Community Energy Scotland

Empowering Communities

Carbon Neutral Islands

Raasay

Energy and Transport Carbon Audit Report

THE ISLANDS SCOTLAND ACT 2018
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Scottish Government
Riaghaltas na h-Alba

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COMMUNITY ENERGY SCOTLAND

Community Energy Scotland (CES) is a Registered Scottish Charity and company limited by guarantee established in 2007. Our main charitable objectives are community development, environmental protection and the alleviation of poverty. Our mission is to build confidence, resilience and wealth through sustainable energy development at community level.

CES has been at the heart of community renewable energy development for over 15 years and with our substantial experience we are best positioned to offer advice and support to Scotland's communities. As Scotland's first, and only, national charity dedicated to supporting community renewable energy development, we have firmly established ourselves as impartial, independent specialists.

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Executive Summary

The island of Raasay is aiming to achieve carbon neutrality by 2040 as part of the Scottish Government's Carbon Neutral Islands programme. This audit examines the emissions activity arising from energy and transport activities across scopes 1, 2 and 3 in accordance with the Greenhouse Gas Protocol's 'Community-Scale Greenhouse Gas Emission Inventories' standard.

Scope 1 covers direct emissions from sources within the island boundary. Scope 2 covers indirect emissions from the use of electricity, steam, heating and cooling within the island boundary, and scope 3 includes all other indirect emissions that occur outside the island boundary due to activities taking place within the island boundary.

Total emissions for the baseline year of 2019 for energy and transport were calculated to be 2,456 tCO_2e, with energy contributing 1,667 tCO_2e (68%) and transport contributing 789 tCO_2e (32%).

Figure 1 provides a breakdown of emissions by sub-sector. The most significant subsector by emissions is residential energy which contributes an estimated 708 metric tonnes of CO_2e per year, followed by emissions from manufacturing at 527 metric tonnes CO_2e. Across most sectors, energy emissions are dominated by fuel combustion used to produce heat (Scope 1), with the exception of waterborne transport, which contributes 417 metric tonnes CO_2e per year, and is dominated by emissions from fuel consumption used on the Raasay ferry route (Scope 3).

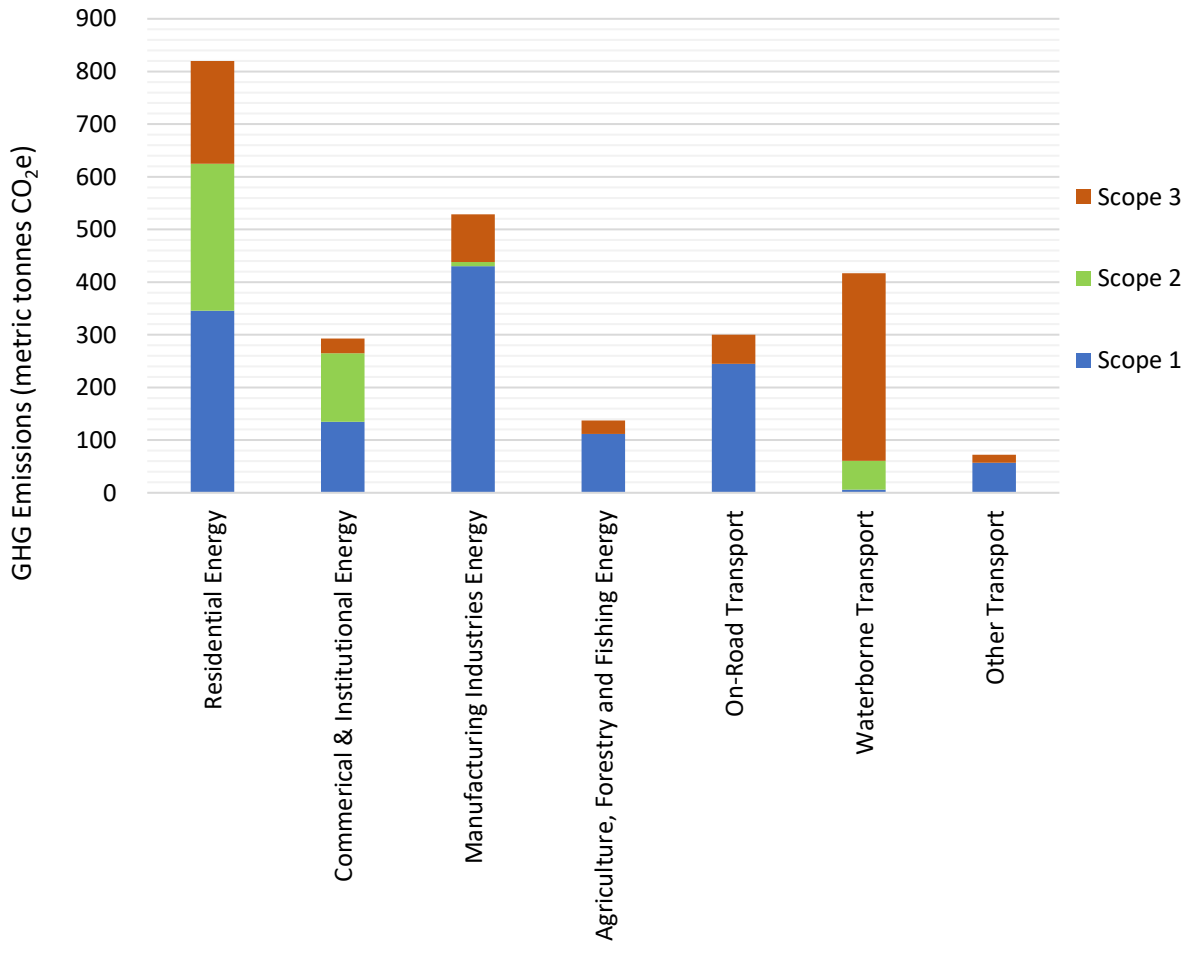

Figure 1. Emissions by sub-sector and scope for Raasay, 2019

Table of Contents

Abbreviations

BEIS – Department for Business, Environment and Industrial Strategy

CAA – Civil Aviation Authority

CCAP – Community Climate Action Plan

CIRIS – City Inventory Reporting and Information System

CNI – Carbon Neutral Islands

DfT – Department for Transport

EF – Emissions Factor

EPC – Energy Performance Certificates

FiT – Feed-in Tariff

GHG – Greenhouse Gas

GPC – Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

IPCC – Intergovernmental Panel on Climate Change

MSOA – Middle Layer Super Output Area

LA – Local Authority

LPA – Litres of Pure Alcohol

LPG – Liquefied Petroleum Gas

LSOA – Lower Layer Super Output Area

LULUCF – Land-Use, Land-Use Change and Forestry

T&D – Transmission and Distribution

Chemical Formulae and Units

CO_2 – Carbon Dioxide

CO_2e – Carbon Dioxide Equivalent

CH_4 – Methane

N_2O – Nitrous Oxide

kWh – Kilowatt Hours

L – Litres

t – Metric tonnes

nm – Nautical Miles

km^2 – Square Kilometres

1 Purpose and context

This audit was carried out as part of the Scottish Government 'Carbon Neutral Islands' (CNI) programme, which aims to support six islands to become carbon neutral by 2040. Carbon neutrality is achieved when emissions of greenhouse gases (GHGs) to the atmosphere are balanced by an equivalent amount being removed. The audits provide a necessary first step in identifying emissions on the islands, and will form part of the evidence basis for the development of Community Climate Action Plans (CCAPs). Supported by Community Energy Scotland, the CCAPs will be compiled by the island communities to reflect their key priorities and to identify the required actions to support their transition to carbon neutrality.

This audit details the emissions activity from Energy and Transport activities attributable to Raasay. Emissions from the Land-Use, Land-Use Change and Forestry (LULUCF), Waste and Blue Carbon sectors have been conducted separately by specialist consultants and reports for these sectors are provided separately.

The audits are not definitive reflections of island emissions and will be subject to ongoing refinement and improvement by the Raasay island community as new data emerges. The audits will highlight data gaps and assist in addressing these through the development of island specific methodologies. Similarly, the audits are intended to be updated as actions are taken to decarbonise, to monitor progress towards decarbonisation – this process is known as benchmarking. By working towards a complete, accurate, consistent and transparent inventory of emissions, as per the Greenhouse Gas Protocol (GPC), island communities can identify key actions to inform the transition to net-zero.

2 General & Background

2.1 Datazone

Raasay covers a land area of approximately 73.37 km^2 within its coastal boundaries. The island is represented in the 'Skye North East – 01' datazone (S01010677), detailed in Table 1, which includes some of northeast Skye, the Isle of Rona, and the uninhabited isles Eilean Fladday and Eilean Tigh. Raasay accounts for around 28.7% of the population of the datazone, and approximately 43.6% of its land area.

Table 1. Datazone summary for Raasay

Local Authority	Datazone I.D. [1]	Datazone Name	Datazone population[2]	Datazone land area (km^2)[3]	Notes
Highland Council	S01010677	Skye North East – 01	572	168.25	Datazone includes part of north-east of Skye and Isle of Rona

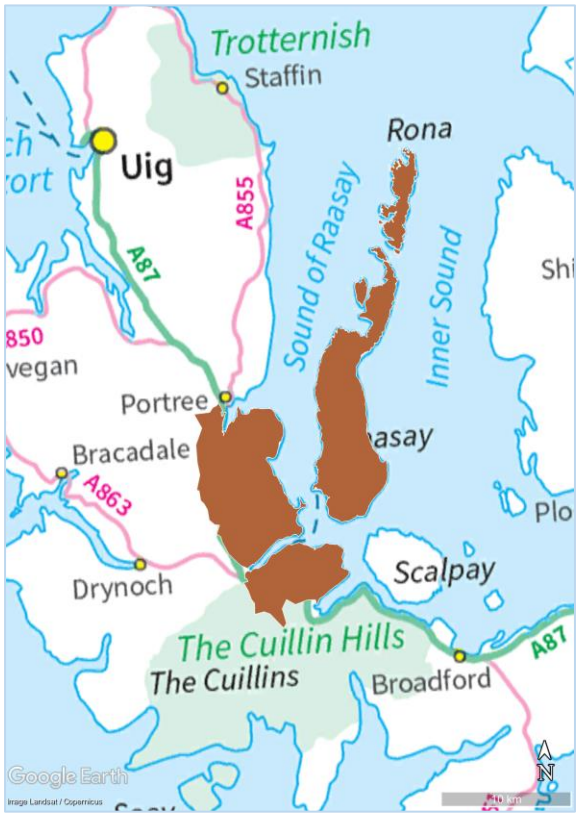

Figure 2. Map showing the extent of the datazone 'Skye North East – 01'

[1] Also referred to as Lower Layer Super Output Area (LSOA)
[2] Scottish Government 'Population Estimates detailed (Current Geographic Boundaries)', available at: https://statistics.gov.scot/resource?uri=http%3A%2F%2Fstatistics.gov.scot%2Fdata%2Fpopulation-estimates-detailed-current-geographic-boundaries
[3] Scottish Government 'Data Zone Boundaries 2011', available at: https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/7d3e8709-98fa-4d71-867c-d5c8293823f2

2.2 Population

A 2023 survey of permanent island residents recorded a population of 179 on the isle of Raasay, an increase from 164 recorded in the 2011 Scottish census.

Table 2. Population statistics for Raasay from 2023 residential survey

Total population	Male	Female	Area (km^2)	Population density (persons/ha)
179	52.27%	47.73%	73.37	0.02

Figure 3 shows the demographic age profile of Raasay from the 2023 survey compared to 2011 census age profiles for the Highland Council local authority area and the rest of Scotland.

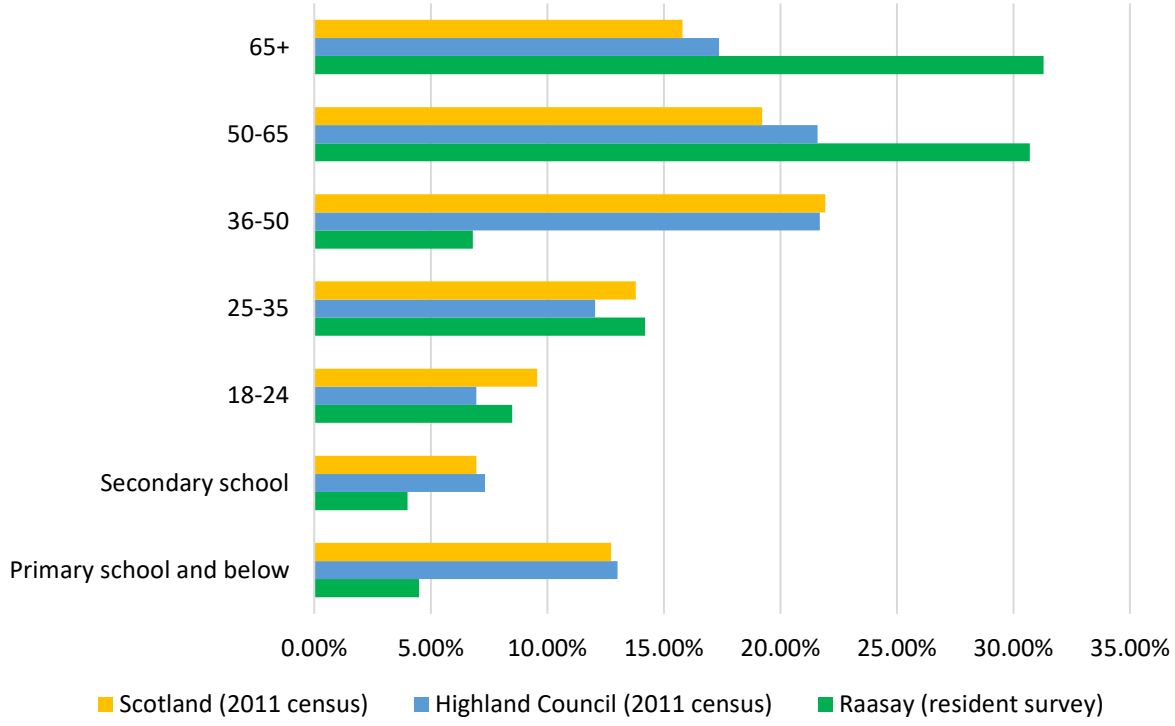

Figure 3. Raasay population by age, compared to Highland Council local authority area and Scotland

2.3 Housing Stock Characteristics

According to the Energy Saving Trust's Home Analytics Database, there are an estimated 179 residential properties on Raasay. Based on a survey by the Raasay Development Trust, it is estimated that approximately 49% are occupied by full-time residents, 34% are holiday or second homes, 9% are vacant and 5% live in caravans full time (Table 3).

The percentage of households in fuel poverty in the Highland Council local authority area is 33% and 24.4% for Scotland as a whole (Table 4), however, a 2017 report by the Highlands Small Communities Housing Trust found that 44% of households in Raasay are in fuel poverty, and since 2017, this figure is expected to have increased.

Table 3. Isle of Raasay estimated no. of dwellings and occupancy[4]

Resident classification	No. of dwellings	%
Full time	87	49
Holiday Home	60	34
Empty	16	9
Nurse	3	2
Other	4	2
Caravan (full time)	9	5
Total	**179**	**-**

Table 4. Fuel Poverty Statistics – Highlands Council 2017-19[5]

Characteristic	Parameter	Highlands	Scotland
Overall fuel poverty	% of households	33%	24%
Age of Dwelling	Pre-1945	44%	26%
	Post-1945	30%	24%
House or Flat	House	32%	22%
	Flat	-	30%
No. of bedrooms	2 or fewer	36%	29%
	3 or more	31%	20%
Tenure	Owner-occupied	28%	16%
	Social Landlord	45%	39%
	Private rented	-	37%
Household type	Older	36%	27%
	Families	21%	17%
	Other	36	27%

Table 5 shows housing stock by tenure on Raasay, with most properties being owner-occupied and Table 6 shows the number of properties that have an Energy Performance Certificate (EPC) including the proportion of properties in each EPC band. This covers 61 or around 35% of the total housing stock on Raasay. Approximately 80% of properties with an EPC have a rating of D or lower.

[4] Isle of Raasay Development Trust

[5] statistics.gov.scot : Fuel Poverty (Scottish House Condition Survey)

Table 5. Raasay housing stock by tenure[6]

Property Tenure	Percentage
Owner occupied	72%
Housing Association	7%
Privately rented	16%
Unknown	4%

Table 6. Number of properties with an EPC and breakdown by EPC band, Raasay

EPC Band	Number	Percentage
A	1	2%
B	4	7%
C	7	11%
D	12	20%
E	13	21%
F	17	28%
G	7	11%
Total	**61**	**-**

The Home Analytics Database gives further characteristics of the housing stock on Raasay, including property age and type; main heating type; wall construction; estimated depth of loft insulation; and glazing type (Tables 7 and 8). This Database combines a wide range of energy efficiency metrics and national databases to provide detailed information about the housing stock in a particular area. It combines both actual values – where concrete data exists – and modelled values, where statistical techniques are used to produce data and fill gaps.

Table 7. Dwellings by property age and property type, Raasay[6]

	Detached house	Terraced	Semi-Detached	Flats	Unknown	Total
Pre-1919	18%	26%	3%	7%	-	55%
1919-1949	2%	5%	-	-	-	6%
1950-1983	7%	-	-	-	-	7%
1984-1991	1%	-	-	1%	-	1%
1992-2002	4%	1%	2%	1%	-	7%
Post-2002	15%	1%	3%	-	-	18%
Unknown	-	-	-	-	4%	4%
Totals	**47%**	**32%**	**9%**	**9%**	**4%**	**-**

[6] Statistics from Home Analytics Database

Table 8. Characteristics of properties by main fuel type, wall construction type, loft insulation depth, and glazing type, Raasay[6]

Main Fuel Type		Percentage
Electricity	Heat Pumps	9%
	Storage Heaters	37%
	Room Heaters	1%
	Boiler	1%
Oil		26%
Solid/Biomass		22%
Other/unknown		5%
Wall Construction Type		**Percentage**
Cavity Construction		11%
Solid Brick or Stone		60%
System Built		-
Timber Frame		25%
Unknown		4%
Estimated Loft Insulation Depth		**Percentage**
0-99mm		39%
100-249mm		45%
250mm+		11%
Unknown		5%
Glazing Type		**Percentage**
Single		10%
Double		84%
Triple		1%
Unknown		4%

3 Methodology

This audit is carried out in accordance with the criteria of the Greenhouse Gas Protocol 'Global Protocol for Community-Scale greenhouse Gas Emission Inventories'[7]. This section provides high level overviews of the methodologies used to estimate emissions from the Energy and Transport sectors.

3.1 General

The audit uses data for the base year of 2019. This year has been selected because national, sub-national, and commercial datasets, where available, are fully compiled for this year, and data has not been distorted by the effects of the COVID-19 pandemic. Where data from this year are not available, data from other years is used and noted where applicable.

Where possible, data from existing audits have been used to provide a consistent inventory of activity data. Activity data that has been obtained through household surveys of island residents and businesses are preferred to provide the most accurate representation of emitting activities. Where household survey data are incomplete or unavailable, data has been estimated as detailed in Sections 3.3 and 3.4.

3.2 GHG Emissions Estimates

GHGs considered are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Emissions, expressed in CO_2 equivalent (CO_2e)[8], are calculated by multiplying activity data by an emissions factor for the activity. Activity data include fuel consumption, electricity consumption, distance travelled, etc. Emissions factors (EF) provide the mass of GHGs emitted per unit of activity:

Emissions = Emissions factor × Activity

Example (diesel combustion)
GHG emissions (kg CO_2e) = Emissions factor (kg CO_2e/litre) × Diesel consumed (litres)

A table of standard emission factors used for this audit are provided in Appendix C, based on BEIS emission factors from 2019.

Emissions are accounted for under three scopes in the inventory, as defined by the Greenhouse Gas Protocol, and detailed in Table 9.

[7] GPC for community-level greenhouse gas inventory reporting, available at: https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

[8] CO_2e expresses the equivalent quantity of CO_2 for a non-CO_2 greenhouse gas, scaled by its global warming potential, as defined by the IPPC 5th Assessment Report (AR5).

Table 9. Definitions of emission scopes, adapted from GPC guidance

Emission Scope	Definition	Examples
Scope 1	GHG emissions from sources located within the island boundary.	**Energy** – emissions from fuel combustion for heating in the island boundary. **Transport** – emissions from fuel combustion for transportation occurring within the island boundary.
Scope 2	GHG emissions occurring from the use of grid-supplied electricity, heat, steam and/or cooling within the island boundary.	**Energy** – emissions from grid supplied electricity. **Transport** – Emissions from grid-supplied energy for in-boundary transportation (electric vehicles).
Scope 3	All other GHG emissions that occur outside the island boundary due to activities taking place within the island boundary.	**Transport** – emissions from portions of journeys occurring outside the island boundary and transmission and distribution losses from grid-supplied electricity.

3.3 Energy

The Greenhouse Gas Protocol guidance considers emissions from five energy sub-sectors. These are residential; commercial and institutional; manufacturing industries and construction; energy industries; and agriculture, forestry and fishing.

3.3.1 Emissions from fuel consumption

For each of the energy sub-sectors, this audit considers emissions from fuel combustion within the island boundaries as Scope 1 emissions. Domestic fuel consumption includes kerosene (also known as burning oil or heating oil), solid fuels including coal, biomass including wood and wood waste, and LPG in the form of butane or propane. Fuel consumption in other sectors includes these fuels often in addition to gas oil, diesel oil and fuel oil.

Within the Scope 1 conversion factors for biomass, the CO_2 emissions value is set as net 'zero' to account for the CO_2 absorbed during growth. The Scope 1 conversion factors contain values for N_2O and CH_4 emissions which are not absorbed during growth. CO_2 released during fuel combustion is reported as 'outside of scopes'. This approach is recommended by UK GHG reporting guidance to ensure transparency and complete reporting of emissions.

Where data is incomplete, consumption activity has been estimated using BEIS national reporting of fuel and electricity consumption. 'Top-down' and 'bottom-up' approaches have been used to estimate fuel consumption and sense check estimates, detailed below:

Top-down approach

- Fuel consumption by fuel type is gathered for the LSOA datazone or Local Authority (LA).
- LSOA or LA fuel consumption data are scaled by an appropriate factor to estimate fuel consumption for the island.
- Scaling factor include adjusting per head of population, sector output, or land area, depending on the sub-sector considered.
- Where possible, activity data has been supplied by property and business owners.

Bottom-up approach

- Energy consumption of a given property are estimated using CIBSE TM49 energy benchmarks, for the property floor area, building type, main heating type, and building use.
- Floor areas and property classifications are determined from Scottish EPC Registry, Home Analytics and Scottish Assessors Association records.
- 'Typical practice' benchmarks are used.[9]

3.3.2 Emissions from electricity consumption

Scope 2 emissions include emissions from grid-imported electricity, using the UK National Grid carbon intensity factor, as defined by BEIS for 2019. Appendix A discusses the impact of using alternative grid carbon intensity factors, including the factor of the Scottish grid. Scope 3 emissions include emissions deriving from transmission and distribution (T&D) losses from grid-supplied electricity.

Like fuel consumption, emissions from electricity consumption are estimated using the same 'top-down' and 'bottom-up' approaches. Additionally, the island Distribution Network Operator (DNO), SSEN have provided measurements of half-hourly meter readings of the total energy supplied to the island. This data provides gross electricity demand supplied[10] to the island and further clarification is required to establish whether SSEN electricity demand data removes local generation. The data is used to account for Scope 2 emissions from grid-supplied electricity and to sense check estimates.

3.3.3 Distillery Industries

Where possible, consumption estimates from distilling industries have been obtained from existing audits and distillery records. Where figures are unavailable, energy consumption may be estimated from the production capacity of the distillery. The Scotch Whisky Association (SWA) 'Scotch Whisky Pathway to Net Zero' report[11] estimates typical energy consumption of 8kWh/LPA. This includes energy requirements for fuel consumption for production and heating, and electricity consumption.

Heat production is the dominant energy requirement, of which distillation accounts for approximately 91% and non-distillation activities, such as malting, account for around 8%. A small fraction of fuel consumption is associated with space heating and low temperature hot water requirements.

[9] TM49 'Typical practice' benchmarks represent energy consumption of the 50th percentile of the cumulative distribution of national properties which inform the CIBSE benchmarks for the given property type.
[10] Gross electricity consumption means total supplied energy, including losses that are not consumed by the end user.
[11] SWA Pathway to Net Zero, available at: https://www.scotch-whisky.org.uk/media/1733/scotch-whisky-net-zero-report.pdf

In addition to emissions from energy consumption by distilling industries, emissions attributable to island boundaries derive from alcoholic fermentation, as discussed in Appendix D.

3.3.4 Energy Industries

All islands considered produce renewable energy locally within their boundaries, which is supplied to the grid. GPC guidance does not allow for the inclusion of missions from generation supplied to the grid. As such, these emissions are not included towards the island's total emissions.

Local renewable generation contributes towards lowering the carbon intensity of the national grid, so can be considered to reduce emissions from grid supplied electricity. Local renewable generation may be estimated from FiT Installation records[12] using BEIS typical load factors[13] or using the online tool, Renewables.ninja[14] to estimate more location-specific load factors. Further clarification is required to establish whether SSEN electricity demand data removes local generation. Emissions saved by local renewable generation may be estimated from the generation capacity and depend on the assumed grid carbon intensity factor, discussed in Appendix A.

3.4 Transport

Emissions from transportation include both journeys that occur wholly within the island boundary and journeys that originate from the island. Transport activity covers transportation for all sectors, including personal and private travel, goods haulage, and waste transport. The GPC categorises emission sources in the transportation sector by mode of transit, including:

- On-road transportation – including electric and fuel powered cars, buses, etc.
- Railways – not applicable.
- Water-borne transportation – including ferries, leisure craft, sightseeing boats, etc.
- Aviation – this includes all flights from the island (not applicable).
- Off-road transportation – includes airport ground support equipment, tractors & quads, etc.

3.4.1 On-road transport

The GPC does not prescribe a specific methodology for calculating on-road transportation emissions due to variations in data availability. Transportation by its nature is mobile and poses challenges in terms of accurately calculating emissions and allocating them to specific areas. For the purposes of this audit, 'bottom-up' and 'top-down' methods have been employed to estimate activity data and to provide a sense check for data, as detailed below:

Top-down approach

- Quantifies total fuel consumption as a proxy for travel behaviour.
- The DfT provides data on total energy consumption for transport at the LA level, which are scaled to estimate the total fuel consumption for transport at the island level.

[12] FiT Installations, available at: https://www.ofgem.gov.uk/publications/feed-tariff-installation-report-30-september-2022

[13] BEIS DUKES 6.3 load factors account for UK averages of the annual generation as a percentage of the potential generation for a given renewable technology, available at: https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes

[14] https://www.renewables.ninja/

- Fuel consumption by vehicle type is estimated using BEIS statistics of sub-national fuel consumption by vehicle and road type at the LA level.
- Consumption data is then scaled by the number of vehicles of each type on the island as a percentage of the number in the LA area.
- Where possible, fuel sales data from local fuel stations have been collected.

Bottom-up approach

- Considers detailed travel activity, including the mode of transport used, vehicle and fuel type, and distances travelled.
- The DfT provides data on the number of licensed vehicles for each datazone, this provides a high-quality indication of the number and type of vehicles being driven on the island.
- Average annual mileages for each vehicle type have been estimated using either:

    1) a sample of MOT results or resident surveys;
    2) national statistics based on vehicle type and urban/rural classification[15]; or
    3) a calculation based on scaling fuel consumption for on-road transport at the local authority level.

Due to data limitations, off-island traffic cannot be disaggregated from on-island traffic. As such, estimates for on-road transport activity data include travel occurring outside the island boundary and shall be accounted as Scope 1 emissions for this audit.

3.4.2 Waterborne Transport

Waterborne travel includes journeys which occur entirely within the island boundary, and transboundary journeys. GPC guidance requires that, for transboundary journeys, emissions associated with departing journeys only are attributed to the island. Although imperfect when faced with complex marine transport routes, this is the standard methodology prescribed by the GPC. This approach ensures that a suitable proportion of emissions from transboundary journeys are attributed to the island community, while the remaining proportion is attributed to the landmass to which the journey links. Emissions from transboundary ferry journeys are accounted as Scope 3 emissions for the present audit.

Journeys which 'pass-through' the island boundaries, including those which enter territorial water but do not dock within the island boundary, would be counted entirely under scope 3 emissions. However, 'pass-through' waterborne journeys are excluded from the present audit due to uncertainty regarding waterborne transport routes.

It could be argued that all emissions from transboundary journeys – not just those from departing journeys – should be attributed to the islands, which would increase emissions from ferries in this audit by up to double. However, this introduces significant challenges for attribution of ownership and origin of activity. As such, for consistency, the present audit is completed in line with GPC guidance and includes emissions from ferries departing the island only.

Where possible, ferry operators have provided annual fuel consumption figures to estimate emissions from waterborne transport. Where fuel consumption is unavailable, activity data is estimated in units

[15] Scottish Government Urban/Rural Classifications, available at: https://www.gov.scot/publications/scottish-government-urban-rural-classification-2020/pages/5/

of passenger kilometres (passenger.km), by multiplying the number of passengers per year by the total distance travelled on a particular route or vessel. Passenger numbers commonly include those for foot passengers, cars, coaches, or commercial vehicles, each with different emissions factors.

3.5 Scope 3 Well-to-tank (WTT) Emissions

Well-to-tank (WTT) emissions are emissions embodied in fuels, materials and goods from upstream activities during the production and transportation lifecycle stages. The GPC methodology allows for the inclusion of WTT emissions as 'other scope 3' emissions. These should be included for resident consumption based GHG emitting activities within the island boundaries. For example, WTT emissions should be included for resident fuel combustion and transport but excluded for tourist and visitor transport.

It can be challenging to accurately separate resident consumption from that of visitors, as such the scale of WTT emissions can be uncertain. For the present audit, WTT emissions have been included for all emitting activities and for transport activities that are clearly attributable only to island residents.

3.6 'Outside of Scope' Emissions

Emissions considered as 'Outside of Scope's under the GHG Protocol includes biogenic CO_2 which account for the CO_2 impact of burning biomass and biofuels. These activities are considered 'outside of scopes' as the Scope 1 emissions of these fuels has been determined to be a net 'zero'. This is because the fuel source sequesters, or absorbs, an equivalent amount of CO_2 during growth as the amount of CO_2 released through combustion. To ensure complete accounting of emissions, reporting of any fuel from a biogenic source should document biogenic CO_2.

3.7 Conversion Factors

In several cases, activity data from the data sources are provided in units of energy (kWh), which are required to be converted to units of mass (metric tonnes) or volume (litres). Appendix B provides a summary of typical conversion factors commonly used for the present audit.

3.8 Data Quality

Due to the variety of estimation methods used and range of data sources, a data quality index has been provided for activity data and emissions factors. Based on GPC guidance, these data quality indices are detailed in Table 10.

Table 10. Description of data quality indices, adapted from GPC guidance

Data Quality Index	Activity	Emission Factor
High (H)	Detailed activity data.	Specific emission factors.
Medium (M)	Modelled activity data using robust assumptions.	More general emission factors.
Low (L)	Highly modelled or uncertain activity data.	Default emission factors.

3.9 Data Sources

Table 11 provides an overview of the main sources of data for the energy and transportation sector activities used for this audit. Where possible, data has also been collected from local sources such as household surveys, business owners, fuel suppliers, transport operators and haulage companies. Table 12 summarises the data sources for emissions factors.

Table 11. Summary of energy and transport data sources

Data Source	Description	Contact/Link
Energy Data		
Department of Business, Environment and Industrial Strategy (BEIS)	The UK Government department for the environment, provides national level energy statistics.	Web: https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy
Home Analytics	Provides property metrics and statistics for use by LAs and developers, maintained by the Energy Saving Trust.	Web: https://energysavingtrust.org.uk/service/home-analytics/
Scottish Assessors Association (SAA)	Voluntary members organisation for property assessments in Scotland, provides register of property metrics.	Web: https://www.saa.gov.uk/
Scottish EPC Register	Maintained by the Energy Saving Trust, provides EPC data for registered properties in Scotland.	Web: https://www.scottishepcregister.org.uk/
Chartered Institute of Building Services Engineers (CIBSE)	Professional association for building services engineers, provides energy benchmarks for various property types.	Web: https://www.cibse.org/
Scottish and Southern Electricity Networks (SSEN)	The Distribution Network Operator (DNO) for the islands, owned by Scottish and Southern Energy (SSE) plc. Provides electricity data for each island.	Web: https://www.ssen.co.uk/

Data Source	Description	Contact/Link
Scottish Energy Statistics	Hub of national energy statistics, provided by the Scottish Government, including grid carbon intensity.	Web: https://scotland.shinyapps.io/sg-scottish-energy-statistics/
Scotch Whisky Association (SWA)	The trade body representing the Scotch Whisky industry, provides production and market statistics for the sector.	Web: https://www.scotch-whisky.org.uk/
Highlands Council	The local authority for the Highlands provides data for council owned and operated properties and assets.	Email: energy-advice@highland.gov.uk
Transport Data		
Department for Transport (DfT)	DfT monitor transport activity and provide statistics on all aspects of transportation.	Email: transport.statistics@dft.gov.uk
Transport Scotland	Scotland's national transport agency, provides statistics at both a national and local authority level.	Web: https://www.transport.gov.scot/
Caledonian MacBrayne Ltd. (CalMac)	The main operator of passenger and vehicle ferries between the mainland of Scotland and the islands on Scotland's west coast.	Email: information.act@calmac.co.uk
RAC Foundation	Provides data relating to motoring and roads including the cost of motoring and public transport.	Web: https://www.racfoundation.org/data

Table 12. Summary of emissions factor data sources

Data Source	Description	Contact/Link
Department of Business, Environment and Industrial Strategy (BEIS)	BEIS provides typical emissions factors for various emitting activities, as measured per calendar year.	https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
Greenhouse Gas Protocol	Based on IPCC Emissions Factors, the spreadsheet from GPC provides emissions factors for various activities.	https://ghgprotocol.org/sites/default/files/Emission_Factors_from_Cross_Sector_Tools_March_2017.xlsx

Data Source	Description	Contact/Link
IPCC Emissions Factor Database	Database of emissions factors as determined by the IPCC, hosted on GPC web domain.	https://ghgprotocol.org/Third-Party-Databases/IPCC-Emissions-Factor-Database
Scottish Energy Statistics	Hub of national energy statistics, provided by the Scottish Government, including grid carbon intensity.	https://scotland.shinyapps.io/sg-scottish-energy-statistics/

4 Energy

4.1 Summary overview

The emissions from energy production are broken down by fuel type in Figure 4, which shows the most significant emissions derive from heating requirements. The major emissions from heating derive from the combustion of heating oil or kerosene (688 tCO_2e). Electricity demand is also a significant contributor to Raasay's emissions, at 453 tCO_2e.

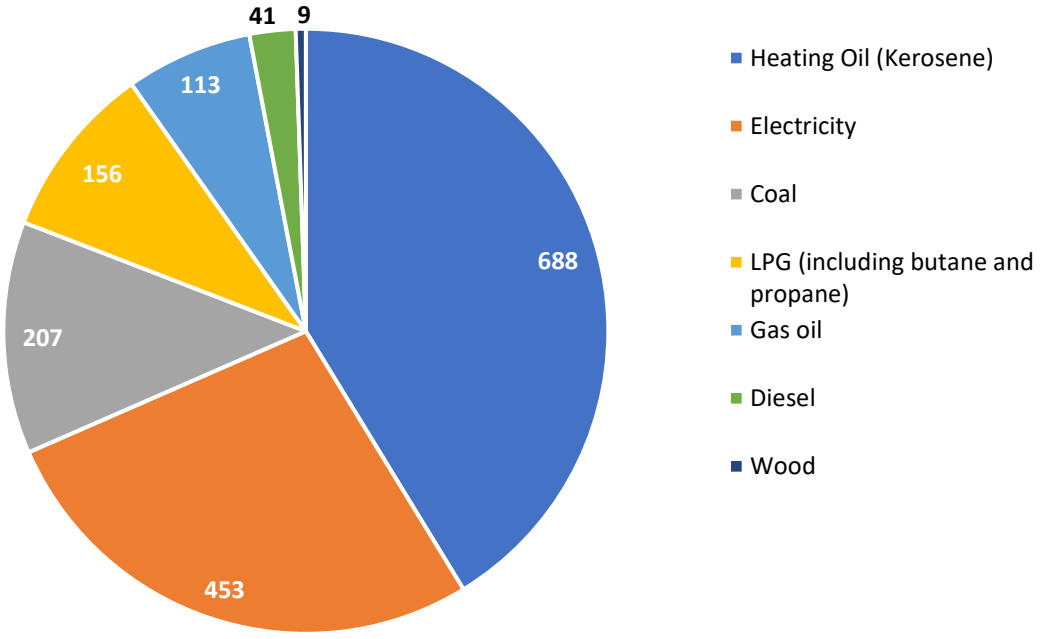

Figure 4. Energy Sector Emissions by Activity/Fuel Type for Raasay (metric tonnes CO_2e)

Table 13. Energy Sector emissions by activity and scope

Energy Emissions by fuel/activity	Total GHG Emissions (tCO_2e)	Outside of Scopes (tCO_2e)[16]
Heating Oil (Kerosene)	688	-
Electricity	453	-
Wood	9	195
LPG (including butane and propane)	156	-
Coal	207	-
Gas oil	113	-
Diesel	41	-
Total	**1,667**	**195**

[16] Within the Scope 1 conversion factors for biomass, the CO_2 emissions value is set as net 'zero' to account for the CO_2 absorbed during growth. The Scope 1 conversion factors contain values for N_2O and CH_4 emissions which are not absorbed during growth. CO_2 released during fuel combustion is reported as 'outside of scopes'.

4.2 Residential

4.2.1 Residential Fuel Use

Residential fuel use for the Isle of Raasay has been determined by requesting data from sales records by the local fuel suppliers. Figures provided for LPG, as butane and propane, and wood have been provided based on actual figures. Coal sales data has not been provided by all coal suppliers on the island, therefore the reported figure is anticipated to be significantly lower than the observed figure. Heating oil or kerosene figures have been estimated from the average annual delivery volume and the number of trips per year. The provided figures are for the year 2021, which are the most accurate figures available.

While the Home Analytics Database indicates around 22% of properties use biomass or solid fuel as their main fuel type, resident surveys indicate that wood fuel is a more significant source of domestic energy. Wood is used for heating to replace or supplement heat from other sources such as electric storage heaters. Table 14 provides consumption figures, data sources and data quality for all domestic fuel types.

Table 14. Raasay annual residential fuel use – from fuel sales

Fuel Type	Activity	Quantity	Energy (kWh)	Time Period	Data Source	Data Quality
Butane	Gas appliances	265 kg	3,604	2021	Community shop sales.	High
Propane	Gas appliances	1,666 kg	22,658	2021	Community shop sales.	High
Coal	Stoves/ open fires	64,700 kg	7,666	2021	Estimate based on Home Analytics data.	Low
Wood	Stoves/ open fires	135,764 kg	766,659	2021	Community shop and wood group.	High
Heating Oil/ Kerosene	Domestic Heating	60,042 L	62,7547	2021	Scottish Fuels Portree – estimate based on average delivery volume and number of trips.	Medium

4.2.2 Residential Electricity Consumption

Residential electricity consumption has been estimated based on recorded metering data for the LSOA datazone. As the datazone includes areas outwith the isle of Raasay, figures have been scaled by the estimated number of domestic electricity meters on Raasay as a proportion of those in the datazone, as detailed in Tables 15 and 16. However, as Raasay has a high number of holiday and second homes which may only be occupied for part of the year, it is difficult to accurately estimate residential electricity consumption.

Table 15. Domestic electricity consumption by Lower Layer Super Output Area (LSOA), Great Britain, 2019[17]

Datazone	No. meters	Total consumption (kWh)	Mean consumption (kWh/meter)	Median consumption (kWh/meter)	Data Quality
Skye North East – 01	454	2,208,362	4,864	3,537	High

Table 16. Isle of Raasay estimated annual domestic electricity consumption

Area	Estimated no. meters[18]	Expected Mean consumption (kWh/meter)	Estimated Total Consumption (kWh)	Data Quality
Isle of Raasay	224	4,864	1,090,844	Medium

4.2.3 Residential Greenhouse Gas Emissions from Energy Use

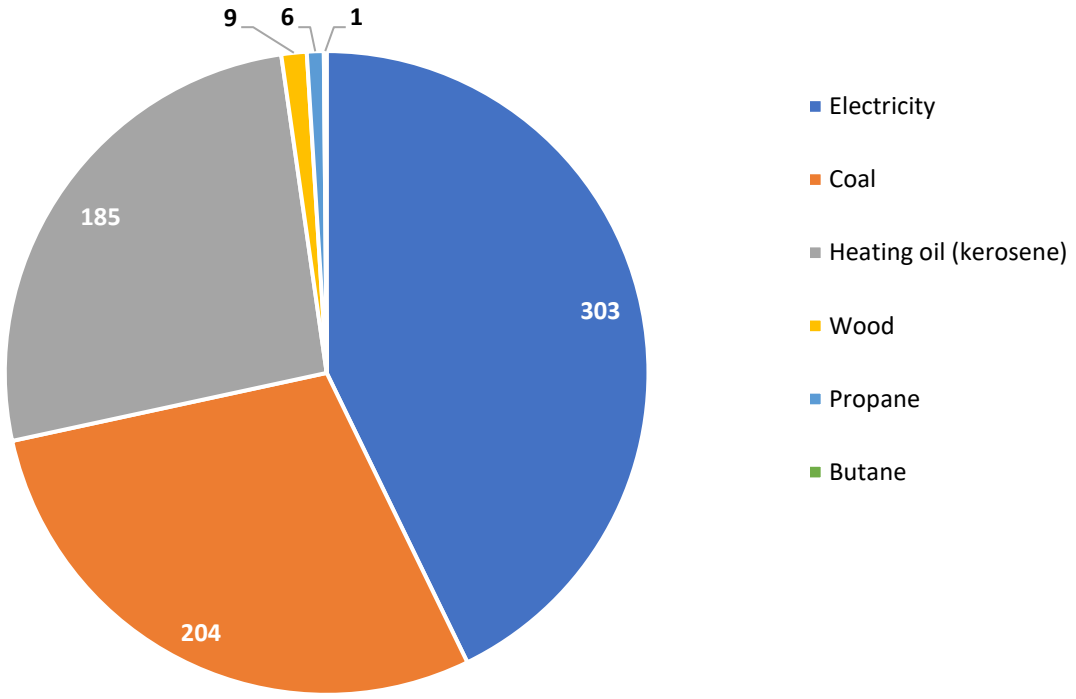

Figure 5. Residential energy emissions by fuel type/activity for Raasay (metric tonnes CO_2e)

[17] Lower and Middle Super Output Areas electricity consumption - GOV.UK (www.gov.uk)
[18] This figure is based on the total number of dwellings and the percentage of dwellings with dual meters

Table 17. Residential Energy Emissions by fuel type/activity and scope

	GHG Emissions (metric tonnes CO_2e)				
Residential Energy	**All**	**Scope 1**	**Scope 2**	**Scope 3**	**Outside of Scopes[19]**
Electricity	303	-	279	24	-
Wood	9	9	-	-	195
Coal	204	178	-	26	-
Heating oil (kerosene)	185	153	-	32	-
Propane	6	5	-	1	-
Butane	1	1	-	0	-
Total	**708**	**346**	**279**	**83**	**195**

4.3 Commercial & Institutional Buildings and Facilities

4.3.1 Commercial & Institutional Fuel Use

Commercial and institutional fuel consumption has been provided by property and business owners, where available. Some commercial and institutional operations exist on the island, which have not been estimated due to limited data availability, though estimates may be refined in future. Table 18 details the commercial and institutional fuel consumption on Raasay, including the data sources and data quality.

Table 18. Commercial & Institutional fuel consumption

Property	Activity	Fuel Type	Quantity	Energy (kWh)	Source	Data Quality
Hotel A	Heating	Gas LPG	49,112 L	349,815	Hotel Records	High
Hotel A	Heating	Coal	1,187 kg	9,578	Hotel Records	High
Hotel B and Visitor centre	Heating	LPG	37,412 L	266,476	Hotel Records	High

4.3.2 Commercial & Institutional Electricity Consumption

Electricity consumption by commercial and institutional properties is detailed in Table 19. Recorded figures have been provided by the main commercial and institutional properties on the island.

[19] Within the Scope 1 conversion factors for biomass, the CO_2 emissions value is set as net 'zero' to account for the CO_2 absorbed during growth. The Scope 1 conversion factors contain values for N_2O and CH_4 emissions which are not absorbed during growth. CO_2 released during fuel combustion is reported as 'outside of scopes'.

Table 19. Commercial & Institutional Electricity Consumption

Property	Estimated electricity consumption (kWh)	Data Source	Data Quality
Hotel A	225,540	Hotel records	High
Hotel B and Visitor centre	216,191	Hotel records (may include some distillery operations)	High
Convenience shop	15,987	Local Energy Audit	High
School	36,366	Highlands Council (2010/11)	High
Waiting room & toilets	13,152	Highlands Council (2012/13)	High

4.3.3 Commercial & Institutional Greenhouse Gas Emissions from Energy Use

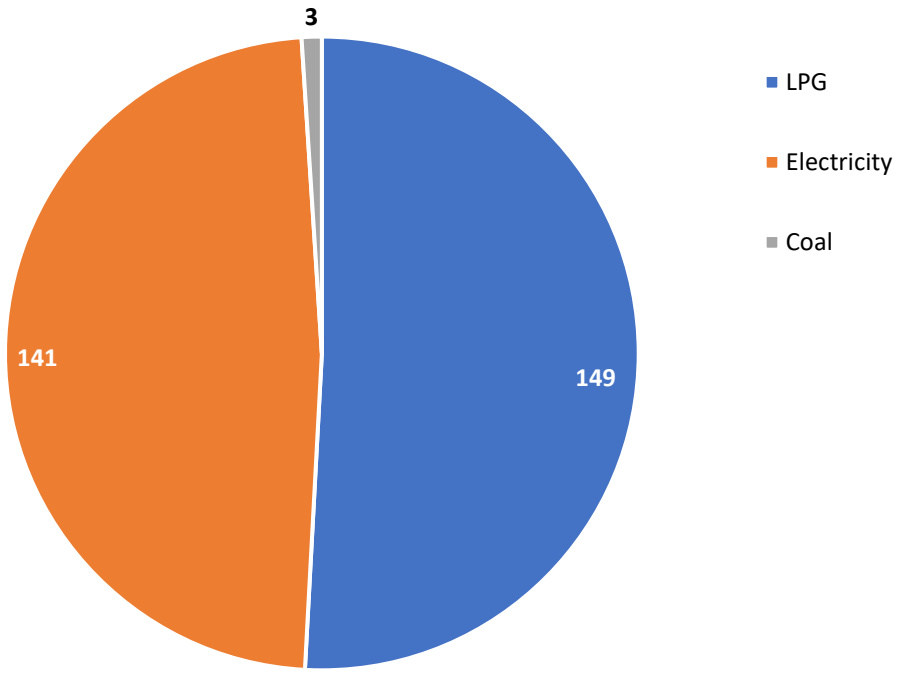

Figure 6. Commercial & institutional energy emissions by fuel type/activity for Raasay (metric tonnes CO_2e)

Table 20. Commercial and Institutional Energy by fuel type/activity and scope

GHG Emissions (metric tonnes CO_2e)				
Commercial & institutional	**Total**	**Scope 1**	**Scope 2**	**Scope 3**
LPG	149	132	-	17
Electricity	141	-	130	11
Coal	3	3	-	0
Total	**293**	**135**	**130**	**28**

4.4 Manufacturing Industries

The Isle of Raasay distillery has a maximum capacity of 190,000 litres of pure alcohol (LPA) per annum[20]. It is understood that the Isle of Raasay Distillery operates below its maximum capacity, however the actual reported capacity is uncertain. As such, the present audit shall use the maximum capacity to inform energy consumption estimates where recorded data are unavailable.

4.4.1 Manufacturing Industries Fuel Use

The Isle of Raasay distillery has provided fuel consumption figures based on recorded usage of kerosene, detailed in Table 21. Kerosene is the dominant fuel used for the distillery's energy requirements, which is used as the primary fuel in the production process.

Table 21. Raasay Distillery annual fuel consumption

Property	Activity	Fuel Type	Quantity	Energy (kWh)	Data Source	Data Quality
Distillery	Production	Kerosene	163,825 L	1,712,276	Distillery Records	High
Distillery	Miscellaneous	Diesel	5,584	59,783	Distillery Records	High

4.4.2 Manufacturing Industries Electricity Consumption

The distillery provided data on electricity consumption from both the hotel and visitor centre attached to the distillery and from the warehouse. Some electricity consumption associated with the manufacturing process may be captured under the hotel and visitor centre consumption, however it is not possible to disaggregate this, and it is assumed the hotel accounts for the greatest portion. The warehouse is on a separate meter and details are provided in Table 22.

Table 22. Raasay Distillery warehouse annual electricity consumption

Property	Estimated annual electricity consumption (kWh)	Data Source	Data Quality
Distillery Warehouse	30,384	Distillery records	High

[20] https://www.whiskyinvestdirect.com/about-whisky/malt-whisky-distilleries-in-scotland , figures sourced from the Scotch Whisky Industry Review 2021

4.4.3 Manufacturing Industries Greenhouse Gas Emissions from Energy Use

Emissions from alcoholic fermentation have been excluded. Refer to Appendix B for details regarding emissions from this activity.

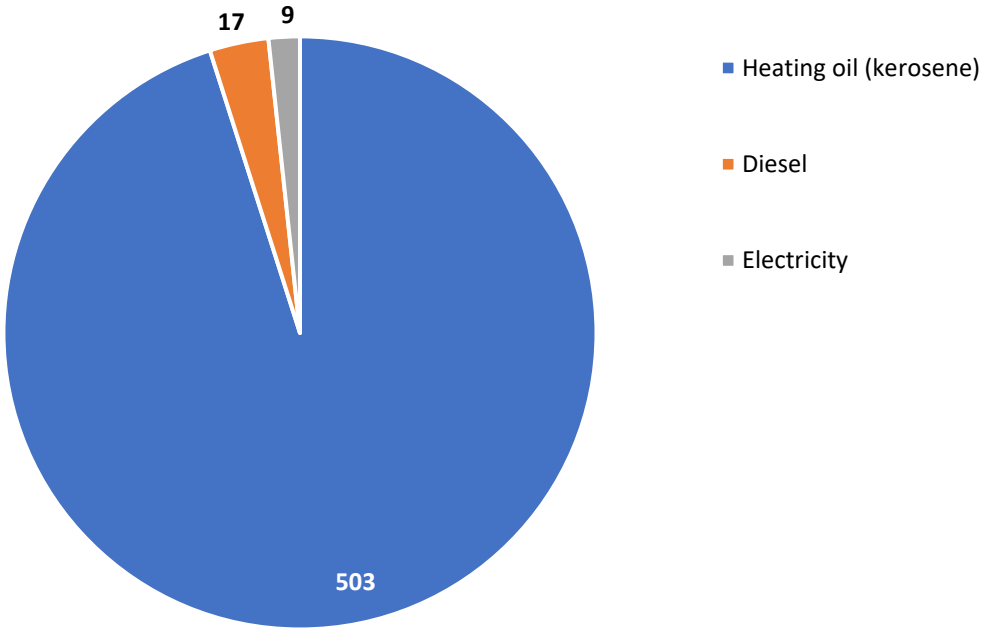

Figure 7. GHG emissions from manufacturing and industry by fuel type/activity, Raasay (metric tonnes CO_2e)

Table 23. Manufacturing and Industry Emissions by fuel type/activity and scope

	GHG Emissions (metric tonnes CO_2e)			
Manufacturing & industry	**Total**	**Scope 1**	**Scope 2**	**Scope 3**
Heating oil (kerosene)	503	416	-	87
Diesel	17	14	-	3
Electricity	9	-	8	1
Total	529	430	8	91

4.5 Energy Industries

The isle of Raasay provides an estimated 216,321 kWh of renewably generated power to the grid. Of this generation, wind accounts for around 16% at 34,821 kWh, and solar PV accounts for 5% at 9,804 kWh, as illustrated in Figure 8. In addition to generation from FiT installations, Raasay has a community owned hydro installation which accounts for 79% of generation. The installation has two turbines, rated at 99 kW and 37kW, respectively. The installation is constrained to export a maximum of 50kW, however grid upgrades are anticipated to be completed in 2026.

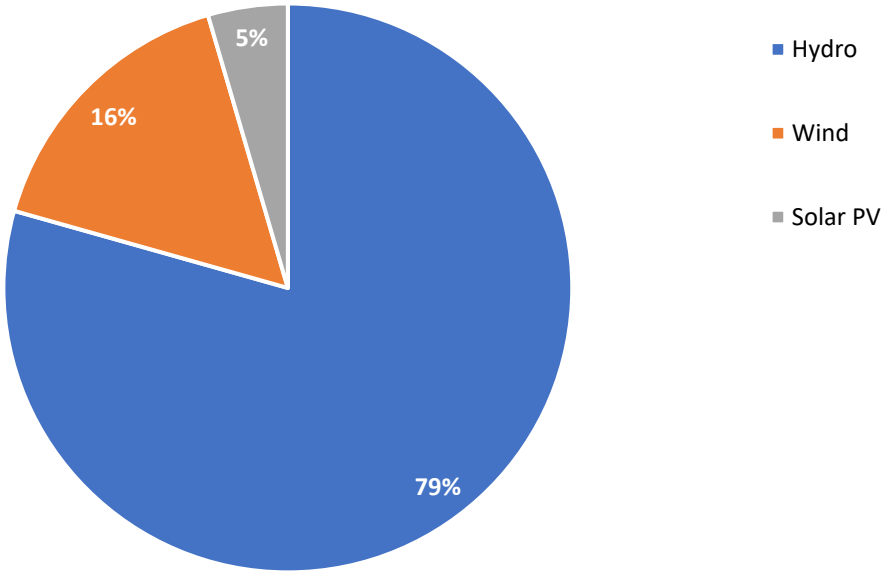

Figure 8. Share of total local renewable generation supplied to grid by generation technology, Raasay

4.6 Agriculture, Forestry & Fishing Activities

4.6.1 Agriculture, Forestry & Fishing Fuel & Electricity Consumption

A survey of crofters on the island has provided estimates of fuel consumption, as detailed in Table 24. Of these, gas oil used by fishing vessels is the primary energy demand, and red diesel and white diesel used by agricultural vehicles and machinery are similar in their share of energy demand.

Table 24. Fuel consumption for agriculture, forestry and fishing on Raasay

Category	Fuel Type	Quantity	Energy (kWh)	Time Period	Source	Data Quality
Agriculture	Red Diesel	3700 L	39,990	2019	Consumption figures provided from 50% of crofters, scaled up to provide an estimate for all crofters.	Medium
Agriculture	White Diesel	3708 L	40,076	2019	Consumption figures provided from 50% of crofters, scaled up to provide an estimate for all crofters.	Medium

Category	Fuel Type	Quantity	Energy (kWh)	Time Period	Source	Data Quality
Fishing	Gas oil	33,494 L	362,004	2019	Consumption figures provided from 50% of fishers, scaled up to provide an estimate for all fishers.	Medium

Electricity consumption for Agriculture, Forestry & Fishing activities on Raasay are unknown, though assumed to be low compared to other sub-sectors and assumed to be included elsewhere in electricity consumption estimates.

4.6.2 Agriculture, Forestry and Fishing Carbon Emissions from Energy Use

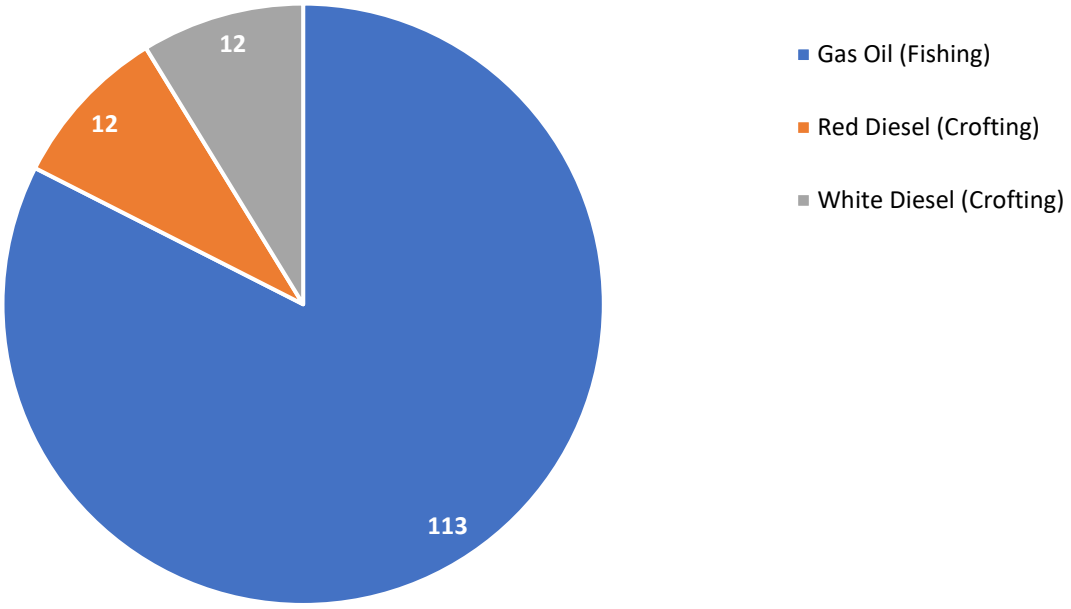

Figure 9. GHG emissions from agriculture, forestry and fishing by fuel type/activity, Raasay (metric tonnes CO_2e)

Table 25. Agriculture, forestry and fishing energy use emissions by fuel type/activity and scope

	GHG Emissions (metric tonnes CO_2e)			
Agriculture, forestry & fishing	**Total**	**Scope 1**	**Scope 2**	**Scope 3**
Gas Oil (Fishing)	113	92	-	21
Red Diesel (Crofting)	12	10	-	2
White Diesel (Crofting)	12	10	-	2
Total	**137**	**112**	**-**	**25**

5 Transport

5.1 Overview

Figures 10 and 11 show the transport sector emissions on Raasay, broken down by vehicle type and fuel type, respectively. The dominant emissions sources are the Raasay ferry which uses Marine Gas Oil as its primary fuel (349 tCO_2e). Cars are the next greatest vehicle type by emissions (257 tCO_2e), followed by other private transport which includes off-road and waterborne transport (78 tCO_2e) and electricity consumed by the Raasay Ferry (60 tCO_2e). The second and third highest emitting transport fuel sources are diesel (236 tCO_2e), and petrol (134tCO_2e).

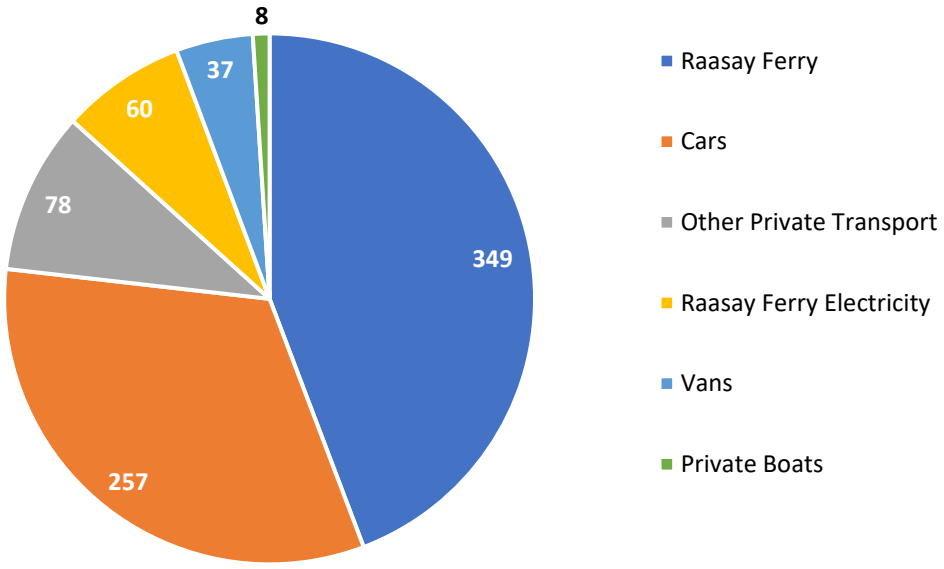

Figure 10. GHG emissions by vehicle type/transport activity, Raasay (metric tonnes CO_2e)[21]

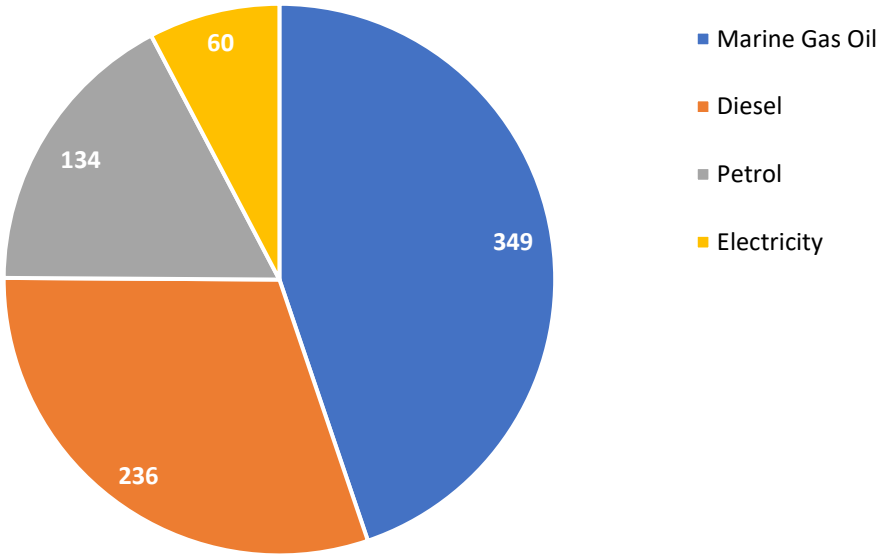

Figure 11. GHG emissions by fuel type in the transport sector, excluding scope 3 emissions, Raasay (metric tonnes CO_2e)

[21] Emissions from ferries are for departing journeys only, as per GHG Protocol.

5.2 On-Road Transportation

5.2.1 On-Road Transportation Activity Data

5.2.1.1 Electric Vehicles

Electric vehicles can be well suited to island locations in many ways. Journey distances are usually short which means that vehicle range may be less of an issue. Fuel costs are often significantly higher on the islands because of having to import it, and this may further incentivise the uptake of EVs which are generally more efficient in terms of running costs, although up-front costs remain high. The condition of the road infrastructure on the island means that residents generally opt for vehicles that can cope with more rugged conditions and have high ground clearance. There are generally limited options available for this type of vehicle in the current EV market.

At present, uptake remains low on Raasay with just two hybrid electric vehicles and no public charge points. Figure 12 shows electric vehicle uptake for the Highland Council area from 2011–2022.

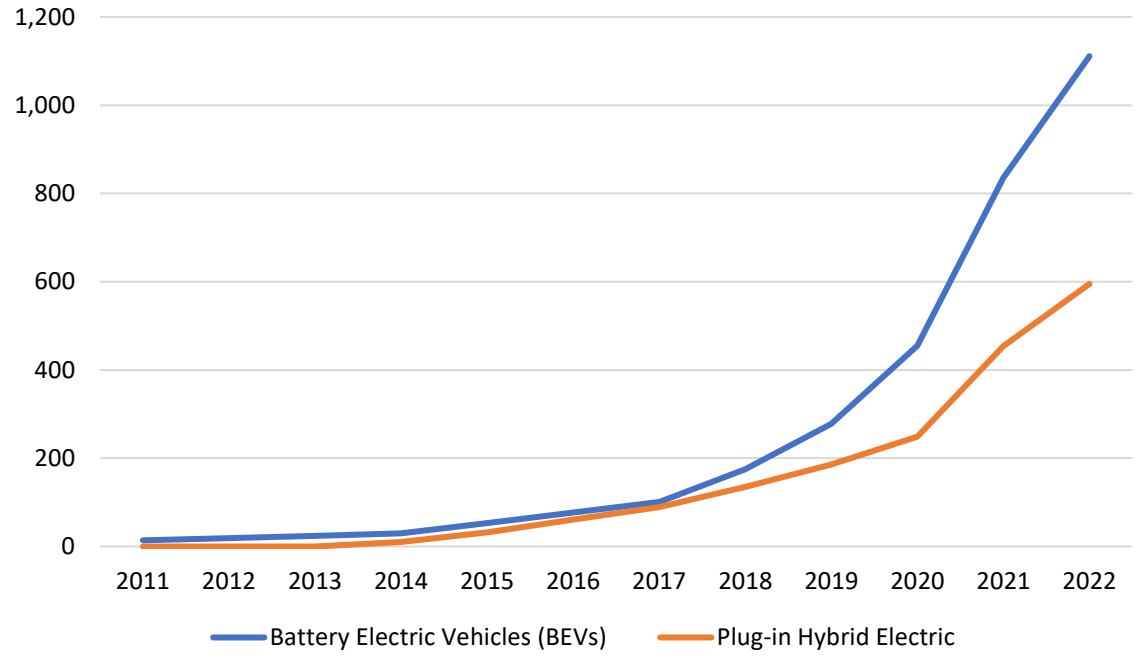

Figure 12. Uptake of electric vehicles (EVs) in Highland Council local authority area, 2011-2022[22]

5.2.1.2 Licenced vehicles and mileage

Table 21 details the number of vehicles, by type, size, fuel type and total mileage based on a survey of island residents. The survey included for 85% of households on the island, so figures have been scaled to account for the total mileage for all households. Vehicle size for hybrid cars, cars with unknown fuel type and motorcycles is uncertain, as such average vehicle size has been assumed. The survey results find that 59% of registered cars are diesel fuelled, and 41% are petrol vehicles. This share is assumed for cars with unknown fuel type.

[22] Table VEH0132, available at: https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

Table 26. Licensed vehicles owned by Raasay residents, by size and fuel type from 2023 survey and MOT data

Vehicle type	Size	No. of vehicles	Fuel Type	Total Mileage (85% of households)	Estimated total mileage (all households)	Data Quality
Cars	Small	6	Diesel	46,489	54,693	High
	Medium	35	Diesel	226,358	266,304	High
	Large	9	Diesel	47,967	56,432	High
Cars	Small	21	Petrol	94,577	111,267	High
	Medium	14	Petrol	63,019	74,140	High
	Large	0	Petrol	-	-	High
Cars	-	2	Hybrid	11,468	13,492	Medium
Cars	-	17	Unknown	97,480	114,683	Medium
Motorcycles	-	4	Petrol	3,257	3,832	Medium
Vans	Class I	13	Diesel	62,604	73,652	High

In addition to household vehicles, a hotel on the island has provided figures for diesel consumption for vehicles owned by the business.

Table 27. Estimated total mileage by vehicle classification for Raasay, based on household survey & vehicle registrations

Property	Fuel Type	Quantity	Data Source	Data Quality
Hotel	Diesel	1,744 L	Hotel Records	High

On-road transport attributable to the island also includes traffic from non-residents. To estimate the number of non-resident vehicles, the number of cars transported to the island via ferry as provided by Calmac has been used. Car passenger figures from the month with lowest usage, January, is assumed to represent primarily island residents with very limited visitors, and is therefore used as a baseline to estimate the number of visiting tourists across the rest of the year.

A share of 50% diesel fuelled vehicles and 50% petrol vehicles is assumed, in line with the Highland Council local authority area[23]. Similarly, the number of coaches carried on the ferry is assumed to cover all visiting coaches to the island. Visiting traffic is assumed to complete journeys of 2.2 miles on the island, covering a return trip from the ferry terminal to Raasay village. The estimated mileage for visiting cars and coaches are provided in Table 28. There is significant scope to improve these estimates for future audits.

[23] Table VEH0105, available at: https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

Table 28. Estimated mileage and fuel consumption for visiting traffic, Raasay

Vehicle type	No. of vehicles	Fuel Type	Estimated total mileage	Assumed mpg[24]	Estimated fuel consumption	Data Quality
Cars	8,138	Diesel	28,807	56	2,339 L	Medium
Cars	8,138	Petrol	28,807	50	2,619 L	Medium
Coaches	15	Diesel	53	9	17 L	Low

Due to data limitations and to avoid double-counting activity data, on-road traffic attributable to Raasay for goods haulage has not been estimated.

5.2.2 On-Road Transportation Greenhouse Gas Emissions

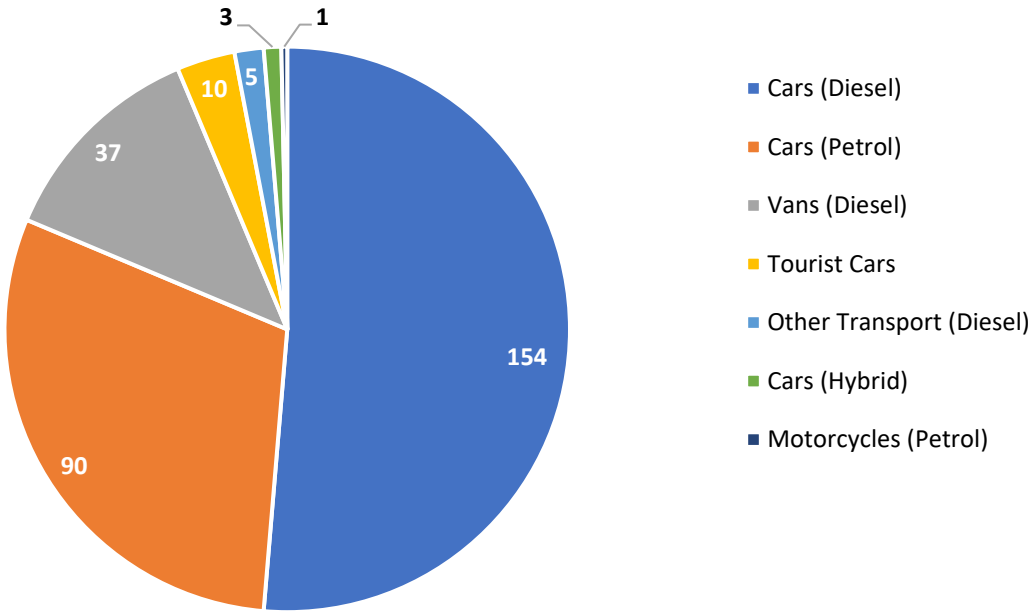

Figure 13. GHG emissions from on-road transport by vehicle type/activity, Raasay (metric tonnes CO_2e)

Table 29. GHG emissions from on-road transport by vehicle type and scope

On-road transport	GHG Emissions (metric tonnes CO2e)			
	All	Scope 1	Scope 2	Scope 3
Cars (Diesel)	154	124	-	30
Cars (Petrol)	90	73	-	17
Vans (Diesel)	37	30	-	7
Tourist Cars	10	10	-	-
Other Transport (Diesel)	5	5	-	-

[24] Assumed mpg taken from Tables ENV0103 & ENV0104, available at: https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env

On-road transport	GHG Emissions (metric tonnes CO2e)			
	All	Scope 1	Scope 2	Scope 3
Cars (Hybrid)	3	2	-	1
Motorcycles (Petrol)	1	1	-	-
Total	**300**	**245**	**-**	**55**

5.3 Waterborne Transport

5.3.1 Raasay Waterborne Transport Activity Data

Raasay is served by Calmac ferries operating on the Sconser to Raasay route. This is a direct route and takes approximately 25 minutes each way. Table 30, below, gives an overview of the routes and the number of sailings operated in 2019.

Table 30. Sconser – Raasay ferry route performance statistics 2019[25]

Route (vessel)	Distance (nautical miles)	Typical Duration (Hours)	Scheduled sailings	Cancelled sailings	Additional sailings	Operated sailings
Sconser – Raasay (M.V. Hallaig)	2.6	25 mins	6,014	62	66	6,018

Table 31 details the number of passengers, cars, coaches, and commercial vehicles travelling on the route in 2019. Figure 14 shows the number of passengers and Figure 15 shows the vehicular traffic travelling on the Sconser – Raasay route for each month in 2019. Passenger numbers and the volume of cars peak during the summer months, whereas commercial traffic remains relatively stable throughout the year.

Table 31. Sconser – Raasay ferry carrying statistics 2019[26]

Route (vessel)	Foot passengers	Cars	Coaches	Coaches (meters)	Commercial vehicles	Commercial (meters)
Sconser – Raasay (M.V. Hallaig)	88,238	31,348	15	106	707	7,355

[25] Data provided by Calmac Information Manager
[26] Calmac carrying statistics, available at: https://www.calmac.co.uk/corporate/carrying-statistics

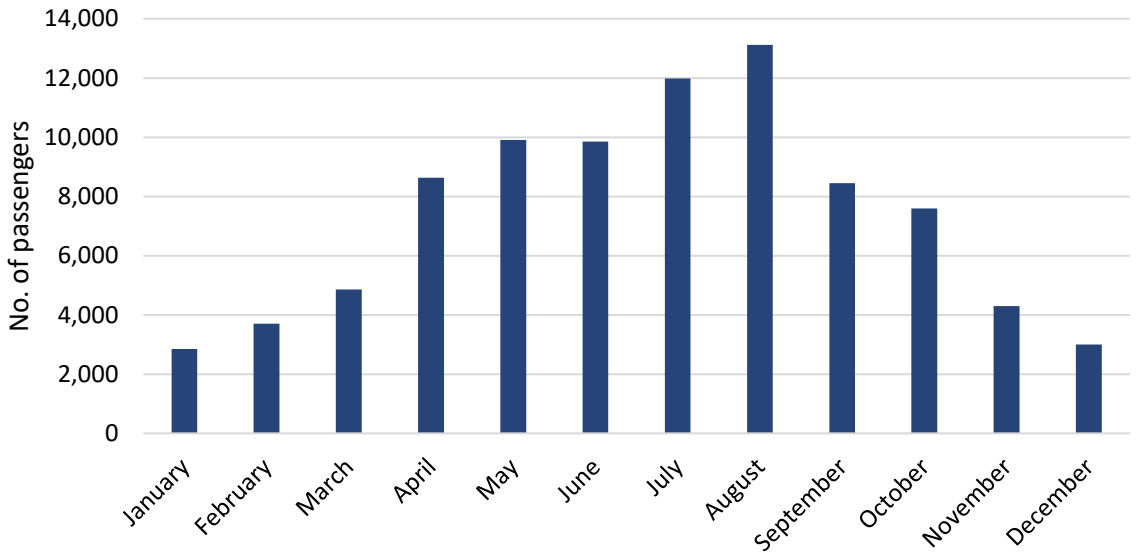

Figure 14. Sconser to Raasay Passenger numbers by month for 2019[26]

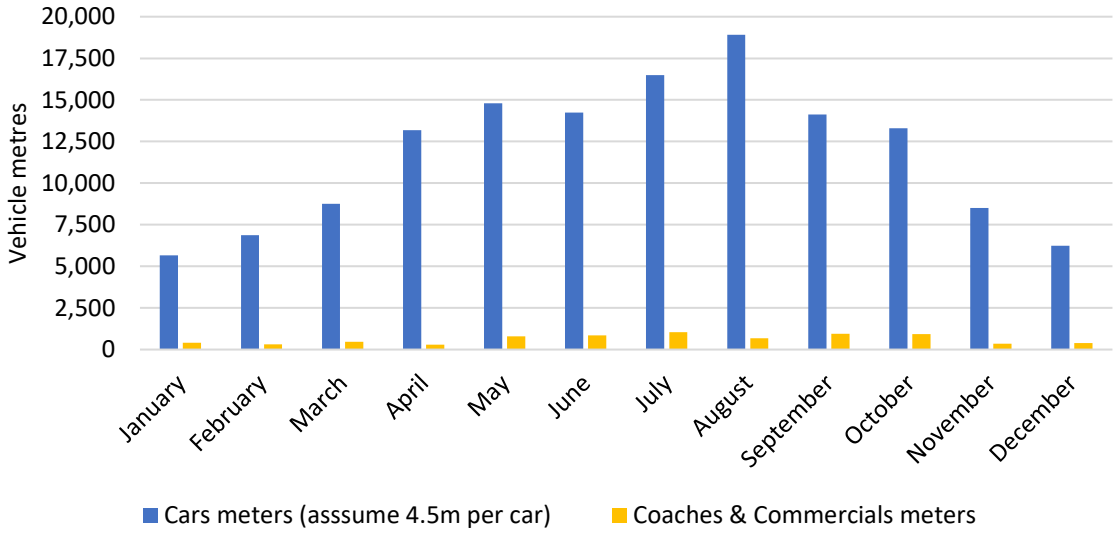

Figure 15. Sconser to Raasay vehicular traffic in metres 2019[26]

5.3.1.1 Raasay Waterborne Transport Fuel Consumption

Tables 32 and 33 show the total annual fuel consumption for the vessel usually operating on the Sconser – Raasay route. It is often necessary for vessels to be moved around in the network or they may be taken out of service for a time for repair and maintenance. Therefore, it is not always the vessel listed below that operates the routes. It is assumed that where routes are operated by replacement ferries, these are generally vessels of a similar size and have a similar fuel consumption profile. On this basis, the total fuel consumption attributable to Raasay has been estimated based on the number of departing sailings multiplied by the typical fuel consumption per sailing[27].

[27] Typical fuel consumption per sailing given by Calmac Information Manager

Table 32. M.V. Hallaig annual fuel consumption, nautical miles travelled, and time at sea

Vessel	Fuel consumption, 2019 (L)	Fuel consumption, 2020 (L)	Fuel Type	Total nautical miles travelled 2019-20	Total time at sea 2019-20 (mins)
M.V. Hallaig	170,266	179,958	Marine Gas Oil	13,182	108,973

Table 33. Estimated total fuel consumption by ferries departing Raasay

Route (vessel)	No. journeys departing from Raasay	Typical fuel consumption per journey (L)	Estimated total fuel usage attributable to Raasay (L)	Data Quality
Sconser – Raasay (M.V. Hallaig)	3,009	34	102,306	High

In addition to the ferry serving the Isle of Raasay, a hotel on the island operates a rigid inflatable boat (RIB). Based on hotel records, the RIB consumed an estimated 2,781 L of petrol per year, detailed in Table 34.

Table 34. Hotel RIB petrol consumption

Property	Activity	Fuel Type	Quantity	Energy (kWh)	Data Source	Data Quality
Hotel A	RIB	Petrol	2,781 L	26,914	Hotel Records	High

5.3.2 Raasay Pier Electricity Consumption

The Raasay ferry is a hybrid ferry, and as such consumes electricity in addition to fuel. Table 35 details the electricity consumed at the Raasay pier by the ferry for the years 2019 and 2020.

Table 35. Raasay Pier Electricity Consumption

Port	Annual Electric consumption, 2019 (kWh)	Annual Electric consumption, 2020 (kWh)	Data Source	Data Quality
Raasay	216,585	204,161	Calmac Information Manager	High

5.3.3 Waterborne Transport Greenhouse Gas Emissions

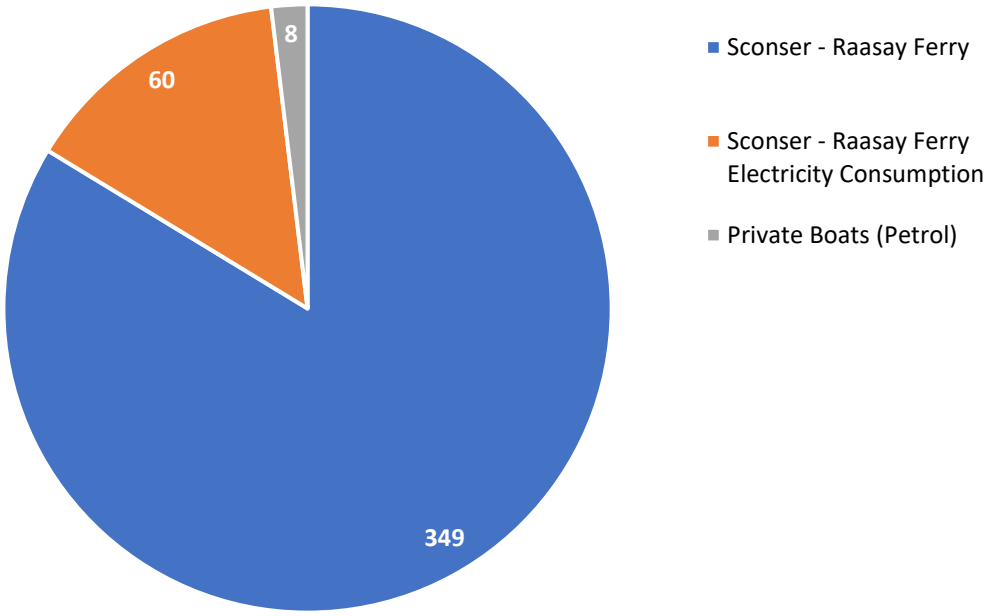

Figure 16. Waterborne transport emissions by activity for Raasay, 2019 (metric tonnes CO_2e)[28]

5.4 Off-Road Transportation

Additional fuel is consumed for personal waterborne and off-road transport as well as fuel used for personal machinery. A household survey of Raasay residents estimates the figures detailed in Table 36.

Table 36. Personal fuel consumption for waterborne and off-road travel, and machinery

Activity	Fuel Type	Quantity (L)	Energy (kWh)	Data Source	Data Quality
Personal fuel use (waterborne & off-road transport, machinery)	Diesel	12,022	128,544	Figures obtained from household survey.	High
Personal fuel use (waterborne & off-road transport, machinery)	Petrol	11,280	109,164	Figures obtained from household survey.	High

Emissions from personal off-road vehicles, boats and machinery which use diesel account for 40 tCO_2e, and those which use petrol contribute 32 tCO_2e.

[28] Emissions from ferries are for departing journeys only, as per GHG Protocol.

6 Discussion and Limitations

The usefulness of any audit which seeks to evaluate the extent of greenhouse gas emissions is determined by the quality, completeness and reliability of data sources used. Where possible Raasay-specific data was sought. In some cases, estimates were made using regional or national data using appropriate scaling factors. It is recognised, however, that the unique character of islands means that estimates calculated from regional or national data do not provide the most accurate results.

SSEN half-hourly meter readings of gross demand for Raasay estimate total demand to be 1,081,014 kWh for 2019. This figure is lower than the estimated total electricity consumption for Raasay in 2019. This discrepancy is likely due to errors which arise from using alternative estimation methods and different modelling approaches. To resolve such limitations, future refinements to the audit should seek to include more figures obtained directly from metered properties to ensure consistency with actual consumption.

With respect to residential fuel consumption, coal sales data has not been provided by all coal suppliers on the island, therefore the reported figure is anticipated to be significantly lower than the observed figure. Estimates would be improved by using data gathered from sales records of local suppliers.

Visitor transport has been calculated using coarsely modelled data as such are anticipated to underestimate visitor traffic. Dedicated traffic counts and surveys of the travel behaviour of island residents would allow more accurate measurement of on-island and off-island traffic, distances travelled by each vehicle type, and the share of traffic attributable to residents and visitors. Gathering more data from public transport providers, haulage companies, and local businesses would also help to improve the accuracy of future audits.

Priorities for future revisions of this audit include obtaining activity data where this has remained unavailable to date from transport operators, haulage companies, fuel suppliers, and local businesses; verifying assumptions, estimates and modelled activity data used; gathering fuel sales and recorded consumption data; and carrying out traffic counts to disaggregate on- and off-island travel and resident and visitor traffic.

Appendix A – Grid Intensity Emissions Factors

GHG emissions from electricity supplied from the Scottish Grid and UK National Grid may be estimated using different carbon intensity factors, also known as grid intensity factors. These factors are provided in Table 31 below. For this audit, UK grid intensity factors have been applied to maintain consistency with existing audits. Consequently, published emissions estimated using the UK grid intensity factor may be inflated over the observed emissions for local renewable generation supplied to the grid (Scope 1) and grid supplied electricity (Scope 2).

The Scottish grid intensity factor does not break down emissions by greenhouse gas, though overall CO_2e emissions are provided and may be compared with the UK grid intensity. As indicated in Table 31, the Scottish grid carbon intensity is around 16.2% that of the UK National Grid.

Table A-1. Comparison of GHG emissions of grid supplied electricity from the Scottish and UK grids

Grid	GHG Intensity Factors (kg/kWh)			
	CO_2	CH_4	N_2O	CO_2e
UK [29]	0.2536	0.0000232	0.00000517	0.2556
Scotland [30]	-	-	-	0.0414

[29] BEIS conversion factors, 2019. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904213/conversion-factors-2019-full-set-v01-02.xls

[30] Scotland grid intensity factor, 2019. Available at: https://scotland.shinyapps.io/sg-scottish-energy-statistics/?Section=RenLowCarbon&Subsection=RenElec&Chart=GridEmissions

Appendix B – Summary of Conversion factors [31] [32]

Table B-1. General unit conversion factors

From	To	Conversion Factor (multiply by)
Mile	Kilometre (km)	1.609
Kilometre (km)	Mile	0.6215
UK gallon (gal)	Litre (l)	4.546
Litre (l)	UK gallon (gal)	0.22
Kilogramme (kg)	Metric tonne (t)	0.001
Metric tonne (t)	Kilogramme (kg)	1000
Kilowatt hours (kWh)	Thousand tonnes of oil equivalent (ktoe)	1.163E10
Thousand tonnes of oil equivalent (ktoe)	Kilowatt hours (kWh)	6.135E-11

Table B-2. Conversion factors by fuel type

Activity	Fuel	Units	Kilowatt hours (kWh)	Thousand tonnes of oil equivalent (ktoe)
Liquid fuels	Aviation gasoline (jet gasoline)	Litre (l)	9.2905	7.98844E-04
	Jet kerosene (aviation turbine fuel, jet fuel)	Litre (l)	10.4519	8.98699E-04
	Diesel oil (diesel)	Litre (l)	10.6924	9.19379E-04
	Gas oil	Litre (l)	10.8080	9.29322E-04
	Kerosene (heating oil, burning oil)	Litre (l)	10.4518	8.98699E-04
	LPG (propane, butane)	Litre (l)	7.1228	6.12447E-04

[31] International Energy Agency (IEA), available at: www.iea.org/newsroomandevents/resources/conversiontables
[32] OnlineConversion.com, available at: https://www.onlineconversion.com/energy.htm

Activity	Fuel	Units	Kilowatt hours (kWh)	Thousand tonnes of oil equivalent (ktoe)
Liquid fuels	Petrol (motor gasoline)	Litre (l)	9.6777	8.32129E-04
	Residual fuel oil	Litre (l)	11.2261	9.6527E-04
	Heavy fuel oil	Litre (l)	11.7	1.0060E-03
Solid fuels	Wood or wood waste	Metric tonne (t)	5,647.0098	-
	Coal	Metric tonne (t)	8,069.9258	-

Table B-3. Mileage conversions by vehicle type

Body type	Fuel	Assumed miles per gallon (mpg)[33] [34]
Buses and coaches	Diesel	9
Cars	Diesel	56
Cars	Petrol	50
Heavy goods vehicles	Diesel	9
Light goods vehicles	Diesel	45
Light goods vehicles	Petrol	52
Motorcycles	Petrol	56
Other vehicles	Diesel	N/A
Other vehicles	Petrol	N/A

[33] Assumed mpg taken from Tables ENV0103 & ENV0104, available at: https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env

[34] It is anticipated that actual fuel efficiency figures are lower, given driving conditions and the age of vehicles on the island.

Appendix C – Emissions Factors

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
Burning Oil/Kerosene	EF_Burning Oil/Kerosene	l (litre)	2.53E+00	2.25E-04	2.38E-05	2.54E+00	
Diesel (average biofuel blend)	EF_Diesel	l (litre)	2.56E+00	1.07E-05	1.29E-04	2.59E+00	
Diesel (100% mineral diesel)	EF_Diesel (mineral)	l (litre)	2.65E+00	1.07E-05	1.29E-04	2.69E+00	
Gas Oil (Diesel Oil, Red Diesel, White Diesel)	EF_Gas Oil	l (litre)	2.72E+00	1.05E-04	1.17E-04	2.76E+00	
Petrol (average biofuel blend)	EF_Petrol	l (litre)	2.20E+00	2.46E-04	2.38E-05	2.21E+00	
Marine gas oil	EF_Marine gas oil	l (litre)	2.74E+00	2.50E-05	1.39E-04	2.78E+00	
Marine fuel oil	EF_Marine fuel oil	l (litre)	3.08E+00	4.50E-05	1.65E-04	3.12E+00	
Coal (domestic)	EF_Coal (domestic)	t (tonne)	2.51E+03	7.29E+00	1.32E-01	2.74E+03	
Fuel oil	EF_Heavy fuel oil	l (litre)	3.17E+00	1.47E-04	2.91E-05	3.18E+00	
LPG (propane, butane) (by mass)	EF_Propane/LPG (mass)	t (tonne)	2.93E+03	6.93E-02	7.21E-03	2.94E+03	
LPG (propane, butane) (by volume)	EF_Propane/LPG (volume)	l (litre)	1.52E+00	3.61E-05	3.74E-06	1.52E+00	

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
Aviation turbine fuel (jet kerosene/jet fuel)	EF_Jet Kerosene	l (litre)	2.52E+00	5.43E-05	8.99E-05	2.54E+00	
Aviation Spirit (Aviation Gasoline, AVGAS)	EF_AVGAS	l (litre)	2.23E+00	1.56E-03	8.00E-05	2.29E+00	
Wood logs	EF_Wood logs	t (tonne)	1.44E+03			1.50E+03	6.38E+01
Wood chips	EF_Wood chips	t (tonne)	1.34E+03			1.39E+03	5.90E+01
Wood pellets	EF_Wood pellets	t (tonne)	1.64E+03			1.71E+03	7.31E+01
Wood/wood waste	EF_Wood/wood waste	t (tonne)	1.75E+03	4.68E+00	6.24E-02	1.75E+03	
Peat	EF_Peat	t (tonne)	1.03E+03	9.76E-02	9.76E-02	1.03E+03	
Electricity Generated (UK)	EF_Electricity (UK)	kWh	2.54E-01	2.32E-05	5.17E-06	2.56E-01	
Electricity Generated (Scotland)	EF_Electricity (Scotland)	kWh				4.09E-02	
Electricity Generated (Shetland)	EF_Electricity (Shetland)	kWh				6.56E-01	
Electrical T&D Losses	EF_T&D Losses (UK)	kWh	2.15E-02	1.79E-06	4.53E-07	2.17E-02	
Electrical T&D Losses (EV)	EF_T&D Losses (average EV, UK)	kWh	7.52E-03	7.14E-07	1.51E-07	7.58E-03	
Distance travelled - Car (small, diesel)	EF_Car (small, diesel)	km	1.40E-01	1.54E-07	6.94E-06	1.42E-01	

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
Distance travelled - Car (medium, diesel)	EF_Car (medium, diesel)	km	1.69E-01	1.54E-07	6.94E-06	1.71E-01	
Distance travelled - Car (large, diesel)	EF_Car (large, diesel)	km	2.08E-01	1.54E-07	6.94E-06	2.09E-01	
Distance travelled - Car (average, diesel)	EF_Car (average, diesel)	km	1.72E-01	1.54E-07	6.94E-06	1.73E-01	
Distance travelled - Car (small, petrol)	EF_Car (small, petrol)	km	1.53E-01	1.14E-05	1.43E-06	1.54E-01	
Distance travelled - Car (medium, petrol)	EF_Car (medium, petrol)	km	1.92E-01	1.14E-05	1.43E-06	1.92E-01	
Distance travelled - Car (large, petrol)	EF_Car (large, petrol)	km	2.82E-01	1.14E-05	1.43E-06	2.83E-01	
Distance travelled - Car (average, petrol)	EF_Car (average, petrol)	km	1.80E-01	1.14E-05	1.43E-06	1.81E-01	
Distance travelled - Car (average, unknown fuel)	EF_Car (average, unknown fuel)	km	2.83E-01	9.29E-06	6.75E-06	2.85E-01	
Distance travelled - Car (average, other fuel)	EF_Car (average, other fuel)	km	1.76E-01	5.71E-06	4.19E-06	1.77E-01	
Distance travelled - Car (average, hybrid)	EF_Car (average, hybrid)	km	1.13E-01	5.71E-06	4.19E-06	1.15E-01	
Distance travelled - Car (average, plug-in hybrid)	EF_Car (average, plug-in hybrid)	km	7.03E-02	7.50E-06	7.92E-07	7.08E-02	
Distance travelled - Motorcycle (average, petrol)	EF_Motorcycle (average, petrol)	km	1.13E-01	6.36E-05	2.23E-06	1.16E-01	
Distance travelled - LGV (average, diesel)	EF_LGV (average, diesel)	km	2.50E-01	3.57E-07	6.94E-06	2.52E-01	

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
Distance travelled - LGV (average, petrol)	EF_LGV (average, petrol)	km	2.35E-01	8.93E-06	2.68E-06	2.36E-01	
Distance travelled - HGV (average, diesel)	EF_HGV (average, diesel)	km	8.67E-01	6.07E-06	4.82E-05	8.80E-01	
Local bus (diesel)	EF_Local bus (diesel)	passenger.km	1.04E-01	1.07E-06	2.91E-06	1.05E-01	
Coach (diesel)	EF_Coach (diesel)	passenger.km	2.73E-02	7.14E-07	1.85E-06	2.78E-02	
Aviation (with RF)	EF_Aviation (with RF)	passenger.km	2.54E-01	4.29E-06	4.75E-06	2.55E-01	
Aviation (without RF)	EF_Aviation (without RF)	passenger.km	1.33E-01	4.29E-06	4.75E-06	1.35E-01	
Ferry (foot passenger)	EF_Ferry (foot passenger)	passenger.km	1.85E-02	2.14E-07	9.51E-07	1.87E-02	
Ferry (car passenger)	EF_Ferry (car passenger)	passenger.km	1.28E-01	1.36E-06	6.57E-06	1.30E-01	
Ferry (average)	EF_Ferry (average)	passenger.km	1.11E-01	1.18E-06	5.72E-06	1.13E-01	
WTT (Burning Oil/Kerosene)	EF_WTT Burning Oil/Kerosene	l (litre)				5.28E-01	
WTT (Diesel - average biofuel blend)	EF_WTT Diesel	l (litre)				6.17E-01	
WTT (Diesel - 100% mineral diesel)	EF_WTT Diesel (mineral)	l (litre)				6.26E-01	
WTT (Gas Oil - Diesel Oil, Red Diesel, White Diesel)	EF_WTT Gas Oil	l (litre)				6.33E-01	

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
WTT (Petrol - average biofuel blend)	EF_WTT Petrol	l (litre)				5.99E-01	
WTT (Marine gas oil)	EF_WTT Marine gas oil	l (litre)				6.33E-01	
WTT (Marine fuel oil)	EF_WTT Marine fuel oil	l (litre)				6.03E-01	
WTT (Coal (domestic))	EF_WTT Coal (domestic)	t (tonne)				3.96E+02	
WTT (Fuel oil)	EF_WTT Heavy fuel oil	l (litre)				6.03E-01	
WTT (LPG - propane, butane - by mass)	EF_WTT Propane/LPG (mass)	t (tonne)				3.69E+02	
WTT (LPG - propane, butane - by volume)	EF_WTT Propane/LPG (volume)	l (litre)				1.91E-01	
WTT (Aviation turbine fuel - jet kerosene/jet fuel)	EF_WTT Jet Kerosene	l (litre)				5.27E-01	
WTT (Aviation Spirit - Aviation Gasoline, AVGAS)	EF_WTT AVGAS	l (litre)				5.83E-01	
WTT (Wood logs)	EF_WTT Wood logs	t (tonne)				5.21E+01	
WTT (Wood chips)	EF_WTT Wood chips	t (tonne)				3.04E+01	
WTT (Wood pellets)	EF_WTT Wood pellets	t (tonne)				1.77E+02	
WTT (Wood/wood waste)	EF_WTT Wood or wood waste	t (tonne)					

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
WTT (Peat)	EF_WTT Peat	t (tonne)					
WTT (Distance travelled - Car - small, diesel)	EF_WTT Car (small, diesel)	km				3.38E-02	
WTT (Distance travelled - Car - medium, diesel)	EF_WTT Car (medium, diesel)	km				4.07E-02	
WTT (Distance travelled - Car - large, diesel)	EF_WTT Car (large, diesel)	km				5.01E-02	
WTT (Distance travelled - Car - average, diesel)	EF_WTT Car (average, diesel)	km				4.14E-02	
WTT (Distance travelled - Car - small, petrol)	EF_WTT Car (small, petrol)	km				4.17E-02	
WTT (Distance travelled - Car - medium, petrol)	EF_WTT Car (medium, petrol)	km				5.22E-02	
WTT (Distance travelled - Car - large, petrol)	EF_WTT Car (large, petrol)	km				7.69E-02	
WTT (Distance travelled - Car - average, petrol)	EF_WTT Car (average, petrol)	km				4.91E-02	
WTT (Distance travelled - Car (average, unknown fuel)	EF_WTT Car (average, unknown fuel)	km				4.52E-02	
WTT (Distance travelled - Car - average, other fuel)	EF_WTT Car (average, other fuel)	km					
WTT (Distance travelled - Car - average, hybrid)	EF_WTT Car (average, hybrid)	km				2.92E-02	
WTT (Distance travelled - Car - average, plug-in hybrid)	EF_WTT Car (average, plug-in hybrid)	km				2.54E-02	

			Data to be input to CIRIS 'Emissions Factors' tab				
Activity	**CIRIS Identifier**	**Unit**	**kg CO_2**	**kg CH_4**	**kg N_2O**	**kg CO_2e**	**kg CO_2e (b)**
WTT (Distance travelled - Motorcycle - average, petrol)	EF_WTT Motorcycle (average, petrol)	km				3.08E-02	
WTT (Distance travelled - LGV - average, diesel)	EF_WTT LGV (average, diesel)	km				6.04E-02	
WTT (Distance travelled - LGV - average, petrol)	EF_WTT LGV (average, petrol)	km				6.42E-02	
WTT (Distance travelled - HGV - average, diesel)	EF_WTT HGV (average, diesel)	km				2.08E-01	
WTT (Local bus - diesel)	EF_WTT Local bus (diesel)	passenger.km				2.88E-02	
WTT (Coach - diesel)	EF_WTT Coach (diesel)	passenger.km				6.56E-03	
WTT (Aviation - with RF)	EF_WTT Aviation (with RF)	passenger.km				2.79E-02	
WTT (Aviation - without RF)	EF_WTT Aviation (without RF)	passenger.km				2.79E-02	
WTT (Ferry - foot passenger)	EF_WTT Ferry (foot passenger)	passenger.km				3.62E-03	
WTT (Ferry - car passenger)	EF_WTT Ferry (car passenger)	passenger.km				2.50E-02	
WTT (Ferry - average)	EF_WTT Ferry (average)	passenger.km				2.18E-02	

Notes:

1) Emission factors required for GPC CIRIS carbon accounting spreadsheet are expressed in units of tonnes of emissions for each greenhouse gas, respectively. This schedule provides figures expressed in kg CO_2e to the desired units.
2) Cells shown in grey are unknown, not applicable, not used, or otherwise not included.
3) Within the Scope 1 conversion factors for biomass, the CO_2 emissions value is set as net 'zero' to account for the CO_2 absorbed during growth. The Scope 1 conversion factors contain values for N_2O and CH_4 emissions which are not absorbed during growth. CO_2 released during fuel combustion is reported as 'outside of scopes'.
4) Column 'kg CO_2e (b)' includes emissions factors for non-CO_2 GHG where provided figures do not specifically detail which GHGs are provided.

Appendix D – Emissions from Alcoholic Fermentation

Emissions from alcoholic fermentation are typically exclude from greenhouse gas inventories for the distilling industry at national or industry wide scales. This is because, the emissions deriving from barley fermentation during the production of alcohol are sequestered when new barley is grown. In principle, provided new barley is grown, then this activity is carbon neutral.

The scale of emissions from alcoholic fermentation are significant. The fermentation reaction converts one chemical mole of glucose into two moles each of ethanol (alcohol) and CO_2 in a 1:1 ratio. Therefore, 0.75kg of CO_2 is produced for each litre of pure alcohol.

For this carbon audit, most barley is imported to island communities, and as such carbon sequestration happens outside the island community. These may be considered Scope 3 emissions sinks, which occur outside the island boundary but derive from island activity. As such, these have been excluded from the present audit. Should CO_2 capture and storage processes be deployed at distilleries for fermentation emissions, then this activity may act as a net carbon sink.