climate change
Scotland's centre of expertise connecting climate change research and policy

Climate action on Scottish islands: an initial mapping of the landscape

Florianne De Boer, James Harries, Lachlan Kirk, Henry Quintana, Sabina Shaikh, Kathryn Smyth and John Watterson

Ricardo Energy and Environment, March 2022
DOI: http://dx.doi.org/10.7488/era/2525

1 Executive summary

1.1 Aims

The Carbon Neutral Island project[1] will support six Scottish islands to become carbon neutral by 2040. It will support islands to run on 100% renewable energy, create circular economies, and explore more sustainable transport options.

This research explored the available data for climate change actions on Scottish islands, especially in relation to climate accounting exercises and good practices in dealing with the climate change emergency.

There were three specific tasks:

Task 1: Approaches for measuring greenhouse gas (GHG) emissions (i.e. GHG accounting) on Scottish islands.

Task 2: Types of GHG reduction projects undertaken on Scottish and other islands.

Task 3: Possible sources of funding for climate action on Scottish islands.

This research was undertaken to help inform the Scottish Government's Carbon Neutral Island (CNI) project, which aims to support six Scottish islands to become carbon neutral by 2040.

A key output of the project was a set of databases, available alongside this report, that capture information on the three topics outlined above. This resource can be used by the Scottish Government in implementing the CNI project, but also by island local authorities and communities as they chart a course, and take actions towards net zero. For example, the findings from Task 1 can inform approaches to ensure consistency in island-level GHG assessments and can support carbon audits across the islands that are planned as part of the CNI project. The findings from Task 2 can support island local authorities and communities to consider possible options for delivering net zero that are tailored to their own circumstances, needs and priorities. The findings from Task 3 can give the authorities and communities a practical overview of options for funding climate action.

[1] https://www.gov.scot/news/carbon-neutral-islands-named/

1.2 Findings

1.2.1 Task 1 – GHG accounting

- Currently, there is not a consistent approach across Scottish Islands to GHG accounting. Different GHG accounting exercises have been carried out at different spatial scales for different reasons.
- No complete GHG inventories exist at the individual island level, although there are many components already available that can be used to develop GHG estimates, including partial GHG inventories, energy audits and data from other reports.
- Most GHG emissions estimates focus on energy (including buildings and transport) and miss out key sectors such as land use, forestry and agriculture.
- This makes comparisons difficult. But some differences between islands are noticeable, for example the proportion of emissions from intra-island transport vary by the size of the island.
- A framework should be developed that gives island local authorities and communities the tools to develop appropriate GHG inventories for their specific circumstances, but at the same time ensures comparability by giving guidance on common approaches, data and emissions factors to use.

1.2.2 Task 2 – GHG reduction projects

- The projects identified exhibit a varied range of innovation and scale, delivering developments using established technologies as well as innovative demonstrator projects.
- The unique challenges associated with islands, while requiring a tailored mitigation approach, also show their suitability as test beds for the development, trial and deployment of emerging technologies appropriate for decarbonisation strategies.
- Both in Scotland and across Northern Europe there are significant commonalities between the barriers being addressed and sector priorities in projects delivered. The potential for knowledge sharing and adapting successful projects to local purposes provides a resource with significant potential. However, it must incorporate a place-based approach and be suited to local characteristics.
- Decarbonisation strategies can provide a means to reduce the need for infrastructure upgrades by maximising the benefits of local assets and revalorising waste outputs, and by adapting existing systems to sustainable processes.

1.2.3 Task 3 – Climate action funding

- Climate interventions required for a net zero society can only be realised with the right allocation of climate finance. Therefore, it is crucial that financial investments are made readily available.
- Financial support within the Scottish Island context needs to connect community-level issues in peripheral islands with the planning agendas of local authorities and central government. Scottish islands' atypical characteristics are often not fully appreciated and considered.
- It is clear that a one size fits all approach for climate finance is not appropriate in the Scottish Island context due to their unique characteristics such as main emission sources and population size. Place-based financial schemes need to reflect these unique island characteristics to ensure the right financial aid addresses different mitigation priorities.
- 88% of funding sources identified are derived from the public sector versus only 9% from the private sector and the remaining 3% is derived from the third sector.

- The largest share of funding streams identified is catered to schemes which provide funding for multiple sectors. The second-largest share is energy and land use funding opportunities.
- Two examples where island community climate challenges are arguably not being addressed sufficiently in current financial initiatives are support for off-grid communities and peatland restoration.
- Small islands can house cohesive communities, which support effective working towards shared climate goals. Thus, community funding can be used as a building block for implementing mitigation measures and increasing community-level adaptive capacity.

1.3 Recommendations

One of the key findings from our work is that the diversity of Scottish islands means that it is important that the CNI project provides support within a framework that is flexible and adaptable to local needs. Examples of what this means in practice are:

- Not all islands will need a GHG inventory to the same degree of accuracy or coverage. However, there is a need for an overarching framework that ensures consistency and comparability and that supports continuous improvement over time.
- Similarly, a climate plan or funding option that is relevant to one island may not be relevant to another island. That said, there are considerable opportunities for joint working and cross-learning between island communities within Scotland.

It is therefore hoped that the CNI project will offer an opportunity for island communities to learn from each other, and to engage with others outside of Scotland, to continue to understand approaches, options and best practices in accounting GHG emissions, implementing climate action and unlocking climate finance.

The databases provided alongside this report should provide an important resource to inform such discussions within and between Scottish Island communities and stakeholders. We recommend that they be made widely available and that resources are put towards maintaining and updating the databases over time to ensure they remain current and live.

Contents

2 Introduction

2.1 Research purpose and objectives

This report summarises research carried out on various issues related to climate action on Scottish islands, specifically:

i. Approaches taken to measuring greenhouse gas (GHG) emissions on Scottish Islands;
ii. Types of GHG reduction projects undertaken on Scottish and other islands;
iii. Possible sources of funding for climate action on Scottish islands.

This research was undertaken to help inform the Scottish Government's Carbon Neutral Island project, which aims to support six Scottish islands to become carbon neutral by 2040.

2.1 Scottish island policy environment and context

As required by the Islands (Scotland) Act 2018, the Scottish Government adopted a National Islands Plan in 2019 to improve outcomes for island communities. The Plan is based on the four principles of fairness, integration, environmental protection and inclusiveness. Under the environmental protection theme, the Plan aims to contribute to climate change mitigation and adaptation and promote clean, affordable and secure energy.

In 2021, the Scottish Government made the Programme for Government Commitment to deliver at least three Carbon Neutral Islands by 2040. This commitment has since been extended and the Carbon Neutral Islands project now aims to support six islands to achieve carbon neutrality by 2040. The project will involve carbon audits across the islands and a pilot phase to inform learning.

This ClimateXChange scoping project will support the successful delivery of the Carbon Neutral Islands project in several ways. It provides evidence to help identify appropriate approaches to estimating GHG emissions, judge the success of potential emission reduction measures, and identify funding routes for implementation of GHG reduction measures.

2.2 Approach

The figure below shows the overview of the project tasks and methodologies, as well as the key deliverables of the project.

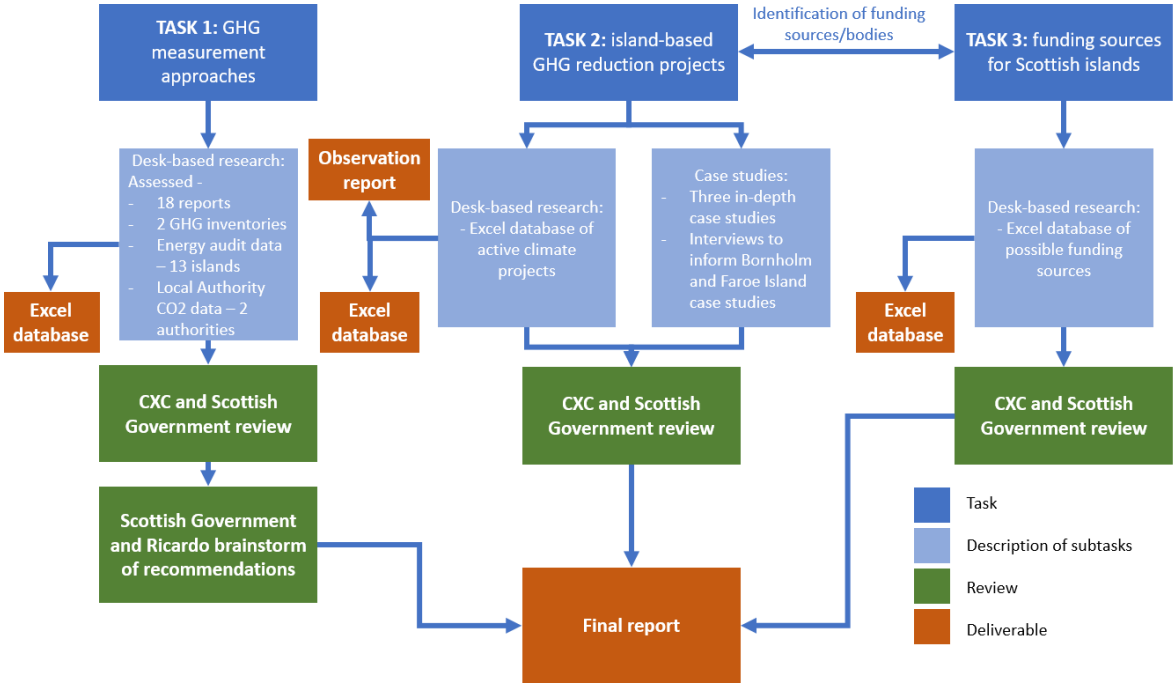


Figure 1: Overview of project methodology, data sources and outputs.

2.3 Terminology

Climate change is caused by emissions to the atmosphere of greenhouse gases (GHG). The main GHG is carbon dioxide, but climate change is also caused by other GHGs including methane, nitrous oxide, and fluorinated gases. The term carbon neutral, also sometimes referred to as net zero, simply means balancing out emissions of GHGs to the atmosphere with removals of carbon dioxide from the atmosphere. Sources of GHGs that are emitted to the atmosphere include carbon dioxide from the combustion of fossil fuels, methane released from animals and from biodegrading waste, nitrous oxide released during fertiliser use and fluorinated gases leaking from refrigeration or air conditioning. On the other side of the carbon neutrality equation, removals of carbon emissions from the atmosphere can either be natural – for example, trees absorbing CO_2 from the atmosphere – or man-made – for example, using carbon capture and storage technology.

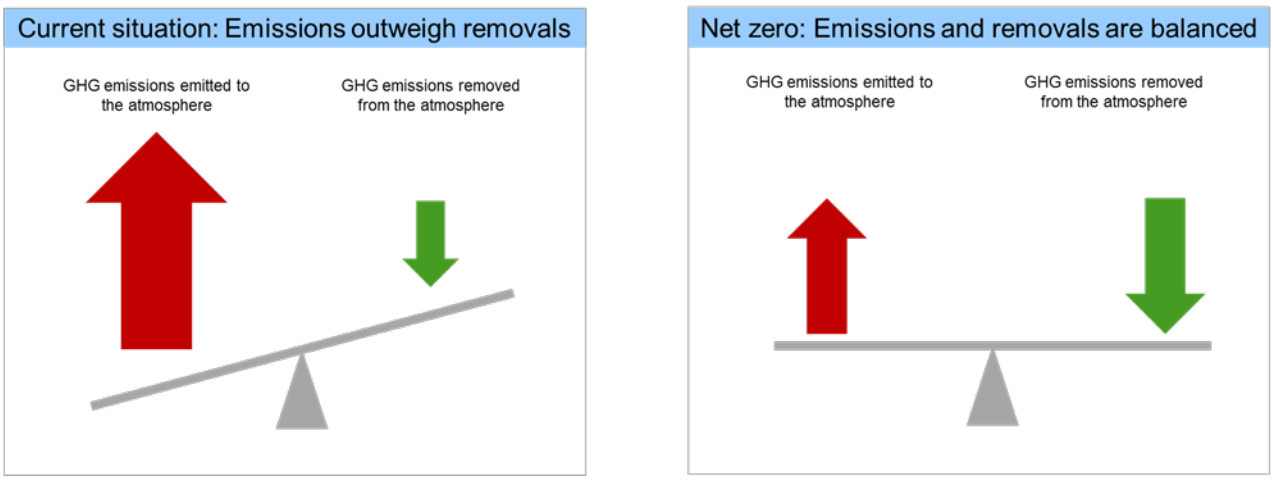


Figure 2: Visual depiction of current situation and net zero state of emission and absorption of GHGs.

3 An assessment of existing GHG emissions accounting exercises on Scottish islands (Task 1)

Key points from Task 1:

- Greenhouse gas (GHG) accounting refers to the approach taken to estimating GHG emissions.
- There is not a consistent approach across Scottish Islands to carbon accounting. Different carbon accounting exercises have been carried out at different spatial scales for different reasons.
- We did not discover any complete GHG inventories at the individual island level, although Skye and Raasay do have a fairly complete GHG inventory covering the two islands together.
- Some GHG estimation is possible from energy audits that have been carried out at island level. However, this excludes emissions from non-energy related activities such as land use. Local authority CO_2 data shows land use is a major source for some Scottish Islands.
- Comparing energy-related CO_2 emissions between islands shows some differences. For example, emissions from transport to and from islands makes up a larger proportion of energy-related CO_2 emissions in islands with smaller populations, as emissions on the island itself are relatively lower.
- The sectors with best coverage in the various emissions estimates we assessed were emissions from domestic buildings and transport. This was followed by non-domestic buildings. The sectors least often included in the GHG estimates are agriculture, land use, waste, and industrial emissions. However, this is partly due to the rationale for the GHG estimates rather than a conscious decision to exclude them. For example, because many of the estimates come from energy audits it is not surprising that emissions from waste and land use are not covered.

3.1 Background and rationale to the task

A GHG inventory is a key scientific tool in the fight against climate change. In simple terms, a GHG inventory is a list of the sources of GHG emissions caused by human activity. Each inventory contains an estimate of net GHG emissions, showing emissions from each of these sources, and, in some sectors, estimates of removals of carbon from the atmosphere by “sinks”. We refer to the process of compiling a GHG inventory as ‘GHG (or carbon) accounting’.

GHG inventories can be used to monitor and report on GHG emissions at different spatial levels. They are a crucial part of the transition to net zero, by first allowing for an understanding of where emissions come from, so action to address them can be appropriately targeted, and also to help track progress in reducing the emissions, as shown in Figure 3 below.

Figure 3: GHG inventories can be used to plan and track effective mitigation action.

GHG emissions are typically estimated by multiplying 'activity data' with an 'emissions factor'. For example, quantity of fuel sold (activity data) multiplied by carbon intensity of that fuel (emissions factor), or number of sheep (activity data) multiplied by emissions per sheep (emissions factor).

Governments use GHG inventories at the national level to inform climate change policy making, but they can also be used at other spatial scales, for example for a local authority, an island, or even an individual community. A complete GHG inventory would cover emissions from all sectors and would cover all greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the fluorinated gases. This is vital information that can then be used to set credible mitigation targets, take effective mitigation action, and monitor progress towards achieving those targets.

3.2 Methodology

The first step in Task 1 was to identify examples of GHG accounting on Scottish islands and the second step was to compare them, to understand how the approaches that were taken differ.

For the first step, we obviously looked for examples of GHG inventories at the island level, but we also looked more broadly at other data sets which could be used to derive a GHG figure for the island despite not being GHG inventories. As an example, some islands had carried out energy audits and the data on energy consumption could be used by the project team to calculate emissions estimates for that island. The aim was to build a picture of what is currently being done, or may be required, to assess GHG emissions on these islands. The initial assessment was conducted by creating a database to record information collected from a range of information.

At the start of the project, we developed a set of comparative criteria, or metrics, which we then used to intercompare the GHG accounting exercises. Our examination and analysis of the studies revealed key themes, gaps, and areas of best practice across the islands.

The initial metrics included:

- Basic approach used in the study – e.g., energy audit-based approach, full GHG inventory approach, by source emissions versus end user emissions, etc[2].
- What GHGs are included – i.e., carbon dioxide, methane, nitrous oxide

[2] Emissions data 'by source' shows where the emissions occur, whilst emissions data 'by end user' shows where the energy is used. For example, in a 'by source' inventory, emissions created when lights are turned on in homes are shown in the power sector (where the emissions from the generation of that electricity occur). In a 'by end user' inventory, the emissions from the power stations are allocated to the sectors where the energy is used.

- Scope of emissions included – Scopes 1, 2 and 3; scopes are a way of categorising the boundaries of emissions[3]
- Sectors and sources covered – such as transport, industry, residential, land use
- Sources of activity data used – for example energy use data, land use types, population, economic growth
- Emission factors and methods used in calculating GHG emissions
- Assumptions and areas of uncertainty.

The metrics were used to help categorise and compare the different datasets, and this assessment has formed the basis of our conclusions. The assessment in the next sections of this report gives our view on the "state of play" of GHG accounting exercises amongst Scottish islands and key findings.

The information and data for our GHG accounting review came from a variety of sources, and the most relevant for this assessment were GHG inventories and energy audits. The energy audits report estimates of CO_2 emissions as a by-product of energy use estimation.

A range of other studies and information helped ground our analysis in the "island context" - these studies included island development plans and the information in the local authority feedback forms[4]. In addition to this, all Scottish islands are covered by CO_2 estimates at the local authority level, as this data is compiled annually (2 years in arrears) by Ricardo for BEIS. These estimates do not go down to the individual island level.

The local authorities with islands are listed in Table 1. Each of these local authorities has a CO_2 estimate covering emissions from transport, industry, commercial, public sector, domestic buildings, and LULUCF.

Table 1: Scottish local authorities with islands.

Local authority	**Examples of islands covered**
Argyll and Bute	Islay, Mull, Gigha
Highland	Skye, Raasay, Rum
Na h-eileanan siar	North Uist, Harris
Orkney Islands	Sanday, Faray, Wyre
Shetland Islands	Fair Isle, Foula, Yell, Fetlar
North Ayrshire	Arran, Great Cumbrae

Figure 4 indicates the approach taken and which sources offered direct (solid line) or indirect (dashed line) information relevant to the task.

[3]GHG emissions can be broken down by scope to indicate whether activities causing these emissions have occurred within the boundary of the jurisdiction or outside. This can apply to all levels of jurisdiction such as at the country, regional, or local level, as well as corporate level. Scope 1 indicates emissions arising from activities within the boundaries of the study, scope 2 indicates emissions that have occurred because of the use of grid-supplied electricity, heat, steam and/or cooling within the boundary, and scope 3 incorporates all other GHG emissions that occur outside of the boundary as a result of activities that have taken place within the boundary. More information can be found at GHG Protocol for Cities | Greenhouse Gas Protocol

[4] The local authority feedback forms were conducted by the Scottish Government as part of the Carbon Neutral Islands programme. The three responses we assessed were from Na h-eileanan siar (Western Isles), Highland, and Orkney councils.

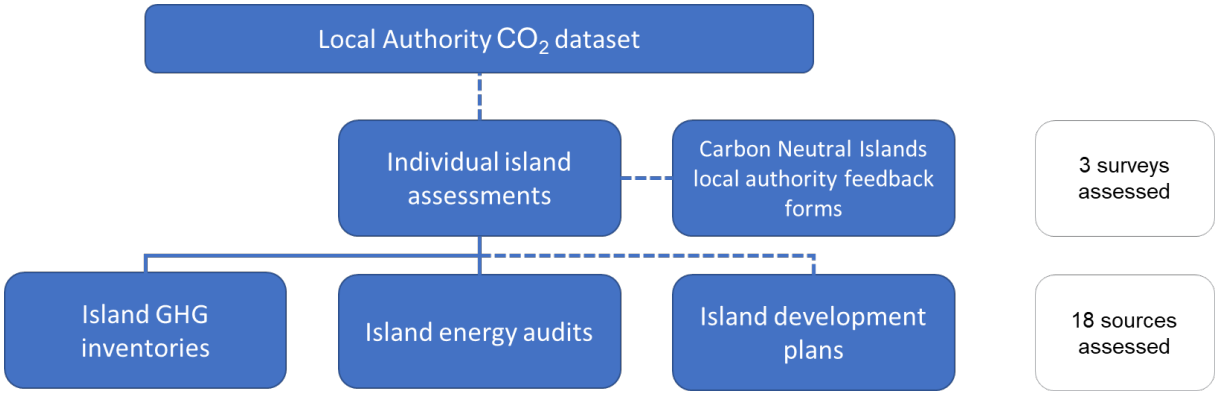


Figure 4: Different sources used in assessing island GHG accounting exercises.

Although not all reports cover all sectors in detail, we have identified certain sectors as important to our study. This is because the activity in these sectors provide us with a broad assessment of the total GHG emissions across the islands. The key sectors are:

- Non-domestic energy use (e.g., electricity, gas, oil, and solid fuels)[5]
- Domestic energy use (e.g., electricity, gas, oil, and solid fuels)
- Transport (within islands and between islands)
- Agriculture, forestry, and land use (AFOLU)
- Industry (both energy use and industrial process emissions)
- Waste

3.3 Observations

Our assessment reviewed 13 studies, consisting of:

- Two localised GHG inventories (one for Skye and Raasay combined and one for Lochaber, which included the associated islands).
- Seven individual island energy audits
- An EU islands energy baseline report on off-grid Scottish islands
- A Ricardo conducted energy system review of 49 islands
- An island development plan
- A Ricardo draft report on the development of a Shetland emissions baseline.

There is not a consistent picture across Scottish Islands in terms of the approach to carbon accounting. Different carbon accounting exercises have been carried out at different spatial scales for different reasons. This includes building an assessment to support GHG reduction efforts and to provide an indication of energy emissions. **We did not come across any complete GHG inventories at the individual island level**.

[5] Emissions from the use of electricity are only included in "end-user" GHG inventories

The Skye and Raasay GHG inventory, published in 2020, provides the most comprehensive GHG emission estimates of all the reports we reviewed, and is the only island study to provide estimates of three key GHGs – carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The sector coverage is also the most complete, providing emissions for electricity and heat use for both domestic and non-domestic buildings; transport on, to and from the island, and from the AFOLU[6] sector; the waste and industry sectors were not included in this inventory. The Lochaber GHG inventory, also published in 2018, was also assessed; however, the geographical area covered in the inventory consisted of a combination of mainland and islands without distinguishing between emissions from the two locations. Both inventories were commissioned as part of the Highland Council's Executive Chief Officer (ECO) network, providing local analysis to increase understanding and efforts of where to address action more effectively as part of the council's initiative to achieve net zero emissions.

The information from the energy audits provides information about the energy consumption for electricity, heating, and transport on and to and from the islands, plus one estimate of the energy use of an on-island oil terminal. In these audits, we have estimates of CO_2 emissions from 13 islands.

The Ricardo energy system review, a scoping study commissioned by Highlands & Islands Enterprise highlights the energy systems of 49 islands and the challenges faced to build resilience and strengthen energy access on these remote islands. Again, this is useful for context but does not provide any GHG accounting exercises to review.

The island development plan offers us further insight into the activities, and plans led by the local council of Papa Westray. It can only be used as contextual information as there are no emissions or energy estimates included, only offering a guide to build a picture of life on the island and an indication of what might be the largest sources of emissions.

Finally, the Shetland GHG baseline is still being developed at the time of writing, so we are unable to extract detailed insights from this. When the inventory is completed, it aims to be Shetland-wide (i.e., not going down to individual island level) focusing on all sectors of the local economy but excluding emissions from the Sullom Voe terminal and the Shetland Gas Plant, which are the focus of other studies and activities such as the Orion Clean Energy Project[i].

3.3.1 Key sectors

The emissions estimates that were collected or calculated as part of this study help "paint a picture" of which sectors may be the largest emitters across the islands. For Skye and Raasay, two islands with a combined population of over 10,000 inhabitants, and the only GHG inventory within our study to look solely at islands with a complete sectoral coverage, the study reported that the sector contributing most to emissions is electricity use. Emissions from this sector account for over 80% of total GHG emissions covered within the inventory. The report also states that the AFOLU sector contributes -26%, in other words the sector is a net carbon sink (it absorbs more than it emits).

[6] Agriculture, Forestry and Other Land Use (AFOLU)

Box 1 – land use change and agriculture

The LULUCF (Land Use, Land-Use Change, and Forestry) and AFOLU (Agriculture, Forestry, and Other Land Use) sectors cover emissions of GHGs and removals of CO_2 resulting from direct human induced land use, land-use change, agriculture, and forestry activities. In simple terms, carbon is sequestered – or taken up by and incorporated into biomass - by forests, peatland, grassland, and cropland. Carbon losses can occur on existing forestland, peatland, cropland, and grassland through the effects of management activities and conversions to other land uses – for example, cropland, grassland, or settlements.

The LULUCF sector has important effects on the global carbon cycle. Net CO_2 emissions from the LULUCF sector can be negative indicating an overall carbon sink in a specific land use type. When negative, the amount of CO_2 removed from the atmosphere outweighs the amount emitted. The net contributions of the LULUCF or AFOLU sectors can be compared to the net total emissions and can result in negative percentages with respect to total net emissions.

Inferring information about key emitting sectors is harder from other data sources as these were not complete with regards to sectors or gases. So, the fact that some sectors appear as the main emitters may not mean that they are in fact the biggest emitters, as even larger sources of emissions may be omitted from the data. The local authority CO_2 data produced every year for BEIS does show that for some Scottish island local authorities, land use can be a very large net source of emissions. For example, in the Shetland Islands, the land use change and forestry sector represented 68% of total CO_2 emissions in 2019, while the figure for Orkney is almost 49% and the figure for the Western Isles is as high as 72%, as indicated below in Figure 4. As these emissions are not related to energy use, they do not appear in GHG estimates based on energy audits. This therefore points to the importance of having good sectoral coverage in GHG inventories, otherwise mitigation efforts might not address those sectors that are the largest emitters.

When focusing on a comparison of energy-related CO_2 emissions there is considerable variation between islands. The information we examined showed that for islands with much smaller populations, such as Rum (38 inhabitants) or Iona (177), transport to and from the island is by the far the largest contributor to energy use, and thus CO_2 emissions. The types of transport include marine transport, such as passenger and freight ferries, domestic air travel, and local fishing or tourism boats. The studies report that these activities are responsible for 91% of energy-related CO_2 emissions in the case of the island of Canna, and 81% and 80% from Rum and Eigg respectively. More specifically it is ferry transport that is the major contributor to individual islands' energy use. These islands all have less than 100 inhabitants living on them so energy use on the island for domestic and non-domestic use, and road transport, is negligible in comparison to travel to and from the island.

As would be expected, the picture is quite different for islands with larger populations. The profiles of emissions show that, with respect to the total emissions, the more populated islands have a greater overall contribution of emissions from energy use from domestic and non-domestic buildings.

3.3.2 Limitations to the energy use studies as a source of GHG accounting information

There are limitations to energy use studies for this work. The CO_2 estimates are a by-product of the energy audits, and the audits present limited information on activity data sources, emissions factors, and dates that the results refer to. In addition, as they are energy focused audits, not all sectors are covered; AFOLU, industry (either industrial process emissions or energy use by industry, or both), and waste sectors are omitted.

To provide a more thorough assessment of the GHG emission profiles, it would be useful to have more island GHG inventories to assess. We did assess the GHG inventory of Lochaber; however, this was an assessment of a region inclusive of the mainland and the island and did not separately assess emissions from the island.

The infographic in Figure 5 presents a selection of key relevant data from two reports for two groups of islands. We have included this infographic to illustrate a range of points: to show what information can be extracted; the difficulties of comparing data from the reports we have assessed; and to show the very different messages about GHG accounting that the reports convey.

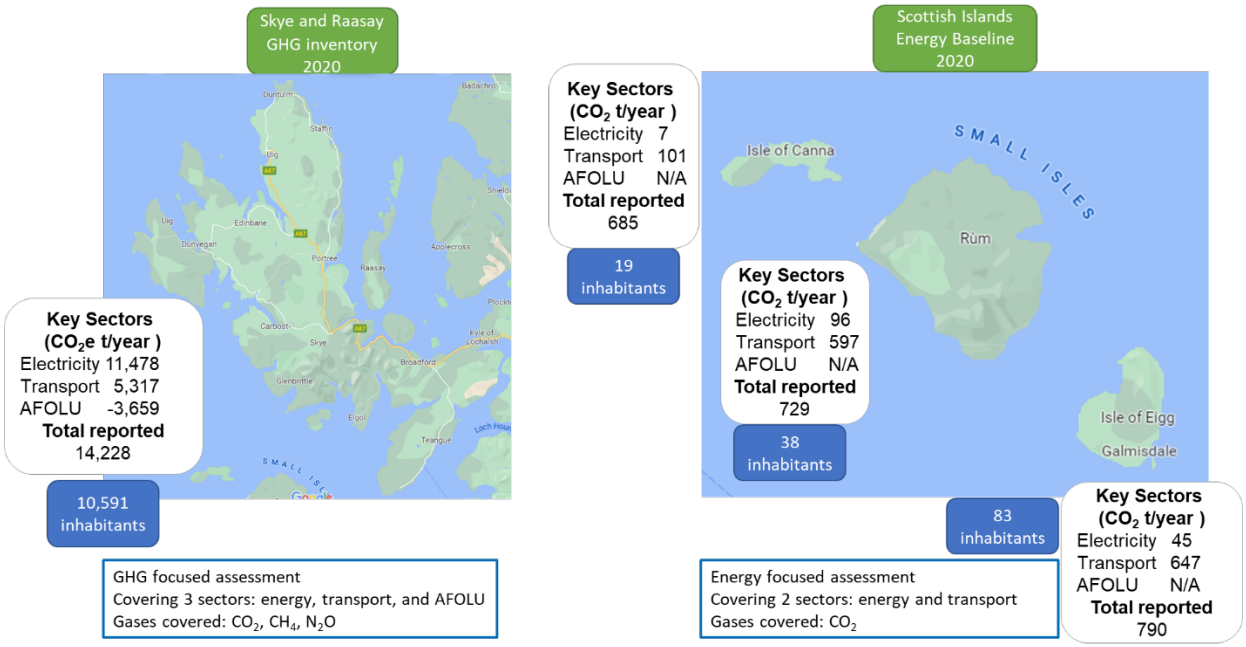


Figure 5: A comparison of information from two reports and key findings relevant to the islands. The sectors considered are Energy, transport, and Agriculture, Forestry, and Other Land Use (AFOLU).

The islands in the figure above are Skye and Raasay, included in the Skye and Raasay GHG inventory and Canna, Rum, and Eigg, included in an energy baseline study. While there may be some similarities in their circumstances, their geo-socioeconomic contexts are unique. One report contained a GHG inventory for Skye and Raasay, and the other an energy baseline conducted as part of a wider assessment for a set of Scottish Islands not connected to the mainland electricity grid. The reports were designed to fulfil separate requirements for different audiences. This means they use different calculation methods and have different coverages of sectors and gases. However, even considering these barriers to intercomparing the results, we can still reach important conclusions.

The results from the Scottish Islands energy baseline study highlight the importance of CO_2 emissions from travel to and from the islands by ferry, including inter-island transport and travel to the mainland. The GHG inventory for Skye and Raasay also has an assessment of these transport emissions, but it reveals the significance of CO_2 emissions from electricity use and shows that there is a net sink of CO_2 within the AFOLU sector. We can make a more definitive comparison of the CO_2 emissions from electricity use and transport to and from the island between the two studies, with the large differences in populations clearly making a significant impact on the magnitude of emissions. The energy baseline study does not consider the AFOLU sector, so this is incomparable across the two reports.

In this study we have attempted to assemble signals and messages from these very different studies into a coherent and more complete picture of GHG accounting in the Scottish islands. We cannot fully overcome the incompatibilities between these studies, and this does limit our conclusions about the overarching "state of play" of GHG accounting exercises of the islands. Without further island specific GHG inventories, it is hard to make a more complete assessment of the islands' GHG emission profiles.

3.3.3 Assessment using the Local Authority CO_2 inventory

Figure 6 displays data for 2019 taken from the Local Authority (LA) CO_2 inventory. The figure shows the contribution of the net LULUCF CO_2 emissions to the net total CO_2 emissions. The local authorities shown are all those that have islands within their areas. The inventory does not provide data disaggregated to the island level.

LULUCF makes a significant contribution to total net emissions in five of the six local authorities. In fact, in three, Na h-eileanan siar, Orkney and Shetland, LULUCF is the major contributor to total net CO_2 emissions with contributions of 72%, 49% and 68%, respectively. In Argyll & Bute and Highland, the situation is very different and LULUCF net emissions account for -102% and -23% of net emissions. Both these councils do not consist solely of islands and the LA CO_2 dataset does not distinguish between mainland and island. This means it is difficult to determine the contribution from the islands to the AFOLU or other sector totals. In North Ayrshire, LULUCF represents 4% of total net CO_2 emissions, but the influence of the islands on the reported data could be quite small with only a small number of islands contained within the council's authority. The Isle of Arran is the biggest island in the region with a population of over 4,000. However, despite speaking with a local environmental organisation on the island, we did not find any information detailing the GHG emissions profile on the island to assist us with determining the relationship between the data at the local authority and island level.

For the Shetland islands, the LA CO_2 inventory data suggests that the largest source of net emissions is from grassland. Emissions arise as peatland is converted to grassland for farming, with the peatland degrading as part of this conversion. This causes the peat to dry out as the water is drained which then causes the stored organic carbon to oxidise, releasing CO_2. Restoring, and thus reversing this process, is not simple and will take many years.

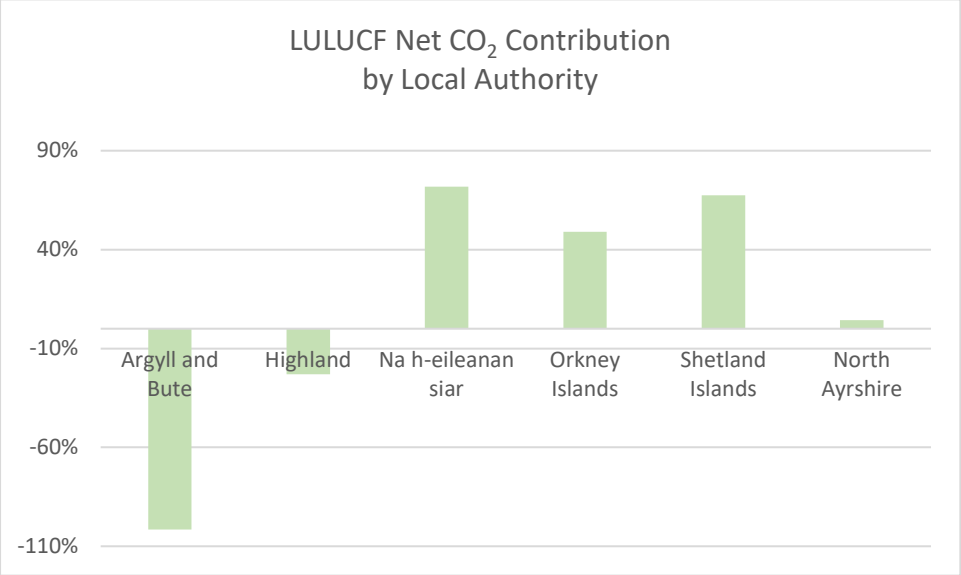


Figure 6: LULUCF breakdown of net CO_2 contribution by local authority. Argyll and Bute, Highland and North Ayrshire local authorities include islands and mainland.

The LA CO_2 inventory is a national statistic, but there are still limitations and uncertainties associated with the inventory. The technical report explaining the LA CO_2 inventory states that LULUCF estimates are associated with a high level of uncertainty. The LA CO_2 dataset is not disaggregated to the individual island level and so it can only be used as contextual information to indicate CO_2 emissions from sources. It also does not offer full coverage of all sectors, with notable omissions from ferry and air transport (road transport within the authority is included), and only contains estimates of CO_2 emissions. The non-CO_2 GHGs are not presented.

Assessment matrix of current GHG estimation practices

We have created an assessment summary matrix to present our findings of existing island GHG estimation practices (Table 2). The matrix indicates the approaches used to estimate GHG emissions, the GHGs covered, and the sectoral coverage of each report assessed. The matrix highlights similarities and differences between the studies and shows the range of analytical approaches used. These are essential points to consider when "painting the picture" of current reporting methodologies and identifying barriers to comparing the results between islands. Within the sector analysis of this matrix, the **E** denotes that an energy use estimate was provided while **G** indicates that a GHG emissions estimate was included.

Table 2: Task 1 Assessment summary matrix table.

Island	Basic approach used	Emissions	Non-domestic	Domestic	Transport	AFOLU	Industry	Waste
Foula	Energy End-user basis	CO_2 (only)	G	G	G			
Fair Isle	Energy End-user basis	CO_2 (only)	G	G	G			
Canna	Energy End-user basis	CO_2 (only)		G	G			

Island	Basic approach used	Emissions	Non-domestic	Domestic	Transport	AFOLU	Industry	Waste
Rum	Energy End-user basis	CO_2 (only)		G	G			
Eigg	Energy End-user basis	CO_2 (only)		G	G			
Muck	Energy End-user basis	CO_2 (only)	G	G	G			
Iona	Energy End-user basis	CO_2 (only)	G	G	G	E		
Gigha	Energy	None included in study	E	E	E		E	
Lismore	Energy	None included in study	E	E	E	E		
Luing	Energy	None included in study	E	E	E			
Barra and Vatersay	Energy End-user basis	CO_2 (only)	G	G	G			
Orkney	Energy End-user basis	CO_2 (only)	E	E	E	E	G	E
Papa Westray	N/A	None included in study						
Shetland	End-user basis	All major GHGs	G	G	G	G	G	G
Islands under 300 households - 49 islands	Energy	None included in study	E	E	E			
Lochaber	GHG	CO_2, CH4, N2O		G	G	G		
Skye and Raasay	GHG	CO_2, CH4, N2O		G	G	G		
Islay	Energy	CO_2e[7]	E	E	E		E	

[7] Specific GHGs not stated within study.

The information in the matrix tells us that the majority of the studies are for the following sectors: domestic and non-domestic buildings, and transport. This is largely because most reports providing emissions estimates are energy audits, with the primary objective to determine energy use from these sectors. Far fewer emissions estimates are available in the AFOLU, industry, and waste sectors. It also highlights that there is only limited compatibility between the assessments. The limited and differing sectoral coverages and differences in calculation methodologies mean that comparing the current set of GHG accounting approaches between islands is hard.

3.3.4 Best practices in estimating GHG emissions

An important question to ask is what would an ideal GHG accounting exercise for a Scottish island look like? Below is a list of best practices to give a complete and comparable island GHG accounting approach. The first three points are crucial activities required for best practice GHG accounting, while the latter three outline what would be required for continuous update and improvement. The best practices are as follows:

- There would be an accurate GHG inventory for each island, this would likely be of varying detail and may be sector specific depending on the size of the island and estimated GHG emissions profile.
- Each inventory would have an associated report explaining the work done to create the inventory and the report would be both complete and transparent.
- A core team from the local authority or community would need to be developed who would oversee compiling the GHG inventory within their jurisdiction. Basic GHG compilation training would be useful for this team to ensure they have the knowledge to understand and challenge the results of the inventory. A mechanism for institutionalising the knowledge for future iterations of the inventory should be implemented.
- The GHG inventory would also have good sectoral resolution providing a breakdown of emissions by sub-sector, suitable to support the definition of GHG mitigation policies, and would help track progress towards any mitigation targets.
- The GHG inventory would accurately estimate all GHG emissions from all sources and removals of CO_2 by sinks.
- Inter-island transport (not part of the local authority CO_2 data) and sectors such as agriculture, land use and waste would be included

Our evaluation has highlighted gaps in the current GHG accounting arrangements of islands and outlined sectors which are important in their GHG accounts. The Skye and Raasay GHG inventory has provided the most comprehensive view of GHG accounting exercises on two islands as it has focused on a number of sectors and gases. There have been “smaller snapshots” into the GHG accounts of the other islands through their energy audits. The data in both the GHG inventories and energy audits have helped support our assessment, but there are insufficient island GHG inventories to identify one or more as an inventory representing “good practice”.

One option could be to develop a set of comparable island GHG inventories, created using methodologies that are comparable between islands, and focusing on the most relevant sectors. The definition of sectoral relevance here would be those sectors that allow the islands to start building the evidence base they need to take effective mitigation action. There is considerable fuel poverty on many of the islands, and the cost of transport is a barrier to economic growth. Added to this, the stored carbon in peatlands is large and vulnerable. These factors suggest then that the GHG inventories should have well developed methodologies covering at least these sectors. Turning now to the direct jurisdictional control the islands have over mitigating GHG emissions, the islands do not have full control over some sectors – for example inter-island ferries – but we believe that jurisdictional control should not be a primary factor controlling which sectors to focus on. GHG inventories should highlight main emissions sources and this information can then be used to inform discussions around who has influence over those sources and what they can do to address them. Including sources over which the island does not have full jurisdictional control will allow the island to better understand who they need to engage with and influence to tackle that emissions source.

Looking to the future, how should the geo-socioeconomic differences between the islands shape the GHG accounting approaches they need? One strategy would be to group the islands into typologies of islands with similarities that are likely to result in similar GHG emissions profiles. Then, GHG accounting approaches could be developed and tailored to the types of islands.

These typologies could help the Scottish Government target islands with mitigation actions most appropriate to the islands. This could include a series of “easy-win” and “no-regret” actions that could apply to all islands. When thinking about mitigation actions, it is important to consider associated co-benefits related to adaptation, climate justice, and just transition. There are serious challenges such as fuel poverty, the impact of waste disposal practices, and the impacts of tourism to consider. The relative importance of these challenges will differ between islands.

The islands could be grouped into typologies of:

- Low, medium, or high population (for example, under 1,000, 1,000 – 3,000, over 3,000)
- Off-grid or connected to the mainland electricity grid
- Economic profiles - heavy reliance on certain economic sectors such as agriculture, industry, tourism.

Considering the approach of categorising islands by economic profile, this may be a useful approach to identifying islands that have GHG emissions profiles that are more diverse and complex than other islands, i.e., that have economies that are reliant on several sectors and a variety of activities. Another consideration is to use these typologies to identify islands that might require a more detailed approach to GHG accounting, for example, for those where there might be large net emissions or sequestration from the AFOLU sector, which we have outlined might prove harder to estimate when accounting for emissions from peatland. If these accounting exercises are undertaken at a local level, it may be useful to bring together these island communities facing similar challenges to share knowledge and learn from each other to build capacity and ensure best practices are followed.

Another consideration about economic profiling of the islands is to identify certain sectors or areas of the economy which may lie outside of the Carbon Neutral Island Programme remit. This could include the oil and gas, fishing, or aviation industries where activities may sit outside of the geographical boundaries of the islands and be open to a wide range of emissions scope considerations. For example, from the Orkney Energy Audit that we reviewed, it states that approximately 130,000 tonnes of CO_2 were emitted in 2012 from the Flotta Oil Terminal. This emission would dwarf other emissions within the direct control of many of the islands, including that of Flotta, and thus makes it very difficult for them to achieve net zero emissions without terminating activity from the terminal. This intervention would be outside of their control.

Lastly, whilst we outline above what an 'ideal' GHG accounting exercise would look like, it is also important to be pragmatic. Some smaller island communities may not have the resources to carry out a complete and detailed GHG inventory, whilst at the same time they may not need such an inventory as they may already have a very clear understanding of the key emissions sources. GHG inventories should never been seen as an end in themselves, they are always a means to an end, and that end is to drive climate action to build a net zero, resilient world. GHG development is therefore not a one-off activity but should be repeated over time to measure progress, improve the emissions estimates, inform decision-making and drive progress.

3.4 Conclusions from Task 1

Our recommendations for Task 1 are:

1. **Applicability**

There is a need to ensure that the accounting exercises taken forward for the islands are applicable and relevant across the set of islands. Consideration needs to be given to the limited data that is available and where each island is on their "GHG accounting journey". In addition, thought needs to be given to the sectors that should be included, and how emissions are tracked, and the resources required to implement these systems. It is also important to consider how effective action can be delivered within the jurisdictional control of the local authorities. For example, tracking emissions from offshore oil and gas terminals may not be useful to the island context if it is out of scope of the Carbon Neutral Islands project.

2. **Comparability**

We have highlighted the difficulty in making direct comparisons in GHG accounting approaches across different typologies of islands. The LA CO_2 dataset is not island specific. Therefore, the methodologies developed for the islands should aim to give results that are comparable at least for the sectors chosen between islands and other local or national inventories. This could support effective progress tracking at the island level and feed into the local authority assessments and planning too.

3. Prioritisation

For accurate GHG accounting it is essential to understand the key activities on the island. Once the activities are understood, these can be mapped to the sectors where the activity from the GHG emissions will be reported. However, before beginning to compile a GHG inventory, a key consideration must be to understand the budget available. If the islands are dealing with limited resources, it is advisable to consider the most impactful actions across the wide array of sectors, thereby guiding what the GHG inventory should initially cover. It may be most useful to start with an assessment of a certain sector or sectors of importance, and use that information and knowledge built from the accounting exercise as a building block for future iterations. Key sectors could be defined by activity data such as economic output and employment figures. As we have outlined in section 2.3.4 covering best practices above, the aim should be for full sectoral coverage, however, this may be something to aim for in the future rather than from the outset. Prioritising key sectors to begin with can start to build a picture of the emissions profile and support with tracking progress of any mitigation actions being implemented within that sector.

4 Review of emission reduction projects on islands (Task 2)

Key points from Task 2:

- The projects identified exhibit a varied range of innovation and scale, delivering both developments utilising established technologies as well as a significant range of innovative demonstrator projects.
- The unique challenges associated with islands, while requiring a tailored mitigation approach, also show their suitability as leaders for the development, trial and deployment of emerging technologies suitable for adapting into decarbonisation strategies.
- Both in Scotland and across Northern Europe there are significant commonalities between the barriers being addressed and sector focuses in projects delivered. The potential for knowledge sharing and adapting successful projects to local purposes provides a resource with significant potential. However it must incorporate a place-based approach and be suited to local characteristics.
- Decarbonisation strategies can provide a means to reduce the need for infrastructure upgrades by maximising the benefits of local assets and revalorising waste outputs and by adapting existing systems to sustainable processes.

4.1 Background and rationale to the task

Task 2 identified “inspiring studies” and best practice examples from emission reduction projects developed for a selection of Scottish and non-Scottish islands. The aim was to develop a database and clear understanding of the kinds of emission reduction projects that can work well in an island context, to give ideas to island communities and stakeholders on how they can support the transition to net zero.

4.2 Methodology

The first step in this task was to identify the projects. To ensure the non-Scottish islands examined shared at least some characteristics with the Scottish islands, the geographical focus for the non-Scottish islands was Northern European. As well as an internet search, we engaged with relevant experts to ask their help to identify suitable island-based projects and refine case studies.

The selection process was to:

1. Identify and develop a “long list” database of emissions reductions projects undertaken across a range of sectors, and then
2. Develop criteria for choosing projects and create a shortlist of potential deep dive case studies.

Three projects were selected from the shortlist, and we developed these into case studies.

4.2.1 Generating a long list database

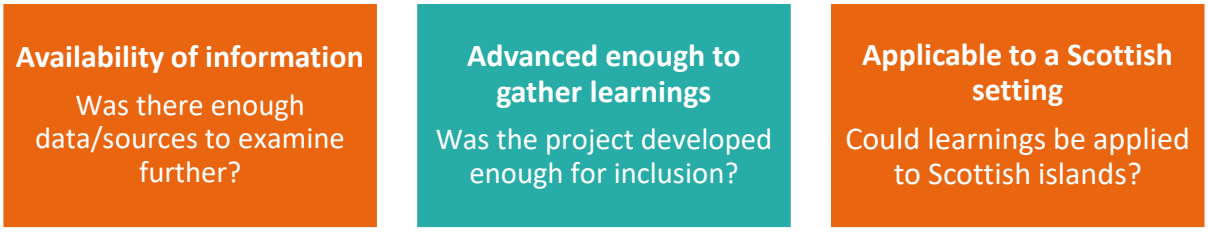
A long list database was established within a Microsoft Excel spreadsheet. Following a high-level review of the data available, this database was then populated with the type of emissions reduction activities on the islands, and a set of supporting information to help understand the activities and projects. This information included the location of the activity, how much it cost, the background to the activity, and funding mechanisms. The URL (web site reference) of any report or study was also included.

These activities were identified and collated through desk-based research, and suitable projects were located from a range of sources including:

- Review of internationally funded projects under significant schemes such as EU Horizon 2020
- Funded schemes under Scottish government e.g. Climate Challenge Funding, Community and Renewable Energy Scheme etc.
- Sector specific web searches and review of websites including government, commercial, trusts and NGOs and project specific reports and assessments.

4.2.2 Shortlisting case studies

A shortlist of projects was then produced by considering how they aligned with key merits; see figure below. From that shortlist, three projects were then selected based on their diversity in mitigation targets, sectoral coverage, and scale of project. By including these factors, we were able to consider a wide variety of case studies.



4.2.3 Deep dive case studies

Three case studies were then produced by our team. As we were preparing them, we took a “deep dive” into the project source material used to develop the studies. This allowed us to provide key background information as well as summarise the lessons the projects provided, and, set out messages about the processes used to implement and track the mitigation actions delivered by the projects.

Each case study was structured to have an objective and background followed by information about:

- How the project was implemented
- What the costs were and/or which funding models were used
- Emission reductions delivered by the mitigation scheme and any notable wider social and environmental benefits
- Barriers to implementation, and success factors.

A wide range of information was used to develop the case studies. This included data from project reports, information on websites consulted following recommendations made by stakeholders, and government sources on specific projects. Some of the most valuable insights were provided by stakeholders involved in the delivery or oversight of the mitigation projects. We have acknowledged the stakeholders and organisations who have contributed to this work in Appendix 1 below.

4.3 Observations

4.3.1 Summary of the mitigation projects implemented on islands

The database produced alongside this report groups projects into the sectors that they cover. One observation that we were keen to draw from the database was the sectoral 'spread' of projects and whether certain sectors were more or less covered.

The data in the two figures below show that the most common mitigation project types were those related to energy, with energy storage, low-carbon heat and renewables comprising around 50% of identified energy sector projects. Transport-related projects were also well-represented, particularly marine and automotive, as these are widely applicable across all islands. The least common areas included industrial and agricultural projects which could be due to the unfavourable geographical and market conditions of islands for businesses operating in these sectors. This will be especially true for the more remote islands.

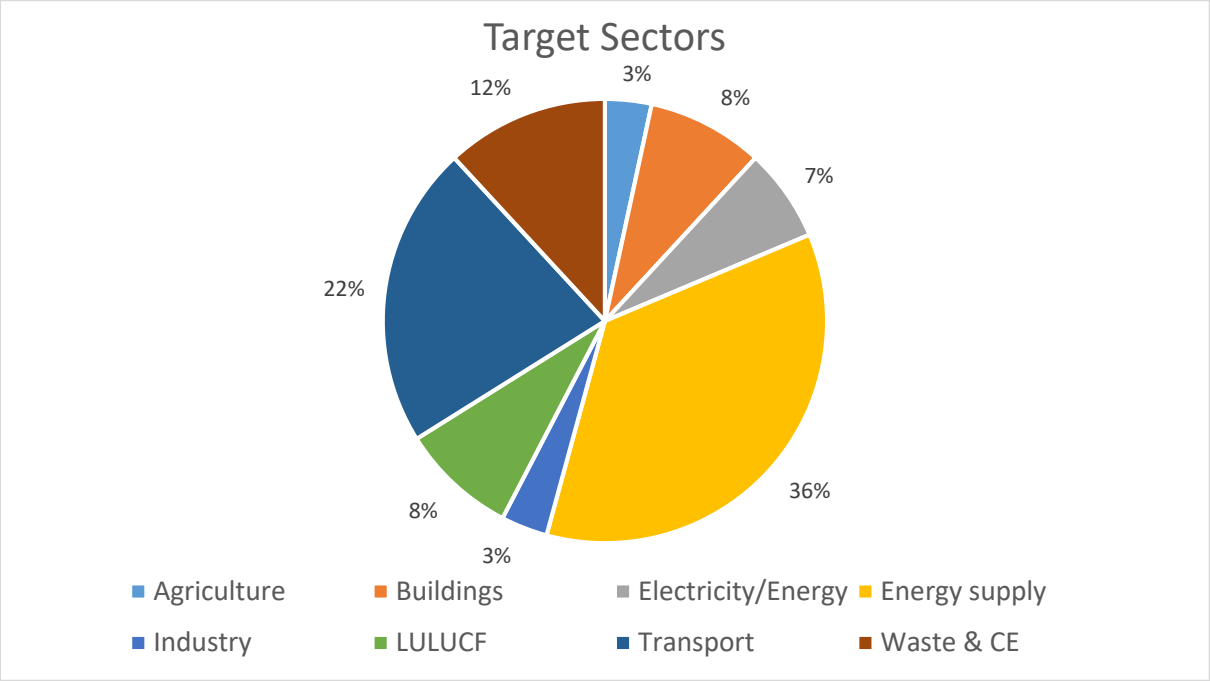


Figure 7: Target sectors of the mitigation projects implemented in islands

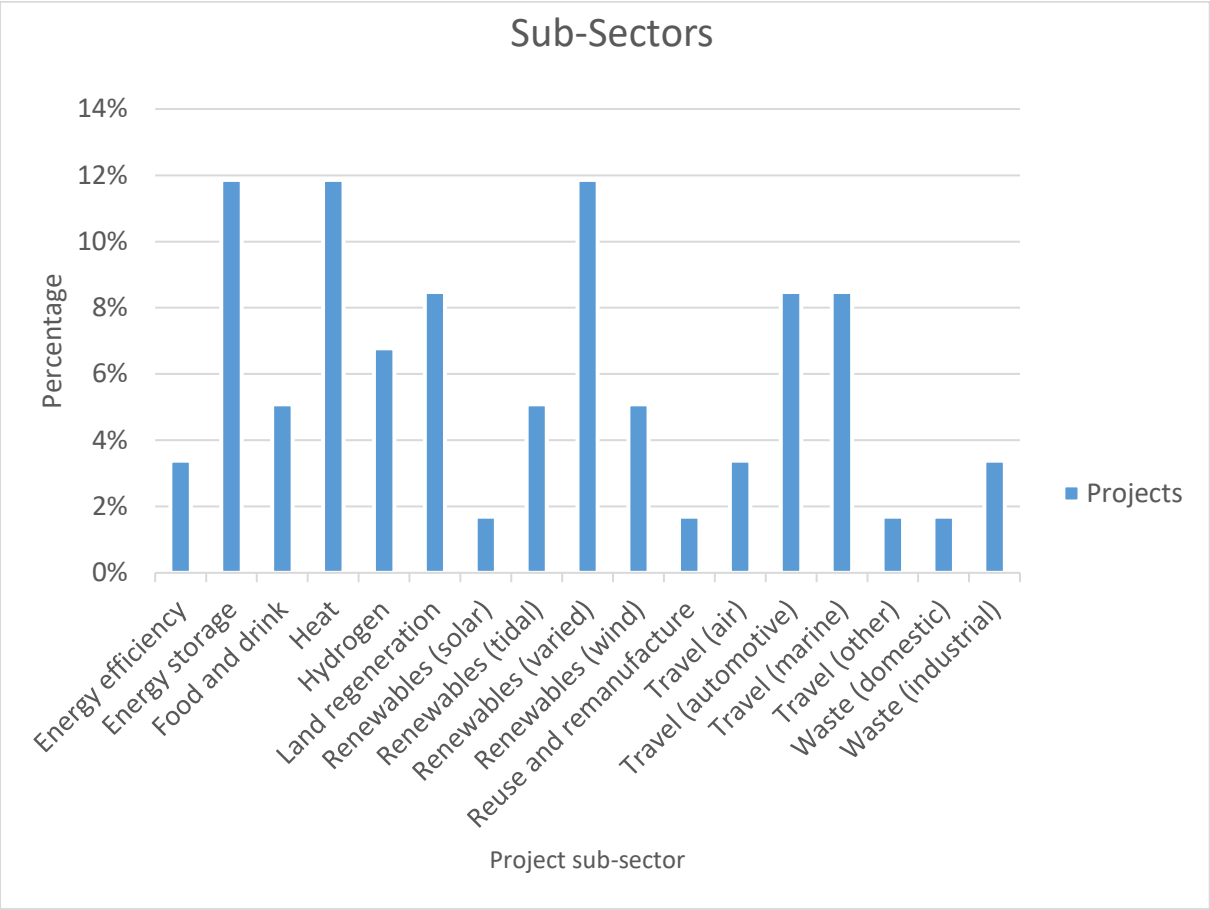


Figure 8: Detail of the target sectors of the mitigation projects implemented on islands.

4.3.2 Key observations on project sectors

This short section of the report, immediately below, summarises our key observations from the assessment of the mitigation projects.

We have assessed the projects to consider what kind of mitigation actions are common in different sectors, and also whether similar projects could be implemented in part, or in full, on other Scottish islands. On the latter point, our assessment indicates that the site-specific nature and challenges of island-based projects make it quite difficult to judge the replicability of a specific project across a wider range of Scottish island settings. For example, island-specific factors that need to be considered when choosing and implementing mitigation projects include electricity distribution grid infrastructure, population size and density, renewable generation potential, local waste streams, industry types and local policy drivers. Nonetheless we can still draw some important conclusions from the approach.

It is worth noting that, in some cases, specific elements from a project may be replicable elsewhere, even if the whole project is not. For example, we could consider an energy-based project which uses storage systems or energy management systems (EMS) as part of the project, alongside wind generation. On islands where 'renewable assets' are constrained, the elements of this example that could be replicated would be the energy storage and EMS components.

We now look in more detail at the mitigation projects for each sector.

Buildings

Most of the projects aimed at reducing emissions from buildings focus on controlling heat balance in buildings. In other words, the projects are designed to improve standards of insulation in buildings and reduce the energy input needed to heat them. More innovative cross sectoral projects were also identified, tying in with circular economy elements (heat from waste) or energy supply projects (heat electrification and maximising renewable penetration, energy management systems), as well as local energy efficiency drives.

Circular Economy & Waste

Circular economy projects support a circular approach to the economy by encouraging reuse of materials, as inputs into other processes and minimising disposal of materials.

Most of the large-scale circular mitigation projects identified were targeted at the industrial sector with a focus generally on reuse of local biological waste (e.g., agricultural waste / wastewater etc). However, a number of projects led at the community level by organisations such as local trusts were also identified in which hubs for specific issues, e.g. food waste or local wood waste re-use, were established. This demonstrated a range in both the scale and diversity in stakeholders involved in the delivery of circular economy projects identified on islands.

Energy

By far the largest proportion of mitigation case studies identified was in the energy sector. The Scottish islands face energy supply and energy security problems, and so we would expect the energy sector to be well represented in the projects. Overcoming these barriers shows islands often adopting innovative approaches, utilising less established renewable generation technologies such as tidal and storage – and this means there are some innovative mitigation ideas represented. In recent years there have been substantial mitigation-related technological developments in the energy sector. These include the maturation of the potential role of “green hydrogen”. The islands also need to consider how they will meet future demand for electricity supplying the electrification of heat and transport.

The highest levels of capital funding identified in our sectoral review were for energy-related projects. The EU and national governments provide significant funding for projects including for a significant number of “demonstrator” projects, which range from technically complex and innovative tidal, energy storage and hydrogen projects, to more established technologies such as wind power generation. The range of scale in energy project sizes was also diverse, with site specific, low generation capacity developments identified along with much larger developments (over a GW capacity) also present such as the Viking Wind Farm on Shetland or Bornholm’s planned offshore wind island.

The combination of high renewable generation potential coupled with limits on capacity to export to the mainland grid frequently encountered by island communities is also addressed in a range of identified projects and with a variety of approaches. With local heat electrification, a variety of storage methods and smart energy management systems are common as a means to maximise the potential of island-based generation assets along with the associated revenue from the additional electricity.

Transport

The transport sector in islands includes several modes of transport – aviation, marine, and road. We look at these in turn.

Aviation

While an island-specific aviation decarbonisation project was identified, very limited information was available from the project sources identified and it is noted as still being within the inception phase. Other than this there was little activity on decarbonising islands' aviation travel. However, whilst not reflected in the projects we reviewed, we are aware of the wider drive for decarbonisation of aviation fuels in non-island settings and much of this will be applicable to islands. Relevant bodies, such as academic institutions, and commercial trials currently engaged in this area should be considered for engagement and for further specialist information sources.

Marine

The GHG accounting review in Task 2 revealed that marine sector emissions, for Scottish islands, are a very important component of total GHG emissions. This means implementing mitigation actions which result in the decarbonisation of the marine transport sector will have a large impact on total GHG emissions.

Marine sector projects identified on islands to date are largely at either the demonstrator stage or at lower levels of technological readiness and focused primarily on passenger transport as opposed to shipping of goods. Our review indicates that marine transport electrification projects appear at the most advanced stage of deployment or at higher technological readiness levels. However, range is currently a critical barrier to the widespread adoption of electric marine transport. Currently, the existing technology cannot deliver the necessary energy to propel shipping over larger distances.

Automotive

In the automotive sector, we identified a range of relatively simple, lower innovation or "low regret" projects. Provided the electricity supply infrastructure and available power is adequate, these projects could be relatively cheap to implement. Some projects we identified are aimed at encouraging the uptake of private electric vehicles as well as supporting the roll out of the necessary supporting infrastructure. This infrastructure would need to include public and private charging points. Additionally, the promotion of e-bikes was also noted as a mechanism to displace car usage.

As well as projects decarbonising private mobility, there were also example of projects looking to decarbonise public transport, for example electrification of buses.

Land Use, Land Use Change and Forestry

The LULUCF sector covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities. The LULUCF sector on Scottish islands, contains large stocks of impermanent stored carbon, vulnerable to release from future approaches to land use and management changes. The sector is split into the following categories: Forest Land, Cropland, Grassland, Wetlands (including peatlands), and Settlements.

Box 2. Tackling emissions from the LULUCF sector

The LULUCF sector represents the movement of CO_2 between the atmosphere and different natural 'reservoirs' such as forests, soil, etc. Some human-induced effects, such as tilling the soil, result in CO_2 being emitted to the atmosphere, while others, such as planting trees, result in CO_2 being absorbed from the atmosphere. For many Scottish islands, a particularly significant carbon reservoir is peat soils[ii]. These can store huge quantities of carbon. But when the peat soil is drained and dried out, for example to use as agricultural land, the soil releases carbon in the form of CO2 and can continue to do so for many years, even decades, after the drainage took place. Hence, we can see very significant levels of CO_2 emissions from grasslands and croplands in some Scottish islands, because of drained peat soils continuing to emit carbon. Tackling these sources will need to be a key element of these islands' net zero strategies and plans. Even if not included within net zero policy, the LULUCF sector remains significant in its own right with regards to ecosystem service provision and environmental integrity. Options could include restoration of peat soils to their original state, through re-wetting, to ensure carbon remains locked in to the soils. But scope for this might be limited, especially if islands wish to be less reliant on food imported from the Scottish mainland. In addition, scope for tree planting to absorb more carbon might also be limited due to the nature of the terrain and soils.

However, as noted by the UNFCCC[iii], a particular drawback of LULUCF mitigation activities is their potential reversibility and non-permanence of carbon stocks as a result of human activities, natural disturbances or a combination of the two with loss of carbon stocks and release of GHGs into the atmosphere as a result.

Of the five mitigation projects identified addressing emissions from land use and land use change, only two were focused on peatland conservation and regeneration with the other three supporting reforestation activities.

Community organisations are delivering many of the LULUCF sector mitigation projects. It is therefore important to consult with these organisations to learn from their experiences, and to help shape the planning and delivery of future successful mitigation projects.

Collaboration between islands in areas such as providing plantings from tree nurseries to neighbouring isles was also noted. Developing potential projects impacting across multiple islands may provide an avenue for maximising positive impacts and available resources.

4.3.3 Case Studies

The three case studies selected for more detailed analysis were selected upon the key criteria of the scale of the project and the potential carbon emissions reductions achievable, with variation sought between them in these regards. Location was also a factor with a Scottish based example to be selected as well as two international examples from a Northern European setting. In addition, it was determined that one of the three (Bornholm - see below) would focus upon an island-wide decarbonisation strategy rather than an individual project, to provide a different perspective. The list of information for inclusion in case studies can be seen in Appendix 1 below

The projects selected are listed below.

	Project type and learnings
Bright Green Island	The Bornholm Bright Green Island strategy is a strong example of an island taking a long-term ambitious decarbonisation strategy and delivering significant progress in decarbonising their energy infrastructure while also evolving and adapting it as is required for future challenges such as transport decarbonisation.
FÖRKA	The FÖRKA biogas plant operating on the Faroe Islands demonstrates strong commercial and public collaboration in the development and embedding of circular principles in the islands energy systems and agricultural sector. Through the re-valorisation of agricultural and local industry waste as valuable bio-resources, the project demonstrates strong cross sectoral collaboration to support the island reduce its emissions.
Heat Smart Orkney	Addressing fuel poverty issues as well as encouraging the increased utilisation of existing energy infrastructure, Heat Smart Orkney sought to maximise the use of locally generated energy that was otherwise wasted through grid constraint by the electrification of residential heat use and smart monitoring and management systems.

4.4 Conclusions from Task 2

The main conclusions we draw from the assessment of mitigation projects in Task 2 are as follows:

- There is a significant diversity in scale of mitigation projects at the island-level, ranging from small community-level projects, up to large-scale infrastructure projects. One is not more important than the other – action at all levels will be required to meet net zero.
- There is currently inconsistency in which sectors are being targeted with mitigation projects. Most projects we found were in the energy sector, including renewable electricity generation, heat decarbonisation, energy efficiency and transport. There were far fewer projects in other sectors.
- Building on this, in some cases there is clearly a mismatch between the sectors that are covered and those that are key to achieving net zero. For example, the land use sector is a large source of emissions in some islands and yet relatively few projects target it. This shows the importance of taking the GHG inventory as the starting point for climate action. Figure 12 in Appendix 1 shows the emissions sources from Shetland with LULCF the highest single emissions source despite all five projects identified, bespoke to Shetland focused on Energy supply (60%) and Buildings- Heat (40%).
- Policy context is crucial to the successful implementation of mitigation projects. A supportive policy environment at the national level is needed, to facilitate climate action at the island level. But it is also important to have strong and coherent net zero strategies adapted for action at the island level, especially for larger islands.
- Funding often comes from a range of sources. A large number of projects that were assessed had more than one source of funding, and some had as many as four. This suggests it is necessary to be creative and flexible when considering possible funding.

- A range of barriers to successful implementation of projects were noted during the case study development, including ensuring initial community engagement is robust and inclusive, be it to de-escalate concerns regarding risk or drive uptake of a strategy. The access to expert specialist advice is also a necessity when developing innovative or technologically complex projects, and when done early in the development can aid in mitigating future barriers.
- It is important that mitigation solutions for Scottish islands are tailored and that generic solutions are not simply applied without thinking about how they can be adapted to the island context. Some sectors are particularly important in an island context, such as aquaculture and fisheries for example. Embedding cross sector circularity can help amplify the benefits of decarbonisation strategies where waste outputs of one sector, provide greener energy or raw materials for another.
- The case studies demonstrated the importance of meaningful local engagement. Doing this obviously helps with local buy-in for the projects, something that arguably is more important than usual because of the strong community identities on many of the islands. But our research has also shown the benefits of taking a place-based approach and building projects around island communities' specific concerns and priorities. For example, in Bornholm in Denmark the strong community reliance on tourism led the projects to focus more on offshore wind and away from onshore, in case of it affecting the landscape. Similarly, in the FÖRKA project in the Faroe Islands, local concern around waste from the fisheries sector led to the project using that waste as an energy input.
- If done well, mitigation projects at the island level can offer a range of co-benefits. In the projects we assessed these included cost savings to inhabitants and reducing fuel poverty, increases in revenue streams from local assets and industry, employment opportunities as well as the displacement of imports with local products or outputs.
- The database of identified emissions reduction projects is intended to act as a live document, as additional projects are completed or identified they may be added to provided a central resource for knowledge sharing.

5 Review of existing UK and Scottish Government climate change related funding (Task 3)

Key points from Task 3

- Climate interventions required for a net zero society can only be realised with the right allocation of climate finance. Therefore, it is crucial that financial investments are made readily available.
- Financial support within the Scottish Island context needs to connect community-level issues in rural islands with the planning agendas of local authorities and central government. Scottish islands' atypical characteristics are often not fully appreciated and considered.
- It is clear that a one size fits all approach for climate finance is not appropriate in the Scottish Island context due to their unique characteristics such as main emission sources and population size. Placed-based financial schemes need to reflect these unique island characteristics to ensure the right financial aid addresses different mitigation priorities.
- 88% of funding sources identified are derived from the public sector versus only 9% from the private sector and the remining 3% is derived from the third sector. The largest share of funding streams identified is catered to schemes which provide funding for multiple sectors. The second-largest share is energy and land use funding opportunities.
- Two examples where island community climate challenges are arguably not being addressed sufficiently in current financial initiatives is support for off-grid communities and peatland restoration.
- Small islands can house cohesive communities, which support effective working towards shared climate goals. Thus, community funding can be used as a building block for implementing mitigation measures and increasing community-level adaptive capacity.

5.1 Background and rationale to the task

Climate finance refers to any type of financing with the purpose of mitigating and/or adapting to climate change. Climate finance can come from a variety of sources including public, private and alternative sources of financing such as philanthropic, and it can flow at different scales from local to national and transnational.

Climate finance can be in the form of either public sector funding or private sector sources (i.e. banks/investors). In order to mobilise financial funds, different types of instruments/mechanisms can be used to deploy funds depending on certain conditions such as the type of activity or implementing agency. Box 4 provides some examples of financial instruments.

Box 4: Financial Instrument Definitions

- **Grants/subsidies, Tax rebates and exemptions:** Grants are sums that usually do not have to be repaid but are to be used for defined purposes. Subsidies, on the other hand, refer to direct contributions, tax breaks and other special assistance that governments provide to offset costs over a period of time.
- **Debt financing/loans**: Debt financing can be in the form of instalment loans, revolving loans, and cash flow loans.
    - Instalments loans have set repayment terms and monthly payments.
    - Revolving loans is a form of credit issued by a financial institution that provides the borrower with the ability to draw down or withdraw, repay, and withdraw again. A revolving loan is considered a flexible financing tool due to its repayment and re-borrowing accommodations.
    - A cash flow loan is a type of debt financing, in which a bank lends funds, generally for working capital, using the expected cash flows that a borrowing company generates as collateral for the loan.

- **Equity finance** : Equity financing is the process of raising capital through the sale of shares. The repayment terms are not set but depend on the performance of the scheme (this is what differentiates equity finance from loans/debt financing).

In order to transition to a net-zero future on Scottish islands, financial support is vital to ensure the transition is achievable by 2045 and is just and fair, as outlined in the National Islands Plan[iv]. Climate finance is not only a critical success enabler to implementing carbon reduction measures on Scottish islands but is also a protective mechanism to ensure vulnerable rural communities are not marginalised by the worsening effects of climate change. Climate interventions required for a net zero society can only be realised with the right allocation of climate finance. Therefore, it is crucial that financial investments are made readily available.

Financial support within the Scottish Island context needs to connect community-level issues in rural islands with the planning agendas of local authorities and central government. Scottish islands' atypical characteristics are often not fully appreciated or understood by decision-makers at Scottish and UK scales.[v]

It is clear that a one size fits all approach for climate finance is not appropriate in the Scottish Island context due to their atypical characteristics such as main emission sources and population size. Placed-based financial schemes need to reflect these unique island characteristics to ensure the right financial aid addresses different mitigation priorities.

The aim of Task 3 is to develop a directory that encompasses a wide range of funding sources that could potentially be used to fund emission reduction activities in Scottish Islands. This could be climate change or energy project-specific funding, but could also cover economic development funds, transport investment funding, conservation funding related to land use, innovation and research funds and philanthropic and community funding.

5.2 Methodology

In order to identify potential funding sources, a desk-based review of available funding sources was carried out. The key criterion for the inclusion of different funding sources was whether the funds can be used by Scottish island communities, covering both public, private and third sector organisations for emissions reduction activities across different sectors.

The output of this task is an MS Excel spreadsheet that captures an assortment of funding sources that island communities could draw on to support the implementation of emission reduction measures. A summary table of the key fields and the information recorded in Task 3 funding directory can be found in the Appendix 2.

5.3 Observations

As highlighted in the methodology, a directory has been developed, encompassing a wide range of funding sources that could fund emission reduction activities in Scottish Islands. In total, 68 funding opportunities have been reviewed, of which 68% (46 opportunities) are open/live funding opportunities, 29% (20 opportunities) are closed funding opportunities and a further 3% (2 opportunities are future funds, yet to be established.

Figure 8 below shows the split between public vs private sector funding sources. As illustrated, 88% of funding sources identified are derived from the public sector versus only 9% from the private sector and the remaining 3% is derived from the third sector.

A new funding approach which combines both public and private sector funding may be opted for more in the short-term. The co-funding approach requests additional private sector financial investment as a condition to access the opportunity with the purpose of crowding in more private sector finance. One way in which public sector actors can do this is by providing de-risking facilities to make investment opportunities more attractive to private sector players.

Secondly, the majority of climate finance is derived from EU, UK government, national and regional governments. This is typical for climate finance, where most financial flows are obtained from national governments through climate policy formation and implementation. This also reflects key findings in Task 2. As mentioned in section 3.3.2, EU and national funding currently provide significant funding for “demonstrator” projects. These range from technically complex and innovative tidal, energy storage and hydrogen projects along with more established technologies such as wind power generation.

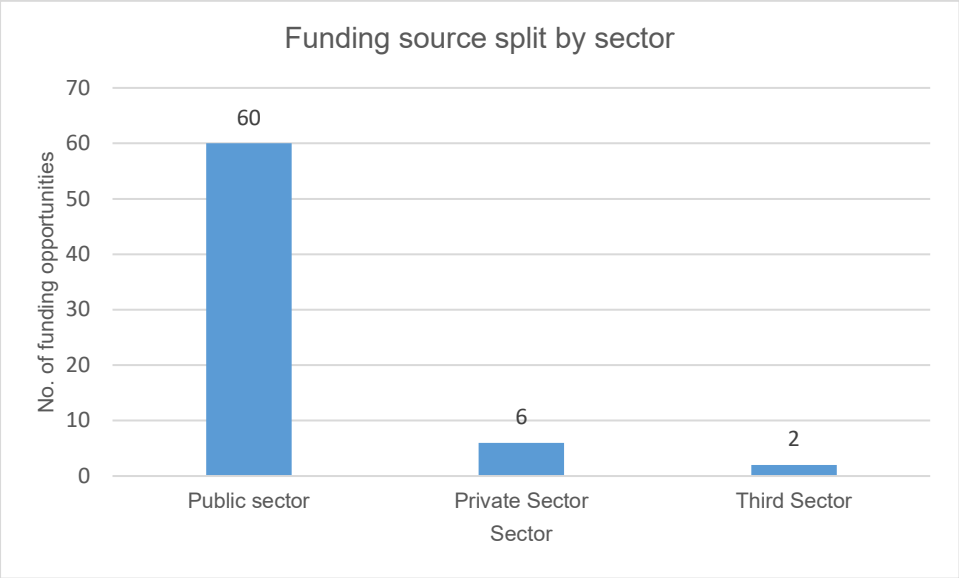


Figure 9: Split of funding opportunities by funding source

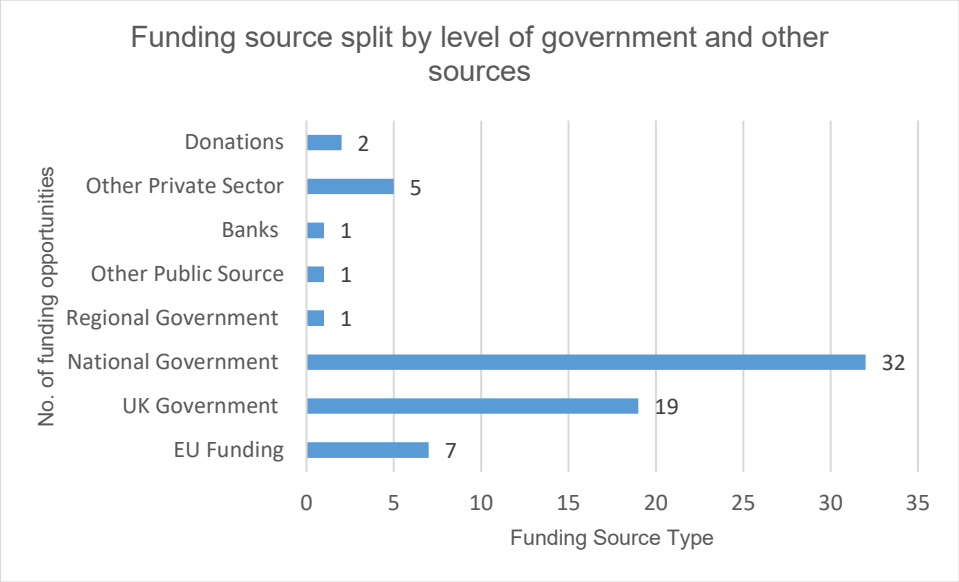


Figure 10: Split of funding opportunities by source type.

Figure 11 maps out the funding split by target sector, i.e., what sector the funding caters to in a net-zero context. This includes:

- Housing – funding for low carbon new builds or retrofitting older builds i.e. increasing the energy efficiency and air tightness.
- Heating – funding for low carbon technology to heat buildings
- Transport – funding to promote active travel, encourage micro-mobility such as walking, cycling and the uptake of electric vehicles (EVs)
- Energy – funding for community renewable projects such as solar PV.
- Waste – funding for improved waste management and sorting facilitates to reduce and avoid waste going to landfill as well as promoting a circular economy.
- Land use – funding to restore land (peatland restoration) or increasing land management (forestry)

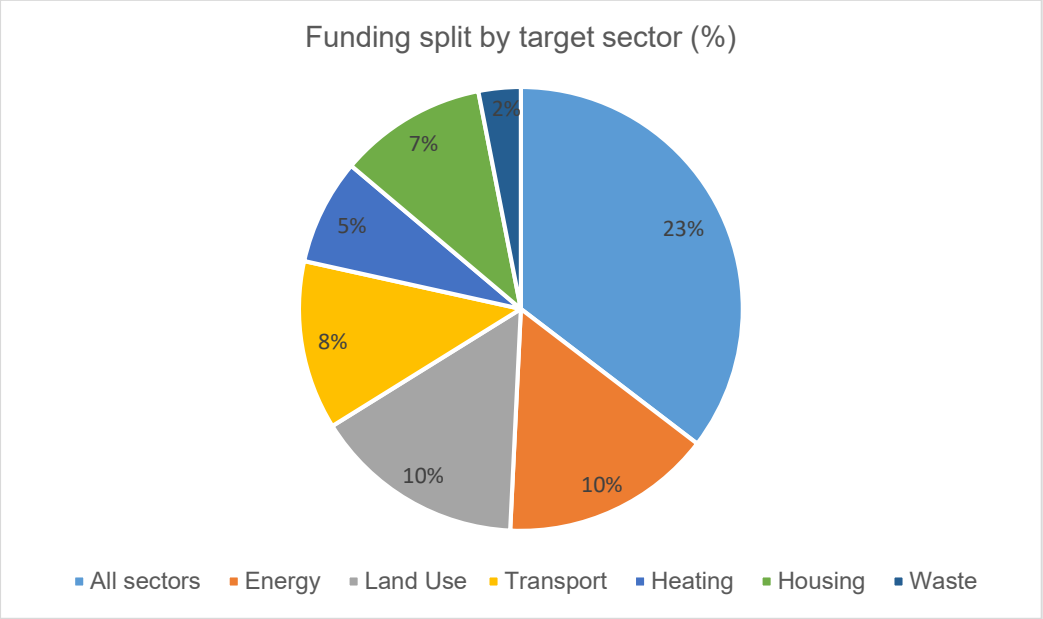


Figure 11: Funding opportunities split by target sector

Box 5: Horizon Europe Funding

Horizon 2020 is a large European funding programme for research and innovation. The United Kingdom officially left the EU in January 2020, but it will continue to participate in Horizon 2020 until all projects are completed. It was announced that UK applicants will be able to apply for funding under the next EU research programme, Horizon Europe - which is worth €85 billion and came into place in January 2021. The EU is still in the process of formalising the UK's association. But UK-based applicants can still apply and access Horizon Europe funding. This is positive news as applicants based in the UK can participate in the same way as those in the EU. There are currently 16 non-EU associated countries, which pay a mandatory contribution to the bloc's research programme in exchange for access to grants.

The largest number of funding opportunities are from schemes which provide funding for multiple sectors. One funding scheme that has been widely used is the climate challenge fund (CCF), which has distributed over £50 million in grants to community-led, carbon-saving projects across the country, focusing on the Scottish Islands.[vi]

The second largest number of funding schemes are for the energy and land use sectors. For energy this is not surprising as it is a major emissions source. This could also partly reflect the finding from Task 2 where a majority of mitigation projects at the island level are within the energy sector. Energy opportunities include a wide range of funding sources such as EU horizon funding which funds large demonstrator projects which showcase innovative low carbon technology such as tidal power and hydrogen projects. To supplement EU funding, Local Energy Scotland (i.e., CARES funding) supports community buildings and community assets to connect to district heating schemes that are powered fully or partially by a renewable source of energy.

Land use opportunities include three different funding schemes under the Woodland Trust that cater to rural communities. For example, the Crofting MOREwoods programme supports crofters, common grazing committees, and smallholders within crofting counties on improved methods and woodland planting. Additionally, the Big Lottery Community Fund supports urban and rural communities to become more resilient and sustainable through the ownership and management of land and land assets. An example of a bottom-up community initiative is Shetland Amenity Trust's Grant Aid designed to provide assistance for heritage related projects.

Transport funding schemes have the third highest number in the directory. The majority of these programmes are derived from national funding, which focuses on encouraging the adoption of electric vehicles and charge points via the Energy Saving Trust. This also includes the Low Carbon Travel and Transport Challenge Fund to facilitate active travel and low carbon transport hubs. £2.48 million of European Regional Development Fund (ERDF) funds are specifically available for projects from the Highlands and Islands.

Housing funding is next, with the majority of funds sourced from national schemes, including the Rural and Island Housing Fund, a £1 million initiative that aims to deploy low carbon heat solutions for buildings.

Heating and waste funding schemes hold the lowest number of funding opportunities. This is a concern, partly due to the high share of emissions from buildings but also because, the cost of energy being increasingly high, vulnerable groups on Scottish islands are already battling with fuel poverty. It has been revealed by Energy Action Scotland that 40% of people living in the Western Isles live in fuel poverty compared to just 13% in East Renfrewshire. The Scottish average was 24% of all households[vii]. From this desk-based review, there appears to be a lack of fuel poverty financial support catered at the community level.

4.3.1 Applicability to Scottish Islands to achieve net-zero

Gaps observed

Key observations can be made from our research on the current financial landscape in Scotland and whether current funding schemes are catered to Scottish Islands in achieving net-zero.

Figure 8 shows that majority of funding opportunities originate from the public sector. One key observation is that these funding programmes often do not fully address the unique challenges island communities face in transitioning to a net-zero future. There may be a disconnect between community-level issues in rural islands and the planning agendas of local authorities and central government. An example of misalignment between national/regional funding support and island needs is financial support for off-grid communities. This is a real issue for these rural communities as there is a reliance on fossil fuel sources to generate electricity, such as diesel generators which are carbon-intensive and pose significant environmental threats to these communities such as large amounts of emissions derive from the use of the generator and through importing diesel to these communities.

One public funding programme which is leading the way in providing funding is the Scottish Government's Community and Renewable Energy Scheme (CARES) which offers a range of financial support to local energy projects in communities. For, example, the Let's Do Net Zero: Off Electricity Grid Communities Fund aims to decarbonise and future-proof the existing local independent electrical grids of those communities that are not connected to the national electricity grid. However, from our research there is a need to allocate more funding to sustain the momentum with Scottish Islands as it suggested on the CARES website this phase 1 (expression of interest) under the Let's Do Net Zero: Off Electricity Grid Communities Fund ended in January 2022.

A secondary area where there is a mismatch in financial support for Scottish Islands is initiatives that directly address the issue of peatland restoration. Peatlands cover more than 20% of Scotland's land area.[viii] Degradation and overexploitation of peatland landscapes release vast quantities of greenhouse gases. Thus, peatland protection and restoration are vital in transitioning to a zero-carbon society for those islands where it is a major emissions source. For example, public and private finance must be mobilised to secure peatlands, provide green jobs and to enable a just transition for those in the communities that currently rely on land that has been converted from peatland.

Opportunities

Small islands tend to house cohesive communities, which support effective working towards shared climate goals. Thus, community funding can be used as a building block for implementing mitigation measures and increasing community-level adaptive capacity. Examples of current funding initiatives that provide this support are Local Energy Scotland CARES funding as mentioned above, which supports community buildings and community assets to connect to district heating schemes powered entirely or partially by a renewable source of energy. In addition, the Climate Challenge Fund supported community-led organisations in Scotland to tackle climate change by running projects that reduce local carbon emissions (to note this fund has now ended). Previously funded projects have helped communities to reduce their reliance on car travel, cut waste, grow local food and lower energy use in homes and community buildings.

5.4 Conclusions from Task 3

To conclude, the directory provides a list of potential funding sources that island communities can draw on to support the implementation of emission reduction measures. The directory draws on various funding sources, bodies and schemes from a wide range of sources.

The key findings from our research via the directory illustrate that Scottish islands have access to a wide range of funding opportunities for the effective deployment of climate interventions in multiple sectors. However, a one-size-fits-all approach that is not specifically catered to the island settings can possibly lead to a disconnect between local priorities and community-scale issues on the one hand and national agendas on the other. Thus, a possibly way to avoid misalignment in funding needs is for rural community perspectives to be considered and to feed into the national processes. Doing so will highlight any misalignment between available funding and the needs and priorities of Scottish island communities now and in the future, as outlined in the previous section.

The directory is aimed to act as a live document which can be added to and updated as new funding schemes and programmes are introduced and as new funding rounds and windows become live.

6 Conclusion

Our work has aimed to gather insight into best practice examples of GHG accounting exercises, emission reduction projects, and climate finance to build a picture of the successes and gaps within the Scottish island context, as well as drawing from international examples too. The findings and recommendations across the three tasks have incorporated the diversity of Scottish islands. This diversity spans various factors, including population size, economy, and geography. It underlines the importance of flexibility to ensure that the work undertaken as part of the Climate Neutral Island programme offers inclusive support to all islands, and their communities, within Scotland.

The importance of ensuring that these three focus areas are tailored to the islands' needs and priorities underpins our recommendations in this report. We have also outlined areas of comparison and replicability that can support the CNI programme to mainstream climate action across the islands. In Task 1 we suggested a comparative GHG accounting framework is developed but acknowledge that emissions profiles across the islands vary dramatically. Therefore, we have provided several best practice examples to follow to ensure that island communities have the right tools to develop appropriate GHG inventories for their specific circumstances. For Task 2 we have identified a number of successful emission reduction projects across island communities that can be replicated within Scottish islands. Here we have also emphasised the need for an adaptable approach to be taken ensuring that the communities are positively impacted by what's being implemented. Finally, our recommendations in Task 3 state that a one-size-fits-all approach will not work at the island level regarding funding opportunities, underlining the need for community engagement, tailored to the island context. This can ensure that the island priorities are met, bridging a possible disconnect between the national and island level.

This research will feed into the Carbon Neutral Islands programme and enable the Scottish Government, its partners, and the island communities to take forward these recommendations through a framework that can support all islands on their journey to net zero.

7 Appendices

7.1 Appendix 1 – Task 2 and case studies

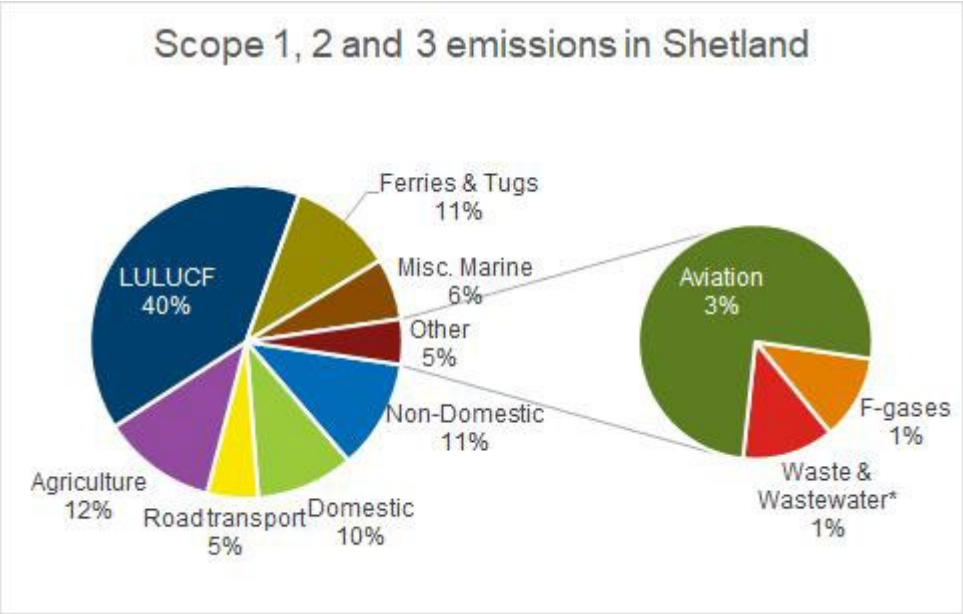


Figure 12- Breakdown of emission sources on Shetland

7.1.1 Background

Information gathered for case studies:

Information gathered	Details
Project Description	Including the sector, barrier tackled and outcomes.
Stakeholders and Implementation	Identifying key project stakeholders as well as roll in implementation.
Cost & Funding model	Details on the methods of financing, funding accessed and capital costs should be identified.
Impacts	Reference the anticipated/achieved emissions reductions of the case studies as well as any additional benefits identified (e.g. community benefits, economic etc.)
Success factors & Barriers	Lessons learnt in the delivery of the project, key success factors and any barriers encountered.

Contacts who provided input to case study development:

Organisation	Case study supported
Department for Development, Bornholm Municipality	Bright Green Island - Bornholm
Director of public affairs of Bornholm Energi and Forsyning (Energy and Utilities)	Bright Green Island - Bornholm
Head of Energy Department, Faroe Islands Environment Agency	Förka - Faroe Islands

7.1.2 Case study 1 – Bornholm (Bright Green Island)

In 2008 a group of residents of the Danish Baltic island of Bornholm consisting of political leaders, community groups, businesses, charities and interested residents formulated the Bright Green Island strategy. At the time it was a conceptual ethos, adopted by the island leadership, however it has now become a strategy and brand that the island has made significant efforts to implement across a range of sectors. Information below is based on interviews with staff at the Bornholm publicly owned energy and utility company (BEOF) and the island municipality, who helped to explain the journey undertaken.

Since 2008 there has been a significant reduction in the emissions from Bornholm's energy sector through the implementation of a range of renewable generation in the form of wind, solar and CHP systems to displace imports of grid electricity. The decarbonisation of the islands heating infrastructure primarily saw the replacement of imported coal and oil systems with biomass district heating and implementing a drive for heat pumps to be installed where appropriate. By 2020 the island had reduced its energy sector emissions by more than 82% on 2010 levels, equivalent to a reduction of over 168,000 tCO2 a year.

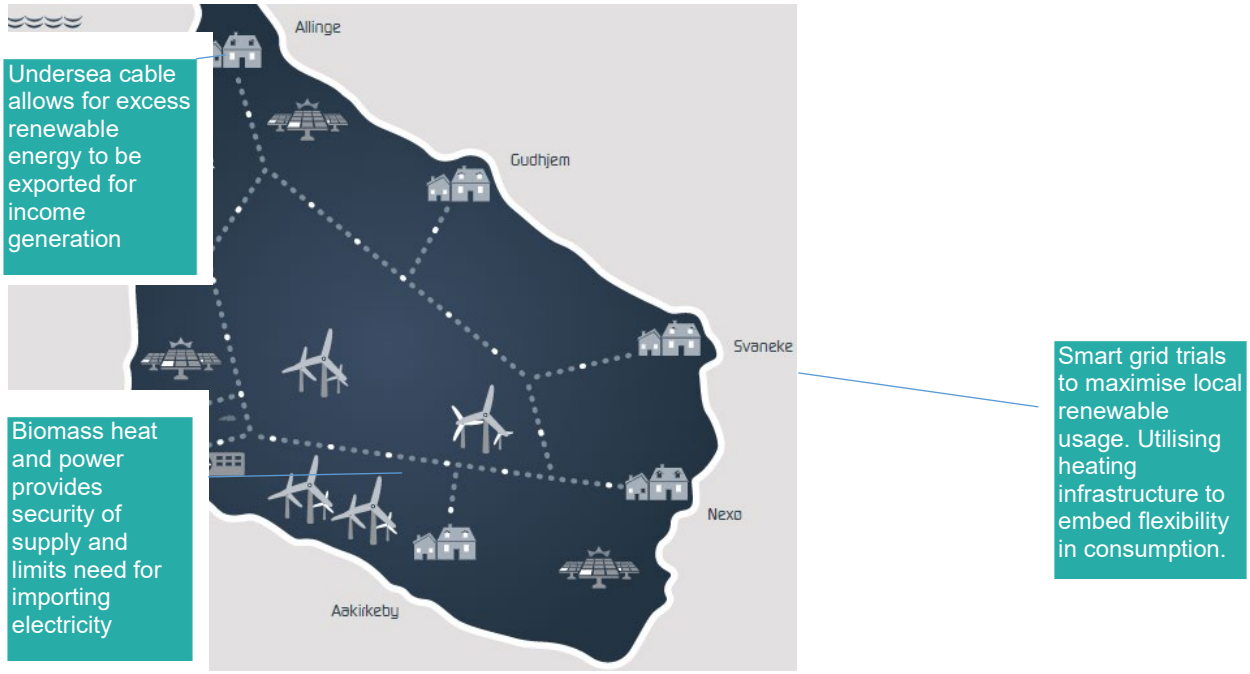


Figure 3: Bornholm Island with associated renewable infrastructure[ix]

Having become a leader in the deployment of innovative technologies, the island has advanced the strategy to develop beyond energy and to increase inclusion of the island's residents in implementing the emissions reduction strategy . There is also a continuing focus on the decarbonisation of the island's transport infrastructure.

The journey

The implementation was initially strategically driven by the municipality and the island's energy supplier, BEOF. The public ownership structure of BEOF helped ensure the key tenets of 'Green, Robust and Affordable' were at the heart d of the process. The strategy required determining how to redesign the island's energy systems at scale to move away from oil, coal and diesel while also ensuring the socio-economic considerations of the transition to protect residents from significant cost increases. Funding for the energy transition came from a combination of sources including national government and the municipality for measures such as energy efficiency upgrades and advice. European funding such as Horizon 2020[x] and the EU ecogrid[xi] project grants were also present as well as financing via 25 year loans paid back by consumers through tariffs. This coincided with increases on tax on coal as tariffs were reduced on biomass to promote uptake. At the residential level funding was provided to improve the island's buildings energy efficiency as well as making expert advice freely available to residents. This was coupled with a 'place-based approach' that sought to ensure the strategy played to the island's strengths. Over 80% of coal utilised on Bornholm was imported from Poland, now over 70% of the biomass that replaced it is locally sourced and is often agricultural waste. Embedding circular principles into the energy system like this was identified as a method to recirculate the funds back into Bornholm and promote local job growth and opportunities.

Table 3: Ten years of progress, key energy emissions figures for Bornholm[1]

	2010	2020
Tons CO_2 per resident	12	8
% of total emissions from energy sector	40%	11%
Tons of CO_2 emitted per annum by energy sector	204,416	36,352
% of heating derived from oil consumption	25%	5.9%

Ensuring the strategy stayed alive and fit for purpose has been a central aim on Bornholm. A revitalisation of the strategy in 2017 saw it align itself with the UN Sustainable Development Goals and develop a set of 8 goals specific to the island to drive the vision further and increase the applicability to residents. In addition, a recalibration was undertaken to promote increased civil society engagement. This was done through bespoke workshops and ongoing discussions. This drove the formation of working groups across a range of topics to help drive progress in specific areas including transport, energy and now between waste management operators and educational institutes, so children across varying educational levels are taught of waste as a resource and Bornholm's net zero ambitions.

The future

Recently the municipality had begun to integrate the strategy more firmly in policy with the 2040 Energy Strategy released in 2021 being the most significant of these[xii]. Considering the island's economic strength as a tourism destination, but with limited development space and landscape considerations, the island will see significant exploration of offshore wind. In 2021 the government approved a 2GW[xiii] offshore wind farm with potential to expand up to 3GW. Providing income and employment, the development will also aid the more recent priority of decarbonising transport. The green energy provided will increase the robustness of the local energy supply, but also enable a flexible approach to supporting both current sectoral decarbonisation targets such as the energy sector and future ones such as transport . This will ensure energy is available for EV infrastructure while also enabling the island to position itself as a hydrogen hub (Power to X) in the Baltics, producing low carbon fuels when there is excess renewable energy generation. With thousands of ships passing the island each year, this may provide a future revenue stream for Bornholm as the decarbonisation of marine transport progresses.

Success factors

The municipality and BEOF contacts also gave insight into some key success factors and barriers encountered as the strategy evolved:

Success Factors	• Make your strategy ambitious and for the long run • Utilise data and know where, when and why your island is consuming energy. • Get help, ask for advice and share knowledge where you can. • Get local community, business and political leaders engaged, they can help identify funding streams and support you may not have been aware of. • Maximise engagement on the civil and residential front but also identifying front runners and organisations within the community who are willing and keen to help drive progress.
Barriers encountered	• The strategy covered lots of sectors so lots of stakeholders had ideas to input. There is a need to be staffed and resourced for this to prevent delays to implementing. • Clearly defined roles within projects and appropriate decision makers needed to be established earlier. • A challenge encountered was ensuring that, while residents are aware of the strategy, they must be able to contextualise it within their specific day to day activities.

7.1.3 Case study 2 – Faroe Islands (FÖRKA)

The FÖRKA biogas plant went live late 2020, providing electricity to the Faroe Islands grid as well as heating to the local municipality of Tórshavn. As part of the islands drive to decarbonise its energy systems by 2030, the plant, the first of its kind on the islands, reported 212 MWh of generation in its first month operating[xiv] in electricity and heat. A collaboration between one of the country's largest salmon producers – Bakkafrost – the Faroe Islands government and the island's farming community, the strong circular economic characteristics of the project has produced a variety of benefits for a diverse group of stakeholders. The head of the energy department for the Faroe Islands Environment Agency (EA) provided insight into how this project developed.

The technology

Methane rich biogas is produced when specialist microbial cultures break down organic matter in an environment absent of oxygen in a process known as anaerobic digestion (AD). This occurs within a sealed environment and the resulting biogas can then be utilised for heating and electricity production through the utilisation of combined heat and power (CHP) systems. The organic matter input can range from a variety of sources such as domestic food waste or agricultural waste such as slurry, and in addition to the energy, the process also produces nutrient rich fertilisers.

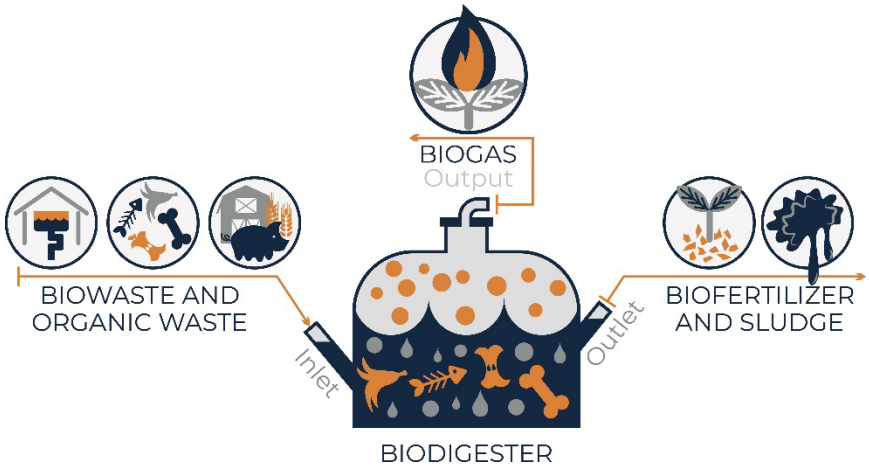


Figure14: Biogas production via AD process diagram.

Development

The plant, owned by Bakkafrost, utilises significant quantities of both aquaculture waste from their operations, including excrement from onshore juvenile salmon hatcheries and deceased adult salmon stock, as well as significant quantities of slurry from local agriculture which is collected from farms by the plant operators.

Impact

The operational plant has provided a strong range of benefits to a variety of stakeholders. The plant is expected to reduce emissions by 11,000 tonnes of CO_2 per annum with 400[xv] homes in the city Tórshavn provided with heating as well as green electricity utilised on the islands grid, displacing fossil fuel usage and providing a saving to residents. This energy provides revenue to Bakkafrost who also provide aquaculture waste as feed for the plant as well as reducing an expensive overhead through waste disposal savings. The farming community, in exchange for the waste slurry utilised, receives the fertiliser produced at no cost. This removes the need for thousands of tonnes of fertiliser to the islands as well as being a higher grade product than the imported variant.

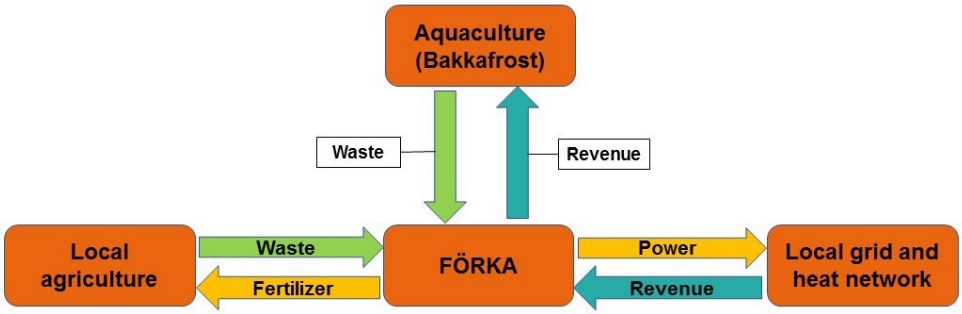


Figure15: Flow and source of inputs as well as outputs from FÖRKA plant

The quantities of organic waste revalorised as bio resources is also significant with the EA reporting 30,000 tonnes of cattle slurry utilised in the plant as well as up to an additional 20,000 tonnes from the aquaculture sector. Figure 14 above demonstrates the flow of inputs from key stakeholders as well as plant outputs and recipients.

Success factors and barriers

The EA provided some insight into their key success factors and some barriers:

Success Factors	• Early, quality advice, involving the institute for aquaculture provided key insight into challenging technical barriers. • Showing both the commercial viability as well as environmental benefits from the start. • Early partner identification and identification of significant waste streams and sectors that may benefit from collaboration on revalorisation were important.
Barriers encountered	• Significant engagement needed to obtain residential and commercial stakeholders' buy in. Specialist demonstrator visits to Denmark undertaken with key stakeholders to help overcome. • Biogas feedstock needs careful assessment. Issues initially encountered in utilising Salmon smolt. • Plant operational logistics required significant consideration. The site location needed an adequate heat demand as well as ensuring accessibility for waste deliveries from across the island.

7.1.4 Case study 3 – Orkney (Heat Smart Orkney)

Introduction

The Orkney Islands experience some of the highest fuel poverty rates in Scotland. While the national rate of fuel poverty is 24.6% as of 2019,[xvi] around 60% of households in Orkney were classified as in fuel poverty, which is defined as "where a household spends more than 10% of its income on fuel[23]". There are a number of reasons for this: Orkney is one of the most remote areas of the country, with national grid connection not established until 1982.[xvii] It also experiences long and cold winters, while its exposed location causes significant wind-chill. Many buildings on Orkney are also not insulated to current standards, which causes much higher heating requirements and costs.

Despite this, however, Orkney consistently generates more than 100% of the island's heating demand due to the favourable conditions for renewable energy generation. The first modern large-scale wind turbines were installed in the early 2000s until a moratorium was imposed in 2012 on new renewable generation developments due to grid constraints. An Active Network Management (ANM) system was established in 2009 to help boost the export of generated electricity to the national grid. However, limitations still existed, and this is only applicable up to meeting the point of maximum demand on the grid at the time. The below graph shows the generation and curtailment of one Orkney-based turbine. The upper bars show the amount of energy generated per year that was consumed on Orkney while the lower bars show the amount generated that was surplus to demand and therefore lost.

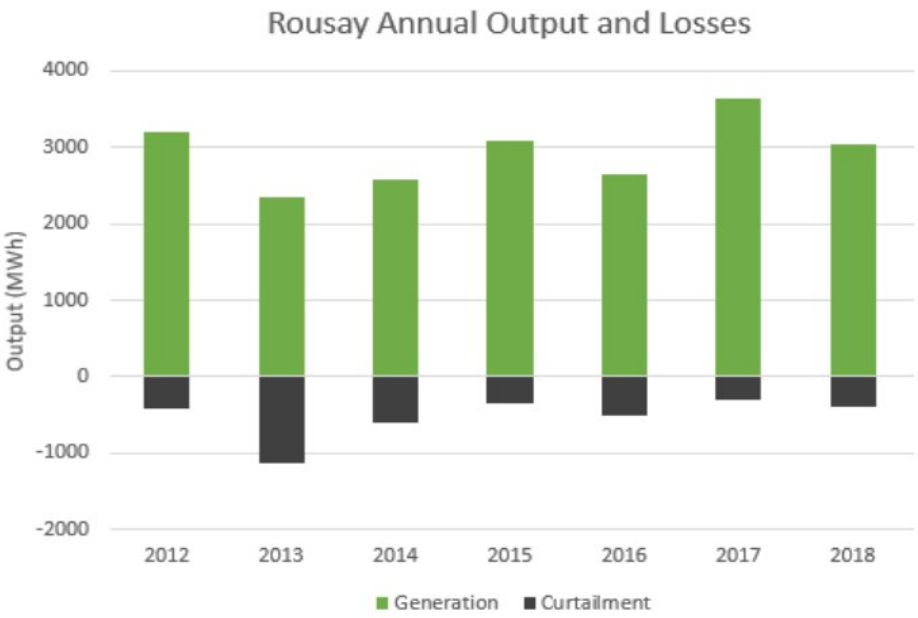


Figure16: Generation and curtailment of Rousay, Egilsay and Wyre community turbine between 2012 and 2018.[xviii]

This loss of generated electricity also means a loss of income for the turbine owners, which can cause issues with loan repayments and result in a loss of funds for local communities. The Heat Smart Orkney (HSO) project aimed to address both the issues of curtailment and fuel poverty on the island by diverting some generated electricity, that would otherwise have been lost, to newly installed domestic heating systems including parallel electrical flow boilers, hot water immersion heaters and Quantum electric storage heaters.[xix]

In 2014, the Rousay, Egilsay & Wyre Development Trust (REWDT), one of the project's partners, received £200,000 of funding from the Local Energy Challenge Fund (LECF) to develop the HSO concept and set up the phase 1 trials. Phase 2 was also partially funded by the LECF. HSO was granted £1.2m from the Scottish Government which was supplemented with an additional £400,000 from REWDT. The project had hoped to gain some of this £400,000 as match funding from the National Innovations Allowance, but this did not move forward. Additional funding sources were the CARES Infrastructure and Innovation Fund (IIF), Big Lottery Fund and a £10,000 investment from REWIRED Ltd.

Impacts

It is estimated that, across the project's two phases, curtailment was reduced by 15% in 2018 and 8% in 2019 as it boosted the levels of locally generated renewable electricity usage on the islands. It also delivered a carbon saving as fossil fuel usage fell, oil by 13,000 litres, solid fuel by 220kg and LPG by 428kg, while electricity use rose by 68MWh. It should be noted that only 18MWh of this electricity usage was directly attributed to reduced curtailment, which suggests a further behavioural change element to the project. The carbon reduction directly attributed to the aims of this project (i.e., not including the increased energy consumption) was around 40tCO_2e.

Journey

Phase 1 of the project consisted of a small-scale trial of the technology. REWDT identified around 700 potential households for participation, before selecting six with a variety of current heating solutions, broadband providers and connection speeds. Each household received a property survey from project partner Catalyst to identify the most suitable equipment, resulting in four quantum storage heaters, one flow boiler and six parallel immersions installed, each run on electricity from the local grid and equipped with digital meters to record kWh usage. Systems were also designed for participants to benefit from rebates, and for VCharge, one of the project partners that was focused on demand side management (DSM), to control household loads and predict future curtailment events.[xx]

Based on the learnings from this, phase 2 saw an expansion of the project to a total of 108 devices installed across 72 properties. It also expanded the rebate system to ensure that participants received value from the project. This rebate payment was an incentive for participants to continue engaging with the project and was sourced from the increased revenue generated by the REWDT as a result of increased electricity consumption. The increased revenue in question equated to £2,300 in 2018 and £510 in 2019, while £692.59 worth of rebates were paid to participants over the 2 years. It was also claimed that homeowners' costs would be further reduced due to the higher energy efficiency of the newly installed devices compared to existing older models.

In the post-project evaluation survey, 23% of participants reported that their heating bills were reduced, 26% that they were roughly the same, with 14% stating that they were now paying more. Additionally, some participants also reported that their home was now warmer. The perception of the project was very positive, with the vast majority of respondents feeling that participating in trials like HSO is a valuable activity. However, due to the limited timespan of the trial period and uncertainty regarding curtailment, it was not felt that the project in its current form tackled the issue effectively. 47% do believe that the project has the potential to address fuel poverty in the future with a further 31% feeling that it has some potential.

Legacy and the future

Following the two-phase trial, the intentions of HSO are to integrate other generators on the Orkney grid to access greater volumes of marginal curtailment. It also aims to increase participation to 500 households, eventually providing 50% of participants' heating and hot water requirements. HSO has set out a plan to grow the network to commercial scale, which will rely on attracting new turbines and households to join the scheme and ensuring sufficient investment to allow for continued growth. Due to the trust and knowledge built up over the course of the project, HSO perceives this as a manageable task though notes that there is a risk of increased competition from new projects expanding on the work of HSO including Project TraDER, which is working to increase responsiveness to network signals to ease grid congestion. Furthermore, if HSO expands to new zones in the Orkney network (having previously only operated in Zone 1), there may be logistical complexities that hamper the project's success in the future.

Successes and barriers

Success Factors	• Local media utilised to engage participants and wider community in remote locations. • Project officer visits providing residents with educational opportunities on billing, tariffs etc.

	• Provided foundation for future projects e.g. Responsive Flexibility (ReFlex) to support whole island decarbonisation
Barriers	• Homes with poor Wi-Fi availability encountered barriers connecting to smart metering. • Delays in connecting Aggregating Controller Platform (ACP) • Manual calculation of rebate was inefficient and time consuming. • Specialised skills required to deliver the technical surveying was challenging to source in remote island community.

7.2 Appendix 2 – Task 3 Funding Directory Summary Table

Table 4: A summary of the key fields and the information recorded in Task 3 funding directory

Directory fields	Description of field	Information captured
Funding source	Where the funds originate from.	Public funding sources: • EU funding • Local government • National government • Regional government • Other public source Private sector funding sources: • Banks (commercial and investment) • Insurance companies • Pension Funds • Other private sector source
Funding body	What governmental department or organisation provides the funds.	Examples include: • European Regional Development Fund (EDRF) • The Woodland Trust • BEIS • Energy Saving Trust • Scottish Government • Big Lottery Fund
Funding programme/scheme	The funding programme/scheme name	Examples include: • The Low Carbon Infrastructure Transition Programme • Forestry Grant Scheme • Community and Renewable Energy Scheme (CARES) funding • Low Emission Zone Retrofit Fund
Description of funding	The aim/purpose of the funding and eligible sectors.	

Type of funding	The financial instrument used to deploy the funding scheme/programme	• Debt financing/loans • Equity finance or risk sharing facilities • Grants/subsidies, tax rebates and exemptions • Grants/subsidies combined with debt financing • Multiple instrument types combined • Other
Target sector	What sector/purpose the funding caters in a net zero context.	• Housing – funding for low carbon new builds or retrofitting older builds i.e. increasing the energy efficiency and air tightness. • Heating – funding for low carbon technology to heat buildings • Transport – funding to promote active travel, encourage micro-mobility such as e-bikes and the uptake of electric vehicles (EVs) • Energy – funding for community renewable projects such as solar PV. • Waste – funding for improved waste management and sorting facilities to reduce and avoid waste going to landfill as well as promoting a circular economy. • Land use – funding to restore land (peatland restoration) or increasing land management (forestry)
Total fund size	The total amount of money allocated to the programme/scheme and the maximum funding available per application	GBP EUR
Eligibility criteria	The requirements that must be met to access the funding	• Climate impact requirements • Type of institution / applicant • Other, such as co-funding requirements

Funding window	Whether the funding is currently live, closed or future funds will be released i.e., next round of funding.

References

[i] ORION, *Clean Energy Project* [accessed: 25 April 2022]
[ii] Scotland's Soils, *Carbon and peatland 2016 map* [accessed: 25 April 2022]
[iii] UNFCC, *Land Use, Land-Use Change and Forestry (LULUCF)* [accessed: 25 April 2022]
[iv] Scottish Government (2019), *National Plan for Scotland's Islands* [accessed: 25 April 2022]
[v] Cunningham, Fiona (2018), *Adaptation to the impacts of climate change in small island communities: an analysis of Scottish case studies* [accessed: 25 April 2022]
[vi] Keep Scotland Beautiful, *Climate Challenge Fund* [accessed: 25 April 2022]
[vii] Energy Action Scotland (2021), *Scottish Fuel Poverty Map* [accessed: 25 April 2022]
[viii] Nature Scot (2022), *Scotland's National Peatland Plan*. [accessed: 25 April 2022]
[ix] PowerLabDK, Bornholms Elsystem [accessed: 25 April 2022]
[x] Insulae, *Lighthouse island 2: Bornholm* [accessed: 25 April 2022]
[xi] CORDIS, *Large scale Smart Grids demonstration of real time market-based integration of DER and DR* [accessed: 25 April 2022]
[xii] Bornholms Regionskommune, *Bornholms energistrategi 2040* [Danish] [accessed: 25 April 2022]
[xiii] Danish Energy Agency, *Denmark's Energy Islands* [accessed 25 April 2022]
[xiv] Bakkafrost (2020), *Biogas plant FÖRKA starts production of green energy from bio-organic waste from Bakkafrost hatcheries* [accessed: 25 April 2022]
[xv] NIRAS (2021), *Award-winning biogas plant brings the Faroe Islands closer to climate goals* [accessed: 25 April 2022]
[xvi] Energy Action Scotland, *Fuel Poverty Overview* [accessed: 25 April 2022]
[xvii]Scottish & Southern Electricity Networks, *Orkney* [accessed: 25 April 2022]
[xviii] Heat Smart Orkney Ltd. (2020), *Heat Smart Orkney (HSO) Project 2016-2018: Final Output Report (for the Local Energy Challenge Fund)* [accessed: 25 April 2022]
[xix] Ibid.
[xx] Rousay, Egilsay and Wyre Development Trust (2016), *Local Energy Challenge Fund GCF 138 – Heat Smart Orkney: End of Phase 1 Grant Report* [accessed: 25 April 2022]

climateXchange
Scotland's centre of expertise connecting climate change research and policy

info@climatexchange.org.uk
+44(0)131 651 4783
@climatexchange_
www.climatexchange.org.uk

ClimateXChange, Edinburgh Climate Change Institute, High School Yard, Edinburgh EH1 1LZ