in the total estimate in Table 4.5 and in the Sankey diagram (Figure 2) in the Executive Summary.

Table 4.4 Kerosene usage by OIC

	2014/15	2015/16	2016/17	2017/18	2018/19
Litres	1,115,109	1,216,260	1,092,503	976,246	900,601
Tonnes	895	976	877	784	723

To get an estimated fuel consumption by sector for kerosene the OIC data has been used in place of the BEIS data for the public admin portion. The remaining portion of the bulk import (non-public admin portion) is the domestic and commercial sector. The same ratio of domestic:commercial use (24:1)) from BEIS data over the last 5 years is applied to the OIC data to estimate the domestic and commercial use as shown in Table 4.5.

Not all public admin usage of Kerosene in Orkney will be reflected in the OIC figures as there may be some usage in NHS buildings so the public admin figures may be an underestimation, however the primary power source for the hospital is electricity powering an air to water heat pump with oil fired boilers as backup (NHS Orkney, 2018).

Table 4.5 Estimated fuel consumption by sector in Orkney based on bulk imports - kerosene

Units	Fuel (sector)	2016	2017	2018
Tonnes	Kerosene (domestic use)	6,845	6,848	8,079
	Kerosene (public administration use)	877	784	723
	Kerosene (commercial use)	285	285	337
	Total	8,007	7,917	9,139
GWh	Kerosene (domestic use)	87.8	87.9	103.7
	Kerosene (public administration use)	11.3	10.1	9.3
	Kerosene (commercial use)	3.7	3.7	4.3
	Total	102.8	101.6	117.3
Tonnes of CO_2	Kerosene (domestic use)	21,561	21,570	25,450
	Kerosene (public administration use)	2,763	2,470	2,277
	Kerosene (commercial use)	898	899	1,060
	Total	25,222	24,939	28,788

Gas

Main gas is also covered by the BEIS data but is not included here as Orkney is not on the mains gas network. Non mains LPG is used in Orkney (see Section 4.2.2).

Peat

Highland Park also uses peat in the whisky making process and the amount of peat cut varies by year, depending on production levels. In 2018, 99 tonnes of peat were cut for use in Highland Park, equivalent to 0.47 GWh (and around 178 tonnes of CO_2).

Electricity

BEIS publishes electricity consumption figures at a local authority level including the split between domestic and commercial/industrial (BEIS, 2019a), based on the meter's profile type. Properties are considered to be in the domestic category based on the meter type (Non-Half Hourly (NHH) meters using standard domestic and economy 7 type tariffs) and where the consumption is less than 100,000kWh annually.

The BEIS data shows that the electricity consumption across the Islands has generally remained constant with slight decreases over the last 12 years. The latest BEIS data is for 2017, showing 110.3 GWh of electricity consumed in Orkney, the lowest over the 2005-2017 period that BEIS data is available for (Table 4.6). At the same time the Average UK grid CO_2 emission factor (BEIS, 2019b) (a measure of the greenhouse gas emissions emitted for each GWh of electricity consumed) has also fallen. Although this data is presented under the buildings section a small amount of this electricity will also be used for charging electric vehicles (see Section 4.4.1) assumed to be mostly from the domestic portion.

Table 4.6 Total estimated annual electricity consumption for Orkney

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
GWh													
Domestic	84.5	84.2	85.5	84.0	81.0	83.1	83.9	83.2	79.8	82.2	81.6	80.0	81.8
Non-Domestic	53.6	59.7	64.1	54.3	52.6	66.0	58.1	58.8	60.3	61.9	62.4	55.3	56.3
Total	**138.1**	**143.9**	**149.6**	**138.3**	**133.6**	**149.1**	**142.0**	**142.0**	**140.0**	**144.1**	**144.0**	**135.3**	**138.1**
Average UK grid CO_2 emission factor													
tCO_{2e} /GWh	546.46	576.40	564.36	556.70	506.94	512.32	495.58	551.53	516.98	468.22	396.54	312.93	276.60
Tonnes of CO_2													
Domestic	29290	34411	36175	30229	26665	33813	28793	32430	31174	28983	24744	17305	15573
Non-Domestic	46176	48533	48253	46763	41062	42574	41579	45887	41255	38488	32358	25034	22626
Total	**75466**	**82944**	**84428**	**76992**	**67727**	**76387**	**70372**	**78317**	**72377**	**67471**	**57102**	**42339**	**38198**

BEIS also releases other statistical information relating to electricity consumption, this includes the average consumption of electricity per customer for both domestic and non-domestic. This calculated through the sales to each meter, Figure 4.1 shows how these figures have evolved for both domestic and non-domestic from 2005 to 2017. For domestic the figure has been slowly decreasing from 2005 to the most recent available data of 2017, where it is currently estimated to be 5,597 kWh a year. For the industrial and commercial sector this figure is estimated at 24,406 kWh a year.

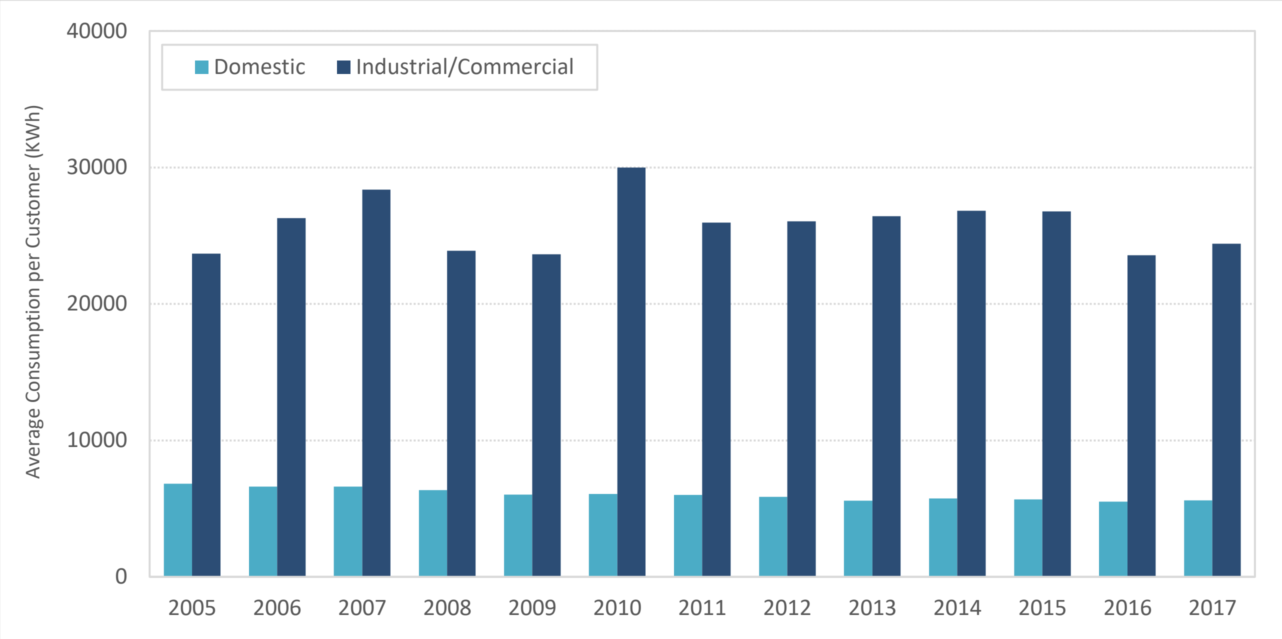


Figure 4.1 Average electricity consumption per customer

Electricity consumption per capita and per dwelling has been calculated using statistics from the Scottish Government on population and housing estimates in each Intermediate Geography Zone, per dwelling; only occupied dwelling figures were used for a more accurate assessment. Figure 4.2 suggests that Kirkwall has the highest electricity use per user and by dwelling, the Isles use less electricity per household but use slightly more electricity per capita than West Mainland, which has the lowest electricity consumption per capita in the Islands.

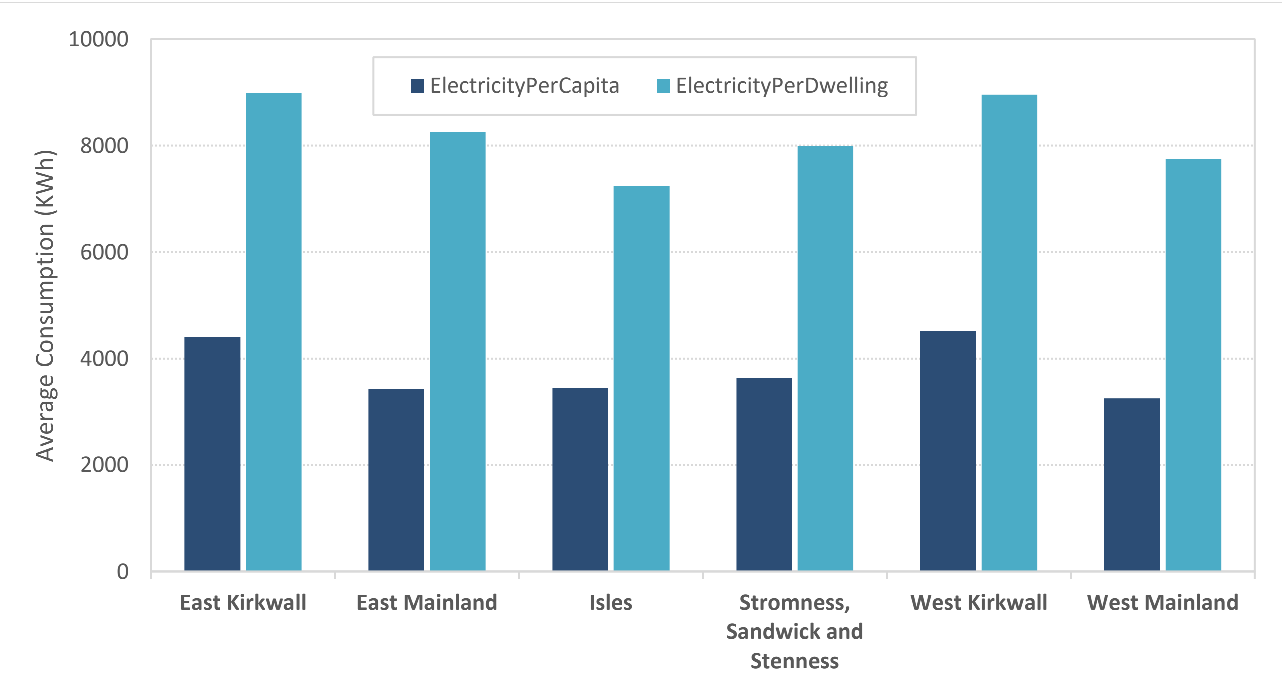


Figure 4.2 Electricity consumption per capita/dwelling in 2017

4.2.2 Data from other data sources

ANM data

As discussed in Section 2.5.4 demand data for Orkney has been collected since 2012 and is shown (Figure 4.3) for an average weekend and weekday for each season which shows higher demand in winter and lower demand in summer, with spring and autumn being somewhere between winter and summer as expected due to the extra demand in the colder months for heating. Interestingly this shows a differentiation between the average weekend and weekday across the seasons especially in the mornings presumably due to differences in the timing of heating demand in the mornings at the weekend.

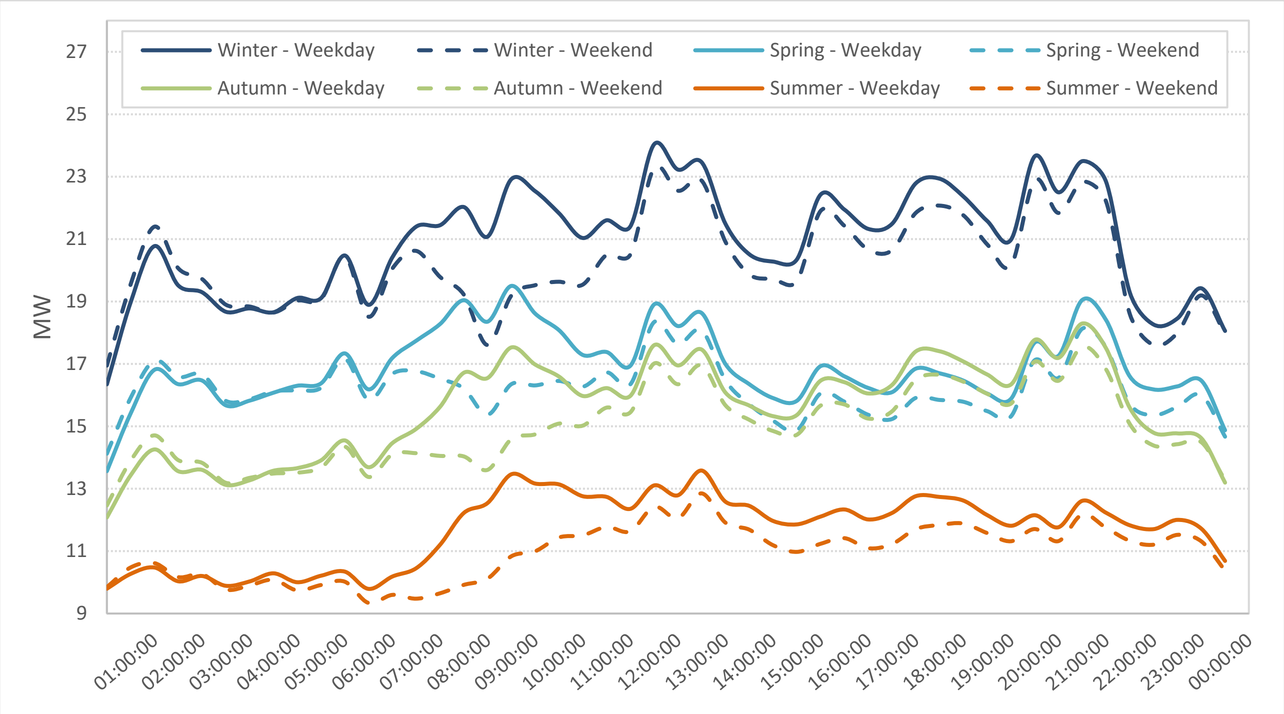


Figure 4.3 Half hourly demand averages for an average weekend and weekday for each season (2012 to 2018)

LPG

OIC use LPG for heating in the new Stromness Primary School, the new Kirkwall Grammar School and the new Papdale Halls of Residence as well as for heating as well as cooking and the science department at KGS, as per Table 4.7.

Table 4.7 LPG estimates for OIC properties

Building	2014/15	2015/16	2016/17	2017/18	2018/19
School - Kirkwall Grammar School	94,799	34,491	83,345	111,911	83,498
School - Stromness Primary School	19,216	7,849	15,079	19,912	11,600
Papdale Halls of Residence	22,755	11,233	19,177	22,104	21,650
Total (Litres)	136,770	53,573	117,601	153,927	116,748
GWh	0.95	0.37	0.82	1.07	0.81
Tonnes of CO_2	204	80	175	229	174

Source: OIC

Data on bottled gas is shown in Section 2.2.2 however there is no data on the final energy use for this fuel although it is most likely to be heating and cooking.

Self-consumption of electrical output

Orkney has a range of renewable energy technology types, as discussed in Section 2.5.4. For households and businesses with their own renewable energy installations a proportion of the energy generated will be consumed by the household or business and will therefore be unseen by the network and therefore is difficult to quantify.

Heat pumps

There are three different types of heat pump in use in Orkney:

- **Ground Source Heat Pumps (GSHP)** - use pipes which are buried in the ground to extract heat from the ground by circulating a mixture of water and antifreeze around a loop of pipe. Heat from the ground is absorbed into the fluid and then passes through a heat exchanger into the heat pump. This heat can then be used to heat radiators, underfloor heating systems, or warm air convectors and hot water.
- **Air Source Heat Pumps (ASHP)** - absorb heat from the outside air in the same way that a fridge extracts heat from its inside. This heat can then be used to heat radiators, underfloor heating systems, or warm air convectors and hot water.
- **Sea Source Heat Pump (SSHP)** – work in a similar way to ground source heat pumps but the pipes are immersed in seawater rather than being buried in the ground.

Ground and air source heat pumps have become increasingly common in Orkney and many private households, as well as public buildings, have heat pumps installed. More than 1,700 heat pumps have been installed in Orkney[17]. From OIC's planning application portal, it was noted that most planning applications for the construction of new dwellings integrate heat pumps as part of the building's heating system, air source heat pumps being the most used technology.

Table 4.8 shows all current Orkney Islands Council's public buildings' heat pump installations. Currently there is approximately 2.2MW of total installed capacity within Orkney Islands Council's public buildings.

Table 4.8 List of heat pumps installed in public buildings

Site	Technology	Rating (kW)	QTY	Total Installed Rating (kW)
Braeburn Court Core Unit	ASHP	12	1	12
Children's Home, Watersfield	GSHP	21	2	42
Evie Primary School	GSHP	112	1	112
Glaitness Primary School	GSHP	12	8	96
		25	2	50
Hamnavoe House	GSHP	45	3	135
Kalisgarth Care Facility	GSHP	15	1	15
Kirkwall Grammar School	GSHP	126	6	756
Papdale Halls of Residence	GSHP	126	2	252
Pickaquoy Camp Site	ASHP	14	2	28

[17] This number has been provided by Orkney Islands Council from the Energy Performance Certificate Database.

Site	Technology	Rating (kW)	QTY	Total Installed Rating (kW)
Pickaquoy Centre	GSHP	126	2	252
Sanday Junior High School	GSHP	12	4	48
Smiddybrae House	GSHP	40	2	80
Stromness Community Centre	ASHP	16	5	80
Stromness Primary School	GSHP	65.6	2	131.2
Stromness Swimming Pool	GSHP	31.2	1	31.2
Warehouse Building	SSHP	40	2	80

Source: OIC

As shown in the graph in Figure 4.4, the great majority of the total installed heat pump capacity in Orkney's public buildings consists of ground source heat pump systems.

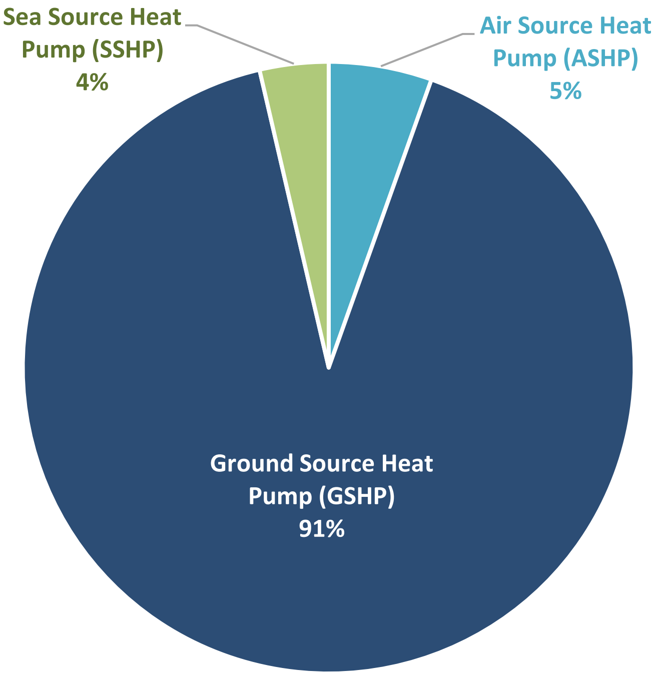


Figure 4.4 Percentages of Orkney's total installed heat pump capacity (kW) by installation type for public buildings

Renewable Heat Incentive Installations

The Renewable Heat Incentive (RHI) is a UK Government financial support programme for renewable heat. The RHI pays participants of the scheme for the generation and usage of renewable energy heat in buildings. There are schemes covering both domestic and non-domestic installations.

The non-domestic RHI was launched in November 2011 and the domestic RHI in April 2014.

Technologies eligible for RHI support are (Energy Saving Trust, 2019):

- Biomass (wood fuelled) boilers
- Biomass pellet stoves with integrated boilers providing space heating
- Ground to water heat pumps
- Air to water heat pumps
- Solar thermal panels (flat plate or evacuated tube only) providing hot water

Renewable heat systems which are not supported by RHI are air to air heat pumps, all log stoves, pellet stoves without back boilers and hybrid photovoltaic thermal panels. Water source heat pumps can potentially be eligible for RHI as they are included within the definition of ground source heat pump. Some cooker stoves and some high temperature heat pumps may also be eligible.

Ofgem keeps a register of RHI installations and publishes details of accredited installations/registered bio-methane producers within the RHI Scheme as well as heat/bio-methane produced and subsequent payments made. The publicly available data collates data for the whole of Scotland (Ofgem, 2019c).

4.2.3 Thermal storage and refrigeration

There are several examples of large-scale refrigeration in Orkney within commercial properties and public buildings, however it has been difficult to gather data on usage and energy ratings for these units. Large scale examples of refrigeration units include supermarkets, food wholesalers, food production and processing units, and public service buildings such as the hospital and schools. It is expected that much of this refrigeration will be electrical and therefore included within the total electrical consumption of Orkney.

Large scale examples of thermal storage are limited. Thermal storage is more commonly found in domestic scale applications such as traditional domestic hot water cylinders. Smart energy systems are increasingly using domestic hot water cylinders along with buffer and accumulator tanks or using batteries or phase change material as a method of storing energy from intermittent renewable energy sources or from off-peak tariff charging. Projects such as the SMILE project are utilising phase change material heat batteries in place of regular hot water cylinders in 30 domestic properties as a form of thermal storage, allowing the batteries to react to and charge during periods of curtailment and excess energy generation.

4.3 TERRESTRIAL NON-ROAD TRANSPORT, INDUSTRY AND AGRICULTURE

4.3.1 Gas oil and sulphur free gas oil

As noted above the BEIS data shown here does not break the petroleum products down into different fuel types. Non-gas, non-electricity and non-road transport petroleum use is broken down by sector. For the agriculture and industrial sectors the fuel is most likely to be gas oil or sulphur free gas oil.

As of 1 January 2011 non-road mobile machinery (which includes tractors and other agricultural equipment, forestry equipment, construction equipment, forklifts, portable generators, railway engines, inland waterway vessels and recreational craft) are now required by EU Directive 2009/30/EC to use sulphur free gas oil (i.e. fuel that contains no more than 10 milligrams of sulphur per kilogram of fuel) (Department for Transport, 2010). The use of gas oil for other purposes, such as heating or stationary equipment do not currently fall under these requirements.

Table 4.9 BEIS modelled residual fuel use in Orkney - Gas Oil and Sulphur Free Gas Oil (GWh)

	Sector	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
GWh	Industry	95.2	84.4	84.0	69.2	66.6	70.8	66.0	54.9	54.8	65.7	68.4	70.9
	Agri-culture	123.9	117.8	111.3	108.6	110.4	111.3	112.9	116.3	114.9	115.9	120.4	121.9
	Total	**219.2**	**202.3**	**195.3**	**177.8**	**177.0**	**182.2**	**179.0**	**171.1**	**169.7**	**181.6**	**188.9**	**192.8**

It is difficult to apportion the use of gas oil and sulphur free gas oil to each sector as both sectors may use both mobile and non-mobile machinery so they are considered as the same fuel here as they will have similar properties in terms of energy and carbon emissions. In addition, these fuels are also used in the marine sector. The ferries to mainland Scotland are likely to be refuelling on the mainland. The fuel used by Marine Services (Section 4.4.2) for their towage, harbour craft and inter-island ferries is known to be supplied by one of the main suppliers and therefore is represented in the bulk imports (see Section 2.2.6).

The estimates produced by BEIS (BEIS, 2018a) for these sectors do not break the petroleum products down into different fuel types but is most likely to be gas oil or sulphur free gas oil. The latest estimates (for 2016) are for 70.9 GWh for Industry and 121.9 GWh for Agriculture however this exceeds the total for gas oil and sulphur free gas oil that is known to be imported into Orkney in bulk.

Of the total bulk gas oil imports (100.3 GWh) we know that around 40.5 GWh of gas oil are used by OIC Marine Services. Therefore, a maximum of 59.8 GWh of gas oil and 80.3 GWh of sulphur free gas oil are left and the use of these between the marine, industry and agriculture sectors are unknown.

4.4 TRANSPORT

4.4.1 Road transport

Petrol and road diesel

BEIS also produces estimates of transport fuel usage at a local authority level. These sub-national road transport fuel statistics cover petrol and road diesel use only. It does not include consumption of biofuels, liquefied petroleum gas (LPG) or electricity. Electric vehicles are discussed in the next section. As for the residual fuel estimates above it should be noted that these estimates are based on modelled rather than real data, and as such are subject to potential modelling error but are shown here to illustrate general trends in fuel consumption. The proportion of fuel use by different vehicle type has been used to estimate the amount of fuel from real import figures across the different vehicle type and therefore purpose of travel.

Table 4.10 shows the estimated petrol consumption in Orkney by vehicle type and by purpose of travel (BEIS, 2019b). The majority of this consumption is domestic cars.

Table 4.10 BEIS Estimated fuel consumption by vehicle type and purpose of travel in Orkney (GWh)

Purpose of travel	Vehicle type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Personal	Motorcycles	0.6	0.6	0.6	0.5	0.6	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.5
Personal	Petrol Cars	42.2	43.3	41.9	38.8	38.2	36.0	33.8	32.1	30.7	29.7	28.3	27.8	26.4
Freight	Petrol LGV	1.4	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.9	0.9	0.8	0.8	0.8
Total petrol		**44.2**	**45.4**	**43.9**	**40.7**	**40.0**	**37.6**	**35.3**	**33.4**	**32.0**	**31.0**	**29.6**	**29.1**	**27.6**
Personal	Diesel Cars	15.6	18.2	19.8	22.2	22.8	22.8	23.5	24.0	25.2	27.2	28.6	29.3	29.8
Personal	Buses	6.1	6.4	7.2	7.4	7.5	8.1	7.7	8.1	8.8	8.9	9.0	9.0	9.1
Freight	Diesel LGV	13.7	14.8	15.8	16.4	16.5	16.8	16.9	16.6	17.8	19.5	20.8	22.7	24.9
Freight	HGV	10.2	10.7	11.2	12.3	12.1	12.5	12.1	10.4	10.5	11.1	11.3	11.7	11.9
Total road diesel		**45.7**	**50.2**	**54.0**	**58.4**	**58.8**	**60.3**	**60.2**	**59.2**	**62.3**	**66.7**	**69.7**	**72.8**	**75.8**

There has been a continued fall in total fuel consumption by petrol cars over the last decade or so and trend towards diesel cars during this period. In fact, total fuel consumption by diesel cars has increased over the same period (as shown in Table 4.11 below).

The modelled BEIS data varies from the real-world bulk imports data from Marine Services. This is likely due to a range of uncertainties associated with the modelled data such as fleet information and fuel consumption factors. However, applying the proportion of fuel use by different vehicle type from the BEIS data to the real-world bulk imports data from Marine Services for petrol and road diesel (see Section 2.2.4 and 0) gives an estimation of the amount of fuel consumption across the different vehicle type and purpose of travel. These figures are given only as a broad estimate and caution should be used if using these figures for other purposes.

Table 4.11 Estimated fuel consumption by vehicle type and purpose of travel in Orkney based on bulk imports (GWh)

Purpose of travel	Vehicle type	Percentage of estimated fuel usage from BEIS data 2013-2017 by vehicle type	Year		
			2016	2017	2018
Personal use	Motorcycles	1.5%	0.6	0.6	0.7
Personal use	Petrol Cars	95.8%	38.8	39.3	41.7
Freight	Petrol LGV	2.7%	1.1	1.1	1.2
Total Petrol			**40.5**	**41.0**	**43.6**
Personal	Diesel Cars	40%	34.4	34.8	34.7
Public	Buses	13%	11.0	11.1	11.1
Freight	Diesel LGV	30%	25.9	26.3	26.2
Freight	HGV	16%	13.9	14.1	14.0
Total DERV			**85.2**	**86.3**	**86.1**

Electric vehicles

The number of electric vehicles registered in Orkney has shown steady rise since the last decade (Figure 4.5), going from a relatively small fleet to 247 vehicles in the third quarter of 2019 (Department for Transport, 2019).

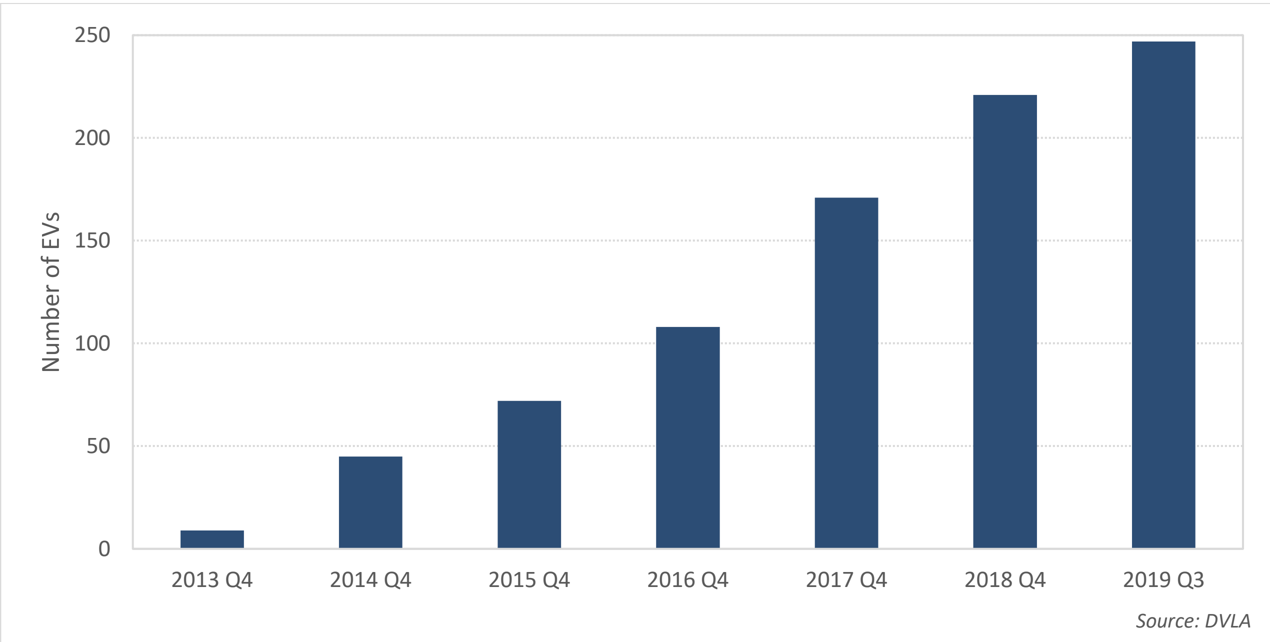


Figure 4.5 EVs registered in Orkney

In parallel to the increase of number of EVs in Orkney, the charging infrastructures have adapted to the increasing fleet of vehicles; commissioning of new charging points across the county has increased. Table 4.12 shows the number of charging events over the main charging points installed in Orkney on the 2013-2019 period. As a consequence of the increased EVs car fleet, the number of charging events has followed a similar evolution, going from 520 charges over the 2013/2014 financial year to around 18000 over the 2018/2019 financial year.

Table 4.12 Number of Orkney's EV charging events for the different charging points installed

Charging Sessions	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Church Road Car Park	-	-	-	7	1,597	1,541
Dounby Primary School	5	16	53	69	1,090	1,506
Ferry Road Long Stay Car Park	-	-	-	9	1,964	2,707
Great Western Road Car Park, Kirkwall	-	730	1,612	3,635	5,446	6,742
Kirkwall Council Offices	-	624	946	1,521	2,217	2,343
Kirkwall Travel Centre	-	-	-	-	3	100
Old Academy Business Centre	498	625	599	781	1,117	1,057
St Margaret's Hope Care Home	-	299	442	445	105	63
St Rognvald's House, Kirkwall	17	100	65	103	48	62
The Pickaquoy Centre, Kirkwall	-	-	338	848	1,313	1,697
Total	**520**	**2,394**	**4,055**	**7,418**	**14,900**	**17,818**

Source: OIC

Figure 4.6 shows the evolution of the electricity consumed for EV charging for different areas of the mainland. Most charging needs are located in Kirkwall which accounted for more than 57% of the electricity consumed for charging in the financial year 2018/2019. In total the EVs' energy demand has increased significantly over the past six years, raising from a few MWh to around 150 MWh in 2018/2019 (Table 4.13).

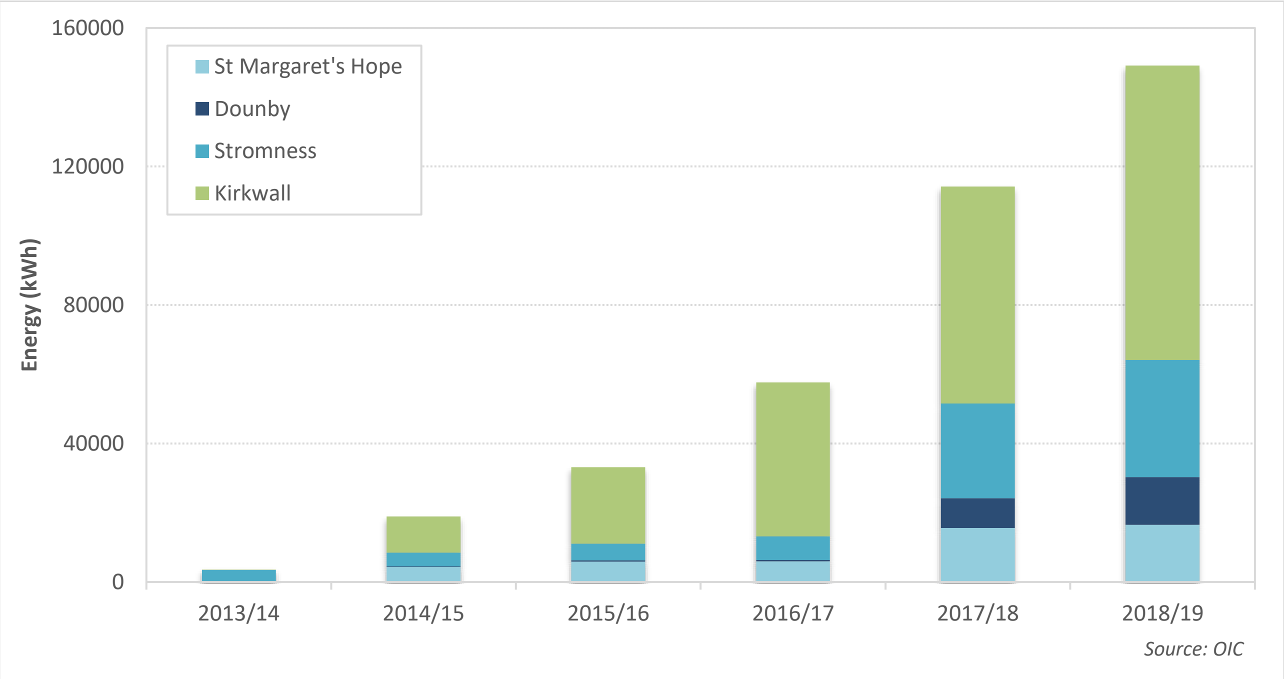


Figure 4.6 Electricity consumed for EV charging

Table 4.13 Amount of energy dispensed (kWh) for EV charging at the different charging points installed

Energy (kWh)	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Church Road Car Park	0	0	0	64	15,117	15,937
Dounby Primary School	73	165	382	299	8,582	13,729
Ferry Road Long Stay Car Park	0	0	0	96	17,003	24,025
Great Western Road Car Park, Kirkwall	0	4,459	11,813	27,301	37,628	49,511
Kirkwall Council Offices	0	5,234	7,951	11,258	17,101	20,167
Kirkwall Travel Centre	0	0	0	0	8	4,153
Old Academy Business Centre	3,383	3,962	4,787	6,736	10,365	9,776
St Margaret's Hope Care Home	0	4,356	5,865	5,960	475	625
St Rognvald's House, Kirkwall	5	761	379	,946	118	706
The Pickaquoy Centre, Kirkwall	0	0	1,940	4,953	7,772	10,546
Total	**3,461**	**18,936**	**33,117**	**57,613**	**114,170**	**149,173**

Source: OIC

On 6 May 2019, charging EVs went from being a free service in Orkney, to the current paid charging scheme. The result of this has been a drop in the number of charging sessions per month. Since the EV fleet has increased during the same period of time, it can be assumed that home charging points have been preferred by users over the public charging, since this became a charged service.

OREF (Orkney Renewable Energy Forum) also collects data from EV owners on their mileage and usage activity on a monthly basis. Analysis of this dataset of 72 EVs shows that the average mileage per day is about 22 miles.

The OREF data also includes information on the year of manufacture and therefore information on the battery capacity, range and efficiency can be obtained from various online databases and forums, these include the EV Database (EV Database UK, 2019); which have real range figures for a large number of EVs. Using these figures, an estimation of an average efficiency (MWh/mile) for the OREF database fleet has been made and used to estimate the annual energy consumption for all DVLA registered EVs in Orkney. The results of this can be in seen in Table 4.14 below.

Table 4.14 Estimated Annual Energy Consumption by Orkney EVs

Average Miles Per Day	Average MWh Per Mile	Number of EVs Registered in Orkney	Estimated Annual Energy Consumed by Orkney EVs (GWh)	Estimated CO_2 emissions (Tonnes)
21.74	0.000299	234	0.555	30

Hydrogen

As part of the BiGHIT project, there are five hydrogen range extended electric vans being trialled in Orkney. Each van has a battery and a fuel cell which converts hydrogen to electricity. Because these are classified as electric vehicles they are included in the total number of electric vehicles in the previous section.

4.4.2 Marine transport

Marine services

Marine Services is a division of Orkney Islands Council, which incorporates the Harbour Authority, Orkney Towage and Orkney Ferries. Orkney Ferries operate nine dedicated inter-island ferries between Orkney's mainland and thirteen island destinations. Orkney Towage is primarily engaged in providing the towage services for the Oil Port of Scapa Flow which includes assisting in the berthing and sailing of oil tankers and gas tankers from the Jetty and Single Point Mooring, plus the berthing and sailing of oil tankers involved in ship-to-ship operations and escort duties for oil tankers arriving and departing Scapa Flow.

Table 4.15 Tugs and harbour craft and inter-island ferries - annual consumption of marine gas oil

	Use	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Litres	Orkney Ferries	2,849,191	2,775,956	2,986,693	2,893,130	2,850,614	2,792,629	2,911,246	2,823,118	2,869,303	2,929,562	2,932,046
	Towage	539,480	672,051	441,686	326,673	265,144	268,104	578,697	414,195	384,547	569,993	649,202
	Harbour Craft	86,860	64,860	92,040	132,650	119,001	114,360	110,171	126,074	151,090	169,494	190,605
	Total	3,475,531	3,512,867	3,520,419	3,352,453	3,234,759	3,175,093	3,600,114	3,363,387	3,404,940	3,669,049	3,771,853
GWh	Orkney Ferries	30.6	29.8	32.1	31.1	30.6	30.0	31.3	30.3	30.8	31.5	31.5
	Towage	5.8	7.2	4.7	3.5	2.8	2.9	6.2	4.4	4.1	6.1	7.0
	Harbour Craft	0.9	0.7	1.0	1.4	1.3	1.2	1.2	1.4	1.6	1.8	2.0
	Total	**37.3**	**37.7**	**37.8**	**36.0**	**34.7**	**34.1**	**38.7**	**36.1**	**36.6**	**39.4**	**40.5**
Tonnes of CO_2	Orkney Ferries	7,755	7,556	8,129	7,875	7,759	7,601	7,924	7,684	7,810	7,974	7,981
	Towage	1,468	1,829	1,202	889	722	730	1,575	1,127	1,047	1,551	1,767
	Harbour Craft	236	177	251	361	324	311	300	343	411	461	519
	Total	**9,460**	**9,561**	**9,582**	**9,125**	**8,805**	**8,642**	**9,799**	**9,155**	**9,268**	**9,987**	**10,266**

Source: OIC

Ferries to mainland Scotland

There are a number of ferry services that provide links between Orkney and the Scottish mainland as detailed in Table 4.16.

Table 4.16 Ferry Services to mainland Scotland

Company	Service	Ports	Vessel
John O'Groats Ferries	Passenger	Burwick and John O'Groats	Pentland Venture
Pentland Ferries	Freight, vehicle and passenger	St. Margaret's Hope and Gills Bay	MV Alfred[18]
Northlink Ferries	Freight	Kirkwall to Aberdeen (and Lerwick)	Hildsay/Hellier
	Freight, vehicle and passenger	Kirkwall to Aberdeen (and Lerwick)	Hrossey Hjaltland
	Freight, vehicle and passenger	Stromness to Scrabster	Hamnavoe

The fuel usage of the Northlink and Pentland Ferries vessels has been estimated previously in the Orkney-wide Energy Audit 2014 and a subsequent addendum (Aquatera Ltd, 2015). The addendum provided updated figures which have taken into consideration the fact that Kirkwall is an intermediate call in what is essentially an Aberdeen-Lerwick service for the Northlink vessels other than the Hamnavoe). According to Northlink Ferries the difference in the direct and indirect crossing (Aberdeen-Lerwick/Aberdeen-Kirkwall-Lerwick) is 85km. If this figure is used as the 'Orkney Contribution' rather than the 248km used by Pedersen Consulting then the energy use would be as given in Table 4.17. As of 1 January 2015, all of these vessels are now using gas oil, rather than the heavy fuel oil used by some of these ships previously, to comply with sulphur limits in North Sea SECA regulations (IMO, 2019). The information presented in the addendum adjusted to reflect the number of crossings in the current timetable[19] has been used to estimate the total gas oil consumption for these services and accounts for 100.7 GWh.

Table 4.17 Total gas oil consumption for Pentland Ferries, Northlink Ferries and John O'Groats Ferries

Gas oil consumption	Total
Litres (Pentland Ferries, Northlink Ferries)	9,452,962
Litres (John O'Groats Ferry)	77,450
Total Litres	9,449,956
Tonnes[20]	8,063
GWh	101.5
Tonnes of CO_2	25,784

Source: John O'Groats Ferry and Orkney-wide Energy Audit 2014 and a subsequent addendum (Aquatera Ltd, 2015)

Other marine fuel use

Other fuel use within the marine transport sector will include fuel used by a variety of other vessels used in sectors (including but not limited to) fishing, aquaculture, marine renewables, cruise liners, oil and gas. These will get their supplies via a variety of routes.

[18] The MV Alfred entered service on 1 November 2019 but calculations of fuel use are based on previous studies when the MV Pentalina was in operation.

[19] Pentland Ferries – 6 crossings per day

Hildasay / Helliar – 5 crossings per week

Hjaltland / Hrossey - 1 crossing per day via Kirkwall except Mondays and Tuesdays between 1 Nov and 31 March.

Hamnavoe - 4 crossings per day except 102 days a year where there are 6 crossings and 4 days where there are none.

[20] 0.832 kg/L

One of the main suppliers of marine fuel (a company set up to supplying marine diesel and low sulphur fuel to commercial vessels across Orkney) was contacted and was able to provide data but it could not be included in the report because it is commercially sensitive information and cannot be anonymised. Therefore, the data presented in this report is not a complete picture of fuel use by boats operating in Orkney.

In addition, it is understood that the larger fishing vessels and a number of dive boats have contracts with the fuel suppliers directly and that other vessels not usually based in Orkney would organise fuel supplies by road tanker fuel suppliers directly.

For these reasons, the use of gas oil and sulphur free gas oil in the marine sector is not completely accounted for in the report.

Hydrogen

Dual Ports (Interreg, 2019), HyDIME (UKRI, 2019), and HySeas III (INEA, 2019) are all marine transport related hydrogen projects ongoing in Orkney. Dual Ports brings together harbour authorities and public/private sector organisations to develop low carbon ports utilities and to promote the use of non-conventional fuel, including hydrogen. HyDIME (Hydrogen and Diesel Injection in a Marine Environment) aims to design and trial a dual hydrogen diesel fuel system for auxiliary power to a car and passenger ferry operating within the Orkney Isles. HySeas III is constructing and testing a hybrid hydrogen fuel cell power system for a vehicle and passenger ferry within Orkney.

4.4.3 Air transport

Domestic and short haul flights from Kirkwall Airport

Data from the Civil Aviation Authority (CAA, 2018) for each airport in the UK shows the number of passengers handled for each route as shown in Table 4.18.

As details of aviation fuel use at Kirkwall airport were not available – and in any case would not reflect all the fuel used for these services as most refuelling happens outside of Orkney, for flights to and from mainland Scotland – an estimation of the total CO_2 emissions and the total amount of aviation fuel used to run these airline services is presented in Table 4.19.

Table 4.18 Kirkwall Airport Passenger Statistics 2018

Route	Passengers Handled
Domestic and short haul flights from Kirkwall Airport	
Aberdeen	57,620
Edinburgh	46,232
Inverness	22,634
Glasgow	22,450
Sumburgh	9,611
Manchester	1,097
Bergen	410
Fair Isle	179
Orkney Inter-Island Flights	
North Ronaldsay	5,953
Papa Westray	4,885
Westray	3,542
Stronsay	3,527
Sanday	2,994
Eday	523

For the domestic routes and short haul flights a total CO_2 for each route has been calculated using a CO_2 emission factor of 0.13483kgCO_2/passenger/km (BEIS, 2019c)[21], and from this an estimation of the fuel used based on the total CO_2 emissions based on standard conversion factors in Appendix A.

[21] This factor does not include the radiative forcing factor as it is thought that the cruising altitude of the small planes used on these routes is lower than the altitudes generally 8–13 km altitude these effects are induced (Kärcher, 2018).

Table 4.19 Estimated CO_2 Emissions and Fuel Usage Kirkwall Airport (Non-Inter-island) 2018

Route	Passengers 2018	One Way Distance (km)	Tonnes of CO_2	Jet A-1 (Tonnes)
Aberdeen	57,620	203	1577	501
Edinburgh	46,232	338	2107	669
Inverness	22,634	172	525	167
Glasgow	22,450	357	1081	343
Sumburgh	9,611	137	178	56
Manchester	1,097	626	93	29
Bergen	410	481	27	8
Fair Isle	179	97	2	1
			Total	**1,774**

Inter-Island Flights

Data obtained from Loganair gives for the Inter-Island Flights estimates an annual usage of AV gas for the inter-island flight to be 140,000 litres.

5 SOCIO-ECONOMIC OVERVIEW

Selected indicators have been included to provide a socio-economic background for Orkney. Baseline information on Orkney's social, economic and environmental setting on an individual, household and regional basis, provides a systematic understanding and context for the energy consumption patterns and trends observed on Orkney. This ensures that the overall sustainability of the energy system is considered, providing a reference against which any wider social, economic or environmental repercussions can be measured as the energy systems continue to develop.

5.1 PEOPLE AND COMMUNITIES

5.1.1 Individual and household indicators

Demographics

The 2018 population estimate for Orkney, 22,190, is the lowest population out of all 32 Scottish council areas. Orkney has experienced a 13.3% increase in population since 1998 (Figure 5.1), representing the sixth highest percentage change across all council areas (NRS, 2019a).

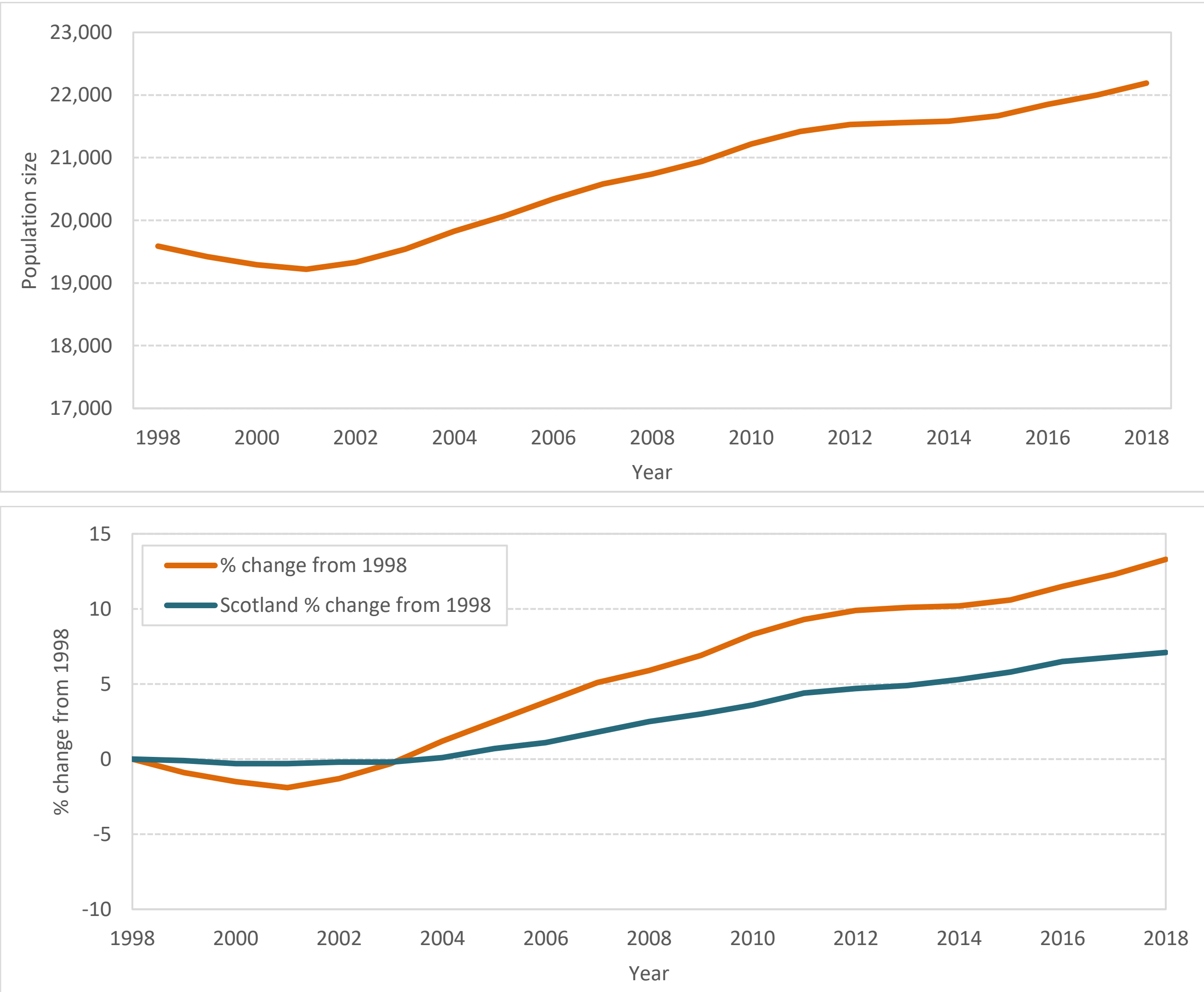


Figure 5.1 Population estimates for Orkney from 1998-2018

As displayed in Figure 5.2, the age distribution for Orkney in 2018 highlights the highest proportion of the population is within the 45 to 64 age group for male and female populations combined (NRS, 2019b). Similar to the 1998 data for Orkney, the lowest proportion of the male and female population in 2018 is in the 16 to 24 age group at 9%, suggesting that prospects of higher education and employment opportunities remain an influence over the migration of young people from remote rural areas (Scottish Government, 2018).

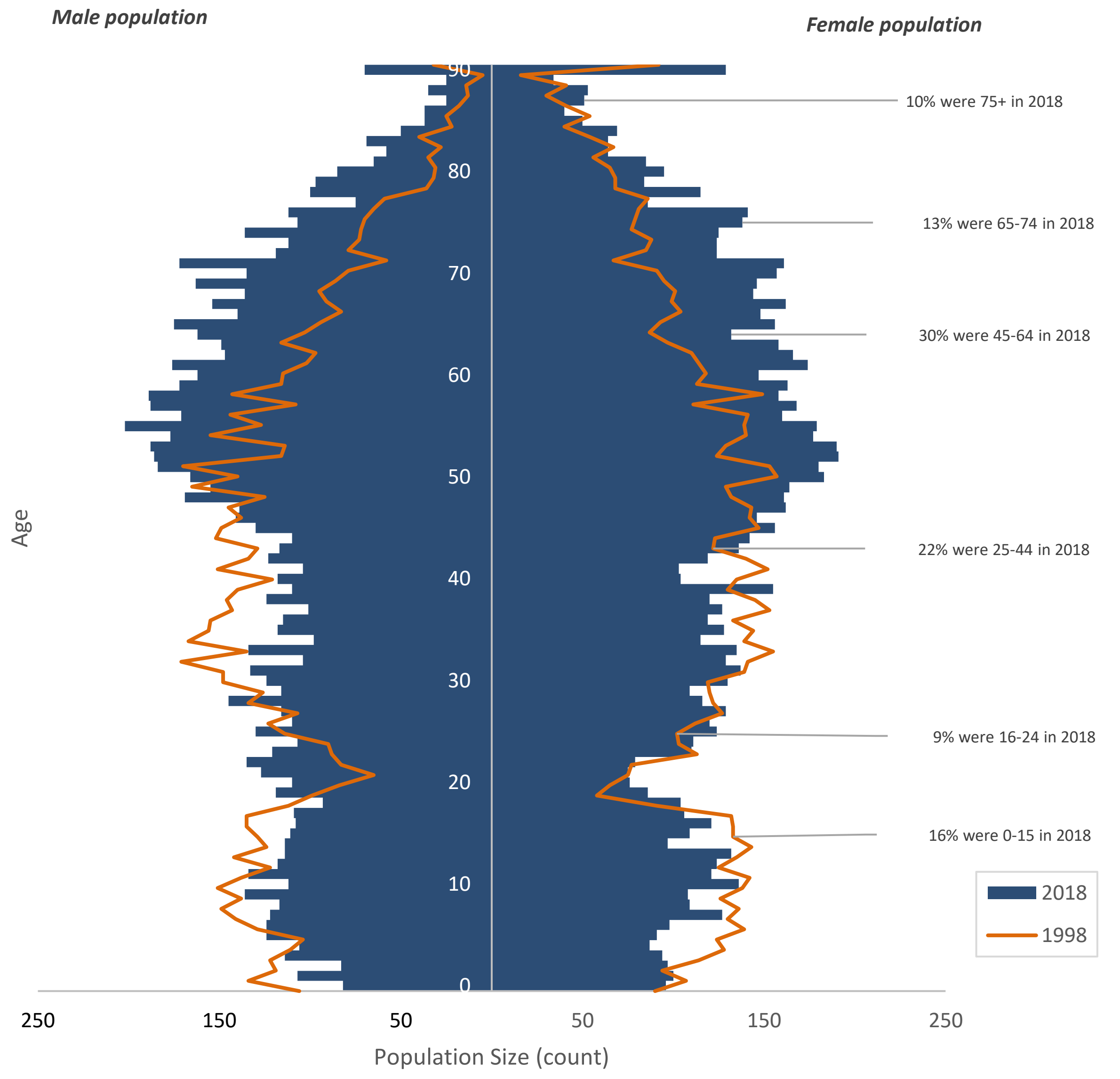


Figure 5.2 Population profile for Orkney, 1998 and 2018

The proportion of household types[22] for Orkney between 2013 and 2017 is displayed in Figure 5.3, which are broadly comparable with the Scottish averages (SHS, 2019). The most notable difference between Orkney and Scotland is the proportion of 'Older smaller' and 'Single older' households, with Orkney having a higher proportion of households containing one or two adults of pensionable age.

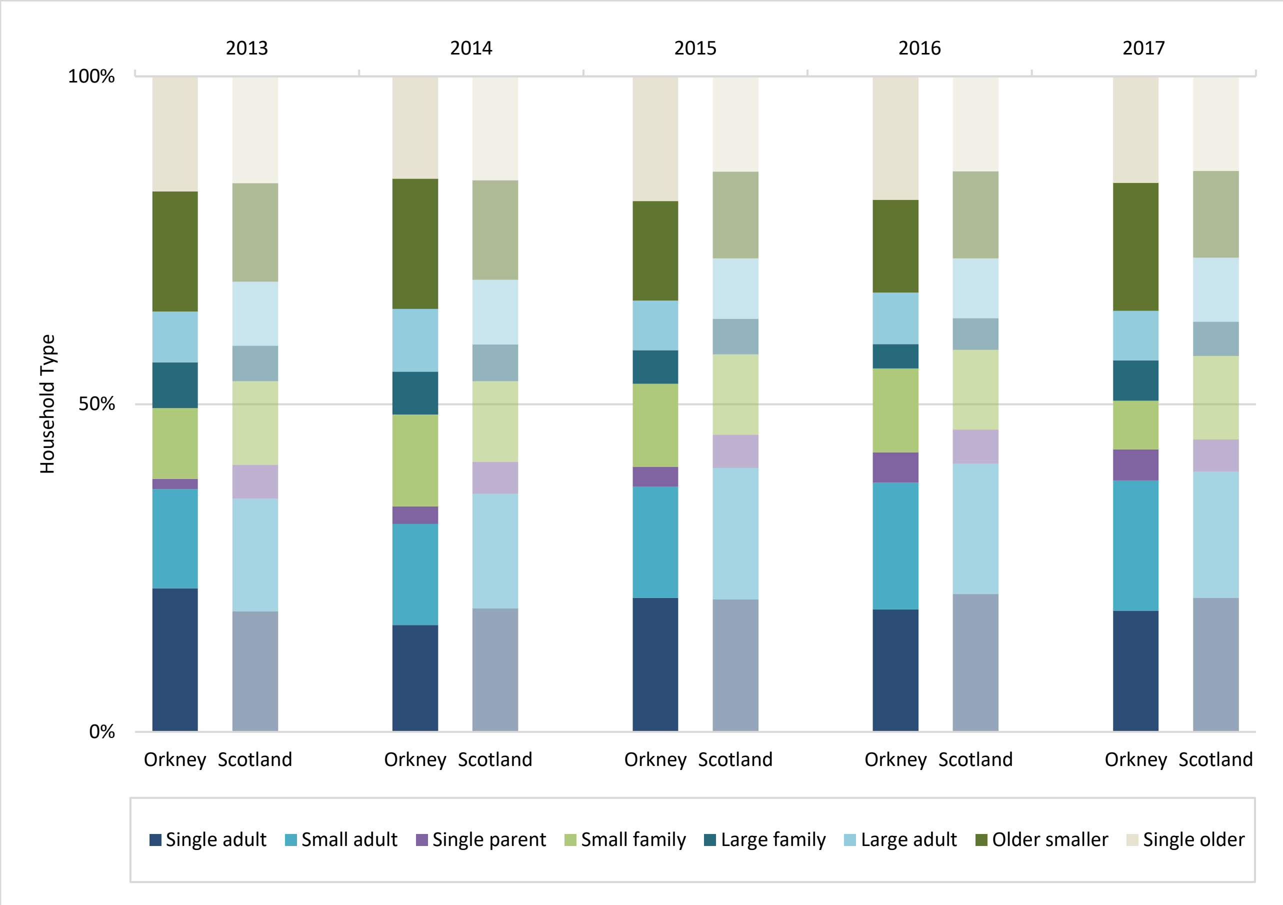


Figure 5.3 Household types for Orkney and Scotland, 2013-2017

[22] Notes: **Definitions of Household Types (Scottish Household Survey, 2017)**
'single adult' household contains one adult of working age and no children
'small adult' household contains two adults of working age and no children;
'single parent' household contains one adult of any age and one or more children;
'small family' household contains two adults of any age and one or two children;
'large family' household contains two adults of any age and three or more children, or three or more adults of any age and one or more children;
'large adult' household contains three or more adults and no children;
'older smaller' household contains one adult of working age and one of pensionable age and no children, or two adults of pensionable age and no children;
'single pensioner' household contains one adult of pensionable age and no children. Pensionable age is 60 for women and 65 for men.

Health

The proportion of the adult population in Orkney living with a long term physical or mental health condition is 29% for 2017, only marginally higher than the figure for Scotland in 2017 at 28% (Table 5.1). 2017 marks the first year since 2012 when the proportion of the adult population living with a long term physical or mental health condition is greater in Orkney than the proportion for the whole of Scotland.

Table 5.1 Percentage of adults in Orkney and in Scotland living with a long term physical or mental health condition, 2012-2017

	2012	2013	2014	2015	2016	2017
Orkney						
Yes	34%	21%	26%	28%	28%	29%
No	66%	79%	74%	72%	72%	71%
All	100%	100%	100%	100%	100%	100%
Base	70	280	270	280	230	240
Scotland						
Yes	27%	28%	30%	29%	30%	28%
No	73%	72%	70%	71%	70%	72%
All	100%	100%	100%	100%	100%	100%
Base	3,200	9,860	9,750	9,370	9,610	9,760

Source: (SHS, 2019)

Education

Comparing the highest qualification attained by both the male and female populations in Orkney in Figure 5.4 reveals some disparities. 43% of the female adult population in Orkney hold some form of Higher Education, including a degree, professional qualification, HNC/HND or equivalent, comparable to 42% of the Scottish female population. 33% of the male population in Orkney hold a Higher Education qualification in 2017 (degree, professional qualification, HNC/HND or equivalent), which is considerably lower than 43% of the male population in Scotland. 21% of the male population in Orkney held no qualification in 2017, compared to 15% of the total male population across Scotland (SHS, 2019).

These patterns of attainment are found in other remote rural communities across Scotland, where a lower proportion of the population possess a degree level qualification (Scottish Government, 2018). It is possible that these patterns are driven by the migration of people away from these communities after achieving their qualifications (Scottish Government, 2018).

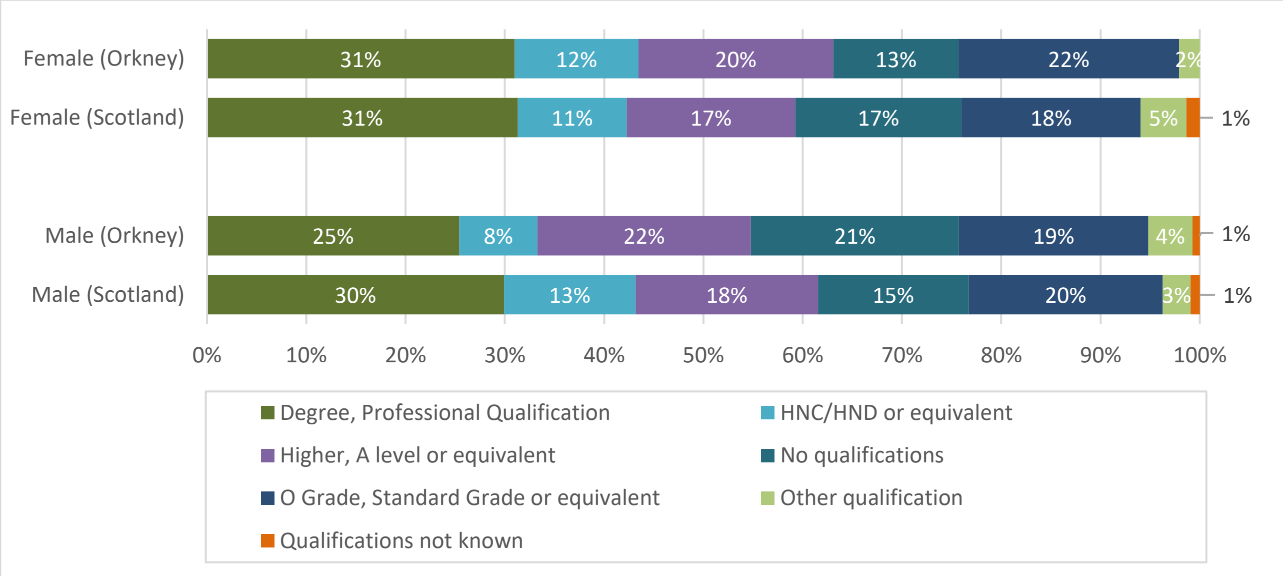


Figure 5.4 The highest qualification held by the adult population for males and females in 2017 for Orkney and for Scotland

Housing services and experiences

In 2018, Orkney had the 2nd lowest number of households across all 32 council areas in Scotland with an estimated 10,506 dwellings (Figure 5.5). Conversely, Orkney has experienced the greatest percentage change in the number of households across all council areas in Scotland since 2001. The 26% increase in household estimates for Orkney is considerably higher than the majority of the other council areas, as well as in comparison to the Scotland wide increase of 12.9% (NRS, 2019b).

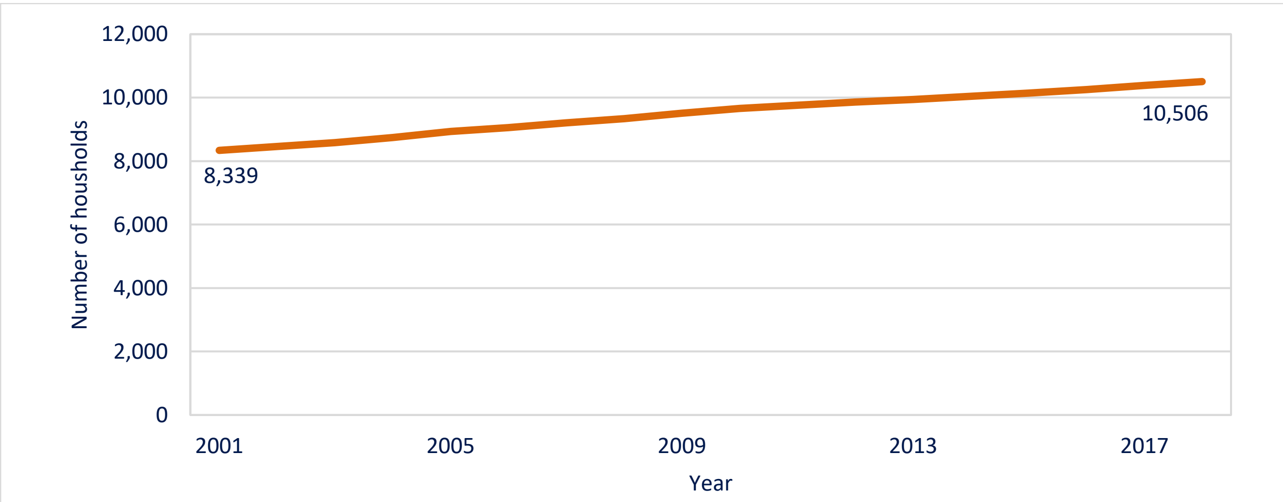


Figure 5.5 The number of households in Orkney between 2001 and 2017

60% of dwellings in Orkney are detached houses, compared to 21% of dwellings in Scotland, as highlighted in Figure 5.6. There are considerably fewer flats and terraced dwellings in Orkney relative to the proportions across the rest of Scotland (NRS, 2019a).

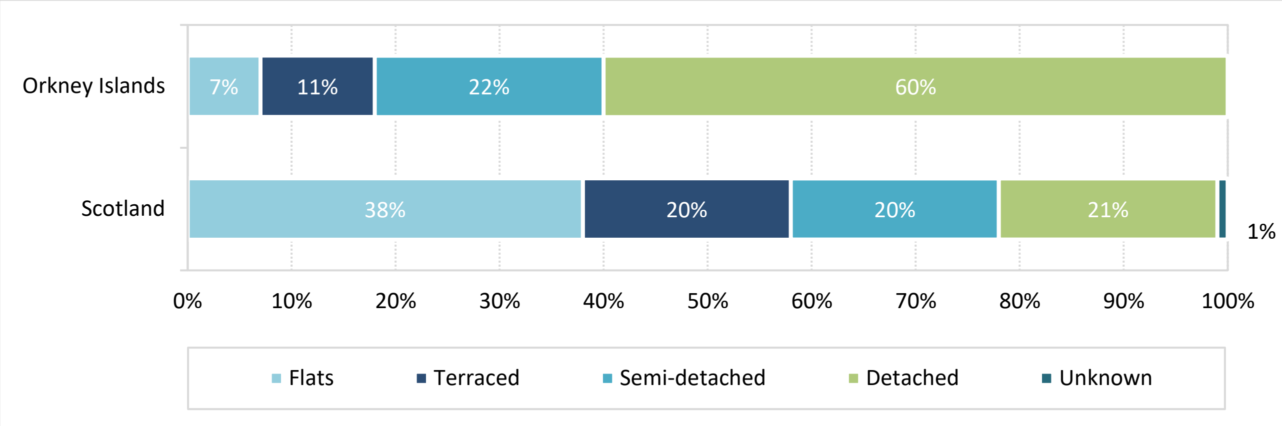


Figure 5.6 Dwelling type in 2018 for Orkney and for Scotland

As observed in Figure 5.7, in 2017 a higher proportion of households in Orkney were owner-occupied (76%) compared with the rest of Scotland (62%). Fewer households rent, either privately or from the local authority or housing associations, in Orkney relative to the rest of Scotland (SHS, 2019). This pattern of housing tenure is common across remote rural areas in Scotland, with proportionally more owner-occupied dwellings (Scottish Government, 2018).

To estimate the energy efficiency of the housing stock in Orkney, the Scottish Housing Condition Survey (SHCS): 2015-2017 Local Authority Tables presents a snapshot of housing condition averages for Orkney (SHCS, 2019). For more comprehensive analyses on household energy efficiency, the Energy Performance Certificate (EPC) Register for Orkney offers a more detailed insight for sampled properties in the area, including the Standard Assessment Procedure (SAP) rating for each property with an EPC. SAP is a standardised methodology which rates the energy and environmental performance of properties with a score from 1 to 100+ based on the calculated annual energy cost, enabling the comparison of dwellings.

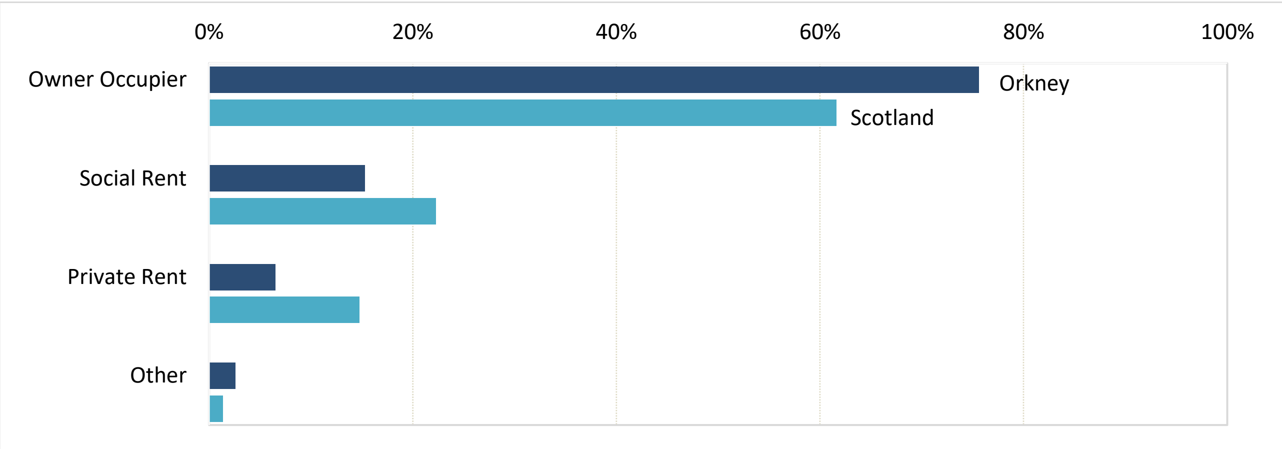


Figure 5.7 Housing tenure in 2017 for Orkney and for Scotland

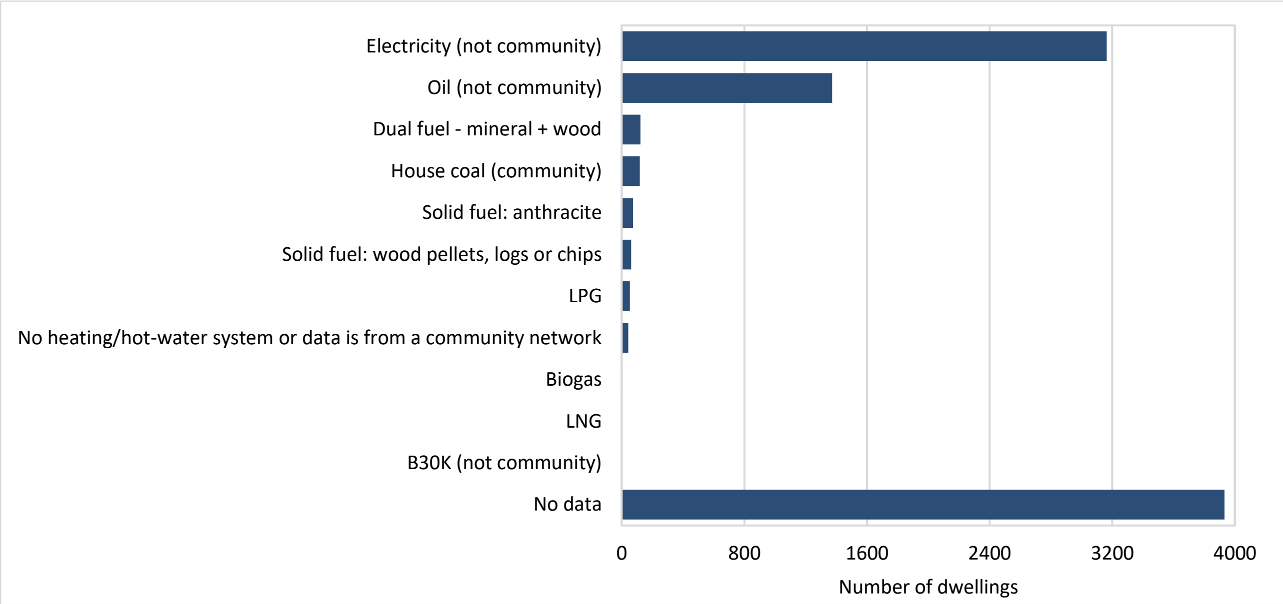
Data from the SHCS 2015-2017 displayed in Table 5.2 shows that the housing stock in Orkney is generally less energy efficient than the rest of Scotland, with a mean SAP 2012 rating of 49.7 compared to 63.6 for the rest of Scotland (lower SAP ratings equate to higher energy consumption and costs as a result of the property's energy performance). Orkney has the 2nd lowest mean SAP 2012 rating out of the 32 Scottish council areas, with the lowest energy efficiency rating found in Na h-Eileanan Siar at 48.8. Low energy efficiency ratings prevail across all dwelling characteristics and household attributes for properties in Orkney, with considerably low ratings for pre-1945 dwellings, owner-occupied dwellings and older household types. With the majority of dwellings in Orkney being owner-occupied (Figure 5.7) as well as a higher proportion of older households than the rest of Scotland (Figure 5.3), it can be assumed that a high proportion of people in Orkney are residing in properties with low energy efficiency ratings.

Table 5.2 Mean SAP 2012 rating for properties with an EPC in 2017 for Orkney and for Scotland, by dwelling characteristic and by household attributes

	Mean SAP 2012 rating	Dwelling characteristics						Household attributes					
		Age of dwelling		House or flat		No of bedrooms		Tenure			Household type		
		Pre 1945	Post 1945	House	Flat	2 or fewer	3+	Owner-occupied	Social Housing	Private Rented	Older	Families	Other
Orkney Islands	49.7	40.2	57.1	49.5	*	48.6	50.3	47.6	58.5	*	46.2	58.0	48.6
Scotland	63.6	57.7	66.3	61.5	67.3	64.8	62.4	62.6	67.4	61.3	62.3	65.1	63.7

Source: (SHCS, 2019)

Note: * indicates base sample too small to report (below 30 cases) or estimate representing 2 or fewer sampled households.



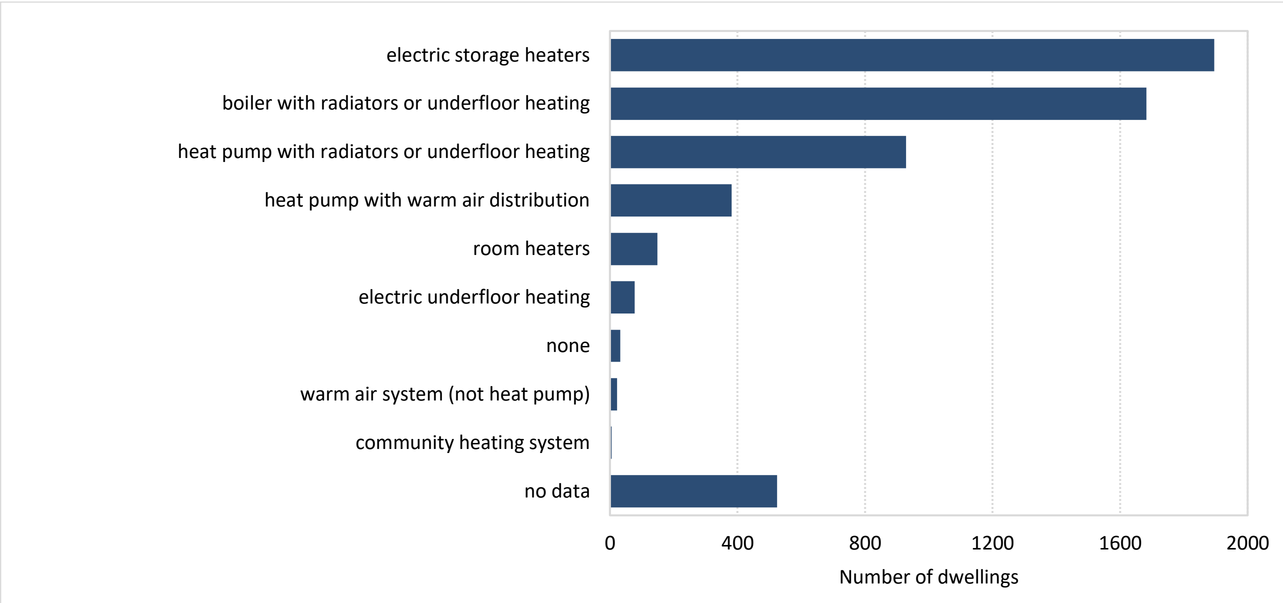


Figure 5.8 Main heating fuel type and main heating type for dwellings in Orkney with an EPC, 2008 - 2019

The Scottish Housing Quality Standard (SHQS) is used to indicate the condition of the housing stock relative to a quality standard. As observed in Figure 5.9, 55% of the properties in Orkney sampled for the SHQS between 2015 and 2017 were non-compliant with the overall quality standards, compared to 43% of the dwellings in Scotland. Considering the comparable proportion of dwellings which fail the "Modern Facilities and Services" and "Health and Safety" criterion between Orkney and Scotland (8% of dwellings lacking modern facilities/services and 11% and 12% of dwellings not healthy, safe and secure for Orkney and Scotland respectively) failure of the SHQS is largely attributed to the poor energy efficiency of dwellings in Orkney. 51% of the dwellings in Orkney and 32% of dwellings across Scotland were considered 'not energy efficient' (SHCS, 2019).

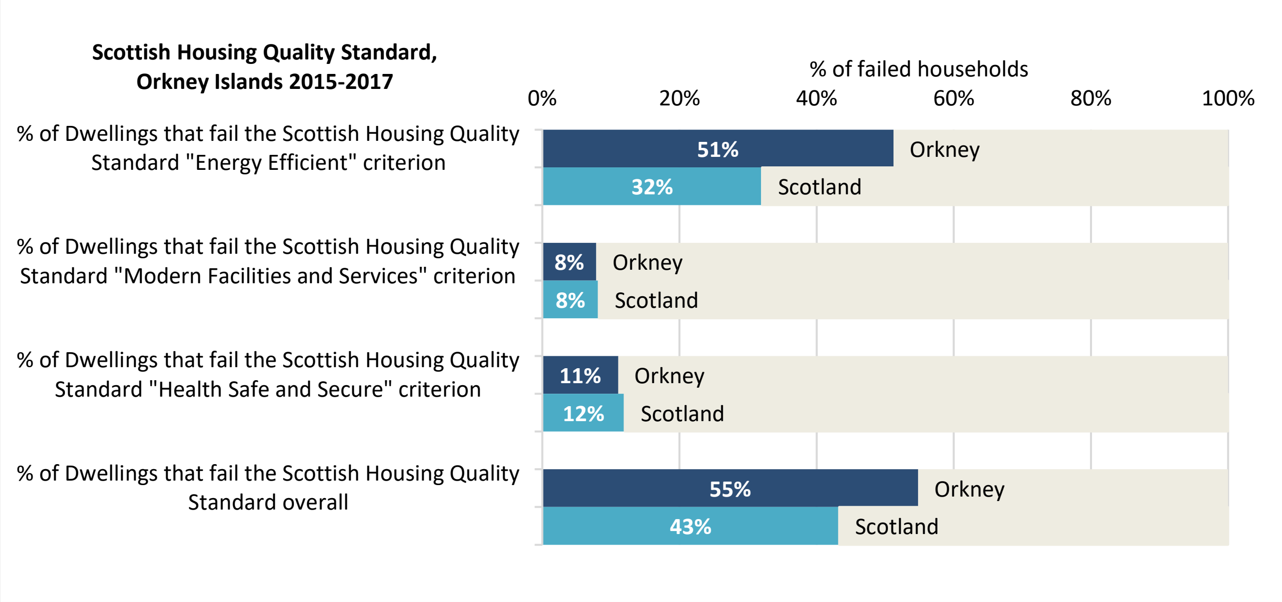


Figure 5.9 Percentage of households which fail elements of the Scottish Housing Quality Standard in Orkney, between 2015 and 2017

Fuel poverty

The Scottish Government previously considered a household to be in fuel poverty if, in order to maintain a satisfactory heating regime, it spent more than 10% of its income on all household fuel use. When more than 20% of its income went towards heating and fuel costs, the household was in extreme fuel poverty. The Scottish Government's Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019 was passed by the Parliament on 11 June 2019 setting out a new definition of fuel poverty. The Fuel Poverty Act 2019 now defines a household as being in fuel poverty if more than 10% of its adjusted net income is spent on fuel costs, and if after deducting such fuel costs, benefits received for a care need or disability (if any) and the household's childcare costs (if any), the household's remaining adjusted net income is insufficient to maintain a decent standard of living for members of the household. When more than 20% of the adjusted net income goes towards fuel costs, the household is in extreme fuel poverty.

The Scottish Household Condition Survey (SHCS) measures and reports on the national fuel poverty rates on an annual basis for every local authority area. To remain consistent with historical fuel poverty data published in the annual SHCS and to take into account the new definition and measure of fuel poverty, the figures displayed in Table 5.3 represent the 2015-2017 Orkney fuel poverty rates under the previous definition and under the newly revised definition.

Fuel poverty and extreme fuel poverty disproportionally affects the lives of people in remote and rural areas and particularly island communities, highlighted in Table 5.3 with data from SHCS 2015-2017 where the highest rates of fuel poverty and extreme fuel poverty were found in island or rural communities. Under the previous fuel poverty and extreme fuel poverty definitions, the highest rates were found in Orkney, with 57% of households in fuel poverty and 23% in extreme fuel poverty. The lowest rates of fuel poverty and extreme fuel poverty were observed in urban counterparts, including Edinburgh, West Lothian and East Renfrewshire. Applying the new definition of fuel poverty highlights that although remote and rural areas still experience high rates of fuel poverty and extreme fuel poverty, the introduction of the income threshold has lowered these levels (Scottish Government, 2019a). This has significantly reduced the number of households in Orkney considered to be in fuel poverty.

Table 5.3 Fuel poverty rates for a selection of local authority areas under the previous and current definition between 2015 and 2017

Fuel poverty, 2015-2017			Extreme fuel poverty, 2015-2017		
Local authority	**Previous definition**	**Current definition**	**Local authority**	**Previous definition**	**Current definition**
Orkney Islands	57%	31%	Orkney Islands	23%	22%
Na h-Eileanan Siar	56%	36%	Na h-Eileanan Siar	23%	25%
Argyll and Bute	44%	34%	Shetland Islands	18%	18%
West Lothian	21%	23%	North Lanarkshire	4%	8%
East Renfrewshire	21%	18%	Renfrewshire	4%	9%
Edinburgh, City of	17%	20%	East Renfrewshire	4%	6%
Scotland	27%	26%	Scotland	8%	12%

Source: (SHCS, 2019) *and* (Scottish Government, 2019a)

There are distinct characteristics found in remote and rural areas which can make households in these communities particularly vulnerable to fuel poverty (Scottish Rural Fuel Poverty Task Force, 2016) including, but not limited to, dimensions related to the household's circumstances, to the housing stock and to the general domestic energy markets. Some of the drivers of fuel poverty particularly relevant to Orkney are highlighted below.

There are particular circumstances that can increase the likelihood of living in fuel poverty which are accentuated in rural areas. Household income strongly influences fuel poverty rates, with households on low incomes more vulnerable to fuel poverty (Scottish Government, 2017a). The relationship between household income and fuel poverty rates is particularly important and complex in a rural context where it has been estimated that disposable incomes in these areas need to be 10-40% higher in order to achieve the UK's Minimum Income Standard (MIS) (HIE, 2013). An Island Community Impact Assessment outlines the proposal that the uplift in the MIS threshold should be used in the measurement of fuel poverty to more accurately reflect the higher cost of living in remote rural areas (Scottish Government, 2019b). Fuel poverty rates determined by the new definition presented in Table 5.3 include the uplift to the MIS for remote, rural areas and island communities.

Fuel poverty disproportionately affects older households (Scottish Government, 2017a), as observed in Orkney in 2015-2017 where 79% of older households were in fuel poverty and 38% were in extreme fuel poverty (Table 5.4). Rural areas generally have a greater percentage of 'older' households with one or more householder of pensionable age, so it is expected that rates of fuel poverty in these areas will be higher. This pattern applies to Orkney, where the high proportion of 'older' households (Figure 5.3) partly explains the high levels of fuel poverty experienced in Orkney households.

Table 5.4 Fuel poverty and extreme fuel poverty rates for Orkney by tenure and household type, 2015-2017

Fuel Poverty by Household Attributes						Extreme Fuel Poverty by Household Attributes					
Tenure			Household Type			Tenure			Household Type		
Owner-occupied	Social housing	Private rented	Older	Families	Other	Owner-occupied	Social housing	Private rented	Older	Families	Other
56%	55%	*	79%	31%	53%	21%	31%	*	38%	8%	18%

Source: (SHCS, 2019)

*Note: * indicates base sample too small to report (below 30 cases) or estimate representing 2 or fewer sampled households.*

Housing stock condition and repair is another important driver of fuel poverty. The housing stock typically found in remote and rural communities predominately consists of older, detached dwellings with features such as solid walls and room-in-roof spaces. Properties tend to be owner-occupied with less social housing. These dwelling attributes are observed in Orkney and can be a driver for fuel poverty, particularly when these characteristics impact on the housing stock condition and repair leading to further implications for the property's energy efficiency. As an example, Table 5.5 notes that 7% of the sampled dwellings in Orkney between 2015 and 2017 experienced damp, relative to 3% of the dwellings across Scotland. The proportion of households in Orkney with damp is greater for dwellings which have been highlighted as susceptible to fuel poverty (Scottish Rural Fuel Poverty Task Force, 2016), with 12% of pre-1945 dwellings, 8% of larger dwellings (3+ bedrooms), 8% of owner-occupied and 6% of older households experiencing damp issues (Figure 5.5), with all proportions greater than the Scotland figures. As a result, with more hard-to-treat properties in poor condition found in rural communities, housing remediation work to tackle fuel poverty can be considered challenging, particularly by supply chain businesses and energy efficiency providers.

Table 5.5 Percentage of dwellings experiencing damp (penetrating or rising) in Orkney, 2015 - 2017, by dwelling characteristic and household attributes

% of Total houses in LA	Damp by Dwelling Characteristic						Damp by Household Attributes					
	Age of Dwelling			House or Flat			Tenure			Household Type		
	Pre-1945	Post 1945	House	Flat	2 or fewer	3+	Owner-occupied	Social housing	Private rented	Older	Families	Other
7%	12%	3%	7%	-	4%	8%	8%	-	*	6%	*	8%

Source: (SHCS, 2019)

Note: * indicates base sample too small to report (below 30 cases) or estimate representing 2 or fewer sampled households. – denotes no sampled cases.

Fuel pricing is a key driver of fuel poverty, and as observed in Figure 5.8 for Orkney, there is a high dependency on alternative heating fuels (electricity, oil, solid fuels) in rural and island communities due to no mains gas coverage. Relying on these fuels can incur a higher cost for household heating demands, particularly when consumer choices in rural and island communities are limited to a restricted range of suppliers or Restricted Time of Use electricity tariffs (e.g. THTC and E10).

5.1.2 Community and regional indicators

Community ownership

Estimates of community owned land and assets have been published for all Scottish council areas in 2017 as experimental statistics (Scottish Government, 2017b), with data for Orkney displayed in Table 5.6. 93.62 acres of land in Orkney have been accounted for as community owned, equating to 0.038% of the total area of Orkney. There are 29 land parcels/assets owned by 16 community groups in Orkney.

Table 5.6 Recorded number of community owned land, number of land parcels/assets and number of community groups for Orkney, 2017

Local Authority	Area of Land (acres)	Number of Land Parcels/ Assets Owned	Number of Community Groups
Orkney Islands	93.62	29	16

Source: (Scottish Government, 2017b)

Data from SHS 2017 displayed in Table 5.7 is used to infer the level of community involvement and engagement with local services. 24% of a sampled Orkney population agreed that they could influence decisions in their local area in 2017, with 19% wanting greater involvement in decision making at a local authority level.

Table 5.7 Percentage of people agreeing with the statement 'I can influence decisions affecting my local area' and 'I want greater involvement in decisions affecting my local areas' in Orkney, 2017

	2007-2008	2009-2010	2011	2012	2013	2014	2015	2016	2017
Orkney									
I can influence decisions	24	25	*	19	23	19	19	30	24
I want greater involvement in decisions	30	26	*	28	24	31	23	28	19
Base	400	350	*	290	280	270	280	230	240
Scotland									
I can influence decisions	21	22	22	21	22	23	24	23	23
I want greater involvement in decisions	38	36	36	33	35	34	34	34	33
Base	19,470	18,730	9,660	9,890	9,920	9,800	9,410	9,640	9,810

Source: (SHS, 2019)

Note: ** indicates base sample too small to report (below 30 cases) or estimate representing 2 or fewer sampled households.*

5.2 ECONOMY AND ENTERPRISE

5.2.1 Individual and household indicators

Economic activity

The economic indicators included in Table 5.8 for the period April 2018-March 2019 highlight that economic activity is greater in Orkney relative to the rest of Scotland, with a greater proportion of Orkney's population economically active (either employed or looking for work) at 90.4% compared to the Scotland average 77.8%, and a smaller proportion unemployed, 2% compared to 4.1%.

Table 5.8 Employment and unemployment rates for Orkney and Scotland, April 2018-March 2019

All People aged 16-64	Orkney Islands (numbers)	Orkney Islands (%)	Scotland (%)
Economically active	12,600	90.4	77.8
Employment rate	12,300	88.7	74.5
Male employment rate	6,600	96	78.1
Female employment rate	5,700	81	71.1
% who are employees	10,500	78.9	65.5
% who are self-employed	1,800	9.8	8.6
Unemployment rate	300	2	4.1

Source: (Annual Population Survey, 2019)

Male and female employment rates in Orkney were higher than the rest of Scotland for the most recent period of study (April 2018 - March 2019), as highlighted in Figure 5.10 (Annual Population Survey, 2019). A difference of 14.6% exists between male and female employment rates for the population aged between 16-64 in Orkney, with 6,600 men in employment (96% employment rate) and 5,700 women in employment (81% employment rate).

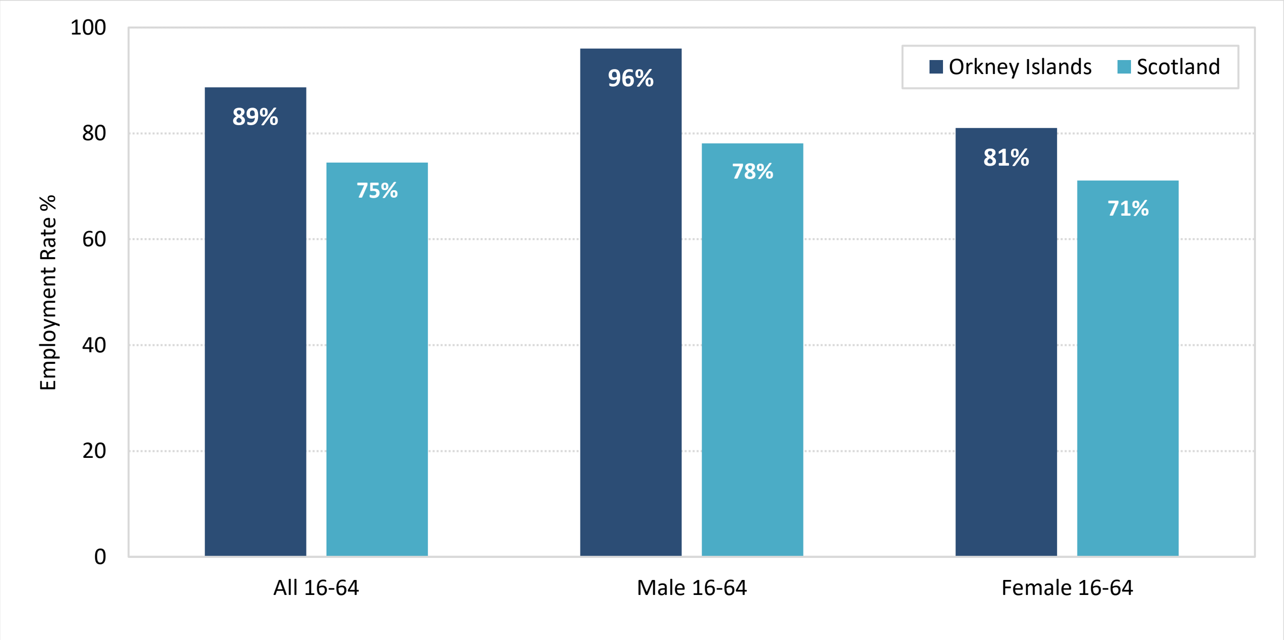


Figure 5.10 Employment rates for Orkney, April 2018 to March 2019 for male and female populations

Income and finance

Table 5.9 displays the median hourly pay and gross weekly pay for full-time workers in Orkney for 2018 (Annual Population Survey, 2019). For the combined male and female populations, both financial indicators are higher in Orkney compared to the rest of Scotland with a median of £15.72 per hour and £636.80 gross weekly pay. However female full-time workers in Orkney earn less both weekly and hourly than the rest of the female Scotland population.

Table 5.9 Gross hourly and weekly earnings by male and female population, 2018

	Orkney Islands (£)	Scotland (£)
Gross Weekly Pay		
Full-Time Workers	636.8	562.7
Male Full-Time Workers	#	599
Female Full-Time Workers	511.1	515.4
Gross Hourly Pay - Excluding Overtime		
Full-Time Workers	15.72	14.3
Male Full-Time Workers	17.58	14.66
Female Full-Time Workers	12.54	13.84

Source: (Annual Population Survey, 2019)

The distribution of net annual income for Orkney in 2017 (for the householder with the highest income) displayed in Figure 5.11 highlights the most common income bracket is £30,001-£40,000 (SHS, 2019).

Figure 5.11 Annual net income of highest income householder, 2017

Income deprivation is based on the number of people claiming income-related benefits. Employment deprivation is the number of people in receipt of employment-related benefits who want to work, but are unable to, due to unemployment, ill health or disability. The rates for both income and employment deprivation on Orkney have consistently remained below the Scotland rates, as highlighted in Table 5.10 (SIMD, 2016).

Table 5.10 Income and employment deprivation for Orkney and Scotland, 2004, 2006, 2009, 2012 and 2016

Income Deprivation	2004	2006	2009	2012	2016
Orkney Islands	8%	8%	10%	8%	7%
Scotland	15%	14%	15%	13%	12%
Employment Deprivation	**2004**	**2006**	**2009**	**2012**	**2016**
Orkney Islands	8%	8%	7%	7%	6%
Scotland	14%	13%	12%	13%	11%

Source: (SIMD, 2016)

5.2.2 Community and regional indicators

Industry specific

Table 5.11 below outlines the distribution of jobs across various sectors of Orkney's economy in 2018. Approximately there are 10,000 jobs total both full-time and part-time, supported by the regional economy.

Table 5.11 Employee Jobs by Industrial Sector 2017

Employee Jobs by Industry	Orkney	Orkney (%)	Scotland (%)	Great Britain (%)
B: Mining and Quarrying	100	1	1.3	0.2
C: Manufacturing	350	3.5	7.4	8.2
D: Electricity, Gas, Steam and Air Conditioning Supply	50	0.5	0.7	0.5
E: Water Supply; Sewerage, Waste Management and Remediation Activities	50	0.5	0.8	0.7
F: Construction	800	8	5.7	4.8
G: Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	1,250	12.5	14.3	15.2
H: Transportation and Storage	900	9	4.4	4.7
I: Accommodation and Food Service Activities	900	9	7.7	7.5
J: Information and Communication	125	1.2	2.8	4.4
K: Financial and Insurance Activities	50	0.5	3.4	3.5
L: Real Estate Activities	75	0.8	1.3	1.7
M: Professional, Scientific and Technical Activities	500	5	6.9	8.4
N: Administrative and Support Service Activities	350	3.5	7.8	9.1
O: Public Administration and Defence; Compulsory Social Security	1,250	12.5	6.4	4.3

Employee Jobs by Industry	Orkney	Orkney (%)	Scotland (%)	Great Britain (%)
P: Education	900	9	7.9	8.9
Q: Human Health and Social Work Activities	1,750	17.5	16.3	13.3
R: Arts, Entertainment and Recreation	400	4	2.8	2.6
S: Other Service Activities	175	1.8	1.8	2

Source: ONS Business Register and Employment Survey: open access).

Notes: % is a proportion of total employee jobs excluding farm-based agriculture. Employee jobs excludes self-employed, government-supported trainees and HM Forces.

The largest employer of local people is the human health and social work sector employing 17.5% of the entire workforce. This is followed in joint second by public administration and wholesale and retail trade which both contribute 12.5%. Other significant employers include education, accommodation and food services, transport and storage all individually making up 9% of the workforce and construction contributing 8%.

There are various notable differences between Orkney's regional economy and the national structure. Firstly, the lack of contribution from the manufacturing sector which makes up only 3.5% of the Orkney workforce, less than half of the Scottish average 7.4%. There is a similar scenario for administration and support services which supply just 3.5% again less than half Scotland's national average of 7.8%. Orkney's public sector is a significantly larger employer of the population than the rest of Scotland with public administration employing 12.5% of the workforce compared to the 6.4% Scottish average which is nearly half. This is supported again by both health and education sectors employing a greater share of the total workforce than both Scotland and Britain as a whole.

The data set does not however, consider the agricultural sector which is a vital component of Orkney's rural economy. According to the 2017 Orkney economic review in total agricultural employs 1,342 additional people; both full-time and part-time. This would make agriculture the second largest employer for the county.

Business demographics

The number of existing business enterprises in Orkney (Figure 5.12) has increased gradually between the years 2012 and 2018. In 2012 the number of existing businesses in Orkney was 1395 but by 2018 the total number of Orcadian businesses reached 1500 (ONS, 2018). That represents a total growth of 7.52%, which equates to an annual average increase of 1.25%.

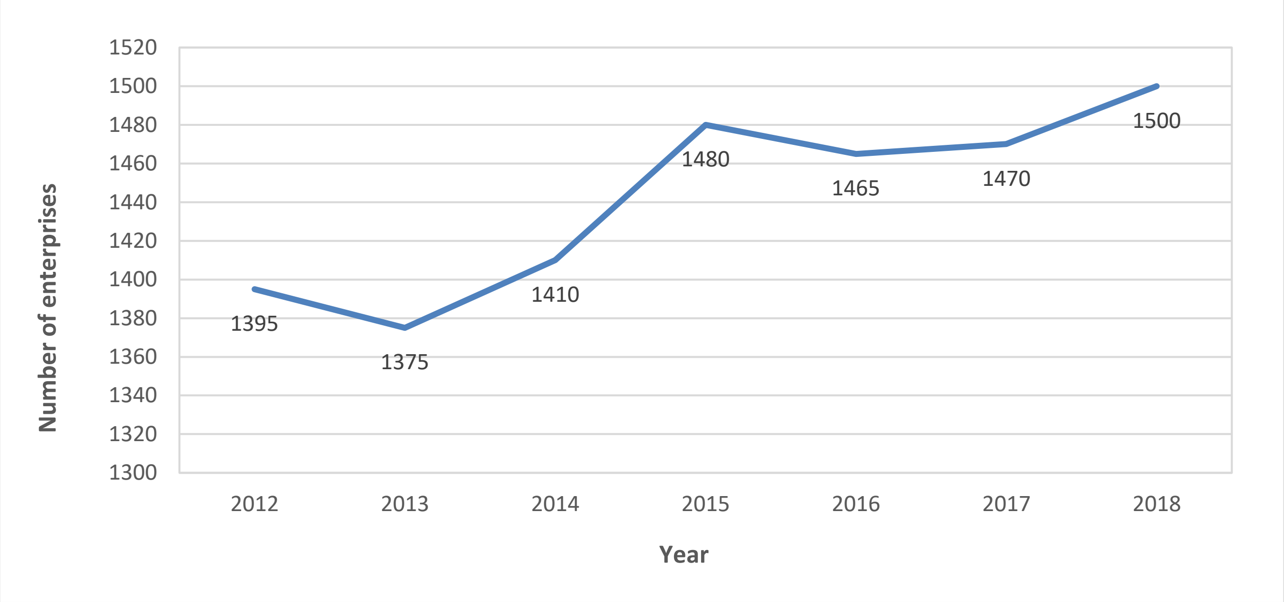


Figure 5.12 Number of enterprises in Orkney between 2012 and 2018

This rise in the number of individual enterprises present on Orkney has coincided with a continued increase in relative job density[23] on the island (ONS, 2019), shown above in Table 5.12. In 2017 the job density in Orkney was 1.06 compared to just 0.81 in the rest of Scotland and 0.86 across the whole of the UK.

Table 5.12 Table outlining the variation Orkney, Scotland and Britain's job density (2012-2017)

Year	Job density		
	Orkney	Scotland	Great Britain
2012	0.88	0.76	0.78
2013	0.88	0.76	0.79
2014	0.87	0.79	0.81
2015	0.91	0.79	0.83
2016	0.97	0.8	0.85
2017	1.06	0.81	0.86

Source: (ONS, 2019)

[23] Jobs density is defined as the number of jobs in an area divided by the resident population aged 16-64 in that area. For example, a job density of 1.0 would mean that there is one job for every resident aged 16-64.

5.3 ENVIRONMENT

5.3.1 Individual and household indicators

Perceptions about climate change

Data gathered from a sample of Orkney's population in the SHS 2017 reveals some perceptions about climate change. Participants were asked whether they agreed or disagreed with a range of statements related to climate change and their association with the issue, as highlighted in Figure 5.13 (SHS, 2019).

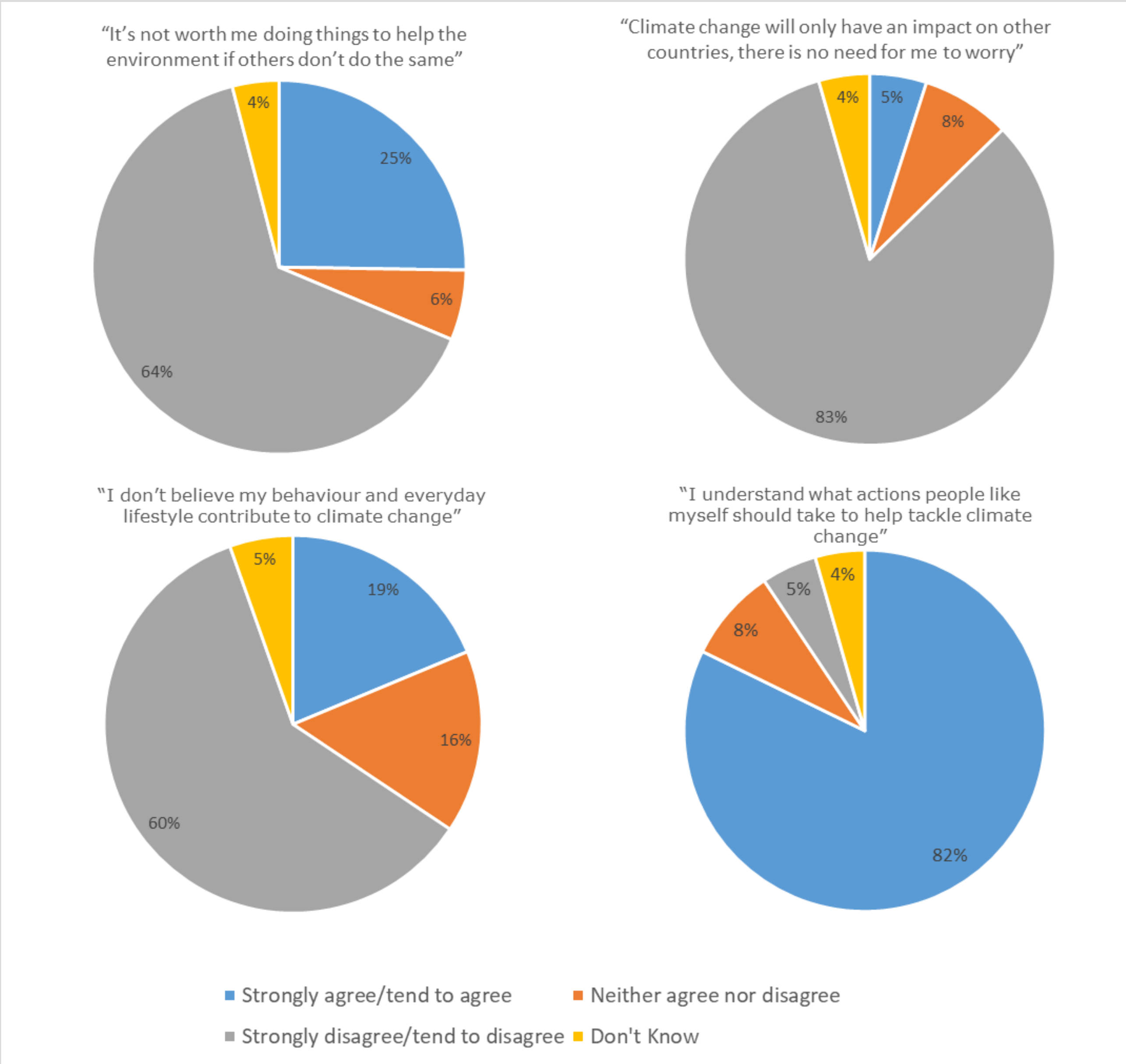


Figure 5.13 Perceptions about climate change as an issue, from a sample of Orkney's population in 2017

Household emissions

Greenhouse gas emission estimates are compiled annually by the UK Government (BEIS, 2019d). As the main greenhouse gas, carbon dioxide data is combined with local energy consumption statistics to estimate carbon dioxide emissions at a local authority level. The data represents "end-user" emissions, allocated to where the energy was consumed or at the point of emission. Carbon dioxide estimates are categorised by the broad sectors of Domestic, Transport, Industry and Commercial, and Land Use, Land Use Change and Forestry (LULUCF).

The dataset provides a spatial disaggregation of CO_2 emissions from the UK Greenhouse Gas Inventory (GHGI). These estimates may differ from those given elsewhere in the report due to the methodologies employed. The Local Authority estimates of CO_2 emissions from the UK Greenhouse Gas Inventory (GHGI) uses a complex disaggregation methodology is complex details of which can be found in published technical report (BEIS, 2019e), but to put it simply emissions from the production and processing of fuels, and the production of electricity, are reallocated to final consumers of the energy to reflect the total emissions relating to that energy use.

The sub national consumption statistics referenced elsewhere in the report by comparison are compiled using a bottom-up approach estimating the fuel consumption by end use (BEIS, 2018a) and estimates of CO_2 emissions have been estimated from those figures (or where possible locally fuel import/use data) and the standard conversion factors given in Appendix A.

Domestic sector emissions are defined as the energy consumed in and around households, consisting of domestic electricity and 'other fuels' for Orkney since domestic gas is unavailable. As displayed in Figure 5.14, the domestic sector emissions have decreased for Orkney since 2005-2017 from a total of 77.4ktCO_2 to 41.5ktCO_2. Since 2005, the decline in emissions from the domestic sector has been driven predominantly by a significant decrease in the emissions associated with domestic electricity consumption, with a 23.3% decrease since 2005. There has been a 12.6% decrease in emissions from 'other fuels', also having a significant impact on the total emissions associated with the domestic sector (BEIS, 2019d).

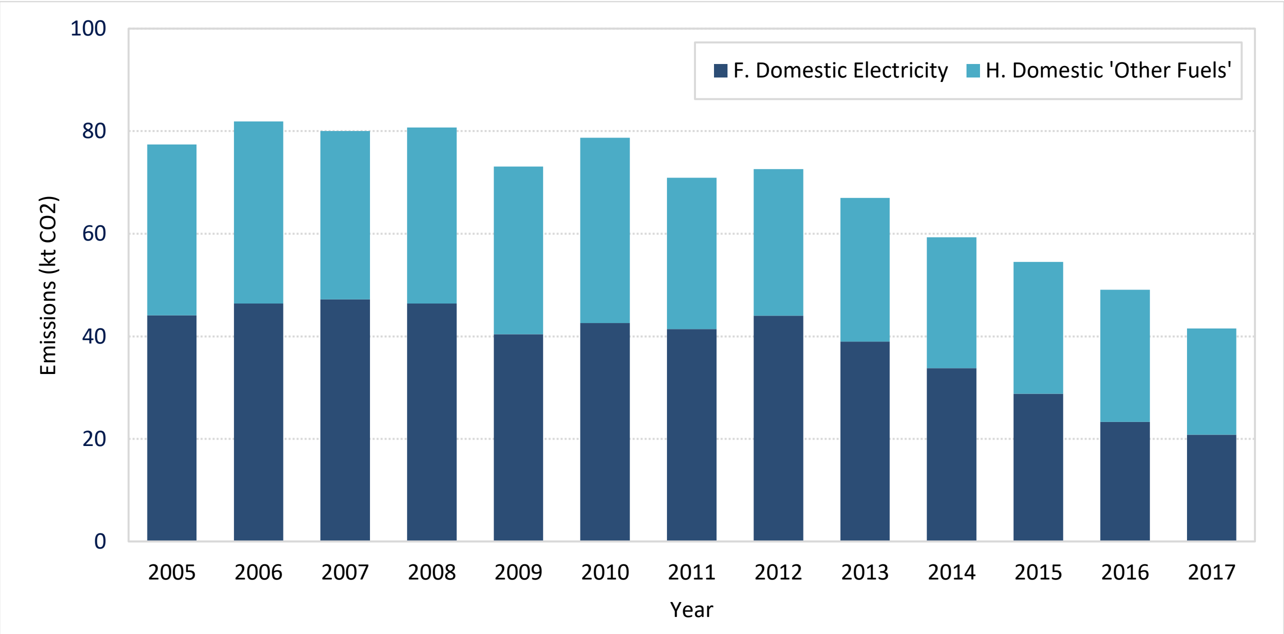


Figure 5.14 Carbon dioxide emission estimates for the domestic sector 2005-2016 for Orkney

Transport sector emissions include the transport of freight and passengers for personal and business purposes within or through the local authority area. Aviation, shipping and military transport cannot be allocated to a singular local authority area so the emission contribution of these modes of transport are excluded. Emissions associated with the transport sector have experienced an increase of 11.5% since 2005 in Orkney, from 29.4ktCO_2 to 32.8ktCO_2 (Figure 5.15). The largest contributor to transport emissions is road transportation (A roads and minor roads) (BEIS, 2019d)..

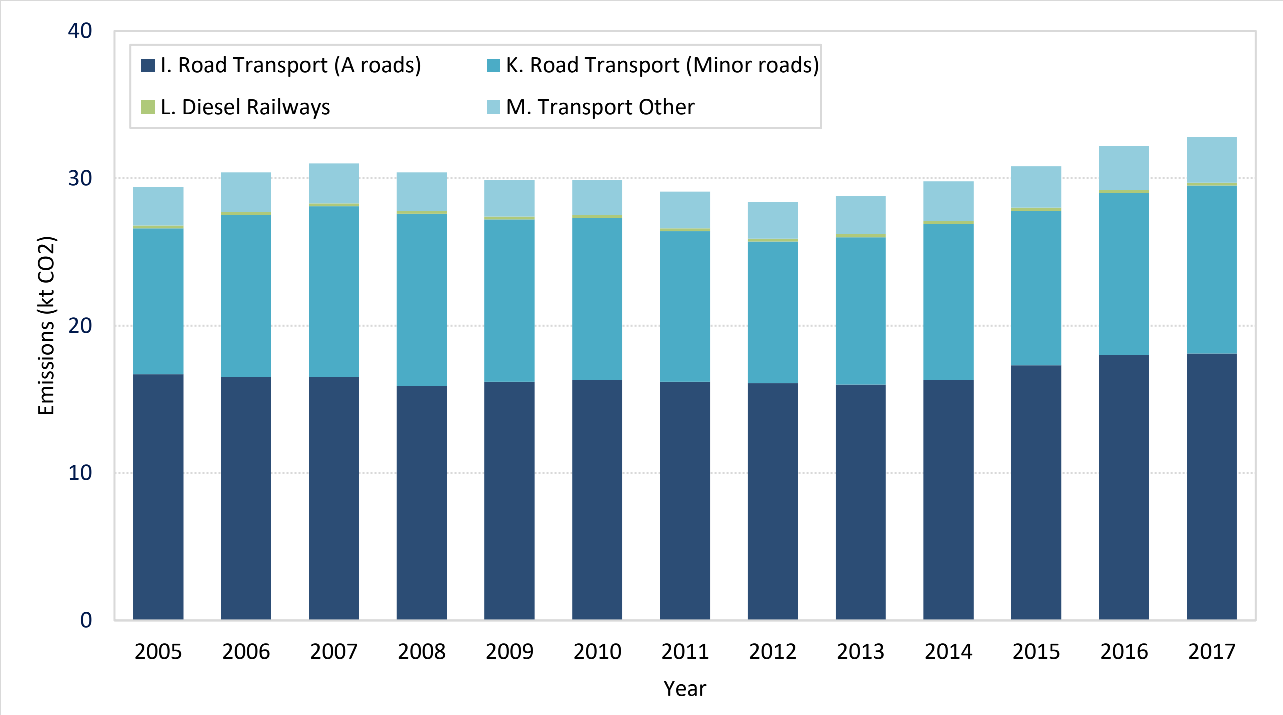


Figure 5.15 Carbon dioxide emission estimates for the transport sector 2005-2016 for Orkney

5.3.2 Community and regional indicators

Industry and commercial emissions

Industry and commercial sector emissions for Orkney consist of electrical and 'other fuel' consumption by local industries and commercial enterprises and by agriculture. There has been a significant decline since 2005 in the total industry and commercial sector emissions, from 98.8 ktCO_2 to 69.9 ktCO_2, driven mainly by a 48.9% decrease in the emissions associated with industry and commercial electricity consumption from 2005 to 2017 as shown in Figure 5.16 (BEIS, 2019d)..

When the sale of electricity within the sub-national dataset cannot be accurately allocated to specific local authority areas due to insufficient address information, the associated emissions are included in an 'unallocated' category not assigned to any local authority area (BEIS, 2019d). This caveat will affect the electricity emission estimates for Orkney for both the industrial and commercial sector and the domestic sector.

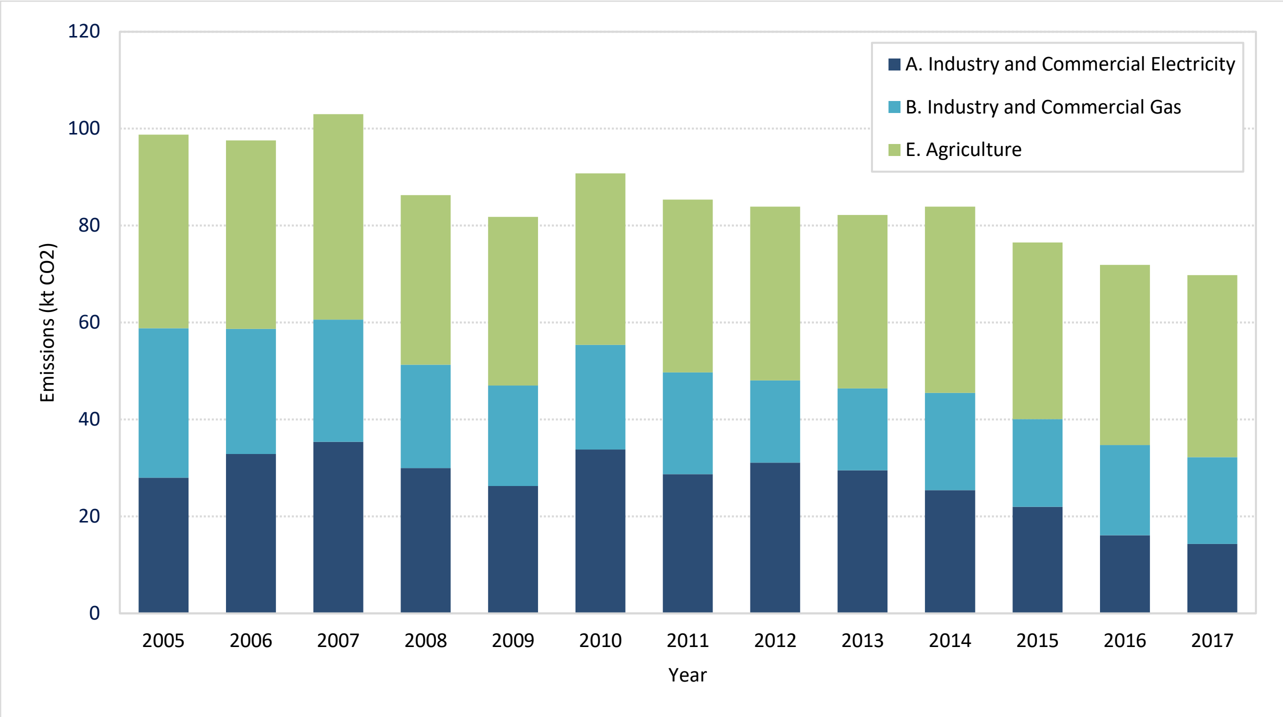


Figure 5.16 Carbon dioxide emission estimates for the Industry and Commercial sector 2005-2016 for Orkney

The total carbon emission estimates for Orkney across all sectors are collated in Figure 5.17, from 2005 to 2016 across the main emission sectors. The decline in total emissions from 268.7 ktCO_2 in 2005 to 192.5 ktCO_2 in 2017 has been largely driven by reduced emissions across the domestic sector and the industry and commercial sector, namely emissions associated with electrical consumption. Land Use, Land Use Change and Forestry (LULUCF) is defined as the impact of human activities on terrestrial ecosystem "sinks", including changes to the land use and forestry activities resulting in the emission or removal of greenhouse gases from the atmosphere. Net emissions from LULUCF can be negative when activities in this sector lead to the removal of carbon dioxide from the atmosphere. Although the LULUCF emission value for Orkney remains positive in 2017 at 48.4 ktCO_2, the value has decreased from 63.1 ktCO_2 in 2005 (BEIS, 2019d).

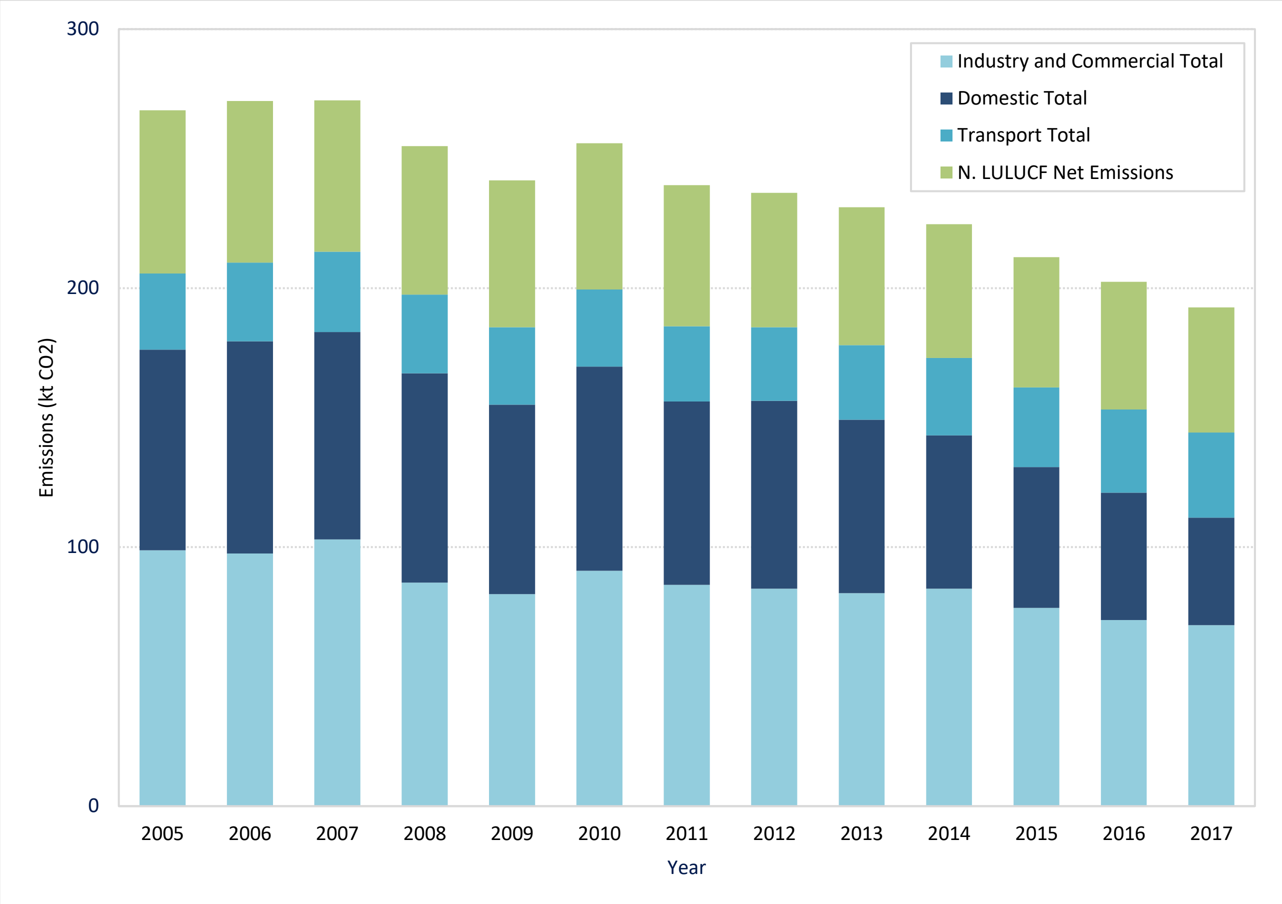


Figure 5.17 Total carbon dioxide emission estimates for 2005-2016 for Orkney

Emissions per capita across all emission sectors for Orkney were 8.7 tCO_2 per resident in 2017, representing the 5th highest per capita emissions out of all 32 council areas in Scotland as highlighted in Table 5.13 (BEIS, 2019d). The average Scotland emissions per capita for 2017 were 5.3 tCO_2 (BEIS, 2019d). It should be noted that some industrial and commercial emissions and transport emissions per local authority area are not driven by the resident population. This should be considered when interpreting the data, particularly for local authority areas where the emissions for these sectors are significant.

Table 5.13 Per capita carbon emission estimates for Scottish local authorities, 2017

Local Authority	Population ('000s, mid-year estimate)	Per Capita Emissions (t) (Ranked lowest to highest)
Argyll and Bute	86.8	0.3
Highland	235.2	0.6
Dumfries and Galloway	149.2	3.2
East Ayrshire	121.9	3.9
East Dunbartonshire	108.1	4.0
Inverclyde	78.8	4.2
South Ayrshire	112.7	4.2
East Renfrewshire	94.8	4.2
Glasgow City	621.0	4.2
West Dunbartonshire	89.6	4.2
Scottish Borders	115.0	4.3
Dundee City	148.7	4.5
Midlothian	90.1	4.5
City of Edinburgh	513.2	4.5
South Lanarkshire	318.2	5.0
Moray	95.8	5.1
Renfrewshire	176.8	5.1
North Lanarkshire	340.0	5.4
Aberdeen City	228.8	5.4
Stirling	94.0	5.5
Angus	116.3	5.6
Aberdeenshire	261.8	5.7
North Ayrshire	135.8	5.8
West Lothian	181.3	6.0
Perth and Kinross	151.1	6.1
Fife	371.4	8.1
Na h-Eileanan Siar	27.0	8.7
Orkney Islands	22.0	8.7
Shetland Islands	23.1	10.2
Clackmannanshire	51.5	10.3
East Lothian	104.8	11.1
Falkirk	160.1	14.9
Scotland Total	5,424.8	5.3

Source: (BEIS, 2019d)

6 DATA GAPS

Sector	Data gap
Coal imports	Data on bulk coal imports was obtained from OIC Marine Services but since 2015 all coal is now arriving in Orkney as freight. As the two main coal merchants were also contacted to obtain data on the amount of coal imported as freight but these companies were unwilling to provide data or unable to give permission to publish it because of commercial sensitivity. There is therefore a lack of data on imports of coal and other similar products for recent years.
LPG imports	LPG comes into Orkney as freight either as bottled gas or in tankers on ferries. Data on bottled gas was only obtained from one of the two suppliers so does not represent the total usage of bottled gas in the islands. Although data was received from one of the mainland ferry companies on the imports of LPG over the past number of years it has not been possible to publish it here because of commercial sensitivity and there may be imports of these fuels on the other mainland service.
Imports of various fuels (kerosene, DERV, petrol, gas oil and sulphur free gas oil)	As above for LPG, other liquid fossil fuels (kerosene, DERV, petrol, gas oil and sulphur free gas oil) the bulk of this comes in shipments, therefore data is available from OIC Marine Services, who have a record of fuel shipments coming into OIC's piers but some fuel also comes in as freight in road tankers. However, it is recognised that the additional freight imports are a small percentage of the total imports of these fuels. Although data was received from one of the mainland ferry companies on the imports of these fuels over the past number of years it has not been possible to publish it here because of commercial sensitivity and there may be imports of these fuels on the other mainland service.
Aviation fuel imports	The company providing aviation fuel at Kirkwall airport was contacted but were not willing to provide details of the aviation fuel provided to the airport. In any case this would not reflect all the fuel used for the domestic and short haul flights as most refuelling happens outside of Orkney. Although data was received from one of the mainland ferry companies on the imports of aviation fuel over the past number of years it has not been possible to publish it here because of commercial sensitivity and there may be imports of these fuels on the other mainland service.
Crude oil	Outline figures of the volumes of crude oil passing through Flotta Oil Terminal are available from published reports but no data on actual figures has been obtained.
Peat	The peat cut for domestic use is difficult to estimate as no records are kept but anecdotal evidence suggests that domestic use of peat has decreased to a low level.
Biomass imports	A number of biomass products such as wood, wood pellets, eco-logs are imported into Orkney but the individual suppliers of these products have not been willing to provide data making it impossible to calculate a total annual energy supply figure for these fuels.
Curtailment	Estimates of curtailment have been made using wind data recorded at the location of some ANM wind turbine generators, relevant power curves to estimate the total un-curtailed generation of the ANM wind turbine generators, however this is only an estimation. Actual curtailment levels were not available from the individual generators.

Sector	Data gap
Electricity generation	It proved difficult to gather exact information regarding the actual energy generation from multiple renewable generators and the Kirkwall power station. Total electricity generation from mature renewable energy technologies (wind, PV, hydro) have been estimated using generic load factors. For households and businesses with their own renewable energy installations a proportion of the energy generated will be consumed by the household or business and will therefore be unseen by the network and therefore is difficult to quantify.
Import Export data	Data provided by SSEN for 2015-2018 has not been cleaned and validated by SSEN therefore permission was granted to use the data for those years to look at annual total but not for monthly analysis.
Energy storage	A description of the various energy storage pilot projects is given in the body of the report which gives some estimates of storage capacity but does not include details on their usage which would be necessary to examine the total energy stored over a given period of time.
Thermal storage and refrigeration	There are several examples of large-scale refrigeration in Orkney within commercial properties and public buildings. Large scale examples of thermal storage are limited. Thermal storage is more commonly found in domestic scale applications such as traditional domestic hot water cylinders. It has been difficult to gather data on usage and energy ratings for these units, however, it is expected that much of the energy used will be electrical and therefore included within the total electrical consumption of Orkney.
Heat pumps	Obtaining accurate data for the total number of installed heat pumps in Orkney proved a hard task. The data available was either very limited or not relevant, therefore it is expected that the total amount of heat pump installations will be considerably higher than mentioned in the report. Further gaps are linked to other renewable technologies or energy storage technologies, as some do not require registration, i.e. batteries.
Coal uses	Estimates from BEIS on coal usage are given and have been used as an estimation but as this modelled rather than real world data. To get an accurate picture of coal uses in Orkney by sector would require data on total sales by sector from the coal merchants.
LPG uses	In terms of other users of LPG, data was obtained from OIC but there may also be other users having LPG delivered by tanker. It has not been possible to estimate the use of LPG by sector (except for the public admin sector) as the BEIS data which has been used elsewhere does not cover non-mains gas. To get an accurate picture of LPG uses in Orkney by sector would require data on total sales by sector from the bottled gas and bulk (tankered) LPG suppliers.
Hydrogen used in road transport	All usage of hydrogen for road transport will be accounted for by the five hydrogen range extended electric vans being trialled as part of the BiGHIT project which refuel at the hydrogen refuelling station at Hatston. No data was collected on the total hydrogen usage at this facility.
Electric vehicles	There is no data source for the energy consumed by home charging of EVs. A proportion of this will include household and businesses with their own renewable energy installations using the energy generated to charge their electric vehicle.
Kerosene uses	Estimated usage by sector is based on data from BEIS on petroleum fuels (assumed to be kerosene for the domestic and commentarial sectors) applied proportionally to the actual imports but this modelled rather than real world data. To get an accurate picture of kerosene usage in Orkney by sector would require data on total sales by sector from the main fuel suppliers.

Sector	Data gap
Petrol and diesel usage	Estimated usage by vehicle type is based on data from BEIS applied proportionally to the actual imports but this modelled rather than real world data. To get an accurate picture of petrol and diesel usage in Orkney by sector would require data on total sales by sector from all the local garages and possibly the main fuel suppliers if there are large users who get their supplies direct.
Gas oil usage	The use of gas oil in the marine sector is not completely accounted for in the report. It is understood that the larger fishing vessels and a number of dive boats have direct contracts with the main fuel suppliers. In addition, one of the main suppliers (a company set up to supplying marine diesel to commercial vessels across Orkney) was contacted and was able to provide data but it could not be included in the report because it is commercially sensitive information and cannot be anonymised. Therefore, the data presented in this report is not a complete picture of fuel use by boats operating in Orkney.

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8 APPENDIX A - STANDARD CONVERSION FACTORS

The following standard conversion factors have been used in the report.

Table 8.1 Estimated average calorific values of fuels

Fuel	GJ per tonne (Gross calorific value)	Reference
Coal	30.2	Digest of United Kingdom Energy Statistics 2018 (BEIS, 2018c)
LPG	49.3	
Burning oil (kerosene)	46.2	
Petrol	47.1	
DERV	45.7	
Gas oil and SFGO	45.3	
Aviation turbine fuel (Jet A-1)	46.2	
Aviation spirit (AV Gas)	47.4	
Peat	17.0	Peat typically about 17-20 GJ/t (Simmons, 2000)

Table 8.2 Fuel conversion factors for converting fossil fuels to carbon dioxide

Fuel	kg CO_2 per tonne	kg CO_2 per kWh	kg CO_2 per litre	Reference
Domestic coal	2631	0.315	-	Digest of United Kingdom Energy Statistics 2018 (BEIS, 2018c)
LPG	-	0.214	1.517	
Burning oil (kerosene)	3150	0.245	2.524	
Aviation turbine fuel (Jet A-1)	3150	0.245	2.514	
Aviation spirit (AV Gas)	3128	0.238	2.225	
Petrol	3135	0.239	2.292	
DERV	3164	0.244	2.650	
Gas oil and SFGO	3190	0.254	2.724	
Peat	1801	0.379	-	28.9 tC/TJ (Simmons, 2000)
Electricity	-	0.22766	-	(BEIS, 2019b)

9 APPENDIX B – SANKEY DIAGRAM DATA SUMMARY

Table 9.1 and Table 9.2 below give the total GWh and tonnes of carbon for each sector and fuel type shown in the Sankey diagram in the executive summary. Note that in both tables below (Table 9.1 and Table 9.2) in some instances the subcategories may not add up exactly to the category total due to rounding.

Table 9.1 Orkney's energy use by sector and end use

Sector and end use	GWh	% of total GWh	Tonnes of CO_2	% of total tonnes of CO_2
Road transport	**130.2**	**17.2%**	**32,045**	**16.6%**
Diesel cars	34.7	4.6%	8,660	4.5%
Diesel LGV	26.2	3.5%	6,531	3.4%
HGV	14.0	1.9%	3,494	1.8%
Buses	11.1	1.5%	2,768	1.4%
Petrol cars	41.7	5.5%	9,998	5.2%
Petrol LGVs	1.2	0.2%	286	0.1%
Motorcycles	0.7	0.1%	156	0.1%
Electric vehicles	0.6	0.1%	154	0.1%
Buildings	**264.3**	**35.0%**	**69,754**	**36.1%**
Domestic	190.8	25.2%	49,760	25.8%
Commercial	4.3	0.6%	1,060	0.5%
Commercial and Industrial	59.1	7.8%	16,481	8.5%
Public administration	10.1	1.3%	2,451	1.3%
Aviation	**23.7**	**3.1%**	**5,805**	**3.0%**
Domestic and short haul flights	22.4	3.0%	5,494	2.8%
Inter-island flights	1.3	0.2%	312	0.2%
Marine transport	**142.0**	**18.8%**	**35,991**	**18.6%**
Ferry services to the mainland	101.5	13.4%	25,724	13.3%
Inter-island ferries	31.5	4.2%	7,981	4.1%
Marine services (towage & harbour craft)	9.0	1.2%	2,286	1.2%
Industry	**55.4**	**7.3%**	**14,039**	**7.3%**
Crude oil processing	55.4	7.3%	14,039	7.3%
Industry, Agriculture & Marine transport	**140.1**	**18.5%**	**35,526**	**18.4%**
Industry, Agriculture, Other marine uses	140.1	18.5%	35,526	18.4%
Grand Total	**755.7**	**100.0%**	**193,160**	**100.0%**

Table 9.2 Orkney's energy use by fuel and end use

Fuel and end use	GWh	% of total GWh	Tonnes of CO_2	% of total tonnes of CO_2
Road diesel	86.1	**11.4%**	**21,452**	**11.1%**
Diesel cars	34.7	4.6%	8,660	4.5%
Diesel LGV	26.2	3.5%	6,531	3.4%
HGV	14.0	1.9%	3,494	1.8%
Buses	11.1	1.5%	2,768	1.4%
Petrol	**43.6**	**5.8%**	**10,440**	5.4%
Petrol cars	41.7	5.5%	9,998	5.2%
Petrol LGVs	1.2	0.2%	286	0.1%
Motorcycles	0.7	0.1%	156	0.1%
Kerosene	**117.3**	**15.5%**	**28,788**	**14.9%**
Domestic	103.7	13.7%	25,450	13.2%
Commercial	4.3	0.6%	1,060	0.5%
Public administration	9.3	1.2%	2,277	1.2%
Electricity	**138.1**	**18.3%**	**38,188**	**19.8%**
Domestic	81.2	10.7%	22,460	11.6%
Electric vehicles	0.6	0.1%	154	0.1%
Commercial and Industrial	56.3	7.5%	15,574	8.1%
Coal and Coal-Based Products	**8.2**	**1.1%**	**2,579**	**1.3%**
Domestic	5.9	0.8%	1,850	1.0%
Commercial and Industrial	2.3	0.3%	729	0.4%
LPG	**0.8**	**0.1%**	**174**	**0.1%**
Public administration	0.8	0.1%	174	0.1%
Peat	**0.5**	**0.1%**	**178**	**0.1%**
Commercial and Industrial	0.5	0.1%	178	0.1%
Jet A-1	**22.4**	**3.0%**	**5,494**	**2.8%**
Domestic and short haul flights	22.4	3.0%	5,494	2.8%
AV gas	**1.3**	**0.2%**	**312**	**0.2%**
Inter-island flights	1.3	0.2%	312	0.2%
Gas Oil	**197.4**	**26.1%**	**50,030**	**25.9%**
Ferry services to the mainland	101.5	13.4%	25,724	13.3%
Inter-island ferries	31.5	4.2%	7,981	4.1%
Marine services (towage & harbour craft)	9.0	1.2%	2,286	1.2%
Crude oil processing	55.4	7.3%	14,039	7.3%
Gas oil and sulphur free gas oil	**140.1**	**18.5%**	**35,526**	**18.4%**
Industry, Agriculture, Other marine uses	140.1	18.5%	35,526	18.4%
Grand Total	**755.7**	**100.0%**	**193,160**	**100.0%**

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