Baselining Inventory for Greenhouse Gas Emissions in the Highlands and Islands

Report

ekosgen

Practically Green

reference economic consultants

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

CONTENTS

1 INTRODUCTION

OVERVIEW

1.1 The Paris Agreement is a legally binding international treaty on climate change, adopted by 196 Parties at the UN Climate Change Conference in Paris (COP21), on 12 December 2015. Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." To limit global warming to 1.5°C, greenhouse gas (GHG) emissions must peak before 2025 at the latest and decline 43% by 2030.

1.2 COP28, the UN Climate Change Conference held in Dubai, the United Arab Emirates at the end of 2023[1], was the first 'global stocktake' of the world's efforts to address climate change under the Paris Agreement. It demonstrated that progress was not rapid enough across all areas of climate action – including reducing greenhouse gas emissions, strengthening resilience to climate change, and providing the required financial and technological support to vulnerable nations. COP28 secured an agreement on the transition away from fossil fuels in energy systems, in a just, orderly and equitable manner. It calls on all parties to accelerate action in this critical decade, to adhere to binding targets under the Paris Agreement through a tripling of renewable energy capacity and doubling of energy efficiency improvements by 2030, and to achieve net zero by 2050.

1.3 Through the Climate Change Act 2008,[2] the UK Government has committed to reducing emissions to net zero by 2050, with legally binding 'Carbon Budgets' being set as milestones towards this overall target. This caps the amount of GHG that can be emitted in the UK over a five year period. The Climate Change Committee advises on the appropriate level of carbon budgets, each of which is set at least 12 years in advance to enable policy-makers, businesses and individuals time to respond. The carbon budgets, once accepted by Government, are legislated by Parliament. Six carbon budgets have been set to date, the most recent running up to 2037.[3]

1.4 The Scottish Government has consistently placed the country at the forefront of robust GHG emission reduction activity. The Climate Change (Scotland) Act 2009 set targets for the reduction of GHG emissions and made provision for advice, plans and reports in relation to emission reduction activity. The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 amended the 2009 Act and presents the target of reducing emissions of all GHG to net zero by 2045 at the latest. This is a more ambitious target than for the UK, reflecting the progress being made in Scotland as well as the natural reserves that facilitate carbon sequestration and storage.

1.5 Highlands and Islands Enterprise (HIE) commissioned research to measure the GHG emissions arising from the area covered by the Highlands and Islands Regional Economic Partnership (HIREP). This area essentially includes the six Local Authority areas of Argyll and Bute, Highland, Moray, Na h-Eileanan Siar (Western Isles), Orkney and Shetland, as well as Arran and Cumbrae in North Ayrshire. For the baselining elements of this study, data was only available at local authority level, and so Arran and Cumbrae were not represented within this. However, wherever data availability allows, analysis for Arran and Cumbrae (North Ayrshire) has been included.

[1] https://unfccc.int/cop28/
[2] Climate Change Act 2008 (legislation.gov.uk)
[3] Carbon Budgets - GOV.UK (www.gov.uk)

1.6 The specific requirements of this project are:

- Use the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC)[4] methodology to provide a baseline GHG emissions for the Highlands and Islands region overall, and for its constituent local authority areas;
- At regional level, assess and quantify (where possible) GHG emissions by sector, identifying the greatest contributors of GHG and therefore those that need to be supported most urgently, to decarbonise;
- Identify gaps in and limitations of national datasets for the measurement of GHG emissions at regional, sub-regional and sectoral level, and explore where data gathering at a more localised level could potentially be enhanced or data quality improved;
- Assess the current and potential contribution of the Highlands and Islands region overall to national renewable energy generation, to establish the importance of the renewable energy sector to the region; and
- Give consideration to the terrestrial carbon sequestration potential in the region.

REPORT STRUCTURE

1.7 The report is structured in the following way:

- **Chapter 2** presents a summary of the strategic context for greenhouse gas emissions and the Net Zero and Just Transition ambitions in Scotland;
- **Chapter 3** sets out a spatial analysis of territorial greenhouse gas emissions in the Highlands and Islands;
- **Chapter 4** provides analysis of the region's greenhouse gas emissions for the sectors outlined in the GPC;
- **Chapter 5** details dwelling characteristics and domestic emissions from residential dwellings in the region based on data from the Energy Savings Trust;
- **Chapter 6** sets out the Highlands and Islands' renewable energy generation capacity – both current and anticipated pipeline capacity;
- **Chapter 7** provides a high-level assessment of the carbon sequestration potential in the region; and
- **Chapter 8** sets out some initial conclusions ahead of resolving some data gaps in the analysis.

[4] https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, World Resources Institute, 2014

2 STRATEGIC CONTEXT

Chapter summary

- NSET outlines the wider transition to net zero and details aims to ensure success in the "decisive decade". It sets out a vision for a wellbeing economy and steps to drive a green economic recovery to meet climate targets while maximising the benefits of a just transition.
- The Just Transition Plan establishes the vision to 2045 for Scotland with regards to its energy system and how best to secure a "Just Transition" to net zero. The Scottish Government has committed £5 billion to energy transformation projects over the remainder of this parliament. It has also committed to a legislative and policy framework over this period, and plans for delivery with regards to increasing renewable supply, and for reducing demand for carbon fuels.
- The Draft Energy Strategy sets out key ambitions for energy in Scotland, such as generation of 20GW of additional renewable wind electricity by 2030, hydrogen providing 5GW (or 15% of Scotland's current energy needs) by 2030 and 25GW by 2045, and the phasing out of new petrol and diesel cars and vans by 2030 (with car kilometres reduced by 20%). It also extends to further decarbonisation action taken in industry, transport and heat, and increasing contributions from solar, hydro and marine energy.
- The overarching vision established in the Environment Strategy is for Scotland, by 2045, to be "transformed for the better" as a result of restoring nature and ending Scotland's contributions to climate change, thereby helping to secure the wellbeing of Scottish citizens for generations to come.
- The 2023-24 Programme for Government builds on commitments outlined in previous years to address the Climate Emergency and restore Scotland's environment. Key points include production of a draft Climate Change Plan, development of a Green Industrial Strategy and publication and implementation of a new Energy Strategy and Just Transition Plan. It also seeks to enhance Scotland's place as a world leading destination for offshore wind investment and to implement steps to develop Scotland's potential in the production of hydrogen.
- The Highlands and Islands region is well suited for reducing carbon emissions and expanding renewable energy due to its abundant natural resources. It has a history of successful renewable projects and ongoing innovations, positioning it at the forefront of the renewable energy sector. However, a comprehensive understanding of current emissions, renewable capacity, and carbon sequestration is necessary to achieve net zero goals effectively.

INTRODUCTION

2.1 This chapter sets out the strategic context for this GHG emissions baseline for the Highlands and Islands, as defined by the HIREP geographic boundaries. It gives consideration to the major national strategies established by the Scottish Government that address the Climate Emergency and are focused on Net Zero and Just Transition outcomes.

STRATEGIC CONTEXT

2.2 In 2019, the Scottish Government declared a global climate emergency and addressing it will require transformative change. A statutory target of 2045 was set for net zero emissions. The transformative changes needed offer social and economic opportunities, although there will be risks and challenges to overcome. The Scottish Government established an independent Just Transition Commission to provide advice on how our transition can also promote social cohesion and equality.

2.3 While there are no statutory control or delegation of targets to sub-regions or sectors, the Scottish Government have tasked public sector organisations like HIE with helping them achieve the country's net zero target. This will involve organisations developing an understanding of where, why and how GHG emissions arise in day-to-day operations, supply chains etc. This report will provide greater visibility of how GHG emissions arise across the Highlands and Islands, and where targeted intervention may be required to accelerate transition to net zero.

National Strategy for Economic Transformation

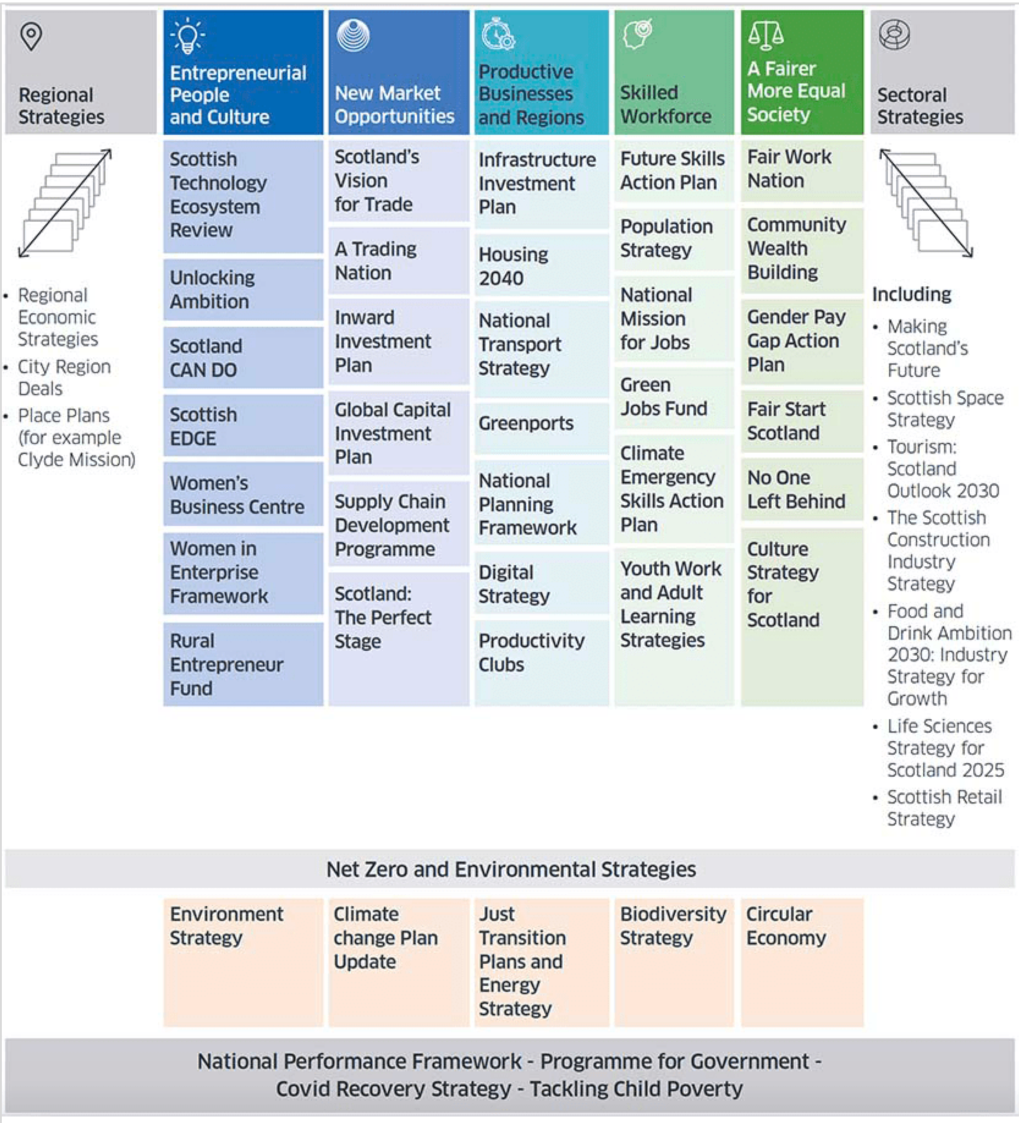
2.4 In May 2022, the Scottish Government published the National Strategy for Economic Transformation (NSET), which sets out the priorities for Scotland's economy over the next 10 years. Recognising the importance of this timeframe within the context of pandemic recovery and the wider transition to net zero, the document details aims to ensure success in the "*decisive decade*". In order to address these wider challenges, the Scottish Government recognises that Scotland has pre-existing challenges such as weak productivity and a lack of new business growth, that need to be encompassed in its strategy.

Figure 2.1: NSET Ambitions and programmes of action

Scottish Government, 2022

2.5 The NSET is a radical departure from its forerunner, *Scotland's Economic Strategy*, and is a roadmap for the Scottish economic model, with the explicit aim of transitioning to an economy that is focused on a "*Wellbeing Economy*" – one that ensures fair work and better wages, and increases productivity through entrepreneurship and innovation. It drives a green economic recovery to meet climate change ambitions while maximising the benefits as part of a just transition.

Figure 2.2: NSET strategy framework



Scottish Government, 2022

Draft Energy Strategy and Just Transition Plan

2.6 The Scottish Government's Draft Energy and Just Transition Plan[5] establishes the vision to 2045 for Scotland with regards to its energy system and how best to secure a just transition to net zero. It also lays out the Government's route map to 2045 in order to achieve this, with almost £5 billion committed to energy transformation projects and a legislative and policy framework, both for the remainder of this parliament, as well as delivery plans for increasing renewable supply, and for reducing demand for carbon fuels.

[5] https://www.gov.scot/publications/draft-energy-strategy-transition-plan/

2.7 The move to a net zero, nature-positive economy (established as a goal within NSET) is underpinned by the concept of a "just transition"[6] from traditional fossil fuels and the oil and gas industry in particular, and is a helpful concept to recognise the need to move to a more sustainable economy in a way that's fair to everyone – including people working in polluting industries, and equipping them with the skills, education and retraining required to support retention and creation of access to green, fair and high value work. Importantly, a just transition is both an outcome and a process – and one that must be undertaken in partnership with those impacted by the transition to net zero.

2.8 The Draft Energy Strategy sets out key ambitions for energy in Scotland, such as generation of 20GW of additional renewable wind electricity by 2030, hydrogen providing 5GW (or 15% of Scotland's current energy needs) by 2030 and 25GW by 2045, and the phasing out of new petrol and diesel cars and vans by 2030 (with car kilometres reduced by 20%). It also extends to further decarbonisation action taken in industry, transport and heat, and increasing contributions from solar, hydro and marine energy.

2.9 Scotland has some of the most ambitious commitments to net zero and greenhouse gas reduction amongst advanced economies. The Scottish Government has committed to implementing the recommendations of the Just Transition Commission[7] to build a net zero economy that is fair for all, including the publication of Just Transition plans for every sector and region, overseen by the Commission. Scotland's commitment to net zero by 2045 is a fundamental driver for its ambition for a just transition[8]. Following the Climate Change Committee's latest progress report on emissions reduction in Scotland,[9] Scottish Government have confirmed that an interim target for a 75% reduction in Greenhouse Gases (GHG) by 2030 is currently out of reach. The Scottish Framework for controlling GHG emissions is now under review, and annual and interim targets are likely to be replaced by a system measuring emissions every five years (similar to the carbon budget approach adopted at UK level). Legislation is likely to be expediated to ensure the legislative framework better reflects the reality of long-term climate policymaking.

2.10 The Energy Strategy and Just Transition Plan notes that, in order to prepare Scotland for a just transition, its citizens must have access to affordable clean energy, that communities and places can participate and benefit from the transition, that a supportive policy environment needs to be created in order to maximise the impact of government expenditure, that a "multi-skilled green workforce" needs to be developed, and there needs to be high levels of innovation, competition and private sector investment.

2.11 Just Transition reflects the need for collaboration, a local approach and proper funding, and its relevance is particularly clear when considering the potential scale of disruption to the labour market that may be anticipated over the next decade.

[6] https://www.gov.scot/groups/just-transition-commission/
[7] https://www.gov.scot/groups/just-transition-commission/
[8] https://www.gov.scot/publications/transition-fairer-greener-scotland/
[9] Progress in reducing emissions in Scotland - 2023 Report to Parliament - Climate Change Committee (theccc.org.uk)

Environment Strategy for Scotland

2.12 The Environment Strategy for Scotland[10] creates an overarching framework for Scotland's existing environmental strategies and plans. As these are reviewed over time (e.g., to reflect changes in international targets or other policy developments), the vision and outcomes established in this Strategy will be used to help guide future development of other accompanying and related strategies.

2.13 The overarching vision established in the Environment Strategy is for Scotland, by 2045, to be "*transformed for the better*" as a result of restoring nature and ending Scotland's contributions to climate change, thereby helping to secure the wellbeing of Scottish citizens for generations to come. The desired outcomes underpinning this vision are framed with respect to the National Outcomes in the National Performance Framework and UN Sustainable Development Goals. Each has an impact in terms of lowering emissions and promoting renewable energy generation in Scotland. The outcomes are as follows:

- Scotland's nature is protected and restored with flourishing biodiversity and clean and healthy air, water, seas and soils;
- We play our full role in tackling the global climate emergency and limiting temperature rise to 1.5°C;
- We use and re-use resources wisely and have ended the throw-away culture;
- Our thriving, sustainable economy conserves and grows our natural assets;
- Our healthy environment supports a fairer, healthier, more inclusive society; and
- We are responsible global citizens with a sustainable international footprint.

2.14 In order to measure progress against each of these outcomes, Scottish Government have committed to developing a monitoring framework for the Strategy.[11] This will set out indicators to track and report progress towards achieving the strategy outcomes (described as outcomes related to nature, climate change, resource use, economy, society and global footprint, respectively). This, in turn, will guide improvements to the strategy and the approach to delivery on these outcomes.

2.15 The Environment Strategy exists in tandem with other high-level policy frameworks in Scottish Government, such as NSET and the National Planning Framework. As such, it is a key foundational document for determining the strategic approach of developing environmental policy, as well as future arrangements for environmental principles, governance, and monitoring.

Programme for Government

2.16 The Programme for Government sets out the Scottish Government's legislative programme for each parliamentary year. Within the Programme for Government 2020-21, there was a commitment to the Building Scotland's Green Recovery report,[12] which emphasised the importance of investment in green and clean skills throughout the pipeline, from school leavers to reskilling opportunities.[13] These commitments were made in the context of post-pandemic recovery, placing clean skills as an exciting opportunity from Scotland through innovation and investment in sectors of importance for the transition to Net Zero and climate targets. These included: £100m investment in a Green Jobs Fund to support businesses to create and maintain jobs that align to the Scottish Government net zero

[10] https://www.gov.scot/publications/environment-strategy-scotland-vision-outcomes/
[11] https://www.gov.scot/publications/environment-strategy-scotland-second-progress-report/
[12] https://www.gov.scot/publications/protecting-scotland-renewing-scotland-governments-programme-scotland-2020-2021/
[13] https://www.gov.scot/news/scotlands-green-recovery/

policies; £60m investment in the Youth Guarantee to ensure people aged between 16-24 have the opportunity of work, education or training; £25m investment in the National Transition Training Fund which aims to help 10,000 people over the age of 25 retrain into clean skills jobs.

2.17 The following year (2021-22), the Programme for Government was titled 'A Fairer, Greener Scotland', which built on the strategy of creating skills and employment opportunities throughout the different stages of one's career and across sectors. This was demonstrated in the creation of the Green Jobs Workforce Academy, which provided £45 million through local partnerships to provide training and employment opportunities and initiatives.[14] Alongside this, funding was made available to specific areas such as SMEs to improve digital skills, recognising sector and regional specific challenges to supporting Clean Growth. These skills and training specific funding streams take a nationwide approach, creating an environment in which clean skills jobs are promoted through targeted action.[15] However, these developments are to be understood within the context of a commitment from national government to support expanding Community Wealth Building to more local authorities, such as those within the Tay Cities region, to take a more active role in economic development.[16]

2.18 The Programme for Government 2022-23[17] set out specific commitments for tackling the Climate Emergency and restoring Scotland's environment. These included:

- Development of a new hydrogen industry in Scotland with the publication of the final Hydrogen Action Plan and a Scottish Hydrogen Investment Proposition;
- Facilitating the development of an offshore wind supply chain, and continuing to support the development of the wave and tidal sector;
- Enhancing the Forestry Grant Scheme to deliver better community engagement, improved biodiversity and increased value for money;
- Development of Scotland's next statutory Climate change adaptation programme for publication in 2024; and
- Reviewing agricultural funding and direct payments to increase alignment with the *Vision for Agriculture*, and increase climate action and nature restoration activity, and other actions needed to reach net zero emissions.

2.19 The current Programme for Government 2023-24[18] builds on these, with further commitments including:

- Production of a draft Climate Change Plan, targeting emissions reduction and related action across transport, heat and natural environment, and maximising economic opportunities;
- Development of Green Industrial Strategy to help businesses and investors realise economic opportunities associated with the global transition to net zero;
- Publish and start implementing a new Energy Strategy and Just Transition Plan, and deliver aligned Just Transition Plans for the Built Environment and Construction, Land Use and Agriculture, and Transport sectors, and for Grangemouth.
- Establish a sector deal with the onshore wind industry to help deliver onshore wind ambition and accelerate consenting processes;

[14] https://www.gov.scot/publications/fairer-greener-scotland-programme-government-2021-22/
[15] https://www.gov.scot/news/scotlands-green-recovery/
[16] https://www.gov.scot/policies/cities-regions/community-wealth-building/
[17] https://www.gov.scot/publications/stronger-more-resilient-scotland-programme-government-2022-23/
[18] https://www.gov.scot/publications/programme-government-2023-24/

- Enhancing Scotland's place as a world-leading destination for offshore wind investment, including updating offshore wind consenting process guidance and shortening consenting timescales;
  Publication of a Solar Vision for Scotland, setting out the ambitions for solar, and the approach to supporting its growth;
- Implementation of the Hydrogen Action Plan and use of the Hydrogen Innovation Scheme and the Hydrogen Investment Programme, through the forthcoming Green Hydrogen Fund, to develop Scotland's potential in the production of reliable, competitive and sustainable hydrogen; and
- Work with industry to accelerate decarbonisation and create energy transition opportunities at major industrial sites with the support of the Scottish Industry Energy Transformation Fund, the Energy Transition Fund and the Emerging Energy Technologies Fund.

2.20 May 2024 saw changes within Scottish Government, with the appointment of a new First Minister. The First Minister first statement to Parliament[19] set out his government's four priorities – eradicating child poverty, growing the economy, tackling the climate emergency and improving public services. This is expected to inform Scottish Government policies in the run up to the next Scottish Parliament election in 2026.

THE HIGHLANDS AND ISLANDS' ROLE IN NET ZERO

2.21 The Highlands and Islands region is an area that finds itself well-placed in its ability to respond to the need to reduce GHG emissions and increase renewable energy generation. This is due to its location and the potential energy generation that can be gathered from its natural assets, already ably demonstrated by existing assets that are present in the region. There is also a wide variety of activity relating to innovation in the sector through various research centres based in the region.

2.22 The Highlands and Islands is rich in natural assets that present opportunities both in terms of generation of renewable energy (such as its vast array of lochs and rivers that can be used in hydroelectric generation, its large swathes of mountainous areas for onshore wind generation and large coastal boundaries for both offshore wind generation and tidal energy generation) and also in reducing emissions through sequestering carbon through its rich peatland and densely wooded areas.

2.23 The Highlands and Islands already benefits from significant renewable energy production from legacy post war constructed hydro schemes, such as that found at Cruachan Power Station. More recent developments and proposed schemes include the Coire Glas pumped hydro project[20] at Loch Lochy, the Loch na Cathrach (formerly known as Red John) pumped storage hydro scheme[21] on Loch Ness, and the Hydro Ness[22] project. Recent years have seen the establishment of various onshore and offshore wind farms in the area, and the Highlands and Islands currently generates more electricity from onshore wind[23] than any other region in Scotland. Development of these assets demonstrates that the region has the technical expertise, the infrastructural capacity and the natural assets that support the area to deliver on further renewable energy projects.

[19] Priorities for Scotland: First Minister's statement - 22 May 2024 - gov.scot (www.gov.scot)
[20] https://www.coireglas.com/project
[21] https://redjohnpsh.co.uk/
[22] https://www.hydro-ness.scot/
[23] https://www.gov.uk/government/statistics/regional-renewable-statistics; https://www.utilitybidder.co.uk/compare-business-energy/renewable-energy-index/

2.24 The region also finds itself at the epicentre of new renewables developments, as evidenced by the majority of projects (c.60% of the 25GW capacity) within the ScotWind leasing round being found around the shores of the Highlands and Islands area.[24] It benefits from a high level of innovation in the renewable sector, as well as research centres such as the European Marine Energy Centre in the Orkney Islands and the proposed “PowerHouse” research centre for floating offshore wind and green hydrogen technologies based at Cromarty Firth.

2.25 In order to fully respond to the challenges of net zero and the climate emergency, however, there is a need to better understand the region’s current emissions, its current capacity in generation from renewables and its potential in both future generation and in carbon sequestration from land in the Highlands and Islands. This will help showcase the energy landscape in the region, illustrating the energy capabilities and requirements (and how much is sourced from both renewable and fossil fuels sources), and provide insight into how best to balance emissions on the route to achieving net zero.

[24] https://www.crownestatescotland.com/scotlands-property/offshore-wind/scotwind-leasing-round

3 REGIONAL EMISSIONS: SPATIAL ANALYSIS

Chapter summary

- In 2019, GHG emissions for the Highlands and Islands were 6,236 kt CO_2e. This equated to around 15% of total GHG emissions for Scotland.
- Per capita emissions are higher in the Highlands and Islands (12.7 tCO_2e per resident) than nationally (7.8 tCO_2e). Sub regional variation is evident, with rates per capita highest in our island areas and lowest in Argyll and Bute.
- Over the period 2005 to 2019, GHG emissions decreased by 20% in the Highlands and Islands, although this lags the rate of decline across Scotland as a whole (33%).
- The top five sources of emissions in the region are *agriculture*; *land use, land use change and forestry (LULUCF); transport*; *domestic* and *industry*. These are the same top five for Scotland overall, however the order and extent of contribution varies.
- Together, agriculture and LULUCF (the top two sources) account for just under half (48%) of the region's emissions compared to around a quarter nationally (25%). The Highlands and Islands accounts for a disproportionately high share of Scotland's total emissions from these sectors (51% of Scotland's LULUCF and 20% of agricultural emissions).
- Transport, domestic and industry account for 46% of GHG emissions compared to 65% nationally (these being Scotland's top three sources of emissions).
- Both regionally and nationally, *waste* (3% regionally) and the *commercial* (2%) and *public sectors* (1%) accounted for a relatively low share of emissions.
- Sub regional variation is evident in terms of key sources of emissions and the extent to which these are being balanced out by carbon sequestration mainly associated with the scale of forestry plantations across the region.
- While the Global Protocol for Community Scale GHG emissions (GPC) provides a structure for assessing regional GHG emissions, there is a lack of data available to facilitate analysis at this level. Data from the UK local authority and regional GHG national statistics dataset is used to provide the baseline, but the top down nature of its calculation in modelling does present challenges. There is an element of error, assumption and data volatility which reflects the imperfect nature of GHG data collection. Use of additional sources help to address data gaps and provide further insight into the nature of emissions within sectors.

INTRODUCTION

3.1 At both UK and Scotland level GHG emissions are reported on three bases: territorial, residence (or production) and footprint (or consumption). Residence (production) emission are aligned with UK National Accounts, enabling emissions to be linked to economic sectors and their resultant activity. Footprint (or consumption) emissions relate to consumption of all goods and services by the UK – essentially the country's "carbon footprint". It is territorial emissions - emissions occurring within the UK's borders – which are used both in measuring progress on UK emissions targets and in facilitating international comparison. This data is published annually by the Department for Energy Security and Net Zero (DESNZ), in line with international guidance from the Intergovernmental Panel on Climate Change (IPCC) and reported to the United Nations Framework Convention on Climate Change (UNFCCC).

3.2 In Scotland, the Climate Change Committee currently advocates the use of a GHG account to measure emissions on a territorial basis.[25] This utilises a clear methodology, including the use of a base inventory (typically 1990 for most GHG) upon which progress is tracked. Key to this is using the same measurement approach to calculate target updates as was used to set the baseline level. Essentially, this helps separate out changes in emissions which can be attributed to policy impact as opposed to methodological improvements. The inventory is realigned at least every five years to reflect the most up-to-date scientific methods for the measurement and estimation of emissions.

3.3 Scottish Government also publish estimates of GHG emissions on a consumption basis (Scotland's Carbon Footprint)[26] to meet requirements set out under Section 37 of the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019. This data is used to inform the Scotland Performs National Indicator on Reducing Scotland's Carbon Footprint.[27]

3.4 This chapter looks at how to measure and analyse GHG emissions for sub-regions such as the Highlands and Islands, highlighting gaps and limitations where relevant. It follows established protocols as far as possible to set out baseline GHG emissions for the Highlands and Islands for 2019. It relies predominantly on the UK local authority and regional GHG emissions data published by the Department for Energy Security and Net Zero[28] but uses other data sources as and when appropriate to provide more granularity or address data gaps. Analysis is provided for local authority areas within the region, and comparisons with Scotland overall provided where relevant.

GLOBAL PROTOCOL FOR COMMUNITY-SCALE GHG EMISSIONS

3.5 This baseline study required the use of a methodology that supported structured and detailed analysis of GHG emissions for the Highlands and Islands area. One such method is the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC) which provides a structure for assessing regional GHG emissions. Initially developed to help support city wide GHG emission analysis, the processes the Protocol identifies, can equally be applied in other geographic area, including rural locations. The Protocol seeks to;

- Help cities/areas develop a comprehensive and robust GHG inventory in order to support climate action planning.
- Help cities/areas establish a base year GHG emissions inventory, set reduction targets, and track their performance.
- Ensure consistent and transparent measurement and reporting of GHG emissions between cities/areas, following internationally recognised GHG accounting and reporting principles.
- Enable city/area inventories to be aggregated at subnational and national levels.
- Demonstrate the important role that cities/areas play in tackling climate change and facilitate insight through benchmarking – and aggregation – of comparable data.

3.6 The GPC emissions inventory covers GHG emissions generated directly and indirectly by the people living and working in an area, as well as the impact of visitors to the area. It includes emissions from a number of different sectors, such as Stationary Energy use, Transport, Waste Treatment, Industrial Processes and Product Use, Agriculture and Forestry. Figure 3.1 provides more explanation of these different sectors.

[25] Scottish Greenhouse Gas Statistics 2022 - gov.scot (www.gov.scot)
[26] Scotland's Carbon Footprint 1998-2020 - gov.scot (www.gov.scot)
[27] National Indicators - Economy | National Performance Framework
[28] https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics

Figure 3.1: GPC sectors and sub-sectors

Sectors and sub sectors	
Stationary energy	**Waste**
Residential buildings	Solid waste disposal
Commercial and institutional buildings and facilities	Biological treatment of waste
Manufacturing industries and construction	Incineration and open burning
Energy industries	Wastewater treatment and discharge
Agriculture, forestry, and fishing activities	
Fugitive emissions from mining, processing, storage & coal transportation	**Industrial processes and product use (IPPU)**
Fugitive emissions from oil and natural gas systems	Industrial processes
Non-specified sources	Product use
Transportation	**Agriculture, forestry and other land use (AFOLU)**
On-road	Livestock
Railways	Land
Waterborne navigation	Aggregate sources and non-CO_2 emission sources on land
Aviation	**Other Scope 3**
Off-road	

Source: Global Protocol for Community-Scale Greenhouse Gas Inventories, 2014

3.7 There is a basket of main GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

3.8 To provide consistent GHG measurement the term "Scopes" is used. The GPC distinguishes between emissions that physically occur within an inventory area (Scope 1), those that occur from the use of electricity, steam, and/or heating/cooling (Scope 2) and those that occur outside the area but are driven by activities taking place within the area boundaries (Scope 3). Scope 1 emissions may also be termed "territorial" emissions, because they are produced solely within the territory defined by the geographic boundary.[29] The Scope 2 emissions included in this report are for nationally supplied grid electricity. A proportion of the electricity consumed in the Highlands and Islands will be produced in the area from increasing renewable energy generation. This output is added into the national grid supply and a national electricity emissions factor is used in analysis.

[29] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, Page 11

Table 3.1: Greenhouse Gas Emission Scopes

Scope Definition	Definition
Scope 1	Emissions from sources located within an area inventory boundary (e.g., within the Highlands and Islands), associated with fossil fuel combustion
Scope 2	Emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within an area inventory boundary (e.g., within the Highlands and Islands).
Scope 3	All other emissions that occur outside an area Inventory boundary because of activities taking place within the area.

Source: Greenhouse Gas Protocol, 2023

3.9 The GPC identifies the sector and sub-sectors for reporting GHG emissions of an area such as the Highlands and Islands. Adopting the GPC and using its reporting structure allows a consistent approach to measuring and reporting GHG for an area. However, a significant challenge to using the GPC is the availability of data that would allow for more granular analysis and reporting for the identified sectors/subsectors. For a number of these sectors/sub-sectors, an official times series of GHG emissions data does not exist, restricting the extent to which analysis for the Highlands and Islands can be undertaken fully in line with the GPC methodology.

3.10 To achieve a consistent and transparent approach to measuring the region's GHG emissions, a national statistics dataset which identifies GHG emissions by local authority can be used. This can be complemented with other sources of official data, for example transport GHG emissions. The following sections of this chapter use the local authority dataset to provide an estimate of the GHG emissions for the Highlands and Islands. Chapter 4 builds on this, exploring additional available data sources to provide more detailed GHG emission reporting for the region that reflects the sectors and sub-sectors of the GPC.

REGIONAL GREENHOUSE GAS EMISSIONS USING LOCAL AUTHORITY DATA

The UK local authority and region GHG emissions data set

3.11 Calculating GHG emissions for the Highlands and Islands relies on a portfolio of data. The *UK local authority and regional GHG emissions national statistics timeseries data set* released each year by the Department for Energy Security and Net Zero (DESNZ)[30] (published previously by the Department for Business, Energy & Industrial Strategy (BEIS)) provides a consistent source of data on territorial GHG emissions, which facilitates comparison with Scotland and other parts of the UK. There is approximately a two-year lag in the publication of data (so data for 2021 was published in June 2023). The extent of the time lag reflects the range and complexity of the data required to produce the estimates. The data is derived as far as possible from the data used for the national inventory which is compiled first.

[30] https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics

3.12 The GHG covered by these statistics are carbon dioxide, methane and nitrous oxide. In accordance with international reporting and carbon trading protocols, each of these gases is weighted by its global warming potential (GWP), so that total greenhouse gas emissions can be reported on a consistent basis (in carbon dioxide equivalent units – CO_2e).

3.13 The UK local authority and regional GHG emissions publication combines data from the UK's Greenhouse Gas Inventory with data from a number of other sources, including local energy consumption statistics, to enable disaggregation of emissions to a local level. Data is allocated on an "end-user" basis (where emissions related to energy use are distributed according to the point of consumption rather than the point of production), and some gases and sources of emissions are excluded (for example fluorinated gases (F gases) and emissions from domestic and international shipping and aviation, exports, and military transport) where it is not yet possible to disaggregate available data to local authority level. These methodological differences mean that estimates are not directly comparable with the Scottish Greenhouse Gas Statistics published by Scottish Government, although consistency is sought as far as possible.

3.14 Analysis for this report has been based on the UK local authority and regional GHG emissions national statistics, 2005 to 2021, published on 29th June 2023. A number of the figures for 2019 in this dataset differ from the figures first published in the UK local authority and regional greenhouse gas emissions national statistics, 2005 to 2019 (released in June 2021). This reflects updated and evolving data collection and modelling processes and facilitates use of the most inclusive data in terms of the GHG included in the reporting.

3.15 Analysis in this chapter uses data available at local authority level for the HIREP area, including Argyll and Bute, Highland, Orkney, Shetland, Western Isles and Moray but excluding North Ayrshire, given that only a small part of its geography (Arran and Cumbrae) falls within the HIREP boundary. Including data for the whole of North Ayrshire would have resulted in an overestimate of local and regional GHG emissions. The North Ayrshire local authority area for example has a population density of 149 people per km^2, compared with 12 people per km^2 for the Highlands and Islands area which would have skewed per capita assessments. Later chapters of the report do draw out data for Arran and Cumbrae where it is available. A case study on emissions in Arran and Cumbrae is also included in this chapter.

Baseline GHG Emissions for the Highlands and Islands

3.16 In 2019, the total GHG emissions for the Highlands and Islands were estimated to be 6,236 kt CO_2e, 15% of the Scottish total (Table 3.2). Highland accounts for almost half (46%) of regional emissions. Na h-Eileanan Siar accounts for 19%. This, and the low share of Argyll and Bute (3%) is influenced by net emissions arising from land use, which is discussed below and in Chapter 4.

3.17 Whilst the emissions per km^2 is lower overall (0.15 kt CO_2e) and within each local authority area than the Scotland average (0.53 kt CO_2e), the regional emissions per capita (12.7 tCO_2e) is considerably higher than for Scotland overall (7.8 tCO_2e), though this ranges from 2.2 tCO_2e in Argyll and Bute to 43.1 tCO_2e in Na h-Eileanan Siar. Factors influencing this will undoubtedly be the region's large area and comparatively low population density (around half of Scotland's population density overall). Only Argyll and Bute has a lower per capita emissions level than the national average. Sub-region variations are explored in more detail later in the chapter.

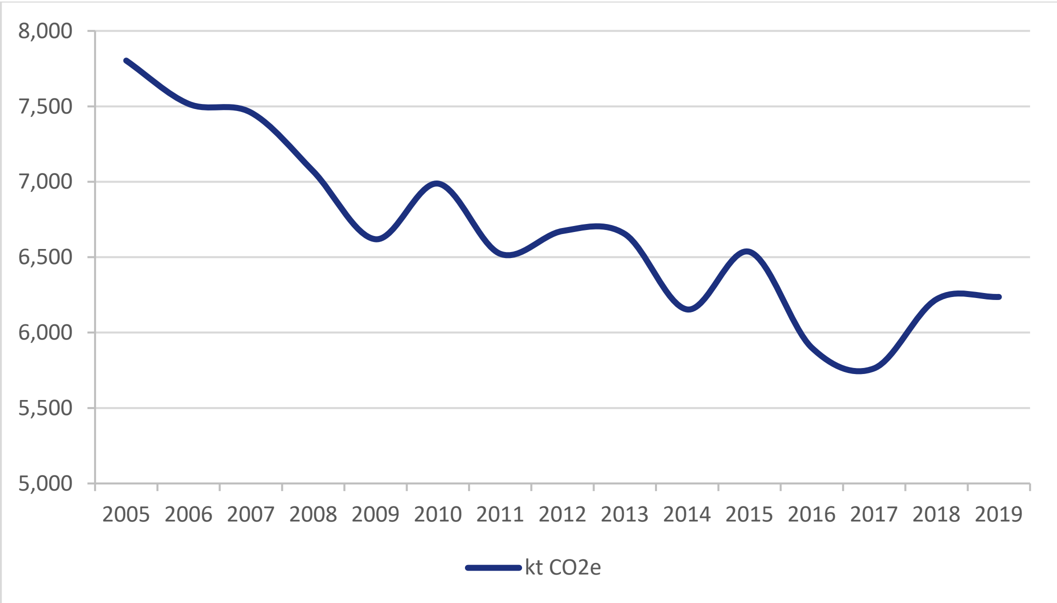
Table 3.2: Local authority territorial GHG emissions estimates, 2019 (kt CO_2e)

LA Area	Total Emissions (kt CO_2e)	% share of regional emissions	Per Capita Emissions (t CO_2e)	Area (km^2)	Emissions per km^2 (kt CO_2e)
Argyll and Bute	188.08	3%	2.17	7,165.17	0.03
Arran and Cumbrae	-	-	-	-	-
Highland	2,894.65	46%	12.21	26,473.95	0.11
Moray	834.87	13%	8.73	2,257.15	0.37
Na h-Eileanan Siar	1,160.07	19%	43.11	3,268.40	0.35
Orkney Islands	375.40	6%	16.81	1,086.49	0.35
Shetland Islands	783.38	13%	34.11	1,657.29	0.47
Highlands and Islands	**6,236.45**	**-**	**12.74**	**41,908.45**	**0.15**
Scotland	**42,469.37**	**-**	**7.78**	**80,232.84**	**0.53**

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. No data available for Arran and Cumbrae; data is only available at the local authority level.

3.18 Though there is some year-on-year fluctuation in the data, the overall trend of emissions in the Highlands and Islands is downwards, decreasing from around 7.8 Mt CO_2e in 2005 to 6.2 Mt CO_2e in 2019 (Figure 3.2).

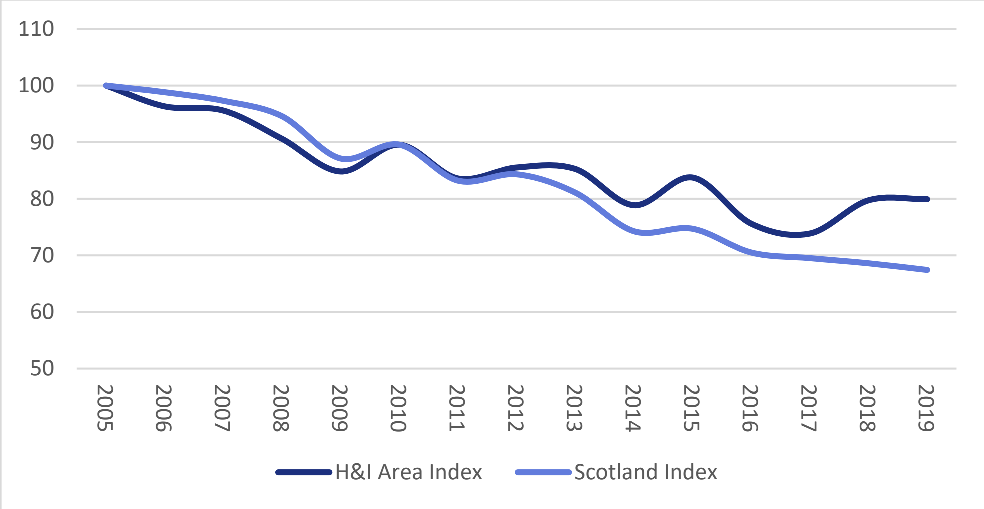
Figure 3.2: Highlands and Islands GHG emissions, 2005 – 2019 (ktCO_2e)



Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Excludes Arran and Cumbrae.

3.19 However, as Figure 3.3 indicates, the rate of decrease is less than for Scotland as a whole, with the Highlands and Islands showing a 20.1% decrease over the period, versus a decrease of 32.6% at the national level (from 63.0 Mt CO_2e to 42.5 Mt CO_2e).

Figure 3.3: Index of Highlands and Islands and Scotland GHG Emissions 2005 – 2019 (ktCO_2e). 2005=100



Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Excludes Arran and Cumbrae.

3.20 It is worth noting that these charts illustrate a key issue – the fluctuation of regional GHG emissions when using national datasets - with no clear explanations for data volatility. For example, the Highlands and Islands net CO_2e emissions figure for wetlands increased from 789.8 ktCO_2e in 2014 to 1,238.7 ktCO_2e in 2015, dropping back to 887.7 ktCO_2e in 2016. It is important to recognise the relative infancy of GHG emissions measurement and management – data collection and measurement is evolving and improving. The local authority data used for this study is the best available time series data, the figures derived from combining data from the UK's Greenhouse Gas Inventory with data from a number of other sources, including local energy consumption statistics, to produce a nationally consistent set of GHG emissions estimates at local authority level. As Department for Energy Security and Net Zero states:

> *These estimates are to help those working on local or regional indicators and inventories as part of their efforts to reduce greenhouse gas emissions. On their own, however, they cannot give all the information necessary to plan and monitor the progress of all local emissions reduction initiatives, this may require additional monitoring at the local level.*

Key sources of GHG emissions in the Highlands and Islands

3.21 Figure 3.4 identifies the key sources of GHG emissions as reported in the annual UK local authority and regional GHG emissions dataset. The top five sources of emissions in the Highlands and Islands in 2019 are:

- Agriculture;
- Land use, land use change and forestry (LULUCF);
- Transport;
- Domestic; and
- Industry.

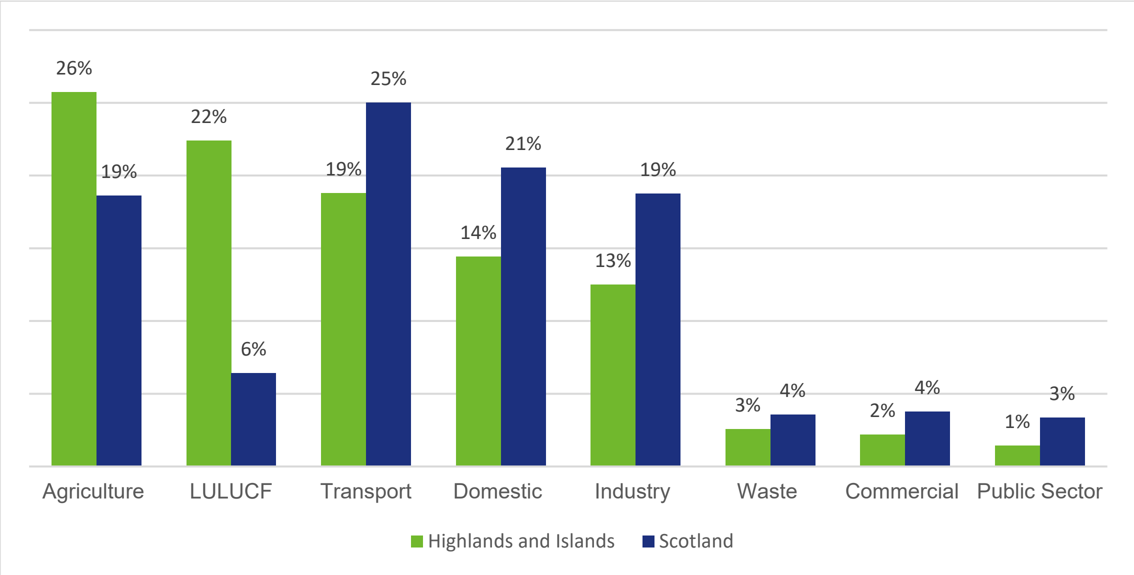
These are the same top five as for Scotland overall, however the order and extent of contribution varies.

3.22 Within the region, the top two sources of emissions – agriculture (1,605.0 kt CO_2e, 26%) and LULUCF (1,396.4 kt CO_2e) – together account for just under half (48%) of the region's total emissions compared to around a quarter (25%) nationally (19% and 6% respectively – ranking fourth and fifth in terms of contribution).

3.23 The next three sectors make up a similar proportion (46%) - transport (excluding aviation and ferries) accounts for just under a fifth of the region's GHG emissions (19%, 1,171.8 kt CO_2e), domestic 14% (898.4 kt CO_2e) and industry 13% (780.1 kt CO_2e). For Scotland these are the top three sources of emissions. It is also worth noting that the region accounts for 10% of industry emissions in Scotland, but 24% of Scotland's industry business base. Emissions per business are lower in the region (115.1 tCO_2e) than nationally (279.1t CO_2e).

3.24 Both regionally and nationally, waste and the commercial and public sectors accounted for a relatively low share of emissions.

Figure 3.4: Regional and Scottish GHG emissions by key source, 2019 (kt CO_2e)

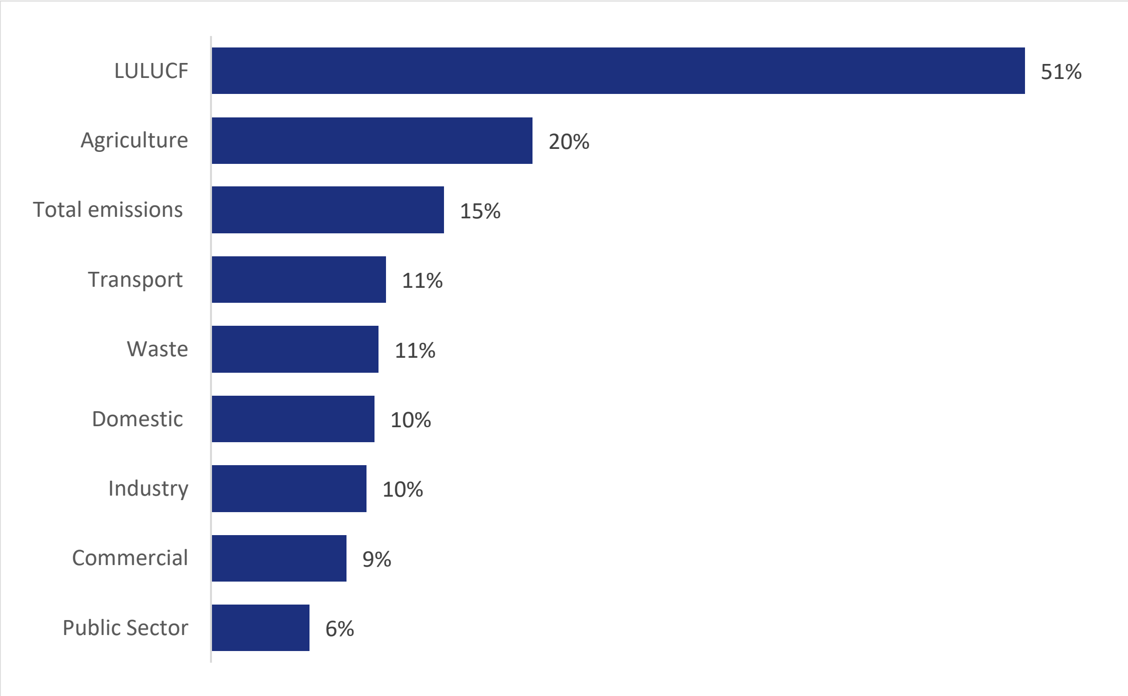


Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Excludes Arran and Cumbrae.

3.25 The Highlands and Islands accounts for a disproportionately high share of Scotland's total LULUCF (51%) and agricultural (20%) emissions (Figure 3.5). However, it accounts for a relatively low share of Scotland's public sector emissions (6%) with the rate per employment (1.3 tCO_2e) lower than nationally (1.9 tCO_2e). The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 sets out specific climate change duties for all public bodies, and a requirement to submit an annual report detailing their compliance with these. Reflecting this, sustained policy interventions and funding have supported the evolution of the public sector estate to be more energy and resource efficient.

3.26 The regional contribution to Scotland's transport emissions (from road and rail) (11%) is in line with the region's share of vehicles and vehicle km (both 11%). Similarly, the region's contribution to domestic emissions is proportionate to its share of domestic properties (both 10%).

Figure 3.5: Regional share of Scotland's total GHG emissions by key source, 2019 (kt CO_2e)



Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Excludes Arran and Cumbrae.

3.27 When assessing emissions by area and key source across the region, some wide variances are evident (Table 3.3). This, in part, reflects the size and population of each area and its sectoral profile, but also the extent of GHG emissions arising from the way land is managed (with land being both a source and sink of emissions). Creating grassland for grazing, by draining peatland or wetlands for example is a significant source of net GHG emissions in Highland, Na h-Eileanan Siar, and the Shetland Islands.[31] In contrast, Argyll and Bute and Moray are both net sequesters of carbon, mainly due to their large forestry plantations.

3.28 In terms of the local authority areas in the region:

- In **Argyll and Bute,** agriculture makes the greatest contribution to emissions, followed by transport. As noted above, the area benefits from significant carbon sequestration and storage in the forestry plantations in the area. There is also a low level of cropland and improved grassland in the area used for livestock, which helps reduce land use GHG emissions. This results in a generally low level of GHG emissions for the second largest local authority area in the overall region.
- **Highland** again benefits from significant carbon sequestration in the area's forestry plantations. However, these are more than cancelled out by the emissions arising from wetlands and grasslands – it is responsible for 50% of Scotland's net emissions from wetlands in 2019. As the largest and most populated local authority area in the Highlands and Islands, there is also a high level of domestic, public sector and commercial energy consumption, all contributing to the area's GHG emissions.

[31] Wetlands and peatlands are stores of carbon. When disturbed or drained, etc., they release greenhouse gases. Our understanding of the carbon storage of peatland and wetland is developing and as a consequence, there is support and funding for carbon/GHG sympathetic management of these areas.

- While there is high energy consumption from industrial consumers in **Moray** (likely driven by the volume of distilleries and manufacturing businesses more broadly), the role of woodland in sequestering emissions is significant. Alongside this, there is a very low volume of emissions released from grassland and wetland.
- For **Na h-Eileanan Siar**, the absence of any significant woodland means the area cannot gain any benefit from carbon sequestration through afforestation. There is also a significant release of emissions from grassland which in more peripheral areas may be a consequence of peatland being drained to provide more favourable grazing.
- In the **Orkney Islands**, agriculture is the key source of emissions. There is a low volume of emissions across a range of sectors in the local economy: industrial, commercial, public sector and transport. There is also a low volume of emissions arising from land management and use.
- The **Shetland Islands** are impacted by the combination of a high level of industry-related emissions and also emissions from grassland, often attributed to the conversion of peatland to provide suitable grazing for livestock.

Table 3.3: Local authority territorial emissions estimates by key sources, 2019 (ktCO_2e)

LA Area	Industry	Commercial	Public Sector	Domestic	Transport	LULUCF	Agriculture	Waste	Total
Argyll and Bute	73.61	39.56	11.36	156.39	205.65	-611.74	291.84	21.41	188.08
Arran and Cumbrae	-	-	-	-	-	-	-	-	-
Highland	340.29	60.09	38.66	438.02	659.35	658.46	628.96	70.82	2,894.65
Moray	304.73	25.47	29.77	169.78	170.91	-168.26	265.06	37.41	834.87
Na h-Eileanan Siar	20.00	4.59	3.40	58.67	50.57	920.04	80.23	22.56	1,160.07
Orkney Islands	11.90	3.62	2.23	38.64	33.89	45.58	236.84	2.69	375.40
Shetland Islands	29.55	3.60	2.98	36.86	51.42	552.25	102.05	4.66	783.38
HIGHLANDS AND ISLANDS	**780.08**	**136.93**	**88.40**	**898.37**	**1,171.79**	**1,396.35**	**1,604.99**	**159.54**	**6,236.45**
Scotland	7,964.74	1,601.39	1,425.24	8,721.33	10,623.79	2,717.41	7,905.99	1,509.48	42,469.37

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023.
No data available for Arran and Cumbrae; data is only available at the local authority level.

3.29 As shown in Figure 3.3, overall, regional GHG emissions declined between 2005 and 2019. However, the nature and extent of change varied across the key sectors whereby there was a decline in emissions for all sectors except for transport (which increased slightly) and LULUCF (Figure 3.6, below). Over the 15-year period 2005-2019:

Sectors experiencing a greater decrease than nationally:

- **Public sector** GHG emissions declined by 52% in the Highlands and Islands and 41% for Scotland. The amount of gas consumed in public sector buildings and the associated GHG emissions increased over this period, regionally and nationally.
- **Domestic** GHG emissions declined by 44% in the Highlands and Islands and 40% for Scotland. Key domestic issues for the Highlands and Islands area will be the transition to lower GHG emission housing stock in the coming years. Despite a higher regional rate of decline in GHG emissions, in comparison to the national rate of decline, the combination of energy availability and price and the quality of housing stock results in elevated levels of fuel poverty in the Highlands and Islands.[32] Over the period 2017–19, along with Dundee City, the six local authorities that make up the Highlands and Islands area had the highest rates of fuel poverty in Scotland. This indicates that whilst the rate of decline has been faster, the Highlands and Islands has a greater challenge to overcome than does Scotland as a whole.
- **Agricultural** GHG emissions[33] in the region declined by 16% compared to a fall of 11% nationally, though the reasons for this difference are not clear from the data. What is known is that the bulk of agricultural emissions in the Highlands and Islands are associated with livestock (63%), while around a fifth (19%) relate to agricultural soils. The decline in emissions could be associated with improved agricultural practices or changes to livestock numbers.

Sectors experiencing a lower change than nationally:

- **Industry** GHG emissions in the Highland and Islands declined by 38% compared with 34% for Scotland as a whole. Within that period, the use of gas and the GHG emissions from larger industrial operation increased in the Highlands and Islands but declined in Scotland.
- **Transport** GHG emissions increased by 4% in the Highlands and Islands but declined by 8% nationally.
- **Waste Management** GHG emissions declined by 44% in the Highlands and Islands and 63% for Scotland.
- Emissions from **LULUCF** *increased* by 45% in the Highlands and Islands while there was a *decline* of 7% across Scotland overall. This is a key sector in the region and has the potential to be a significant driver in Scotland working towards its Net Zero by 2045 commitment.

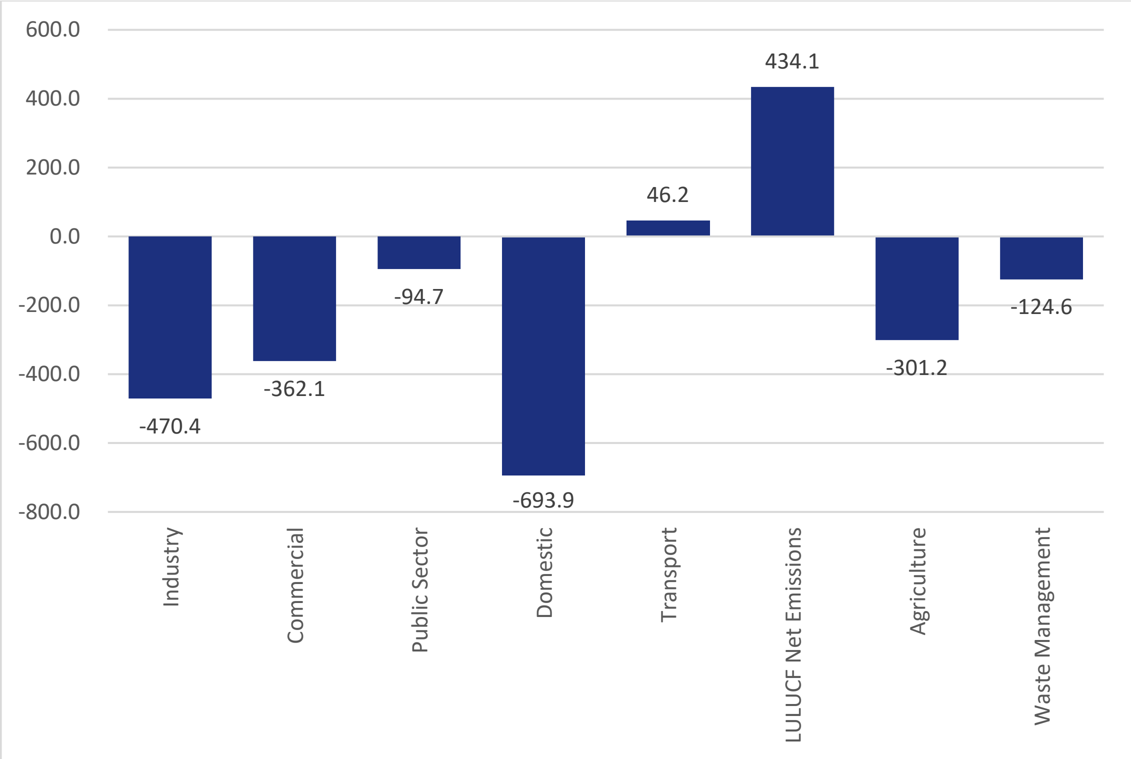
Sectors experiencing a similar decline to Scotland overall:

- Commercial activity GHG emissions fell by 73% in the Highlands and Islands and by 75% in Scotland. There was a greater decline in the use of gas in commercial activity for Scotland, compared to the Highlands and Islands. However, the consumption of other fuels in commercial activity declined at a greater rate in the Highlands and Islands.

[32] A household is deemed to be in fuel poverty "if, in order to maintain a satisfactory heating regime, total fuel costs are more than 10% of the household's adjusted net income (after housing costs), and if after deducting fuel costs, benefits received for a care need or disability and childcare costs, the household's remaining adjusted net income is insufficient to maintain an acceptable standard of living".

[33] This covers agricultural activity. Land management emissions is captured under LULUCF and is considered further with regard to *Agriculture land use, forestry land use and other land use* in Chapter 4.

Figure 3.6: Highlands and Islands – change in GHG Emissions by key sources, 2005-19 (ktCO₂e).



Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Excludes Arran and Cumbrae.

Arran and Cumbrae

Though part of the North Ayrshire local authority area, Arran and Cumbrae are part of the Highlands and Islands Regional Economic Partnership geography. As islands at a sub-local authority level, it is typically challenging to find data that is directly comparable with national, regional and local authority level data on territorial and sectoral carbon emissions.

Arran and Cumbrae are pursuing their own path to net zero, with both positioned as Green Islands. The Green Islands Net-Zero Project was developed in partnership with Arran EcoSavvy and North Ayrshire Council; and Phase 1 was funded by the UK Government UK Community Renewal Fund. The aim is to support the islands of Arran and Cumbrae to accelerate the path to Net-Zero carbon emissions by 2030.[34]

Both islands have developed a Net-Zero Carbon Action Plan each, as part of the project.[35] Taking into consideration emission across domestic and commercial fuels for heating, domestic and commercial electricity consumption, electricity transmission and distribution, biomass burning, public and private transport, fermentation for brewing and distilling, water supply and treatment, waste management, and well-to-tank emissions for fuels consumed, the following emissions have been estimated[36] for Arran and Great Cumbrae:

[34] https://arranecosavvy.org.uk/green-islands-plans/
[35] Adler & Allan for North Ayrshire Council/Arran Eco Savvy (2023) Net Zero Carbon Action Plan, Arran; North Ayrshire Council/Arran Eco Savvy (2023) Net Zero Carbon Action Plan, Great Cumbrae
[36] Because of differences in methodology, these emissions estimates have not been included in the main territorial and sectoral analysis of emissions in Chapters 3 and 4.

- Arran: 59,461 tCO_2e (59.5 $ktCO_2e$); 13.11 tCO_2e per capita
- Great Cumbrae: 5,777 tCO_2e (5.7 $ktCO_2e$); 4.46 tCO_2e per capita

Both plans set out recommended actions to achieve an 80% reduction in its emissions and become net zero in doing so. These cover: energy efficiency in buildings; community energy buying; renewable energy generation and heat production, alternative fuels, electric vehicles, public transport improvements (across both coverage and vehicle propulsion), and skills and training to support the transition. It also sets out suggested actions on carbon offsetting and sequestration to bolster net zero activity.

Cumbrae is also one of Scotland's Carbon Neutral Islands (CNI)[37], along with Barra and Vatersay, Hoy and Walls, Islay, Raasay, and Yell. The project is a 2021-2022 programme for government commitment aimed at supporting six islands to become carbon neutral by 2040. It provides an opportunity to demonstrate the low carbon energy potential of islands as hubs of innovation in relation to renewable energy and climate change resilience.

The Community Climate Action Plans for each of the islands provide a useful emissions profile, illustrating target areas to be addressed to achieve net zero. For Cumbrae, the greatest volume of emissions is from energy (3523 tCO_2e) and transport (3500 tCO_2e). In terms of LULUCF, Cumbrae is a net sequester, primarily due to forestry. LULUCF is the dominant source of emissions for most of the other islands in the CNI project, with the exception of Raasay which is also a net sequester (no data is available on this for Islay).

As with our regional emissions profile, it is clear that LULUCF is fairly integral to reducing emissions at individual island level, and its success in doing so is evident in Cumbrae and Raasay. Transport decarbonisation and the energy transition will also be key.

Table 3.4: Carbon Neutral Islands, Emissions by Sector (tCO2e)

	LULUCF	Agriculture	Waste	Energy	Transport	Total
Barra and Vatersay	17,334	1,210	898	6,564	13,197	39,203
Cumbrae	-3,200	1,700	400	3,523	3,500	5,923
Hoy and Walls	16,928	4,652	204	3,193	2,490	27,467
Raasay	-906	513	177	1,677	789	2,250
Yell	70,742	3,887	306	7,906	6,048	88,889
Islay	not available	not available	9,500	68,300	21,500	not available

Source: Community Climate Action Plans for each Island - https://cni.scot/community-climate-action-plans-ccaps/

Cumbrae's Community Climate Action Plan identifies the following key priorities:

- Warmer homes, lower energy bills and reduction of fuel poverty
- More sustainable transport, particularly the ferry route and a reduction in the number of private vehicles
- Nature based solutions and habitat restoration
- Feasibility of community owned energy generation on Cumbrae.

[37] https://cni.scot/

SUMMARY DISCUSSION

The UK Local Authority and regional GHG emissions dataset has been used to provide a regional baseline of GHG emissions for the Highlands and Islands. It does utilise a top-down approach, and thus lacks the granularity of other data sources, for example, focusing on land-based transport at the expense of water-based and aviation – both of which are critical transport modes in an extensive and hugely diverse geographic region. As the data is only disaggregated to local authority level it does not capture emissions for Arran and Cumbrae (which constitutes only a small part of the North Ayrshire local authority but is contained within the HIREP boundary). Other data sources have been used to provide some illustration of this. However, the UK Local Authority and regional GHG emissions dataset does provide a consistent time-series against which progress can be tracked, and which facilitates comparison with Scotland overall.

Despite the imperfect nature of the data, it does provide a clear illustration of the nature and extent of GHG emissions across a range of sources, how this varies across the region, and how it relates to Scotland's emissions profile.

Having such a baseline is important in the context of decarbonising economic (and indeed domestic) activity in the Highlands and Islands and supporting the transition to net zero. It provides clarity on where policy and action need to be focused. Agriculture and LULUCF are the two predominant sources of emissions, and both account for a disproportionately high share of Scotland's agriculture and LULUCF emissions. Addressing this will be fundamental to reducing the region's GHG emissions. Higher reliance on road transportation, with limited alternative options signal a need to accelerate the rollout of infrastructure to support a modal shift to vehicles using greener sources of fuel.

Another key factor at play is the reliance on alternative (carbon intensive) fuels for heating in domestic and non-domestic properties in the Highlands and Islands. Compounding factors for all of this include the balance of land use practices, the energy efficiency of our buildings, location of where people live, access to services, work, public transport, etc. and the impact of the region's geographical characteristics on this.

The analysis suggests that a more intensive and co-ordinated approach to decarbonisation may be required at the regional level. Additionally, consideration of sub-regional variations highlights some potential priority action areas at the local level.

The next section gives further consideration to sectoral analysis of GHG emissions.

4 REGIONAL EMISSIONS: SECTORAL ANALYSIS

Chapter summary

- Much of the region’s emissions arise from a dependency on carbon intensive fossil fuels, particularly for space heating but also in industrial and manufacturing processes.
- GHG emissions from energy consumption in non domestic activity has been consistently decreasing in recent years. However, lack of available data presents a challenge to estimating emissions for specific types of commercial and/or industrial activities.
- There is an extensive public sector estate in the region which has been proactive in its decarbonisation activity, supported by legislation and sustained policy interventions.
- Most (70%) of the region’s transport emissions relate to road transport and more than half of this is attributable to diesel and petrol cars. A high proportion (over three fifths) relates to personal rather than commercial use. With the exception of petrol fuelled cars, emissions from all other forms of road transport have increased in recent years.
- Emissions from ferries are estimated to be between 250 300 ktCO_2e (22% of all transport emissions). Replacement programmes for the region’s ferry fleets include a shift to more sustainable fuel sources. However, there is a lack of data to facilitate analysis of emissions from other sources of water based transport such as fishing vessels and leisure craft.
- While emissions from aviation accounts for a relatively small proportion of regional transport emissions (90.5 ktCO_2e, 7%), emissions per passenger are typically higher than for other modes of transport. The region is leading on trialling and demonstrating hybrid and electric air transport though projects such as the Sustainable Aviation Test Environment (SATE).
- Reflecting, in part, the absence of rail infrastructure in many parts of the region, rail emissions are relatively low (18 ktCO_2e, 1% of all transport emissions). The region’s rolling stock is currently diesel powered, with no electrification of lines as yet. The number of passengers using railway stations in the region grew steadily between 2000 and 2019.
- GHG emissions occurring from industrial processes, product use, and non energy uses of fossil fuel (IPPU emissions) are estimated to total around 794 KtCO_2e in 2019. IPPU emissions are attributable to a small number of high polluting industrial sites across the region. Shetland accounts for around 65%, driven by activity related to the Sullom Voe Terminal.
- While emissions from landfill activity in the region and across Scotland overall have declined in recent years, it still accounts for the majority of waste emissions in the region. Based on a measure of the whole life carbon impacts from waste, household waste emissions per person are estimated to be higher in the region than nationally. Given the diverse range of waste production collection and management/treatment in the region, it is challenging to assess the specific GHG emissions arising from different waste streams and processing.
- The LULUCF sector contains both sources and sinks/stores of GHG, with the region currently a net contributor of LULUCF emissions. While the region benefits from a significant level of GHG absorption by existing woodland and forestry plantations, there is currently significant release of GHG emissions from grasslands and wetlands. Sub national variation is evident Argyll and Bute and Moray are both net sequesters in terms of LULUCF emissions, mainly due to their large forestry plantations. The island local authorities have net positive emissions, with agricultural and land management and peatland degradation, and the absence of large forestry plantations all being factors of this.

INTRODUCTION

4.1 The emissions estimates within the UK Local Authority and Regional GHG Emissions dataset published by the Department for Energy Security and Net Zero (DESNZ) presented in Chapter 3 is the baseline for the region. It provides a high level GHG emissions profile for the Highlands and Islands by key areas of activity, based on territorial (Scope 1) emissions only. It allows comparison with Scotland overall and other parts of the UK and is updated on an annual basis to facilitate tracking over time. However, it does not provide emissions figures for all the sectors and sub-sectors identified in the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC).

4.2 These sectors/subsectors are identified as the consistent building blocks when completing an area GHG inventory. A significant challenge in undertaking such an inventory is the infancy of data collection and reporting for GHG analysis and the absence of data for the sector/subsectors identified in the GPC. To try and address the shortcomings in the provision of official data for the sectors/subsectors, a range of data sources has been reviewed to try to identify a “best fit” for the subsequent GHG analysis. This approach has provided varying degrees of success.

4.3 Within the chapter, analysis of the Highlands and Islands GHG emissions is sub-divided into sub-sectors, and where beneficial, into sub-categories (see Figure 3.1 in the preceding chapter). For example, stationary energy consumption can be divided into commercial and domestic property, amongst others, and on-road transport can be split between cars, lorries, buses, etc.

4.4 Where necessary, a composite picture of analysis has been developed using a combination of data sources. For example, transport fuel consumption and subsequent emission estimates were derived through a combination of approaches and data, and this is discussed in more detail in the relevant section below. Some of the datasets will identify the actual units of energy consumed, for example kWhs of electricity. Others will identify the level of energy consumed as tonnes of oil equivalent (TOE). Having extracted these different figures, they are then converted to the respective GHG emissions totals. This approach has been taken to both sense-check the data presented in Chapter 3, examining it in more detail, and to assess the robustness of alternative data sources where these exist.

Examples of alternative data sources used

4.5 Domestic electricity and gas use can be collected for specific meter points. Using this data, analysis based on electricity consumption has a high degree of accuracy. In Scotland, this information is available for Middle Layer Super Output Area (MSOA) and Lower Layer Super Output Area (LSOA)[38] although the LSOA has more data points. Gas consumption[39] is also recorded by specific meter points and cross-referenced with volumes of gas distributed by national and major transporters. Gas and electricity consumption data has been sampled for MSOA and LSOA and found to correspond. They also correspond with subnational (local authority) energy consumption totals.

4.6 Within the Highlands and Islands, natural gas mains infrastructure is limited to main urban centres with significant use of alternative fuels used in rural properties. The consumption of these alternative fuels is recorded in UK Government Sub-national residual fuel consumption statistics datasets.[40] This data facilitates a more accurate profile of domestic energy consumption across the

[38] https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-electricity-consumption
[39] https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-gas-consumption
[40] https://www.gov.uk/government/statistics/sub-national-residual-fuel-consumption-2005-to-2019

Highlands and Islands, as well as in specific local authority areas. This is an important aspect of the Highlands and Islands GHG emissions profile. There is a significant range in the age, type and construction of housing stock in the region. These factors all contribute to the energy efficiency of properties and corresponding issues such as higher levels of fuel poverty in some of the region's more peripheral coastal and island areas. Making these properties more energy and fuel efficient will be a key challenge and business opportunity in the coming years.

4.7 Commercial energy consumption is more challenging to identify at smaller geographies. This is a result of protecting the identity of large local users, especially at very small geographies. The energy consumption of large consumers is grossed up to an "unallocated" category for a larger area, often the local authority area. At the local authority level, commercial electricity and commercial gas consumption figures are available through UK Government regional and local authority level electricity and consumption statistics.[41,42] MSOA and LSOA electricity[43] and gas[44] consumption statistics are an alternative source here.

STATIONARY ENERGY

4.8 The GPC uses the term 'stationary energy' to reflect the energy consumption and associated GHG emissions arising from a number of different sources, as illustrated in Figure 3.1 and identified below:

- Residential buildings
- Commercial buildings
- Institutional buildings and facilities
- Manufacturing industries
- Construction
- Energy industries/utilities
- Agriculture, forestry and fishing activities
- Non-specified sources
- Fugitive emissions from mining, processing, storage, and coal transportation
- Fugitive emissions from oil and natural gas systems

4.9 The following fuels (electricity is not classed as a fuel but is also consumed in properties in the area) are consumed in properties in the Highlands and Islands and subsequently release emissions:

- Mains supplied natural gas is used primarily in the settlements of Nairn, Inverness, Dingwall and around the north shore of the Cromarty Firth. Stornoway, Thurso, Wick, Oban and Campbeltown are on town gas networks that are operated as Scottish Independent Undertakings (SIUs). Gas is consumed mainly for heating in the domestic sector. More than 6 out of 10 domestic properties in the Highlands and Islands area are not able to access a gas grid supply, compared with just under 2 in 10 domestic properties for Scotland as a whole.[45] Natural gas is also consumed in the commercial sector.

[41] https://www.gov.uk/government/statistics/regional-and-local-authority-electricity-consumption-statistics
[42] https://www.gov.uk/government/statistics/regional-and-local-authority-gas-consumption-statistics
[43] https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-electricity-consumption
[44] https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-gas-consumption
[45] https://hansard.parliament.uk/commons/2024-03-06/debates/C6CD4206-C186-4E6D-B401-BCBDC10F4386/EnergyRebatesHighlandsAndIslands

- LPG and heating oil provide domestic and commercial space and water heating in properties that do not have access to mains gas. Several local and national commercial suppliers provide this fuel.
- Coal is primarily used to provide space and water heating in domestic and commercial properties that do not have access to mains gas.
- Biomass is consumed in domestic, commercial, and institutional properties.

4.10 There is a cost consideration as well as an emissions perspective to the type of fuels used in domestic and non-domestic buildings. Recent years have seen an increase in the wholesale prices of gas and electricity, driven by a number of macro-economic geopolitical factors. Though prices have stabilised to a degree, energy prices are now much higher than previously. In contrast to domestic consumers, there is no price cap on electricity or gas bills for commercial and industrial customers. The prices for other fuels, including oil, heating oil and vehicle fuel have increased significantly. Over half the business units in Scotland not connected to the gas network are in the Highlands and Islands, and these account for more than 60% of all business units in the region. The resulting over-reliance on electricity and other fuels, particularly for heating, means that businesses typically pay more per kWh for their fuel needs, and are also more exposed to price rises and price volatility. [46]

Domestic (residential) energy consumption and resulting GHG emissions

4.11 Two primary sources of energy are used in residential properties – electricity and mains supplied natural gas (or alternative heating system fuels). The former can provide heating as well as powering appliances, etc. Gas is primarily associated with domestic heating in more urban locations while coal, heating oil and manufactured fuels are more associated with heating in off-gas grid locations.

4.12 Based on small area energy consumption figures, domestic energy consumption in the Highlands and Islands in 2019 was approximately 3.96 billion kWh, which equates around 926.7 ktCO_2e (Table 4.1). Emissions from electricity generation and consumption accounted for the largest share, followed by emissions from heating oil. Electricity is produced from a range of sources and distributed around the country in the national grid. There is an amount of GHG emissions produced for each kWh of electricity generated in a power station. Each year the carbon intensity of electricity consumed is declining, as more renewable energy feeds into the national electricity grid. These emissions are attributed to the electricity consumer as a Scope 2 emission. When distributing this power station output to consumers, some of the power is lost in the transmission process. This is known as Transport and Distribution losses (T&D Losses) and these are allocated to a consumer or area, region etc as a Scope 3 emission. The combustion of natural gas, heating oil, coal and manufactured fuels all involve the consumption of a fuel in the Highlands and Islands area. As a result, they are presented as Scope 1 emissions.

4.13 The regional baseline identified domestic property GHG emissions as 898.4 ktCO_2e. The following table, informed by accessing the smaller area energy consumption figures, which we then multiply by the respective GHG emission factors, identify domestic property GHG emissions at 926.7 ktCO_2e. The difference between the figures is around 28 ktCO_2e, which reflects the difference from including/excluding Scope 3 Transmission and Distribution (T&D) loss GHG emission figures.

[46] ekosgen, for HIE (2022) Impact of energy price rises on businesses in the Highlands and Islands

Table 4.1: Domestic energy consumption and GHG emissions for the Highlands and Islands, 2019

	Residential kWh	Scope 1 $ktCO_2e$	Scope 2 $ktCO_2e$	Scope 3 $ktCO_2e$	Total $ktCO_2e$
Electricity	1,337,462,079	0.0	338.4	0.0	338.4
Natural Gas	1,431,209,673	262.6	0.0	0.0	262.6
Heating Oil	1,124,621,000	276.1	0.0	0.0	276.1
Coal	30,238,000	9.5	0.0	0.0	9.5
Manufactured Fuels	32,564,000	11.3	0.0	0.0	11.3
T&D Losses	0	0.0	0.0	28.8	28.8
Total	**3,956,094,752**	**559.6**	**338.4**	**28.8**	**926.7**

Source: Department for Business, Energy & Industrial Strategy Lower and Middle Super Out Areas Electricity and Gas Consumption, 2020; Sub-national residual fuel consumption in the United Kingdom and Energy Consumption in the UK, 2019; UK Government GHG Conversion Factors, 2020; BRES, 2018[47] Excludes Arran and Cumbrae.

Low Carbon and Domestic/Residential Property

In the Highlands and Islands, domestic/residential GHG emissions are responsible for about 14% of the overall total, compared to 21% nationally. Table 4.1 identifies the range of GHG emissions arising from energy consumption in domestic properties in the area. Over the coming years, a number of policy interventions will seek to influence and reduce the production of these domestic/residential GHG emissions. This will drive new training requirements, as well as business opportunities in the local construction/trades sectors.

From 1 April 2024, the Building (Scotland) Amendment Regulations 2023 will prohibit the use of direct emission heating (DEH) systems in new buildings in a bid to eliminate the GHG emissions associated with delivering space heating, hot water, and cooling in new buildings, as well as conversions of existing buildings under specific circumstances. This is the first regulatory step in changing the way Scotland’s buildings are heated and cooled to be compatible with net zero.

Private rented accommodation (private rental sector; PRS) generally has poorer energy efficiency than other areas in the domestic sector. The Scottish Government had proposed to introduce regulations requiring all PRS properties to reach a minimum standard equivalent to EPC rating C on a change of tenancy from 2025, with a backstop date of 2028 for all remaining properties in the PRS to reach an EPC standard of C. However, the November 2023 consultation “Delivering Net Zero for Scotland’s Buildings Changing the way we heat our homes and buildings” confirms more relaxed interventions will be applied to make the housing stock more energy efficient.

A key risk for the HIREP area is that there is not a suitably sized, qualified and trained workforce, or businesses, to undertake this work. This is already well-evidenced in the house insulation sector where public sector contracts have to source installers from outwith the Highlands and Islands. While there remains a significant number of poorer energy efficiency performing domestic properties, this leaves the area’s residents vulnerable to significant energy price increases and the prevalence and persistence of fuel poverty.

[47] Sources used for all subsequent tables

Commercial buildings

4.14 Energy consumption and associated GHG emissions from non-domestic activity has been consistently declining in recent years. Two primary sources of energy are used in commercial properties – electricity and mains supplied gas. The other main sources of energy used in the commercial sector are petroleum and coal.

4.15 While there is a high level of robust disaggregation of energy consumption information and data available for domestic properties, the same is not the case for commercial premises. The middle layer super output area (MSOA) combines both commercial and industrial electricity consumption, to provide a single non-domestic source of energy consumption information, so the ability to disaggregate analysis for the commercial, industrial, and institutional sectors is limited. There is also the challenge with smaller area commercial energy consumption data of identifying specific consumers. To protect confidentiality, the consumption of larger operators in rural areas is collated in an "unallocated" heading. However, the UK local authority and regional greenhouse gas emissions national statistics: 2005-2021 data for the Highlands and Islands can be used to provide more detail on the nature of commercial property emissions in the region.

4.16 Emissions arising from energy consumption in commercial properties in the Highlands and Islands totalled around 137 ktCO_2e in 2019 (around 2.2% of the region's overall GHG emissions) (Table 4.2). Most of these emissions were accounted for by electricity consumption. No emissions figure for T&D losses is included as the official data sourced for commercial property emissions is presented in ktCO_2e and not the actual units of energy consumed; as such T&D emissions cannot be calculated.

Table 4.2: Commercial property GHG emissions 2019 ktCO_2e

	Scope 1 ktCO_2e	Scope 2 ktCO_2e	Scope 3 ktCO_2e	Total ktCO_2e
Electricity	0	85.3	0	85.3
Natural Gas	45.9	0	0	45.9
Other	5.7	0	0	5.7
Total	**51.6**	**85.3**	**0**	**136.9**

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021 Department for Energy Security and Net Zero (DESNZ). Excludes Arran and Cumbrae.

4.17 The region accounts for a relatively low share of the national total (9%), reflecting its share of Scotland's commercial business base (10%). Commercial emissions per employment in the region are in line with the national figure (both 1.1 tCO_2e), but emissions per business (9.48 tCO_2e) are lower (11.44 tCO_2e nationally).

4.18 In many parts of the region, lack of access to the on-grid energy supply and quality and age of buildings – whether commercial premises or residential dwellings – is a compounding factor, driving up energy consumption, and thus carbon emissions. The absence of a price cap on electricity or gas bills for commercial and industrial customers coupled with the over-reliance on electricity and other fuels, also means that businesses typically pay more per kWh for their fuel needs, and are more exposed to price rises and price volatility.[48]Although there in ongoing emphasis on energy efficiency in buildings, and reducing energy consumed, a significant challenge to financial and GHG emission

[48] ekosgen, for HIE (2022) Impact of energy price rises on businesses in the Highlands and Islands

savings arising from this is the lack of a local supply chain to undertake this work. This is already impacting on the ability to reduce stationary energy use and associated emissions in the region.

4.19 Whilst the energy efficiency of equipment in commercial buildings has improved, there are also several structural issues which have helped to reduce commercial building fossil fuelled energy use. These include greater levels of renewable energy (especially heat), buildings used to deliver more service-related activity and operations which are undertaken in more insulated, better heated, managed, and constructed properties.

Institutional buildings and facilities

4.20 There is an extensive public sector estate in the Highlands and Islands. This includes healthcare facilities; hospitals, local medical practices, dental surgeries, and such like, as well as regional office/service-based activity. There are also a range of leisure and recreation facilities managed by the public sector and other charitable bodies such as Shetland Recreation Trust and Highlife Highland. As Table 4.3 illustrates, emissions arising from fossil fuel consumption in public sector buildings and facilities in the Highlands and Islands amounted around 88 ktCO_2e in 2019. The region accounts for a relatively low share of Scotland's public sector emissions (6%) with the rate per employment (1.3 tCO_2e) lower than nationally (1.9 tCO_2e).

4.21 Legislation, sustained policy interventions and funding have supported the evolution of this public sector estate to be more energy and resource efficient. The displacement of traditional fossil fuelled heating systems with, for example, biomass has helped to reduce GHG emissions. Recent years have also seen the installation of significant numbers of photovoltaic (PV) arrays, which displace consumption of grid supplied electricity. However, there is also a significant legacy of old, high energy consuming and GHG emitting buildings that will be costly to make more energy efficient and lower GHG emissions. There is ongoing discussion about how the public sector estate needs to reduce in size and what will happen to these buildings. Some rationalisation is already evident which will see the further reduction of emissions associated with public sector buildings. However, a key challenge is that any buildings disposed under this rationalisation and then obtained by for example a local community group, would still need to "decarbonised". There are different sources of energy efficiency and renewable energy funding that new commercial and community owners of disposed public estate buildings, can apply for, to help with this decarbonisation.

Table 4.3: Public sector buildings GHG emissions 2019 – ktCO_2e

	Scope 1 ktCO_2e	Scope 2 ktCO_2e	Scope 3 ktCO_2e	Total ktCO_2e
Electricity	0	43.2	0	43.2
Natural Gas	42.5	0	0	42.5
Coal / other	2.7	0	0	2.7
Total	**45.2**	**43.2**		**88.4**

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021 Department for Energy Security and Net Zero (DESNZ). Excludes Arran and Cumbrae.

4.22 Within the HIREP area there is 2.7 ktCO_2e arising from the use of "other" fuels in public sector buildings. This is likely to include biomass fuel consumed to provide space and water heating. The use of biomass provides an extremely low GHG emission fuel for use in the public sector estate. It is not possible to confirm the proportion of the "other" fuels that is derived from biomass.

Manufacturing and production industries

4.23 The Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC) provides a structure for considering commercial and industrial GHG emissions (see Table 3.1 in previous chapter). Unfortunately, there is no single source of GHG emission data for these different sectors[49] that we can use to inform the Highlands and Islands GHG emissions profile at the level of sector/subsector identified in the GPC.

4.24 To try and address this gap in commercial and industrial GHG emissions data a number of different sources of sectoral energy consumption and GHG emissions information were reviewed. In June each year, the Office for National Statistics (ONS) release UK level statistics for energy use: fossil fuels by fuel type and industry.[50] This data enables identification of the energy/fuel consumption for different sectors at a UK level. It is possible to assess the proportions of total fuel consumed at a UK level and relate this to the different sectors. Working on the assumption that the proportions of fuel consumed in different industrial activities equates to the same share of total local authority area GHG emissions for the commercial and industrial sector allows us to use these ratios to inform GHG emissions for the manufacturing and production industries.

4.25 Table 4.4 identifies how by using this modelling approach, stationary energy consumption and associated GHG emissions can be disaggregated to different commercial activity (for example, manufacturing industries and construction and energy industries to give an estimate of emissions by broad groupings of economic sectors. As can be seen, manufacturing, construction, and energy account for around 2,078.2 ktCO_2e of GHG emissions.

Table 4.4: Private sector GHG emissions 2019 – ktCO_2e

	Argyll and Bute	Arran and Cumbrae	Highland	Moray	Na h Eileanan Siar	Orkney Islands	Shetland Islands	Total (Highlands and Islands)
Manufacturing industries	32.3	-	497.3	143.4	199.3	64.4	134.5	1,071.3
Construction	1.3	-	20.1	5.8	8.1	2.6	5.4	43.4
Energy industries	29.1	-	447.3	129.0	179.2	57.9	120.9	963.5

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023, Energy use: fossil fuels by fuel type and industry, Office for National Statistics 2023. Data available at local authority level only, and so excludes Arran and Cumbrae.

4.26 The analysis of sector GHG emissions is obviously an important consideration for regional stakeholders and could be an area for further analysis. However, it is essential to note the caveats involved with such a high level of modelling, particularly in using national factors and applying these to rural areas with different conditions such as a lack of mains supplied natural gas. Other significant assumptions used to support analysis in Table 4.4 include:

- UK-wide data for fuel consumption for manufacturing industries, construction and energy industries is used in the analysis given that this is not available at local authority/regional levels. It is assumed that the fuel consumed to deliver the economic activity in the Highlands

[49] No data available for Arran and Cumbrae; data is only available at the local authority level.
[50] https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsfuelusebytypeandindustry

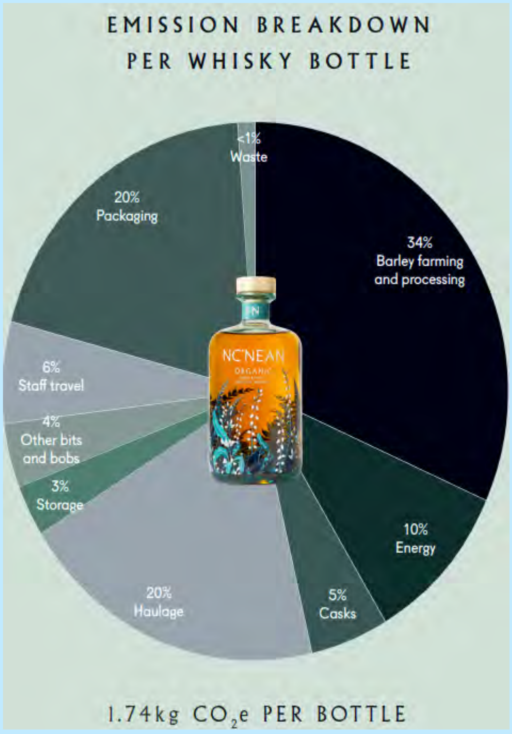
and Islands would be equivalent to the UK average. However, given that there is limited access to mains supplied natural gas outwith the more urban parts of the Highlands and Islands, consumption of gas in different sectors in the Highlands and Islands is likely to be restricted in comparison with the rest of the UK.
- Fuel consumption does not necessarily equate to emissions depending on the way it is used, efficiency considerations, and such like.

Whisky sector (manufacturing)

In 2022, Scotch Whisky accounted for 77% of Scottish food and drink exports and 25% of all UK food and drink exports. The Scotch Whisky industry provides £5.5bn in gross value added (GVA) to the UK economy (2018). With its significant use of energy, Scottish whisky is a key source of GHG emissions. For example, Table 3.2 in the preceding chapter identifies the high overall and per capita production of GHG emissions in Moray, where there are around 50 distilleries.

Recognising the need to reduce emissions, the Scottish Whisky Association has clear commitments for the industry to develop lower emission operations and move towards Net Zero.

Some individual producers are going further. Overlooking the Sound of Mull, **Nc'nean** is an independent organic whisky distillery that exists to create experimental spirits and pioneer sustainable production. The business is at the forefront of measuring and addressing its GHG emissions, comprehensively assessing the emissions from its operations, as well as its supply chain.



The business annually reviews its GHG emissions. Together with all the emissions associated with its supply chain, the total carbon footprint for a whole year is less than one return plane journey from London to New York. In 2021-22 the carbon footprint per bottle produced decreased from 1.87kg CO_2e per bottle, to 1.74kg CO_2e. In 2021 Nc'nean became the first UK distillery to achieve net zero emissions for its production, beating the whisky industry target by 20 years.

The business's use of the metric of CO_2e per bottle (an alternative is per litre of spirit) is a helpful intensity factor that allows a comparison across years but also across different production facilities. In multi-site businesses, this type of metric/intensity factor can help identify higher emission activity and the scope for targeted energy efficiency interventions.

TRANSPORT

4.27 The Highlands and Islands covers around half the landmass of Scotland. The most populated areas are located in the east where there are main (trunk) roads, rail access and the region's main airport at Inverness. Moving to the west and north, transport infrastructure changes to primarily road-based and the population density decreases in these more peripheral areas. This presents challenges in terms of alternatives to car travel, with frequency and viability of public transport a persistent issue. Most of the region's local authorities (excluding Moray) contain islands, with Na h-Eileanan Siar, Orkney and Shetland being full island authorities. These island groups are reliant on ferry and air travel, while road networks are used to provide on-island personal, commercial, and public transport.

4.28 Journeys via road, rail, water, or air can either be wholly contained within the Highlands and Islands or cross boundaries where travellers will leave or enter the region. Moving from, or into the region is known as transboundary travel. There are three types of transboundary trips:

1. Trips that originate in the Highlands and Islands but terminate outwith the area,
2. Trips that originate outside, but terminate within the Highlands and Islands,
3. Trips that pass-through the Highlands and Islands (though there are extremely limited options for pass-through travel).

4.29 A key challenge in calculating the emissions impact of the region's transport is the very mobile nature of the production of these emissions. This is compounded by the challenge of identifying transboundary emissions in a meaningful manner. As such, there can be differences in the degree of confidence and accuracy arising from emissions derived from accurate road count and fuel use data and modelled assumptions concerning the origin and destination of transboundary travel. However, with growing uptake of low emission and non-internal combustion engine vehicles, there is increasing value in understanding the source of transport emissions and how these will be addressed as we reduce transport reliance on fossil fuels.

4.30 The baseline transport emissions for the region outlined in Chapter 3 are calculated from the UK Regional and Local Authority GHG Emissions dataset published by DESNZ. However, this is based on emissions for road transport (A roads, minor roads and motorways (of which there are none in the Highlands and Islands)), diesel railways and 'other' transport (LPF and coal). Water transport and aviation, vital to the Highlands and Islands are not included. In this chapter, other data sources have been used to address gaps, to identify the sources of emissions for different types of vehicles and modes of transport, and to explore trends over time.

4.31 To facilitate detailed analysis and reflecting guidance from the GPC, the Highlands and Islands area transport sector is divided into five sub-sectors:

- On-road transportation
- Railways
- Water transport
- Aviation
- Off-road transportation – this category typically includes all-terrain vehicles, landscaping and construction equipment, tractors, bulldozers, amphibious vehicles, snowmobiles and other off-road recreational vehicles. Due to the complexity of collecting data for this diverse sector, it is excluded from this assessment.

On-road transport

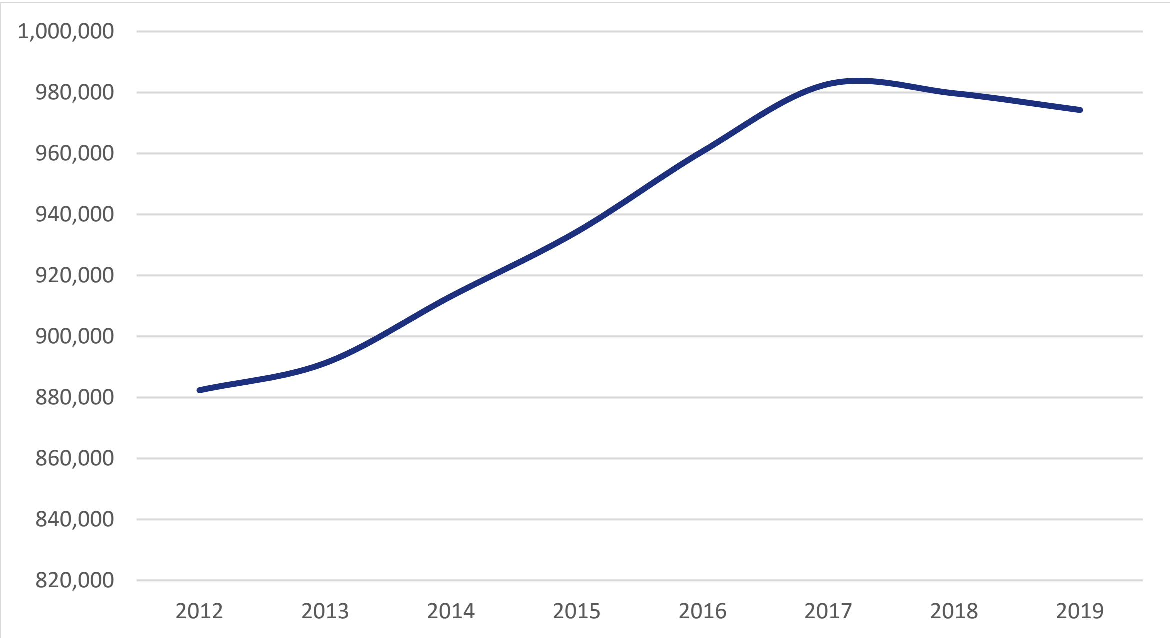
4.32 The GPC defines emissions from road transport as all emissions arising from the combustion of fossil fuels for transport vehicles and mobile equipment. Emissions from these sources can be calculated directly from the fuel consumed or vehicle km travelled. The GPC divides transport emissions into within-boundary trips (Scope 1) and cross-boundary trips (Scope 3).

- **Scope 1:** Includes all GHG emissions from the transport of people and freight occurring within the Highlands and Islands area boundary.
- **Scope 2:** Includes all GHG emissions from the generation of grid-supplied electricity used for electric-powered vehicles.
- **Scope 3:** Comprises emissions from the portion of transboundary journeys occurring outside the region. Also includes the transmission and distribution losses from grid-supplied electricity for charging electric vehicles. This includes the out-of-inventory portion of all transboundary GHG emissions from trips that either originate or terminate within the Inventory boundary.

4.33 There is a significant road network in the Highlands and Islands. Data from the 2019 edition of Scottish Transport Statistics show 15,195 kilometres of roads in the area.[51] This represents 26% of the Scottish road network. Further, road transport in the region accounted for 5,457 million vehicle kilometres in 2019, around 11% of the 48,714 million kilometres travelled by vehicles in Scotland.

4.34 Road transport generated GHG emissions for the region have been growing up to the 2019 baseline year (+12% from 2012 figures), reflecting a number of national issues that are discussed later in this section.

Figure 4.1: Highlands and Islands area road transport GHG emissions 2012-2019 tCO_2e



Source: Sub-national road transport fuel consumption in the United Kingdom, 2005 to 2021. Department for Energy Security & Net Zero. Data available at local authority level only, and so excludes Arran and Cumbrae.

[51] This excludes Arran and Cumbrae. Data on road network length is only available at the local authority level.

4.35 Based on data published by the Department for Energy Security and Net Zero on sub-national road transport fuel consumption, road transport GHG emissions for the region were estimated to be 974.3 ktCO_2e in 2019. This equates to around 83% of the baseline transport emissions figure set out in Chapter 3. The emissions arise from a range of vehicles with more than half (55.6%) attributable to diesel and petrol cars. In terms of road use, just over three-fifths (61.7%) of road transport emissions relate to personal use (buses, cars and motorbikes) (Table 4.5). Diesel cars account for the largest share of emissions, though trends indicate emissions from petrol cars are increasing. This is likely linked to historical vehicle preferences of consumers, production volumes of diesel and petrol cars from different manufacturers, and the higher fuel efficiency available from diesel engines – an important consideration given the often long distances that those living in the region have to travel to access services. The trend towards diesel cars is now being reversed as policy focuses on petrol as a cleaner vehicle fuel, and with a modal shift towards petrol/electric hybrids. LGV use in the region is in line with the increase elsewhere, being driven by increases in online shopping and a commensurate increase in local deliveries, and this is problematic.

4.36 The nature and condition of roads, especially in rural areas could have an impact on the efficiency of road transport. However, there could also be implications of less congestion on vehicle movement, transport efficiency and emissions production. Residents and businesses in the Highlands and Islands are dependent on road transport to a much greater extent than elsewhere in Scotland. That said, emissions per km of road in the Highlands and Islands are much lower than nationally – with around 64 tCO_2e per km of road emitted in the region, versus around 180 tCO_2e per km of road nationally. Emissions per registered vehicle are around 2.9 tCO_2e in the Highlands and Islands, lower than nationally (3.5 tCO_2e respectively).

Table 4.5: GHG emissions (ktCO_2e) for road travel in the Highlands and Islands area 2019

Vehicle type	ktCO_2e	% of total road travel GHG emissions
Diesel Cars	289.8	29.7
Petrol Cars	251.9	25.9
HGV	189.2	19.4
Diesel LGV[52]	178.4	18.3
Buses	53.2	5.5
Motorcycles	5.8	0.6
Petrol LGV	5.6	0.6
Personal[53]	**600.8**	61.7
Freight	**373.3**	38.3
Total	**974.3**	**-**

Source: Sub-national road transport fuel consumption in the United Kingdom, 2005 to 2021. Department for Energy Security & Net Zero. Figures may not sum due to rounding. Data only available to local authority level, and so excludes Arran and Cumbrae.

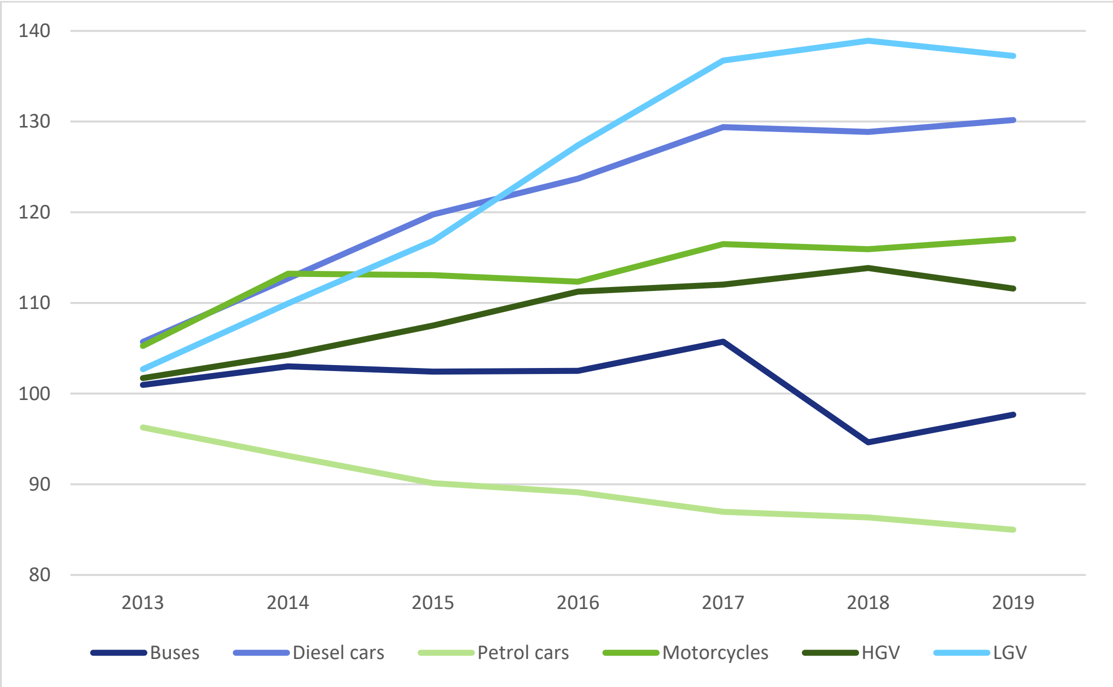
4.37 Figure 4.2 illustrates the changes in different vehicle emissions over the period 2013 – 2019 in ktCO_2e. With the exception of petrol fuelled cars and buses, the GHG emissions of all other forms of road transport increased. This reflected a general move away from petrol to diesel fuelled vehicles over recent years, though that trend is now reversing, a consequence of concerns about diesel

[52] LGV – Lights Good Vehicles which are defined as a commercial motor vehicle with a total gross weight of 3,500kg or less
[53] Buses, cars and motorbikes are classed as personal.

emissions, diesel prices and the move to more petrol/EV hybrids and ultimately full electric vehicles. While there remains a key policy focus on bus travel as a low GHG emission alternative to private vehicles, overall, passenger numbers using buses continues to decrease.

4.38 The lowest increase in road vehicle GHG emissions over that period was for HGVs. The largest increases in GHG emissions were for diesel cars and also light goods vehicles (LGV). The use of petrol fuelled light goods vehicles decreased over the period with increases in the use of diesel fuelled vehicles. This coincided with growth in online shopping and subsequent increases in local deliveries, along with increased use of these vehicles in key sectors such as engineering, and construction.

Figure 4.2: Index of Highlands and Islands area road transport GHG emissions (ktCO$_2$e) 2012-2019 (2012 = 100)



Source: Sub-national road transport fuel consumption in the United Kingdom, 2005 to 2021. Department for Energy Security & Net Zero. Data only available to local authority level, and so excludes Arran and Cumbrae.

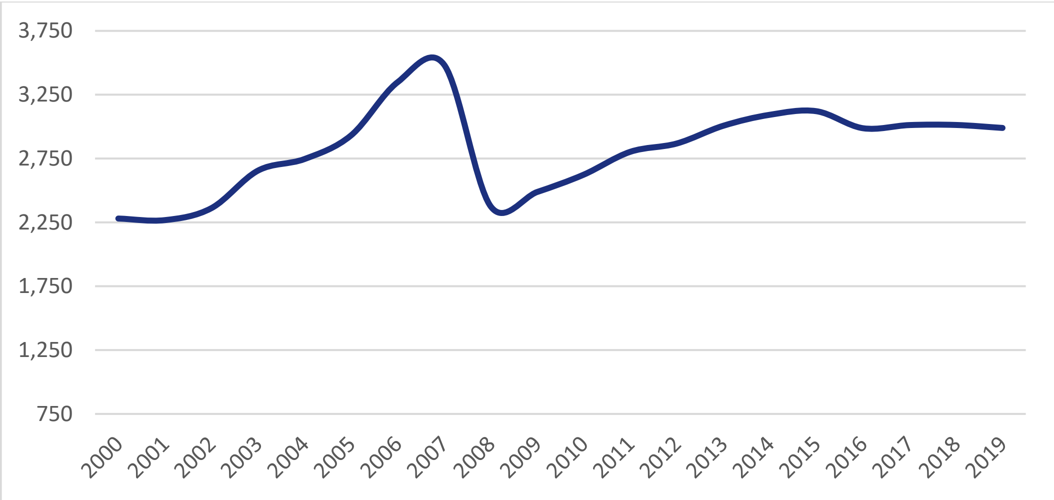
4.39 These charts illustrate how historical GHG emissions have changed up to the base year (2019). It is important to note the transition underway to alternatively powered, lower GHG emission vehicles. This transition is not clearly articulated in the historical data. However, the transition (for example reduced purchase of diesel cars and the increased purchase of alternatively fuelled vehicles) increases pace as we move beyond the 2019 baseline year. For example, in the UK in January 2023, the 45,379 battery, plug in and hybrid vehicle registrations were 77% and 85% of the respective total UK registration of petrol- and diesel-powered vehicles. This transition towards lower GHG emission powered road transport vehicles is also incorporating the lights goods and heavy vehicles markets. While alternatives to fossil fuels can be challenging in these larger vehicles, there can be different solutions, for example HVO (hydrotreated vegetable oil, sometimes known as Renewable Diesel) and hydrogen. Work is currently underway amongst local authorities to 'green' their vehicle fleets,[54] but it is arguable that the pace of change can and should be much faster. The rollout of charging and fuelling infrastructure to support this transition is therefore vitally important.

[54] https://www.highland.gov.uk/download/meetings/id/77419/item_12ii_developing_the_approach_to_greening_the_fleet

Railways

4.40 The rail network, running in Argyll and Bute, Moray and Highland, is an important aspect of the area's transport infrastructure. Data from the UK Office of Road and Rail show the number of journeys starting or ending in Highlands and Islands stations. Figure 4.3 plots the overall numbers of passengers using railway stations in the region in the period 2000 to 2019. Over this two-decade timeframe, passenger numbers grew steadily. The significant drop in passenger numbers around 2007-2009 was due to a data collection issue rather than a fall in users. The steady increase in passenger numbers was challenged after the baseline 2019 year, the outbreak of COVID-19 resulting in a subsequent drop in passenger numbers reflecting travel restrictions imposed and reduced service provision.

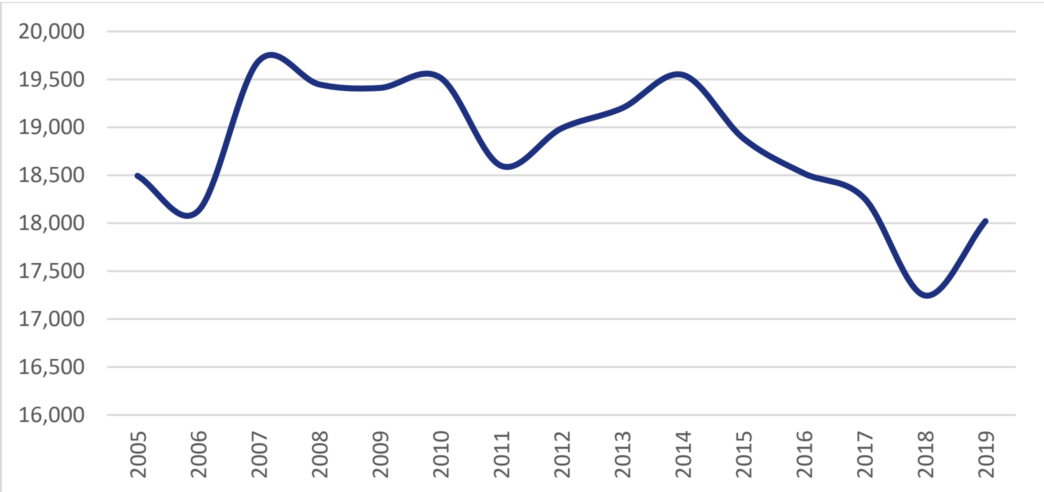
Figure 4.3: Rail users with journeys starting or ending in the Highlands '000s



Source: Regional passenger journeys, Scotland, annual data, April 1995 to March 2022

4.41 Following a decrease from 2014, rail emissions increased between 2018 and 2019. All rail power units in the region – Argyll and Bute, Moray and Highland are fuelled by diesel. In 2019, 18,021 tCO_2 was allocated to rail transport in these local authority areas, reflecting rail travel GHG emissions for the overall Highlands and Islands area.

Figure 4.4: Rail diesel GHG emissions for Highlands and Islands area 2019 (tCO_2)



Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023

4.42 As there is currently no electrification of the railway network in Inverness or the wider Highlands, Scope 2 emissions will arise from electricity use in various stations, with this being accounted for in Stationary Energy.

4.43 As with all forms of travel in the region, there is a contribution from transboundary movement; with people starting journeys in the area and leaving or vice versa. These would be recorded as Scope 3 emissions. HITRANS commissioned a Rail Passenger survey in Autumn 2010[55] to collect data on passengers using the Highland rail network. While this research provides analysis of travel within the area, there is insufficient data to calculate Scope 3 emissions. As a result, transboundary rail Scope 3 emissions have been excluded from this report.

4.44 As set out in the National Transport Strategy 2,[56] there are ambitions to electrify the Highland Main Line and the Far North Line as far as Tain, with proposals to switch to alternative fuels for power units on the remainder of the Far North Line, Kyle of Lochalsh Line and the West Highland Line. This will support the decarbonisation of the rail network in the region.

Water transport

4.45 Emissions from waterborne transport are not included in the regional baseline outlined in Chapter 3, however it is a sub-sector identified within the transport sector of the GPC. It covers emissions from ferries as well as other forms of marine transport including fishing vessels and leisure craft. Assessing the emissions from waterborne transport is challenging due to the level of detail required. In terms of fishing vessels and leisure craft, data on fuel sold in harbours, ports and marinas could potentially be used, but this data was not available to us for this study. Data from Transport Scotland has been used to provide an estimate of overall emissions from ferry travel.

4.46 Water transport is crucial infrastructure in some parts of the region, with island communities reliant on ferries for personal and business travel and for transportation of goods. Scotland has a considerable number of ferry services with the majority of these, more than 60, operating in the Highlands and Islands. These services typically receive public funding for revenue and capital purposes.

4.47 Scottish ferry services are often a mix of passenger, car and freight services and are comprised of:

- Clyde and Hebrides ferry services - operated by CalMac;
- Northern Isles ferry services which connect Orkney, Shetland and the Scottish mainland -operated by Northlink Ferries;
- A number of local authority operated and/or funded services - in Argyll and Bute, Highland, Orkney and Shetland;
- A small number of privately operated routes.

4.48 Using data from 2019, Transport Scotland undertook an assessment of the emissions of the domestic Scottish ferry fleet.[57] The result was an estimated range of 0.25-0.3 $MtCO_2e$ per annum for all domestic ferry services in Scotland.

[55] HITRANS Rail Passenger Survey April 2011
[56] https://www.transport.gov.scot/publication/national-transport-strategy-2/
[57] This used data supplied to Transport Scotland by operators during 2019. (It should be noted that there will have only been limited changes since then in terms of the routes operated and vessels deployed).

4.49 For the purposes of this report and in the absence of more granular data, the Scotland wide figure has been fully attributed to the Highlands and Islands. Most of the ferry services in Scotland operate on routes solely within the Highlands and Islands and these emissions will be Scope 1. Only a small number of routes operate in other parts of Scotland. Additionally, estimations of transboundary emissions have not been factored in. Most of these will be associated with Northlink vessels and because of their size, speed and usage, these vessels are among the biggest contributors to domestic ferry fleet emissions. These caveats are all important to note, and highlight that while the Scotland wide figure used is clearly an over-estimation, the Scope 1 emissions for the region's ferries will still account for a fairly significant proportion of the range provided.

4.50 The vast majority of the ferries currently use fossil fuels. The exceptions include a small number (three) of smaller CalMac vehicle ferries which are diesel electric hybrids[58].

4.51 The current ferry fleet in Scotland is ageing, the median age of the fleet operated by CalMac being 27 years, while that of the internal ferry fleets in Orkney and Shetland is more than 30 years. The ferries replacement programme is underway and will see a shift towards vessels using more sustainable fuel sources. There are six new ferries on order[59] for Caledonian Maritime Assets Ltd. (CMAL), which owns the ferries, ports and harbours and infrastructure necessary for ferry services in Scotland. In addition, the Scottish Government have agreed in principle to fund the business case to investigate the replacement of Orkney's internal fleet.[60]

The draft ***Islands Connectivity Plan***,[61] sets out the Scottish Governments longer term plans for ensuring necessary and sustainable transport links for Scotland's islands. Within this, the Vessels and Ports Plan[62] outlines objectives for the services for which Scottish Government ministers are directly responsible.

This includes commitments to:

- Reduce the average age of the Clyde and Hebrides and Northern Isles fleets to around 15 years old by the end of the decade.
- Reducing emissions of both fleet and port operations in line with wider Government targets.

Fleet replacement will include introducing more efficient vessels with alternative, zero/low emission propulsion options (potentially all-electric) and, potentially in the longer-term, vessels powered by green hydrogen, ammonia or methanol.

The Plan also acknowledges that local authority fleets face similar challenges to those facing those in the Clyde and Hebrides and Northern Isles. It notes that local authorities have undertaken, or are undertaking, appraisal and planning work in support of their own investment cases. The consultation phase for the draft plan ended in early May 2024 and responses are currently being analysed.

[58] However, it is worth noting that recent reports suggest one of these has had to default to diesel only usage as a result of the battery failing, and repairs are not expected until Spring 2025: https://www.bairdmaritime.com/work-boat-world/passenger-vessel-world/ro-pax/scottish-hybrid-ferry-forced-to-run-only-on-diesel-due-to-battery-repair-costs/
[59] https://www.cmassets.co.uk/project/svrp/
[60] https://www.gov.scot/news/orkney-internal-ferry-replacement-task-force/
[61] https://www.transport.gov.scot/media/52720/draft-for-consultation-long-term-plan-for-vessels-and-ports-on-the-clyde-hebrides-and-northern-isles-networks-2023-2045-islands-connectivity-plan.pdf
[62] https://www.transport.gov.scot/publication/islands-connectivity-plan-vessels-and-ports-plan-draft-for-consultation/

Aviation

4.52 Aviation is a vital travel mode within and to and from the Highlands and Islands. Good domestic and international air connectivity is key to achieving sustainable economic growth in the region and supporting day-to-day living in some of our more rural and island communities, with some air services designated as lifeline services. Aviation in the region involves a range of plane models and flight paths. The main airport (in terms of numbers travelling and in providing international access) for the Highlands and Islands is Inverness, which is operated by Highlands and Islands Airports Ltd (HIAL). HIAL operate a further nine airports in the region.

4.53 HIAL commissioned Ricardo Environment and Energy to undertake regular audits of air travel GHG emissions in the Highlands and Islands. The calculation of aviation emissions is relatively straightforward for Scopes 1 and 2 but more complex for Scope 3. The 2019 report for HIAL provides analysis for Scopes 1 and 2 only. These total 2.7ktCO_2e, arising from fuel use onsite, and the consumption of grid supplied electricity. When using the GPC, Scopes 1 and 2 are already included in the area inventory through the assessment of stationary energy, fuel emissions and electricity consumption. The calculation of Scope 3 emissions is considered below.

4.54 When considering aviation (and also marine transport emissions, discussed below) a key consideration is the extent of transboundary travel and how this is disaggregated. The emissions from this transboundary travel are added to the emissions from air travel solely within the region.

4.55 In their HIAL Airports Carbon Footprint 2023 report, Ricardo identified Scope 3 emissions from aircraft movement of 88.7 ktCO_2e. This represented 92% of the overall HIAL Scope 3 emissions for 2023. However, in 2020, aircraft movement Scope 3 emissions were 90.5 ktCO_2e. The 2020 analysis reviewed airport emissions ahead of the COVID-19 pandemic as well as those in the period afterwards when flights were greatly reduced. From this, it appears that the 90.5 ktCO_2e Scope 3 aviation movement GHG emissions would be an appropriate proxy for possible transboundary aviation Scope 3 GHG emissions for this baseline inventory.

4.56 Emissions from aviation and air travel is a relatively small proportion of overall emissions within the region. Whilst overall aviation emissions in the region are not particularly high, they are nevertheless typically higher per passenger km than for alternative modes of transport. Looking at national data, domestic flights typically have much higher emissions per passenger kilometre than other modes of transport. Domestic flights emitted around 255 gCO_2 per passenger km in 2019, versus 181 gCO_2 per passenger km for petrol cars, or just 28 gCO_2 per passenger km for coach travel (Table 4.6).

Table 4.6: CO_2 emissions: grams per passenger-kilometre, 2019, in Scotland

Mode of Transport	gCO_2 per passenger km
Domestic flights	255
Long haul international	196
Petrol cars	181
Diesel cars	173
Short haul international	158
Petrol motorbike	116
Hybrid	115
Ferry	113
Bus	105
National rail	41
Light rail and tram	35
Coach	28

Source: Transport Scotland, Scottish Transport Statistics 2019

Facilitating Low Emissions Transport

Road: As part of a wider effort to tackle climate change, the UK government set targets to ban the sale of new petrol and diesel cars by 2030. However, targets have had to be revised, moving from 2030 to 2035. Under the proposed ban, only electric cars will be allowed to be sold new in the UK. A key challenge for this transition is the provision of electric vehicle charging infrastructure. Where infrastructure delivery may be less commercially attractive or viable, a partnership approach may help achieve economies of scale and provide a more attraction proposition.

Bus: In February 2023, Stagecoach Highlands launched the UK's first all-electric city bus network. The transport operator invested £10.8million in the purchase of 25 new zero-emission Yutong E10 buses to operate on Inverness city centre routes. The project was supported by the Scottish Government's Zero Emission Bus Challenge Fund (ScotZEB), designed to support Scotland's transition to net zero by 2045. Operators and representatives hope the green switch will inspire people to ditch their cars in favour of public transport to help reduce carbon emissions.

Aviation: The Sustainable Aviation Test Environment (SATE) is the UK's first low carbon test environment at an operational airport. SATE is based at HIAL's Kirkwall Airport in the Orkney Islands. SATE demonstrates emerging technologies along with real-world 'use cases' that highlight the environmental, social and economic contribution sustainable aviation can make.

Launched in November 2020, the project has seen pioneering sustainable aviation technology demonstration flights delivered, including:

- Successful collaboration between drone specialist technology firm Windracers with Royal Mail on autonomous flights;
- Demonstrations of Flare Bright's parcel-sized gliding drone system; and
- The first hybrid electric flights for Scotland pioneered by Ampaire.

SATE provides the blueprint for net zero regional aviation, placing the Highlands and Islands at the forefront of the transition to low carbon aviation. The Highlands and Islands Transport Partnership (HITRANS) is currently the lead partner for the project.

4.57 As Table 4.7 shows, the majority of regional transport emissions come from road transport. Whilst water transport comprises a sizeable proportion of transport emissions, efforts are underway here to decarbonise transportation as far as possible. Efforts should therefore be focused on reducing road transport emissions.

Table 4.7: Summary of transport emissions estimates, 2019

Mode	Emissions ($ktCO_2e$)
Road transport	974.3
Rail	18.0
Water	250.0-300.0
Aviation (Scope 3)	90.5

4.58 It is worth noting that whilst transport is the predominant source of national GHG emissions (25%), our regional contribution to this is disproportionately lower (our road and rail transport accounting for around 10% of Scotland's total). Unsurprisingly, most of our regional transport emissions relate to road transport. However, the emissions we have are in line with our regional share of vehicles and vehicle km (11%).

INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

4.59 GHG emissions are produced from a wide variety of industrial activities, including non-energy related industrial activities and product uses. The GHG emissions occurring from industrial processes, product use, and non-energy uses of fossil fuel are assessed and reported under the heading of Industrial Processes and Product Use (IPPU) in the GPC. The main emission sources are releases from industrial processes that chemically or physically transform materials. During these processes, many different GHGs, including CO_2, CH_4, N_2O, HFCs and PFCs, can be produced.

4.60 In the regional baseline data reported in Chapter 3, IPPU emissions are presented on an end-user basis, i.e., at the point of consumption. In this chapter, alternative data sources have been explored to provide a disaggregation of the sources of IPPU GHG emissions. This included assessing the Scottish Environment Protection Agency's (SEPA) Scottish Pollutant Release Inventory (SPRI). The SPRI provides GHG emission values when they exceed reporting thresholds. Analysis for the Highlands and Islands for 2019 identified 25 entries in the SPRI. These emissions have been allocated as Scope 1 for carbon dioxide and methane. Most of the sources of GHG emissions were related to the waste sector. As waste is considered as a standalone sector in the next section of the report, these sources of waste related GHG emissions have been excluded from Table 4.8. Additionally, there is one record of an agriculture business in the Highland area with operations generating recordable volumes of methane. This too has been excluded from Table 4.9 to avoid double counting with agriculture and land use emissions.

4.61 Based on the SPRI data, IPPU emissions for the region in 2019 totalled just over 794 $ktCO_2e$ (around 13% of regional emissions). Shetland accounts for the majority of these emissions, with more than 512 $ktCO_2e$ (65% of regional IPPU emissions). Of these, 83% are accounted for by activity related to the Sullom Voe Terminal.

Table 4.8: GHG emissions from industrial processes Highlands and Islands, 2019

Site	Activity	Emission	Amount (Tonnes)	$ktCO_2e$
Argyll and Bute				
Only waste related sites	-	-	-	-
Arran and Cumbrae				
No sites	-	-	-	-
Highland				
Norbord Europe Limited.	Wood products	Carbon dioxide	87,580	87.5
Glensanda Quarry	Mineral Industry	Carbon dioxide	11,050	11.0
Liberty Lochaber Smelter	Metal materials	Carbon dioxide	63,960	63.9
Liberty Lochaber Smelter	Metal materials	Perfluorocarbons (PFCs)	0.790	5.8
Moray				
Only waste related sites	-	-	-	-
Orkney				
Orkney – Flotta Terminal	Energy Sector	Carbon dioxide	112,440	112.4
		Methane	44.6	1.1
Shetland				
Shetland – Laggan Tormore Shetland Gas Plant – Sullom Voe	Energy Sector	Carbon dioxide	208,006	208.0
Shetland – Laggan Tormore Shetland Gas Plant – Sullom Voe	Energy Sector	Methane	100.99	2.5
Shetland – Sullom Voe Terminal Refinery	Energy Sector	Carbon dioxide	29,680	29.6
Shetland – Sullom Voe Terminal Refinery		Methane	173.22	4.3
Shetland – Sullom Voe Terminal		Carbon dioxide	180,910	180.9
Shetland – Sullom Voe Terminal		Methane	11.08	0.2
Shetland – Lerwick Power Station	Energy Sector	Carbon dioxide	72,680	72.6
Shetland – Lerwick Power Station	Energy Sector	Nitrogen Oxides	2.02	
Shetland – Lerwick Energy Recovery Plant	Energy Sector	Carbon dioxide	14,080	14.0
Western Isles				
Only waste related sites	-	-	-	
			Total	**794.4**

Source: SEPA Scottish Pollutant Release Inventory, 2023

WASTE

4.62 A range of waste material is produced in the Highlands and Islands. This includes solid waste and wastewater that will be disposed of and/or treated at local facilities or removed and treated/disposed elsewhere in Scotland. Emissions consist of CO_2, N_2O and CH_4 from waste incineration, CH_4 from solid waste disposal on land, and both CH_4 and N_2O from wastewater handling and biological treatment of solid waste.

4.63 The baseline of GHG emissions for the region set out in Chapter 3 indicates 159 $ktCO_2e$ arising from waste produced in the Highlands and Islands area in 2019, with emissions distributed across local authorities based on where the waste is produced. The majority of this (71%, 113.0 $ktCO_2e$) is associated with landfill activity and the remainder attributable to waste management more broadly (29%, 46.6 $ktCO_2e$). The waste management sector constituted just over 3% of all GHG emissions in the region in 2019 and 4% nationally.

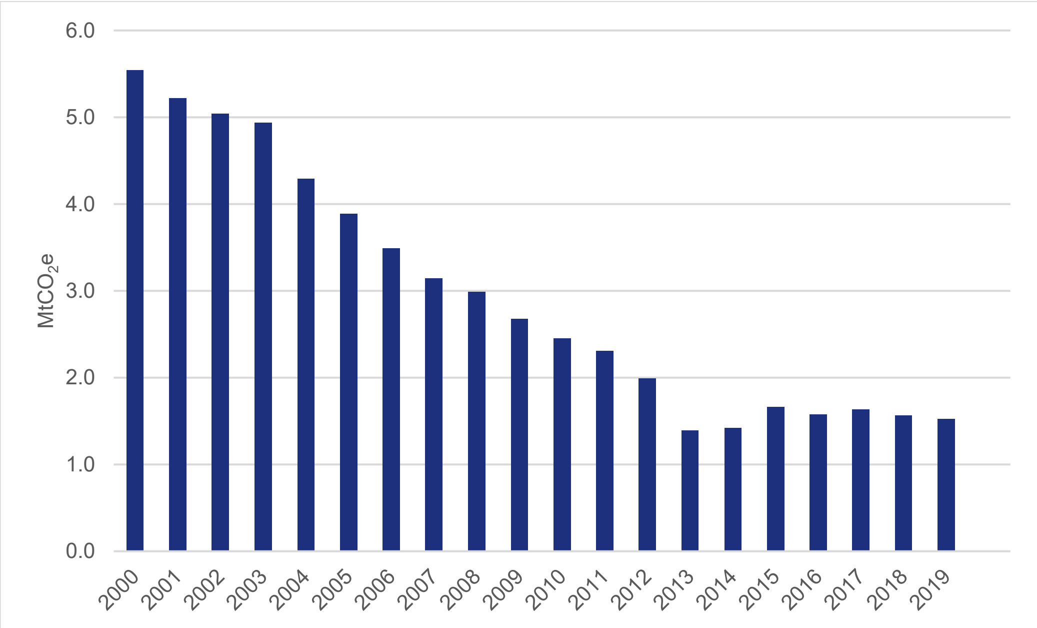
Table 4.9: Breakdown of waste emissions in the Highlands and Islands, 2019

	Landfill ($ktCO_2e$)	Other waste management ($ktCO_2e$)	Total emissions ($ktCO_2e$)
Argyll and Bute	16.9	4.5	21.4
Arran and Cumbrae[63]	-	-	-
Highland	57.7	13.2	70.8
Moray	22.2	15.2	37.4
Na h-Eileanan Siar	10.8	11.7	22.6
Orkney Islands	1.9	0.8	2.7
Shetland Islands	3.5	1.1	4.7
Highlands and Islands	**113.0**	**46.6**	**159.5**

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Figures may not sum due to rounding.

4.64 Emissions from the waste management sector in Scotland have reduced from 5.5 $MtCO_2e$ in 2000 to 1.5 $MtCO_2e$ in 2019 as illustrated in Figure 4.5. This has been driven primarily by reductions of emissions from landfill, achieved by the progressive introduction of methane capture and oxidation systems within landfill management.

Figure 4.5: Total GHG emissions from waste management in Scotland 2000 – 2019



Source: Scottish Greenhouse Gas Statistics 2020

4.65 There has been an increasing focus on the amount and types of waste being generated in Scotland, supported by the Government's Zero Waste Scotland Plan. Data on waste has traditionally been made available through several online platforms in Scotland.

4.66 SEPA produces alternative data regarding waste generation, management and related emissions. There are two specific waste streams produced in the Highlands and Islands: commercial and industrial (business), and domestic. Based on SEPA waste reporting data,[64] in 2018[65] there were 514,428 tonnes of commercial waste produced in the region. Of this, 56% or 285,644 tonnes was

[63] No data available for Arran and Cumbrae; data is only available at the local authority level.
[64] https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/
[65] No business/commercial waste data was collected or reported on for 2019 or 2020 (for publishing in 2021 and 2022)

vegetal waste. SEPA had a data breach in late 2020 which has limited the availability of 2019 data. Currently, there are no estimates of CO_2 emissions available through SEPA data for commercial and industrial waste.

4.67 For the same period (2018), the SEPA data estimates that there were 257,570 tonnes of domestic waste produced in the Highlands and Islands, of which 122,464 tonnes (48%) was landfilled. In 2019, this was 252,561 tonnes, with 118,627 tonnes landfilled (47%). The remainder was recycled, incinerated, or composted. Based on this, the estimated carbon impact of household waste generation and management in the Highlands and Islands in 2018 was 624.1 ktCO_2e, and in 2019 it was 596.3 ktCO_2e.[66] This equates to between 0.92 tCO_2e and 1.37 tCO_2e per person, dependent on local authority (Table 4.10). SEPA estimates are based on Zero Waste Scotland's approach to modelling carbon impact of waste.[67] This is a measure of the whole-life carbon impacts of waste, from resource extraction and manufacturing emissions, right through to waste management emissions, regardless of where in the world these impacts occur.

Table 4.10: Estimates of carbon impact (tCO_2e) per person arising from household waste, 2019

Local Authority	Carbon Impact (TCO_2e per person)
Argyll and Bute	1.37
Arran and Cumbrae	-
Highland	1.26
Moray	0.92
Na h-Eileanan Siar	1.37
Orkney Islands	1.21
Shetland Islands	1.28
Highlands and Islands	**1.22**
Scotland	**1.04**

Source: SEPA waste data reporting – household waste data, 2020
No data available for Arran and Cumbrae; data is only available at the local authority level.

4.68 To provide an estimate for the regional emissions arising from waste management based on modelled emissions per capita as a means of sense-checking different data sources, national waste emissions figure from the UK Greenhouse Gas Inventory, 1990 to 2019, Annual Report for Submission under the Framework Convention on Climate Change[68] has been used. This indicated that for 2019, waste management in the UK was responsible for the production of 19.3 million tCO_2e. Using a UK population figure of 66.84m for 2019 equates to 0.288 tCO_2e waste related GHG emissions per UK resident. Based on a Highlands and Islands population figure of 489,430, this then suggests that waste management in the region in 2019 was responsible for the production of 141ktCO_2e. This is not too significantly different from the 159ktCO_2e, identified in the baselining inventory (Table 4.9). The difference noted may be partially linked to revisions of data informing the two different data sets.

4.69 This difference in estimated carbon emissions arising from waste underlines the impact of the nascency of modelling carbon impacts and GHG emissions more widely, and the effect of differing – but equally valid – methods of calculation.

[66] https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/household-waste-data/
[67] https://www.zerowastescotland.org.uk/content/what-carbon-metric
[68] https://naei.beis.gov.uk/reports/reports?report_id=1015

4.70 There is a complex mix of distribution of regional wastes which are handled and dealt with through different processes and in different locations. For example, a proportion of Orkney and Shetland's waste is incinerated to produce heat in Lerwick. And in the past, waste produced in mainland parts of the region was exported to the continent for further processing/disposal. While it is not currently possible to provide a complete profile of different waste weights, treatment, and subsequent emissions, future work may facilitate this, enabling assessment of the specific GHG emissions arising from these different waste streams and processing. However, due to the diverse range of waste production collection and management/treatment in an area that covers half of Scotland's landmass, this will require a level of detailed analysis that is beyond the scope of this study.

4.71 The following sections provide commentary on waste management in the Highlands and Islands.

Waste disposal

Emissions from landfill sites

4.72 Online assessment of the Scottish Pollutant Release Inventory identified the production of methane during 2019 from a number of landfill and waste treatment sites in the Highlands and Islands. This is a database of annual mass releases of specified pollutants, including GHGs, to air, water and land from SEPA regulated industrial sites. These records identify the volume of waste related emissions in 2019 and these are recorded in Table 4.11, below.

Table 4.11: GHG emissions for Highlands and Islands waste/waste management sites, 2019

Site	Activity	Emission	Amount (Tonnes)
Argyll and Bute			
Lingerton Landfill Site – Lochgilphead	Waste and waste water management	Methane	260
Dalinlongart Landfill	Waste and waste water management	Methane	148
Gartbrek Landfill Site Islay	Waste and waste water management	Methane	64.4
Moleigh Landfill Site Oban	Waste and waste water management	Methane	115
Glengorm Landfill Site Mull	Waste and waste water management	Methane	71.5
Arran and Cumbrae			
No sites	-	-	-
Highland			
Seater Land Fill Bower Caithness	Waste and waste water management	Methane	85.4
Portree	Waste and waste water management	Methane	99.1
Highland Council Granish Landfill Aviemore	Waste and waste water management	Methane	43.4
Duisky Landfill		Methane	211
Moray			
Kirkhill Landfill	Waste and waste water management	Methane	253
Orkney			
Only industrial sites	-	-	-
Shetland			
Gremista Landfill	Waste and waste water management	Methane	229
Rova Head Landfill Site	Waste and waste water management	Methane	227
Western Isles			
Benadrove Landfill	Waste and waste water management	Methane	624
Rueval Landfill Site	Waste and waste water management	Methane	15.6

Source: SPRI/SEPA, 2020

4.73 The methane produced at these sites has 25 times more impact than the same volume of CO_2. To reduce the release of methane to the environment, emissions are often flared at site and this process can be integrated with a turbine to produce energy. The flaring process converts the methane to CO_2, and this emission is considered a natural process and is therefore not considered in GHG inventories.[69] Not all sites will have this flaring in place and so these sites will have a release of emissions. Differentiating between sites that have flaring and those that do not, and assessing subsequent volumes of released methane, would require a detailed review of the area's landfill sites and the amounts of waste, type and age, that they contain. This is beyond the scope of this current study. To avoid potential double counting of waste methane emissions, no total is provided for landfill emissions.

4.74 There will be a proportion of the solid commercial and domestic waste that is disposed out with the region, likely in landfill, which subsequently results in the release of emissions. Analysis of this would require more detailed data from waste contractors on, for example, where waste is being disposed. For example, some of the domestic waste taken from the Highlands and Islands is processed elsewhere in Scotland, with a proportion exported to Scandinavia for incineration.

Waste treatment – biological, incineration and waste water treatment and discharge

4.75 In the Highlands and Islands, some of the garden and food waste and waste from the food and drink sector which is collected is transferred out of the area for processing/composting, etc. while some is retained. This material can be composted, and a proportion of this organic waste (as well as agriculture waste) used in anaerobic digestion. This process converts organic waste to energy. Though this will produce GHG emissions, this is a complex waste stream to assess due to these different destinations and uses for the waste.

4.76 During 2019, 1.23 million tonnes of waste were incinerated in Scotland across 24 permitted incineration facilities. No breakdown of incineration by local authority is readily available. There are both methane and nitrous oxide emissions that arise from this combustion process. The transport of waste to incineration sites will also produce GHG emissions. Accurate calculation of these emissions requires detailed information on the volumes of different wastes sent for incineration and also the type of incinerator process used. However, using waste in anaerobic digestion and incineration, where the resulting gases and heat are used, helps to displace the consumption of fossil fuels, with the associated GHG emission savings. Nevertheless, this is beyond the scope of this study so emissions arising from waste incineration have been excluded from the analysis in this chapter.

4.77 Wastewater treatment gives rise to methane and nitrous oxide from the storage, settlement, processing and spreading of sewage sludge. While there are numerous wastewater treatment facilities across the region, there are also a significant number of rural domestic properties with their own private drainage and treatment arrangements. Across the Highlands and Islands, Scottish Water facilities serve a population of around 489,330.[70] Using a Scottish Water provided Scotland-wide average figure of 0.19g CO_2e per litre of wastewater treated and an average of daily wastewater flows of 150 litres per person suggests water treatment emissions in 2019 of around 5.1 ktCO_2e or about 3.5% of the overall waste treatment GHG emissions total.

[69] UK Greenhouse Gas Inventory 1990 to 2014: Annual Report for submission under the Framework Convention on Climate Change, DECC 2016, Page 414
[70] National Records of Scotland mid-year population estimate for 2019

AGRICULTURE LAND USE, FORESTRY LAND USE AND OTHER LAND USE

4.78 The use and management of land, whether for agriculture, forestry or other uses, makes a vital contribution to the economy of the Highlands and Islands. Historically, land in the region produced much of the food consumed in the area with high levels of self-sufficiency. Food production in the region makes a significant contribution to national exports, although food imports are also high. Recent years have seen a societal shift with increasing emphasis on local production and consumption. Alongside this, changes to import and export regulations are seeing a refocusing of target markets with increased focus on domestic markets and the rest of the UK. Businesses wanting to lower carbon emissions is another driver for this. This presents opportunities in terms of agriculture and land use, although a clear balance has to be struck in terms of lowering emissions, contributing to food security, and supporting biodiversity.

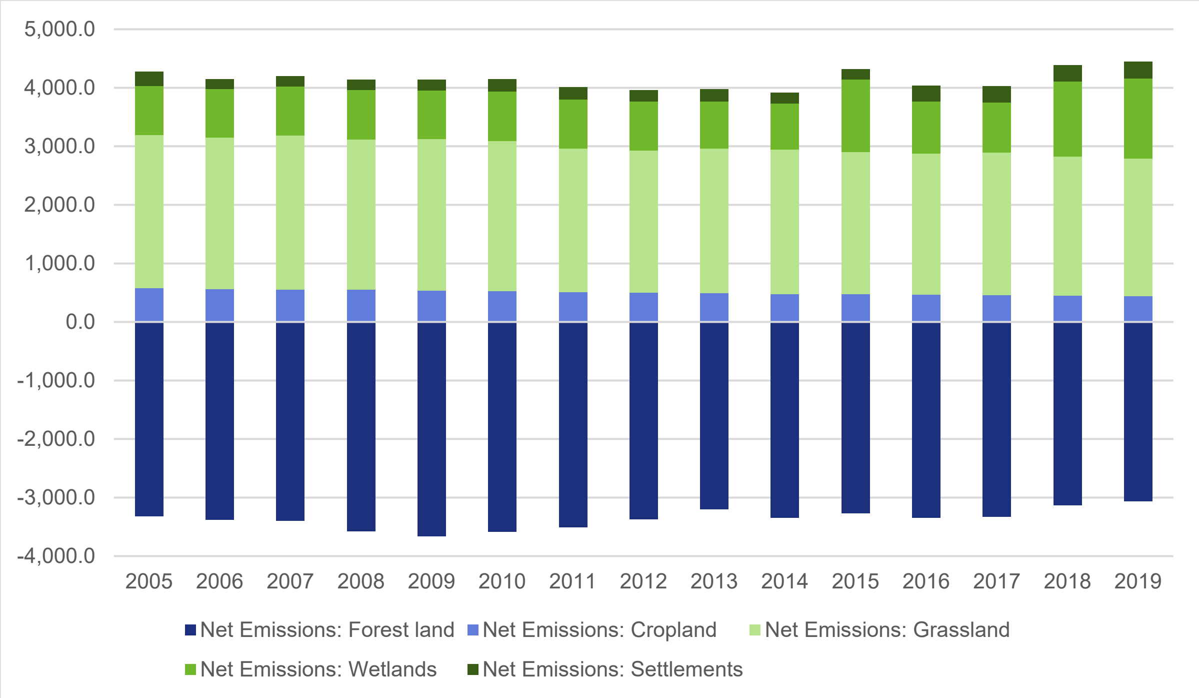
4.79 The production of renewable energy is now a key output of land use in the Highlands and Islands. And as our engagement with climate change develops, understanding how land management can be used to offset GHG emissions, store carbon or be managed to avoid the release of carbon, is evolving. The Scottish Government's Land Use Strategy[71] identifies some of the more common uses of land:

- Ecosystems – habitats and species
- Crops and livestock
- Trees for absorption/sequestration of carbon
- Peatbogs to store carbon and water
- For our children to play, learn and laugh
- Onshore wind energy
- Bioenergy feedstock
- Sustainable housing
- Industry, roads and infrastructure
- Processing our waste
- Our health and wellbeing
- Our heritage and scenic landscapes

4.80 The Land Use, Land Use Change and Forestry (LULUCF) sector differs from other sectors in the region's GHG Inventory in that it contains both sources and sinks/stores of GHG. The LULUCF sector covers emissions and removals of greenhouse gases resulting from direct human induced land use and land management (including agricultural land management), land-use change and forestry activities. GHG emissions arise due to the way land is managed and also due to changes in land use which provoke a transition between one level of carbon and another. Carbon is sequestered by forestry and grassland, while carbon losses occur on existing cropland and natural land (e.g. grassland) that is converted to cropland or settlement. The sources, or emissions to the atmosphere, are given as positive values; while the sinks, or removals from the atmosphere, are given as negative values. One of the reasons that Scotland has a net zero target five years earlier than the UK is the potential sink role provided by woodland and peatland.[72] The following chart illustrates how land use GHG emissions for the Highlands and Islands has evolved over time, up to 2019.

[71] Scotland's Third Land Use Strategy 2021-2026. Scottish Government, March 2021
[72] https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

Figure 4.6: Highlands and Islands area land use and land use change – emission estimates ($ktCO_2e$), 2019



Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Data only available to local authority level, and so excludes Arran and Cumbrae.

4.81 The estimates of these LULUC GHG emissions are made using national dynamic models of changes in stored carbon, driven by land use change data. This relies on national modelling and also a range of data used to inform the modelling process. This analysis has estimated the net LULUCF emissions at 1,396.4 $ktCO_2$ in 2019. This can be disaggregated as set out in Table 4.12.

4.82 The region benefits from a significant level of GHG absorption by existing woodland and forestry plantations. As these timber reserves are harvested, their replacement is essential to maintain this sink. Replacement planting is proving to be problematic with actual planting areas consistently falling significantly below annual targets for a number of years. The impact of this shortfall in planting should not be underestimated.

4.83 Within the Highlands and Islands, there is significant release of GHG emissions from grassland and wetlands. Emissions from grassland are predominately linked to the drainage of peatland and its subsequent use for rough grazing, primarily in Na h-Eileanan Siar and Shetland. The conversion of wetlands for alternative uses can also compromise vibrant carbon stores/sinks and result in the release of GHG emissions.

4.84 Indirect N_2O emissions are those that arise when Nitrogen, often applied as fertiliser, leaches into waterways or is lost to the atmosphere as ammonia or nitrogen oxides (NOx). This ‘escaped’ nitrogen is emitted as N_2O further downstream or when it is redeposited on soils from the atmosphere. Understanding of this source of GHG emissions is helping to inform better land management and the application of manures and fertiliser.

Table 4.12: Highlands and Islands net emissions estimates (000 ktCO_2e), by land type, 2019

Net Emissions: Forest land	Net Emissions: Cropland	Net Emissions: Grassland	Net Emissions: Wetlands	Net Emissions: Settlements	Net Emissions: Harvested Wood Products	Net Emissions: Indirect N_2O	LULUCF Net Emissions
-3,060.1	441.6	2,347.7	1,365.8	291.3	0	10.1	1,396.4

Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Data only available to local authority level, and so excludes Arran and Cumbrae.

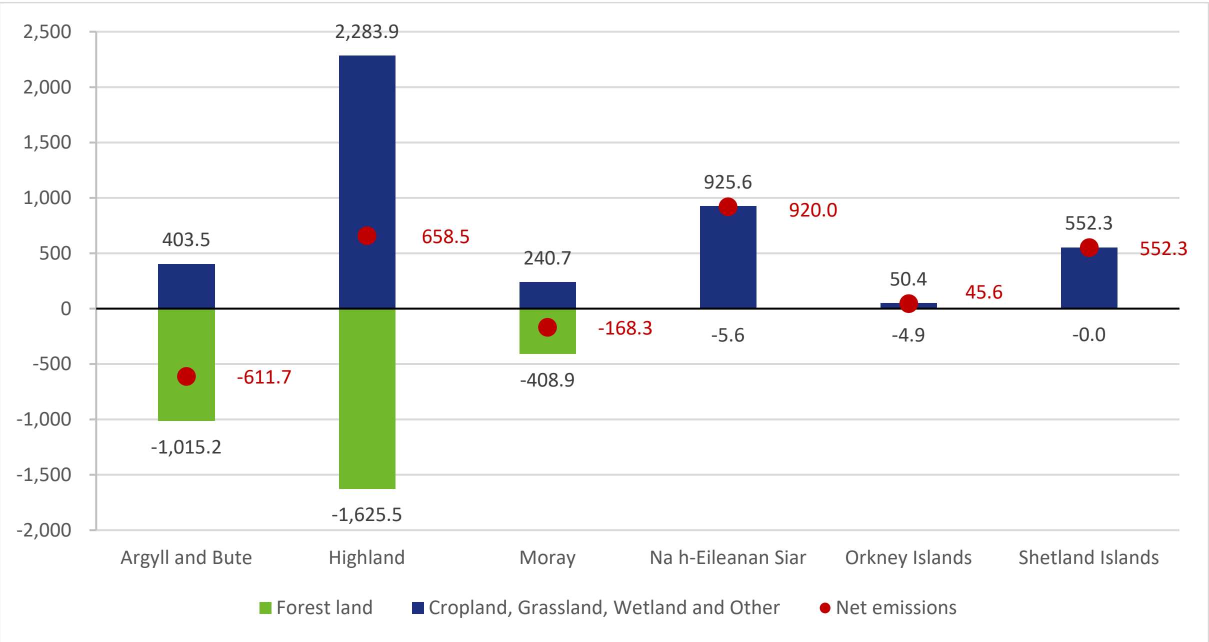
Intra-Regional LULUCF GHG emissions

4.85 Land use within the Highlands and Islands has many common features. However, there are also some very local land management challenges and opportunities related to climate change and GHG emissions. The following chart identifies the net GHG emissions for local authorities in the region that arise from Land Use and Land Use Change in 2019.

4.86 The local authority areas of Argyll and Bute, Highland and Moray, all have net negative GHG emissions associated with LULUCF. This is primarily a result of the large forestry plantations which, as highlighted earlier, are responsible for sequestering carbon each year through photosynthesis. The absence of large forestry plantations from the island groups negates the possible GHG emissions benefit from this land use. Sustaining and increasing forestry carbon sequestration will be a vital element of Scotland and the Highlands and Islands achieving its Net Zero target for 2045.

4.87 In Na h-Eileanan Siar, a significant proportion of land use GHG emissions arises from grassland, often land that has been developed and managed for animal grazing. This is also a significant source of GHG emissions in Shetland. Some of this grassland has been developed from areas of land that are predominately peat. There is now greater awareness of how changes to peatland can result in significant carbon emissions.

Figure 4.7: Net land use and land use change GHG emissions, 2019 (ktCO_2)



Source – Source: UK local authority and regional greenhouse gas emissions national statistics: 2005-2021. Department for Energy Security and Net Zero, 2023. Data only available to local authority level, and so excludes Arran and Cumbrae.

4.88 There is growing awareness of the value of peatland in storing carbon. Due to the process of peat accumulation, peatlands are carbon rich ecosystems that store and sequester more carbon than any other type of terrestrial ecosystem. They exceed thereby the global above-ground carbon stock of forest ecosystems. When peatlands are drained and converted to grassland, for example, the carbon from organic matter contained in peat dries and oxidizes gradually to CO_2 and is permanently lost from the system. Over time, this process also results in soil compaction and subsidence, making it difficult to restore proper hydrology without water table management. The map set out in Figure 4.8 provides an illustration of the peat resource in the Highlands and Islands.

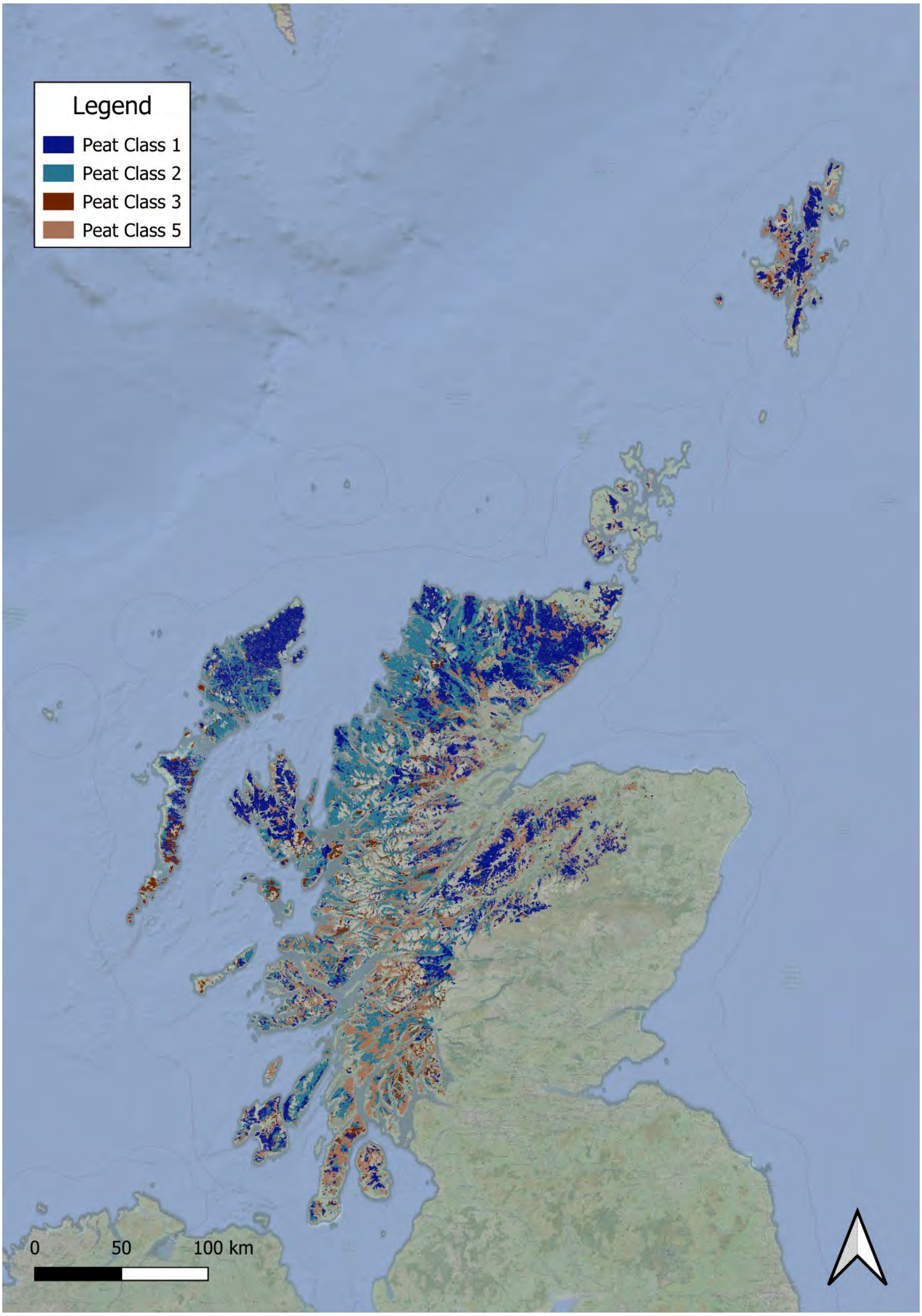
4.89 This map highlights the significant and nationally important peat resource in several locations; Shetland, Lewis and north Highland. A large proportion of Scotland's agricultural land on peat is of relatively poor production capability, with associated low productivity but with significant GHG emissions. The economic cost of incentivising land managers to reduce agricultural practices (mostly grazing) on this land is relatively low per unit area. However, changing these land management practices will have economic impacts in parts of Scotland where opportunities for replacement income are poor. There are also social impacts to consider where specific land management practices are common (e.g., crofting). Challenges with traditional grazing practices on peat exist, but there may be opportunities for low-density, high-quality livestock grazing with low GHG emissions on restored peat.

4.90 Specific geographical locations have been identified where conditions combine to provide a good opportunity for significant emission reductions. The case for replacement agricultural practices that are economically and physically viable is less strong than the case for rewetting and restoration of natural peat vegetation. In many cases, it is not to be recommended. Financial incentivisation for land managers to implement these emission reductions therefore appears mostly aligned with 'compensation' rather than 'market opportunities'.

4.91 Peatland restoration has a significant role in tackling the global climate emergency and helping Scotland meet its ambitious climate change targets. Globally, peatlands are the largest natural terrestrial carbon store, containing about 25% of global soil carbon. However, they have been damaged by overexploitation. The Scottish Government has committed to restoring 250,000 hectares of degraded peatland in Scotland by 2030, though it is worth noting that this is only around 10% of total peatland in the region (see Chapter 6).

4.92 Most of the emissions reduction could be achieved on poor production quality land where extensive grazing is currently carried out. The geographical areas of Scotland likely to provide the highest levels of emission savings are Shetland, Lewis, the Monadhliath Mountains, several areas in the Cairngorm Mountains, and Sutherland.

Figure 4.8: Peatland resource in the Highlands and Islands



Source: Scottish Government/Scotland's Soils, 2023

Figure 4.9: Peatland classification in Scotland

Class description	Indicative soil	Indicative vegetation
Class 1 - Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas likely to be of high conservation value	Peat soil	Peatland
Class 2 - Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas of potentially high conservation value and restoration potential	Peat soil with occasional peaty soil	Peatland or areas with high potential to be restored to peatland
Class 3 - Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich soils, with some areas of deep peat	Predominantly peaty soil with some peat soil	Peatland with some heath
Class 4 - Area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils	Predominantly mineral soil with some peat soil	Heath with some peatland
Class 5 - Soil information takes precedence over vegetation data. No peatland habitat recorded. May also include areas of bare soil. Soils are carbon-rich and deep peat.	Peat soil	No peatland vegetation
Mineral soil - Peatland habitats are not typically found on such soils (Class 0)	Mineral soils	No peatland vegetation
Unknown soil type – information to be updated when new data are released (Class -1)	Not classified (unknown soil type)	Not applicable
Non-soil (e.g. loch, built up area, rock and scree) (Class -2)	No soil	Not applicable

Source: Scottish Government/Scotland's Soils, 2023

SUMMARY DISCUSSION

Table 4.13 sets out the emissions baseline presented in Chapter 3 alongside alternative and modelled emissions totals by key source as discussed in this chapter for comparison. It demonstrates the variance in total estimated emissions across different calculation methodologies and the limitations of the available data. The alternative or modelled emissions aim to provide a more comprehensive picture of emissions as outlined by the GPC.

Table 4.13: Comparison of emissions by key source across approaches

DESNZ emissions estimates		Alternative or modelled emissions[73]	
Emissions source	**$ktCO_2e$**	**Emissions source**	**$ktCO_2e$**
Domestic	898.4		
Industry	780.1	Manufacturing industries	1,071.3
Commercial	136.9	Construction	43.4
Public Sector	88.4	Energy industries	963.5
Transport	1,171.8	Road transport	974.3
		Rail	18.0
		Water	250.0-300.0
		Aviation (Scope 3)	90.5
Land Use, Land Use, Change & Forestry	1,396.4		
Agriculture	1,605.0		
Waste	159.5	Domestic waste (whole-life carbon impacts)	596.3
Per capita emissions (tCO_2e)	*0.33*	*Per capita whole-life carbon impact emissions (tCO_2e)*	*1.22*
		Water treatment	5.1
Total emissions (kt CO_2e)	**6236.5**		**-**

There are a range of fuels used in buildings in the Highlands and Islands, with much of the region's emissions arising from a dependency on carbon intensive fossil fuels, particularly for space heating, but also in industrial and manufacturing processes. However, the carbon intensity of electricity consumed in buildings is declining, as more renewable energy feeds into the national electricity grid and this will continue with the electrification of heat as an alternative to fossil fuel use for heating. There are some good examples of commercial decarbonisation, particularly within the whisky sector. As an energy intensive industry, it is leading the way in decarbonising its production processes, as well as offsetting wherever possible through carbon sequestration activity.

For on-road transport, combustion engine powered vehicles remain the most common form of transportation in the region. The modal shift to hybrid- and fully-electric vehicles currently faces a number of barriers in the region, including limited (albeit growing) charging infrastructure. Installation of charging infrastructure is also being hindered by constraints on grid capacity, thus slowing that shift to lower carbon forms of road transport.

Emissions from waterborne transport are not included in the regional baseline outlined in Chapter 3, and estimates are challenging to provide due to the level of detail required across a range of different sources as well as the need to consider transboundary emissions. While Transport Scotland data has been used to provide an estimate of emissions from ferries, there is a considerable gap in terms of other forms of water-transport such as fishing vessels and leisure craft. In terms of decarbonisation of ferries, Caledonian Maritime Assets Ltd (CMAL) has a leading role to play in ensuring the next generation of vessels use cleaner forms of energy. The Transport Scotland draft Long Term Plan for Vessels and Ports on the Clyde & Hebrides and Northern Isles networks will be critical in articulating plans to reduce emissions in maritime transport.

Aviation transport emissions in the region are not extensive relative to overall transport emissions, but still high when viewed in terms of emissions per passenger kilometre for domestic flights in particular.

[73] No total included as emissions by key sources rely on different modelling methodologies and approaches

However, there is a good level of aviation innovation in the region. Through projects such as the Sustainable Aviation Test Environment (SATE)[74] and the demonstrator activities of companies such as Ampaire[75] in partnership with HIAL, the region is leading the way on trialling and demonstrating hybrid and electric air transport.

For rail transport, the key challenge is how to decarbonise the rail network in the Highlands and Islands given that electrification ambitions only cover part of the region's rail network. As such, the focus must be on alternative fuel sources for power units.

In terms of waste emissions, how we deal with waste in the region is changing. The move to a more circular economy has reduced volumes of waste disposed in landfill, although this is still a notable source of GHG emissions. Calculating waste emissions is a complicated process, requiring detailed information on the volume of waste, disposal dates, etc. This is an area where better data capture will be required to provide more accurate estimations of emissions from landfill and waste management at the local level.

Within the Highlands and Islands, emissions from industrial processes, product use and non-energy uses of fossil fuel are skewed by those associated with activity at the Sullom Voe Terminal in Shetland. As an oil and gas terminal it will continue to play a strategic role in energy provision to Scotland and the UK, as well as in Scotland's energy transition. Operators in fields such as the West of Shetland oil and gas field are already exploring the potential for electrification of extraction operations. Other forms of innovation are also evident and will become increasingly important as the negative and extreme impacts of climate change increase and the sector is increasingly acknowledged to be contributing to these impacts.

Land Use, Land Use Change and Forestry is a dynamic area of GHG emissions production, storage and management, and our understanding of this interaction is improving. The area's woodlands, peatlands, blanket bogs and wetlands are crucial carbon sinks for the region, and for Scotland, and are a significant factor in Scotland's Net Zero target being five years earlier than the UK. Significant Government funding and policy need to be targeted at supporting management of this resource that maintains and increases the carbon storage of land and results in new land management practices, creating new business, employment, and training/skills opportunities. Fundamental to this will be sustaining the woodland and peatland resource to benefit from the carbon "sink" role they make. Supporting the supply chain needs to be a critical area of focus, to ensure sufficient capacity and people with appropriate skills to support this activity.

[74] https://www.hial.co.uk/sate
[75] https://www.hial.co.uk/news/article/42/ampaire-demonstrates-first-hybrid-electric-aircraft-in-scotland

5 REGIONAL DOMESTIC CARBON EMISSIONS

Chapter summary

- There are around 275,000 dwellings in the Highlands and Islands around 10% of all dwellings in Scotland. Almost two thirds of these are in either remote or very remote rural areas (remote/very remote small towns or remote/very remote rural areas).
- Detached dwellings are the most common house type in the region two in five are detached, almost double the national rate. The region's houses are typically older, with less energy efficient construction materials e.g., solid walls, solid floors and little or no insulation.
- Reflecting lack of access to the gas grid, fewer houses in the region than nationally have mains gas, and there is a greater reliance on carbon intensive fuels either as a primary or secondary fuel sources. Boiler heating systems are the most common heating system, although less so than nationally, followed by storage or room heaters which more rely on than nationally.
- The use of heat pumps is more prominent in the region than across Scotland as a whole particularly in Orkney albeit the overall number is not high.
- A significant proportion of dwellings are in exposed or very exposed locations. This is particularly the case in island and remote rural areas.
- Dwellings in the Highlands and Islands account for 13% of CO_2 emissions from dwellings across Scotland. Mean CO_2 emissions per dwelling are considerably higher than nationally, and highest in remote rural and island areas.
- The Standard Assessment Procedure (SAP) rating and Environmental Impact Rating (EIR) of dwellings in the Highlands and Islands is typically lower (worse) than nationally.
- There is a particular challenge in the region to bring domestic properties up to the required energy efficiency standard, since the property profile in the Highlands and Islands, and dispersed nature of dwellings in many areas, makes retrofit more complex.

INTRODUCTION

5.1 Domestic CO_2 emissions are a key factor in overall GHG emissions in the Highlands and Islands. This chapter examines Home Analytics data sourced from the Energy Saving Trust (EST) on households in the HIREP region. Location, property characteristics, fuel and heating, exposure zone, CO_2 emissions, SAP rating and environmental impact data are analysed primarily in terms of local authority, urban or rural setting, and property tenure. Some comparisons are also drawn between regional and national level data. As the data is aggregated from household level to area geographies, this did facilitate analysis for the whole HIREP region, including Arran and Cumbrae from North Ayrshire.

LOCATION

5.2 There are 274,586 dwellings in the Highlands and Islands, 10% of all dwellings in Scotland (Table 5.1).[76] Reflecting the population profile of the region, Highland accounts for the greatest share of dwellings, with more than twice the number of dwellings than any other area. As may be expected, the island areas of the region account for the lowest number of dwellings.

Table 5.1: Dwellings by sub-region

Area	Number	Percent
Argyll and Bute	52,234	19%
Highland	128,213	47%
Moray	48,185	18%
Na h-Eileanan Siar	15,936	6%
Orkney Islands	12,351	4%
Shetland Islands	12,044	4%
Arran and Cumbrae	5,623	2%
Highlands and Islands Total	**274,586**	**100%**
Scotland	**2,766,436**	

Source: Energy Saving Trust, 2023

5.3 The Highlands and Islands is an expansive, sparsely-population region. It accounts for around 72% of Scotland's remote rural land mass and has over 90 inhabited islands. Reflecting this, approximately 57% of dwellings are in a rural location whilst almost 65% are classified as remote (either rural or small town; Table 5.2), and just under a quarter (23%) are on an island (Table 5.3).

Table 5.2: Urban and rural classification

<table>
<tr><th rowspan="2"></th><th colspan="2">Classification</th><th colspan="2">Banded classification</th></tr>
<tr><th>N</th><th>Percent</th><th>N</th><th>Percent</th></tr>
<tr><td>1. Large Urban Area</td><td>-</td><td>0%</td><td rowspan="2">49,541</td><td rowspan="2">18%</td></tr>
<tr><td>2. Other Urban Area</td><td>49,541</td><td>18%</td></tr>
<tr><td>3. Accessible Small Town</td><td>12,390</td><td>5%</td><td rowspan="3">67,824</td><td rowspan="3">25%</td></tr>
<tr><td>4. Remote Small Town</td><td>20,127</td><td>7%</td></tr>
<tr><td>5. Very Remote Small Town</td><td>35,307</td><td>13%</td></tr>
<tr><td>6. Accessible Rural</td><td>34,328</td><td>13%</td><td>34,328</td><td>13%</td></tr>
<tr><td>7. Remote Rural</td><td>28,034</td><td>10%</td><td rowspan="2">122,893</td><td rowspan="2">45%</td></tr>
<tr><td>8. Very Remote Rural</td><td>94,859</td><td>35%</td></tr>
<tr><td>Highlands and Islands Total</td><td>274,586</td><td>100%</td><td>274,586</td><td>100%</td></tr>
</table>

Source: Energy Saving Trust, 2023

Table 5.3: Dwellings by island and mainland

	Frequency	Percent
Island	62,949	23%
Mainland	211,637	77%
Highlands and Islands Total	**274,586**	**100%**

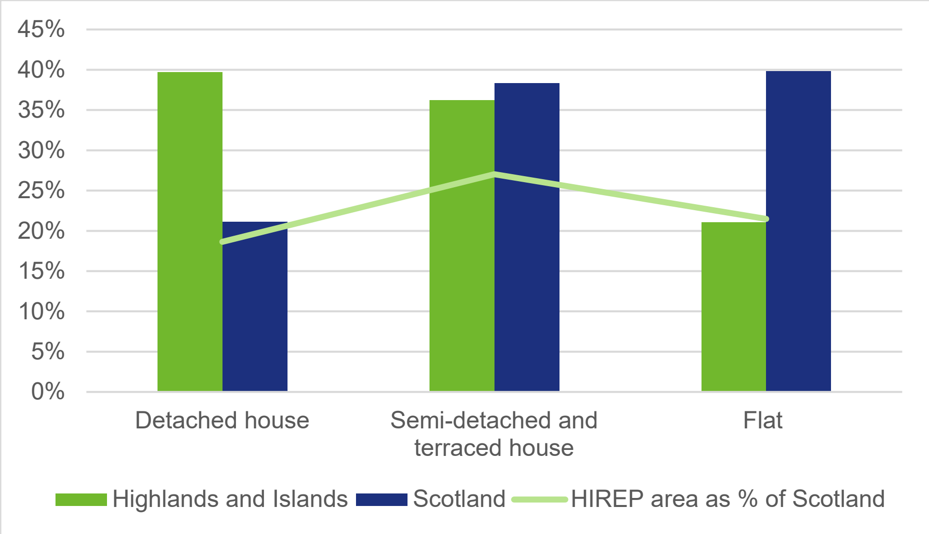
Source: Energy Saving Trust, 2023

[76] NRS is based on council tax data and so excludes long term empty and those registered for non-domestic rates (mainly short-term lets).

PROPERTY CHARACTERISTICS

5.4 The vast majority of dwellings in the Highlands and Islands are houses (76%) and just over a fifth (21%) are flats. This differs to Scotland overall where around three-fifths (59%) of dwellings are houses and around two-fifths (40%) are flats. Detached houses are the most common property type in the region - 40% of dwellings are detached, with this almost twice the national rate (21%). This reflects the rural nature of region, with its population being dispersed over a large area.[77]

Figure 5.1: Property type



Source: Energy Saving Trust, 2023

5.5 The Highlands and Islands has a broadly comparable mix of tenure to the rest of Scotland (Table 5.4). Owner occupied dwellings account for around two thirds (66%) of domestic properties in the region, at a slightly higher rate than for Scotland overall (63%). There is a much lower proportion of social housing stock in the Highlands and Islands than nationally (18% versus 23%), both in terms of dwellings owned by housing associations (10% versus 11% nationally) and local authorities (8% versus 12%). The lower share of local authority housing stock may, in part, be derivative of Argyll and Bute and Na h-Eileanan Siar transferring their housing stock to housing associations in 2007 though this of course does not affect overall levels of social housing.

Table 5.4: Property tenure

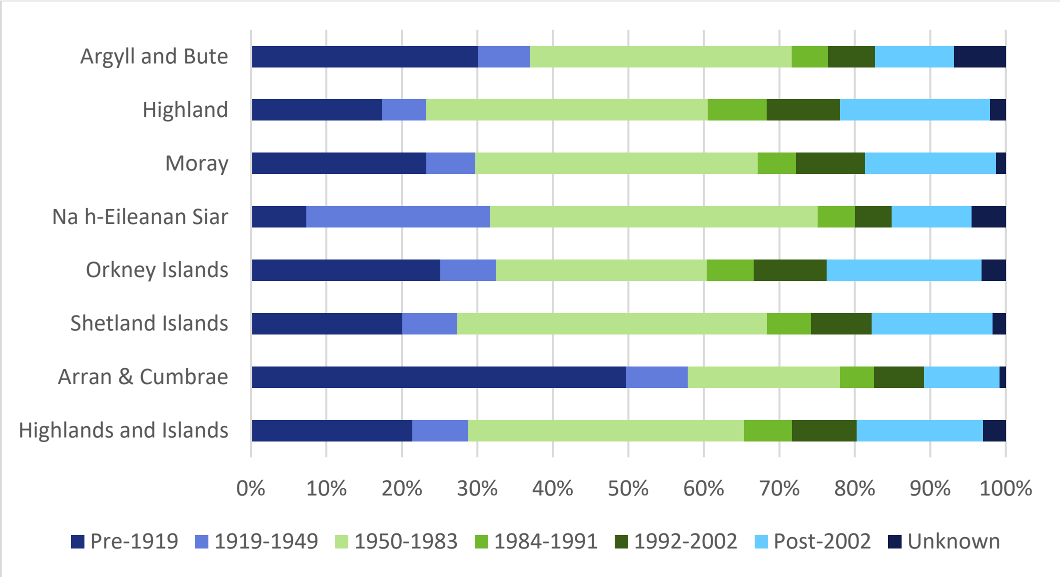
	Frequency	Percent	Scotland Percent	Highlands and Islands as % of Scotland
Housing Association	27,533	10%	**11%**	**9%**
Local Authority	22,969	8%	**12%**	**7%**
Owner Occupied	180,908	66%	**63%**	**10%**
Privately Rented	34,950	13%	**13%**	**10%**
Unknown	8,226	3%	**1%**	**42%**
Total	**274,586**	**100%**	**100%**	**10%**

Source: Energy Saving Trust, 2023

[77] Approximately 3% of properties are categorised as either 'Unknown' and 'other in the Highlands and Islands which is more than Scotland as a whole (0.7%).

5.6 There is a high proportion of older dwellings in the Highlands and Islands. Around 21% of dwellings are pre-1919 compared to 18% nationally. Though representing a small proportion of dwellings in the region overall, Arran and Cumbrae have the highest proportion of dwellings that are pre-1919 – almost 50%. Argyll and Bute (30%), the Orkney Islands (25%) and Moray (23%) also have a considerable proportion of pre-1919 housing compared to the Scottish average.

Figure 5.2: Property age by sub-region



Source: Energy Saving Trust, 2023

5.7 In addition to the high proportion of older dwellings in the region there is also a high proportion of dwellings with poor or no wall insulation (50% have insulated walls compared to 58% across the whole of Scotland). Only 30% of dwellings in Arran and Cumbrae have wall insulation. Dwellings in island and remote rural parts of the region are less likely to have insulated walls (46% and 45% do) than those in accessible rural (59%), small towns (52%) and urban (52%) locations.

5.8 The proportion of dwellings in the Highlands and Islands with double glazing is in line with the national average (88% versus 89%), and a similar proportion have single or partial glazing (7% versus 8%). Dwellings in remote rural areas are less likely to have double glazing than those in other areas, although the majority do have this type of glazing (85%).

5.9 Dwellings in the Highlands and Islands are more likely to have solid walls (31%) and solid floors (22%) than dwellings across Scotland overall (26% and 17% respectively). The combination of a high proportion of older dwellings, with solid walls and floors, and that are less likely to have wall insulation results in a housing stock in the Highlands and Islands that may be less energy efficient than the housing stock of Scotland as a whole. Additionally, these dwellings may be least suited to current retrofitting processes and/or require more expensive interventions.

5.10 Many of the older residences may be existing or former farmhouses, croft houses and/or agricultural buildings. Three quarters of residencies which predate 1919 are owner occupied, compared to 67% of those built between 1992 and 2002, and only 65% of those built after 2002. Moreover, there is a much higher percentage of those in the latter two categories which are housing association or local authority owned. This has implications in terms of housing retrofit. Typically, energy efficiency measures – insulation, low carbon heating systems, etc. – are more complex and costly to implement in older buildings.

FUEL AND HEATING

Main fuel type

5.11 Table 5.5 shows the main fuel type by sub-region in the Highlands and Islands. Mains gas is the most common fuel type in the region, used by 35% of properties. However, this is less than half the rate for Scotland as a whole (77%), reflecting a lack of access to the gas grid in some parts of the Highlands and Islands.[78] Instead, the region has a higher proportion of dwellings than nationally that are reliant on electricity (29% versus 13%) and high carbon fuel sources such as LPG, heating oil and solid fuels (e.g. coal) (31% versus 8%) as their main fuel type.

5.12 Reflecting access to the gas grid, the majority of dwellings in Moray (65%) use mains gas as their primary fuel type, a much higher proportion than in other parts of the region. In island and remote rural communities (with no, or limited access to the gas grid), there is a greater reliance on electricity (45% and 38% respectively) and heating oil (34% and 40%).

Table 5.5: Main fuel type by sub-region[79]

	Argyll and Bute	Highland	Moray	Na h Eileanan Siar	Orkney Islands	Shetland Islands	Arran and Cumbrae	Total	Scotland	Highlands and Islands as % of Scotland
Biomass	2%	2%	1%	1%	1%	6%	1%	**2%**	**0%**	**35%**
Electricity	31%	27%	13%	31%	54%	57%	70%	**29%**	**13%**	**22%**
LPG	3%	3%	1%	7%	1%	1%	2%	**3%**	**1%**	**27%**
Mains Gas	39%	34%	65%	5%	0%	0%	0%	**35%**	**77%**	**5%**
No fuel	1%	0%	1%	1%	0%	1%	1%	**1%**	**1%**	**7%**
Oil	14%	28%	17%	46%	36%	SC%	23%	**25%**	**6%**	**39%**
Solid	4%	4%	1%	5%	5%	3%	2%	**4%**	**1%**	**46%**
Unknown	7%	2%	1%	5%	3%	2%	1%	**3%**	**1%**	**42%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**10%**

Source: Energy Saving Trust, 2023

5.13 The reliance on high carbon fuel sources such as LPG, heating oil and solid fuels presents an acute issue in terms of domestic carbon emissions, particularly given the high proportion of dwellings in island (42%), remote rural (50%) and accessible rural (40%) areas that rely on such fuel as their main fuel type. It is further exacerbated when considering that around a fifth (21%) of dwellings in the Highlands and Islands use such fuels as their secondary fuel type (this rises to 33% in remote rural areas; 28% in island communities and 24% in accessible rural areas versus 6% nationally).

5.14 Within the region, high carbon fuels are much more likely to be the main fuel used in owner occupied (37%) and privately rented dwellings (36%) than in housing association and local authority dwellings (both 9%). When considering energy efficiency and alternative fuel measures, the extent to

[78] Mains gas is not available across the whole region. Approximately 59% of dwellings are off the gas grid compared with 19% nationally. There is no provision in Orkney, Shetland, Arran and Cumbrae, most of Na h-Eileanan Siar, and most of the more rural parts of the Highland Council area.

[79] It is understood that data for Na h-Eileanan Siar shows dwellings that have access to the Stornoway town gas network rather than mains gas. There are around 1,600 properties that are connected to the town gas network: https://cne-siar.gov.uk/wp-content/uploads/2023/12/Local-Heat-and-Energy-Efficiency-Strategy-FINAL.pdf. It is worth noting that Thurso, Wick, Oban and Campbeltown also have town gas networks (Statutory Independent Undertakings; SIUs), and this may also be reflected in the data.

which owner occupiers and private landlords can be influenced will be a key factor. Research undertaken by HIE in 2022[80] indicated that only 6% of households were planning to switch their fuel type over the next two to three years, higher still amongst those using oil (51%). For those not planning to switch, barriers to doing so included cost (53%), not wanting to change (34%) and lack of financial support from government (30%).

Heating

5.15 Boilers are the most common method of heating homes in the Highlands and Islands, although the level of use is lower than nationally (65% versus 84%) (Table 5.6). Boilers are most common in mainland dwellings, and in Moray in particular (82%). Storage heaters are the second most common source of heating, used in just under a fifth (18%) of dwellings. However, they are the most common heating source in Arran and Cumbrae (46%) and the Shetland Islands (44%) with use higher in island areas more broadly (28%). This correlates to the lower usage of mains gas for rural areas and suggests a need to find alternative heating sources to the standard boiler system.

5.16 Heat pump usage in dwellings is higher in the region (7%) than nationally (2%), highest in the Orkney Islands (20%) and Na h-Eileanan Siar (12%). The Shetland Islands also have a comparatively high share of dwellings with communal heating (8%) – these are dwellings connected to Lerwick's District Heating Scheme.[81]

Table 5.6: Main heating system by sub-region

	Argyll and Bute	Highland	Moray	Na h Eileanan Siar	Orkney Islands	Shetland Islands	Arran and Cumbrae	Highlands and Islands Total (%)	Scotland (%)	Highlands and Islands as % of Scotland
Boiler	60%	68%	82%	61%	39%	33%	32%	**65%**	**84%**	**8%**
Communal	1%	1%	1%	0%	0%	8%	0%	**1%**	**1%**	**7%**
Heat pump	7%	6%	7%	12%	20%	8%	8%	**7%**	**2%**	**40%**
No heating or hot water system	1%	1%	0%	1%	0%	1%	1%	**1%**	**1%**	**7%**
Other	1%	2%	0%	1%	3%	1%	1%	**1%**	**1%**	**21%**
Room heaters	5%	3%	2%	5%	4%	3%	11%	**4%**	**3%**	**14%**
Storage heaters	19%	17%	7%	16%	31%	44%	46%	**18%**	**8%**	**22%**
Unknown	7%	2%	1%	5%	3%	2%	1%	**3%**	**1%**	**42%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**10%**

Source: Energy Saving Trust, 2023

[80] My life survey | Highlands and Islands Enterprise | HIE
[81] https://sheap-ltd.co.uk/details-of-the-lerwick-scheme

5.17 Dwellings in remote rural areas (54%) and small towns (65%) are less likely than those in accessible rural (76%) and other urban (82%) areas to have a boiler as the main heating system. Conversely, the use of storage heaters is higher (Table 5.7).

5.18 Use of heat pumps is higher in accessible (10%) and remote rural areas (11%) than in small towns (4%) and other urban areas (1%). Housing association and local authority owned homes have the highest usage of heat pumps (21%, 10%) and storage heaters (24%, 23%). On the other hand, owner-occupied and privately rented houses have higher usage of boilers and room heaters (Table 5.7).

Table 5.7: Main heating system by urban rural banded classification and property tenure

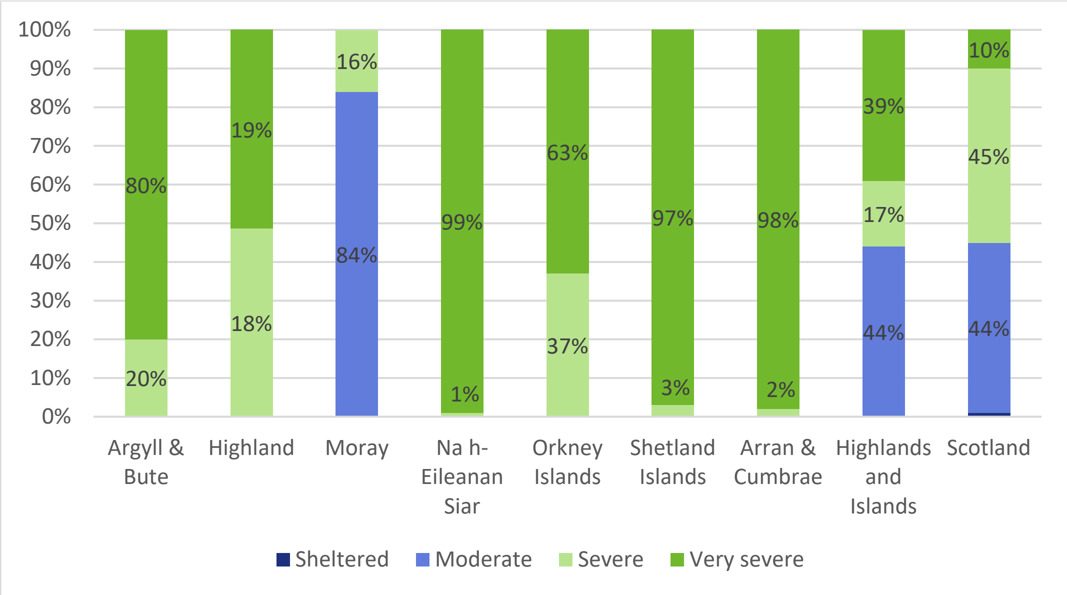
	Urban rural classification				Property tenure				Total (%)	Scotland (%)	Highlands and Islands as % of Scotland
	Other Urban Area	Small Towns	Accessible Rural	Remote Rural	Housing Association	Local Authority	Owner Occupied	Privately Rented			
Boiler	82%	65%	76%	54%	46%	61%	71%	66%	**65%**	**84%**	**8%**
Communal	1%	2%	1%	1%	5%	1%	1%	1%	**1%**	**1%**	**7%**
Heat pump	1%	4%	10%	11%	21%	10%	6%	4%	**7%**	**2%**	**40%**
No heating or hot water system	1%	1%	0%	1%	2%	0%	0%	1%	**1%**	**1%**	**7%**
Other	2%	1%	1%	1%	1%	3%	1%	1%	**1%**	**1%**	**21%**
Room heaters	3%	3%	2%	5%	2%	2%	4%	6%	**4%**	**3%**	**14%**
Storage heaters	10%	21%	8%	23%	24%	23%	17%	22%	**18%**	**8%**	**22%**
Unknown	1%	2%	2%	5%	0%	0%	0%	0%	**3%**	**1%**	**42%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Energy Saving Trust, 2023

EXPOSURE ZONE

5.19 Figure 5.3 illustrates the extent to which dwellings are exposed to wind driven rain. Most dwellings in the region are in very severely (39%) or severely (17%) exposed areas, with a higher proportion of dwellings than nationally very severely exposed (10% nationally). Across the region, Moray is the exception, in that the majority (84%) of its dwellings are in moderately exposed areas. In all other parts of the region, the exposure to wind driven rain is classed as severe or very severe for all properties. Nearly all dwellings in Arran and Cumbrae, Na h-Eileanan Siar and Shetland are in very severely exposed locations, reflecting their geography, location and climate.

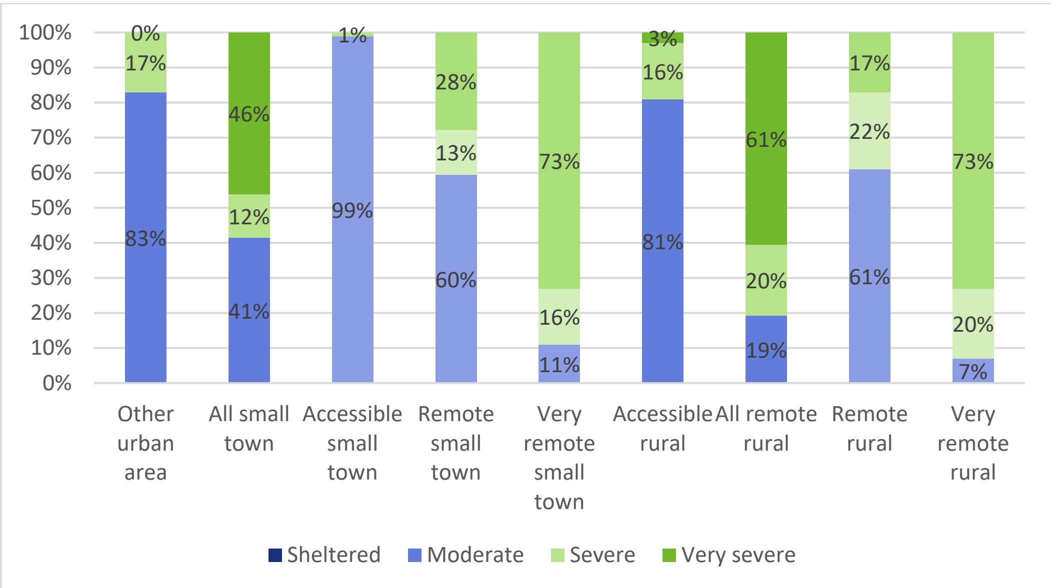
Figure 5.3: Exposure zone by sub-region



Source: Energy Saving Trust, 2023

5.20 Understandably, the most remote areas in the Highlands and Islands are also the most exposed to wind driven rain. The majority of dwellings in very remote rural and remote small towns are very severely exposed (both 73%).

Figure 5.4: Exposure zone by urban rural classification



Source: Energy Saving Trust, 2023

CO_2 EMISSIONS

5.21 Based on modelling by the Energy Savings Trust, dwellings in the Highlands and Islands produce an estimated 1.59 million tonnes of CO_2 emissions per year, 14% of all emissions produced by dwellings in Scotland. It should be noted that due to differences in data collection and modelling, these emissions estimates vary considerably from those set out in Chapter 3 and are almost double the level of emissions estimated in Department for Energy Security and Net Zero (DESNZ) data.[82] This suggests that households are not heating their homes to the standard heating regime used in the EST modelling, and this may be accounting for the differences between the two estimates.[83]

5.22 Average (mean) emissions per dwelling are higher in the region than nationally (6.0 tCO_2 per property versus 4.3 tCO_2 nationally). Dwellings in island areas produce considerably more CO_2 emissions per property than those in mainland areas. For example, although dwellings in Highland are responsible for nearly half of the region's emissions, they have the second lowest CO_2 emissions per dwelling. The level of CO_2 emissions per dwelling is highest in Na h-Eileanan Siar (7.8 tCO_2) and Arran and Cumbrae (7.6 tCO_2).

Table 5.8: CO_2 emissions estimate by sub-region

Local Authority	Dwellings	Total (tCO_2)	Mean (tCO_2)
Argyll and Bute	48,672	290,114	6.0
Highland	125,559	731,682	5.8
Moray	47,553	248,037	5.2
Na h-Eileanan Siar	15,214	118,961	7.8
Orkney Islands	11,959	81,478	6.8
Shetland Islands	11,828	78,409	6.6
Arran and Cumbrae	5,575	42,363	7.6
Highlands and Islands Total	**266,360**	**1,591,046**	**6.0**
Scotland Total	**2,766,436**	**11,681,067**	**4.3**

Source: Energy Saving Trust, 2023

5.23 It is worth noting that there is a degree of variation in domestic emissions in the Highland local authority area. For example, whilst dwellings in Highland overall have a mean emission of 5.8 tCO_2, this is much lower in the Inner Moray Firth (5.3 tCO_2), and higher in both Caithness and Sutherland (7.0 tCO_2) and Lochaber, Skye and Wester Ross (6.6 tCO_2).

5.24 The level of CO_2 emissions produced per dwelling increases with rurality. Other urban areas have a rate of 4.3 tCO_2 emissions per property, whereas very remote rural areas have a rate of 7.4 tCO_2. Dwellings in island areas also typically have a higher mean rate of CO_2 emissions (Table 5.9).

[82] At this point, it is worth noting that carbon assessment is in its infancy, and therefore different datasets will provide different results. It is assumed that the difference between the data presented here and that for domestic emissions presented in Chapter 3 is a result of a top-down versus a more bottom-up modelling approach.

[83] Further research into the DESNZ data and EST modelling is required to better understand the assumptions used, and the reasons for this variation.

Table 5.9: CO_2 emissions estimate by urban rural banded classification

Urban Rural Classification	Dwellings	tCO_2	Mean (tCO_2)
Other urban area	49,257	211,035	4.3
All small town	66,557	345,940	5.2
Accessible small town	12,343	58,565	4.7
Remote small town	19,370	97,374	5.0
Very remote small town	34,844	190,001	5.5
Accessible rural	33,798	185,931	5.5
All remote rural	116,748	848,139	7.3
Remote rural	26,660	183,406	6.9
Very remote rural	90,088	664,734	7.4
Island	60,756	419,502	6.9
Mainland	205,604	1,171,543	5.7
Highlands and Islands	**266,360**	**1,591,046**	**6.0**
Scotland Total	**2,766,436**	**11,681,067**	**4.3**

Source: Energy Saving Trust, 2023

5.25 The highest concentration of CO_2 emissions in the region is from owner-occupied properties which are more likely to be older, less energy efficient and have a high reliance on fossil fuels (Table 5.10).

Table 5.10: CO_2 emissions estimate by property tenure

Property Tenure	Dwellings	tCO_2	Mean (tCO_2)
Housing Association	27,533	99,400	3.6
Local Authority	22,969	95,279	4.1
Owner Occupied	180,908	1,190,582	6.6
Privately Rented	34,950	205,784	5.9
Highlands and Islands	**266,360**	**1,591,046**	**6.0**
Scotland Total	**2,766,436**	**11,681,067**	**4.3**

Source: Energy Saving Trust, 2023

5.26 One factor in the level of emissions per household is the level of energy consumption. Dwellings in the region have a higher mean domestic electricity and gas consumption than Scotland or Great Britain.[84] Some of the reasons for this are explored below.

SAP RATING AND ENVIRONMENTAL IMPACT

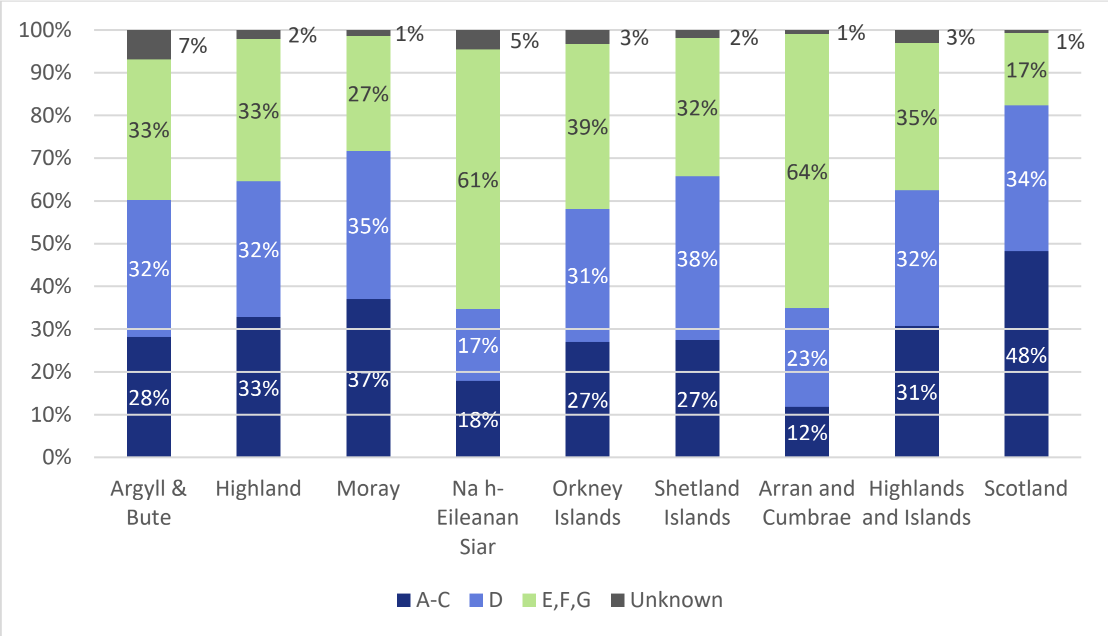
5.27 The Standard Assessment Procedure (SAP) is the UK Government approved way of accessing the energy performance of a dwelling. The SAP rating denotes the level of energy cost contrasted with the energy efficiency, giving a rating of A-G, with A being the most efficient (low energy cost and high energy efficiency), and G being the least (high energy cost and low energy efficiency).

5.28 Under SAP, the mean energy efficiency rating of dwellings in the Highlands and Islands was 58.7, compared to 65.0 nationally. Around 35% of dwellings have poor SAP ratings (bands E-G) – more than double the national rate (17%). These dwellings account for 20% of those in Scotland with an SAP rating of E-G. Conversely, fewer than nationally had a rating of C or above (31% compared to 48%).

[84] ekosgen, for HIE (2022) Impact of energy price rises on businesses in the Highlands and Islands

5.29 Dwellings in Arran and Cumbrae and Na h-Eileanan Siar typically have lower (poorer) energy and environmental performance, with these areas having the highest proportion of dwellings on the lower end of the SAP rating scale (64% and 61% respectively rated E-G).

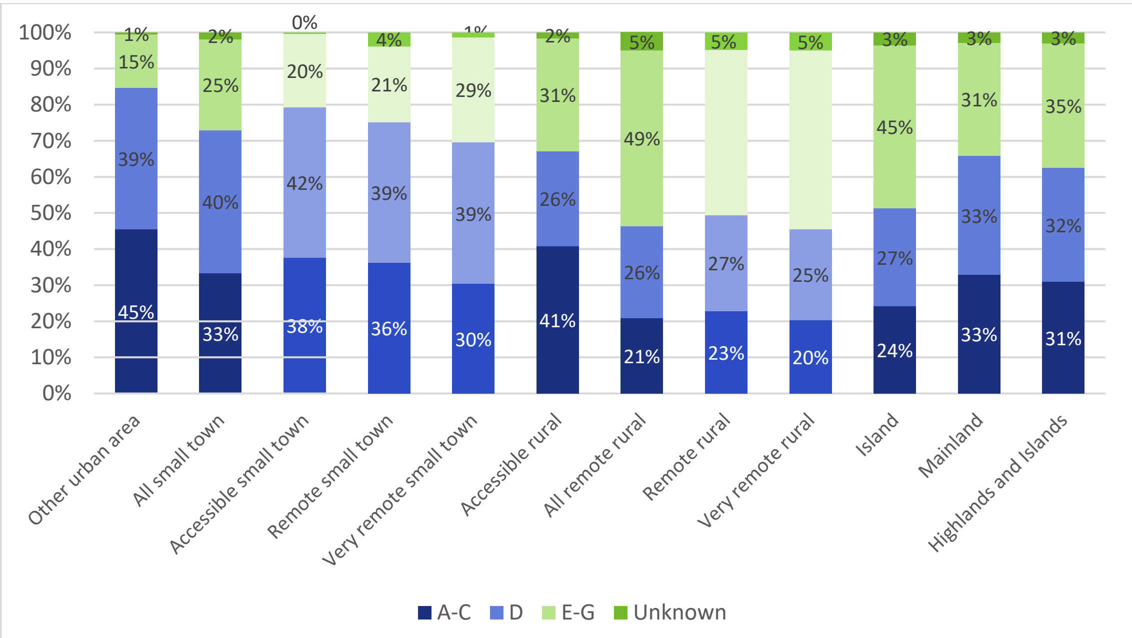
Figure 5.5: SAP rating banded by sub-region



Source: Energy Saving Trust, 2023

5.30 Furthermore, the most rural parts of the region have the highest proportion of dwellings with an energy efficiency rating banded E-G. As Figure 5.6 shows, almost half (49%) of very remote rural properties and 46% of remote rural dwellings had SAP ratings of E-G, compared with only 15% of those in other urban areas. Those in island locations were more likely to have a rating of E-G (45%) than those in mainland locations (31%).

Figure 5.6: SAP rating banded by urban rural banded classification



Source: Energy Saving Trust, 2023

5.31 As Table 5.11 shows, privately rented households had the highest proportion of E, F, and G ratings (42% did so), followed by owner occupied households (40%). Housing association households on average had the best SAP ratings with 60% being rated A or B.

Table 5.11: SAP rating banded by property tenure

SAP Rating Band (Grouped)	Housing Association	Local Authority	Owner Occupied	Privately Rented	Unknown	Total	Scotland %	Highlands and Islands as % of Scotland
A, B	60%	40%	27%	28%	0%	**31%**	**9%**	**14%**
C, D	26%	41%	33%	30%	0%	**32%**	**73%**	**9%**
E, F, G	14%	19%	40%	42%	0%	**35%**	**17%**	**45%**
	0%	0%	0%	0%	100%	**3%**		**43%**

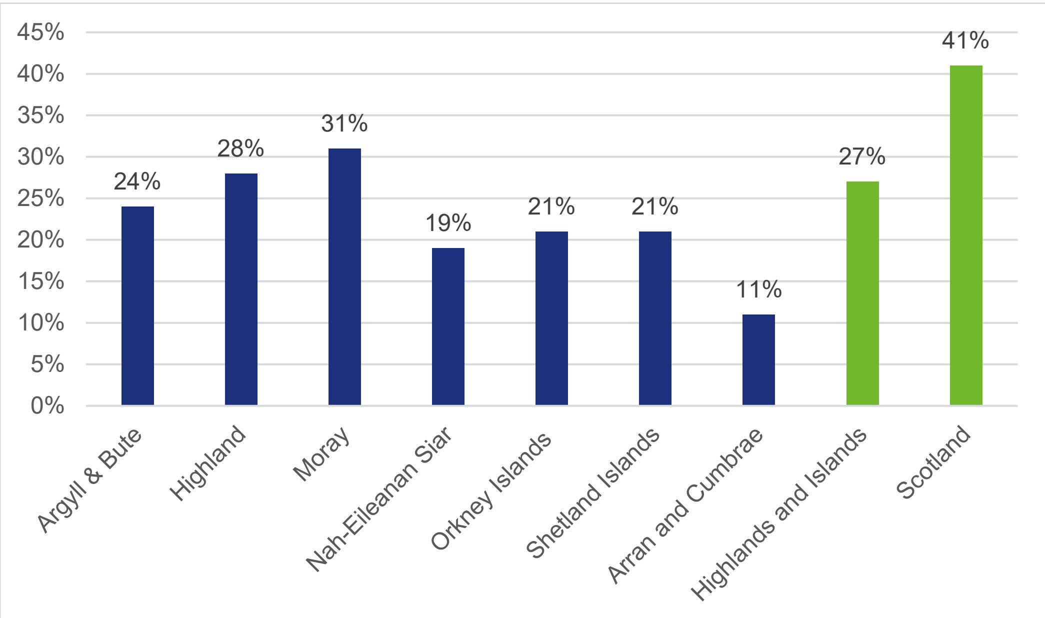
Source: Energy Saving Trust, 2023

5.32 The Environmental Impact Rating (EIR) represents the environmental impact of a dwelling in terms of carbon emissions associated with fuels used for heating, hot water, lighting, and ventilation. Ratings are adjusted for floor area, so they are independent of dwelling size for a given built form.

5.33 Just over a quarter of dwellings (27%) in the Highlands and Islands were rated C or better – almost 14 percentage points lower than for Scotland as a whole (41%). A higher proportion than nationally are in bands F-G (23% versus 8%), higher still in island and remote rural areas (both 35%). The median EIR rating for dwellings in the Highlands and Islands was 54.0, versus 65.0 at the Scotland level, both of which fall within Band D.

5.34 Mainland areas had a higher proportion of dwellings rated C or above compared to the island areas. Only 11% of dwellings in Arran and Cumbrae and 19% of dwellings in Na h-Eileanan Siar had a rating of C or above, compared to 28% of dwellings in Highland and 31% of dwellings in Moray.

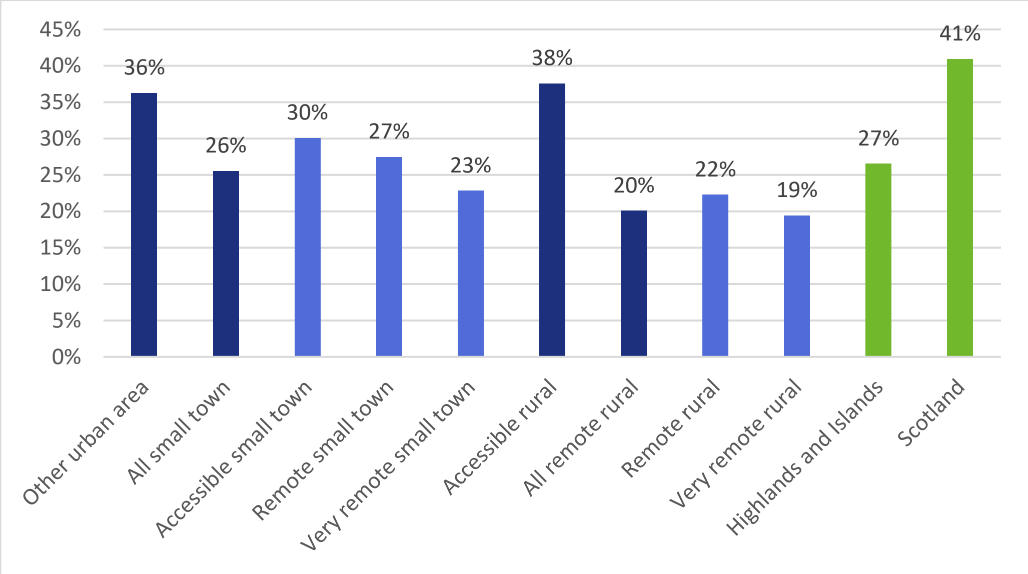
Figure 5.7: Environmental impact rating band C or above by sub-region



Source: Energy Saving Trust, 2023

5.35 The housing stock in accessible rural areas has the lowest environmental impact, with 38% of dwellings having an EIR rating of C or above, closely followed by other urban areas at 36%. As Figure 5.8 shows, properties in remote rural areas had the highest environmental impact, with only around a fifth of residences having an EIR rating of C or higher.

Figure 5.8: Environmental impact rating band C or above by urban rural banded classification



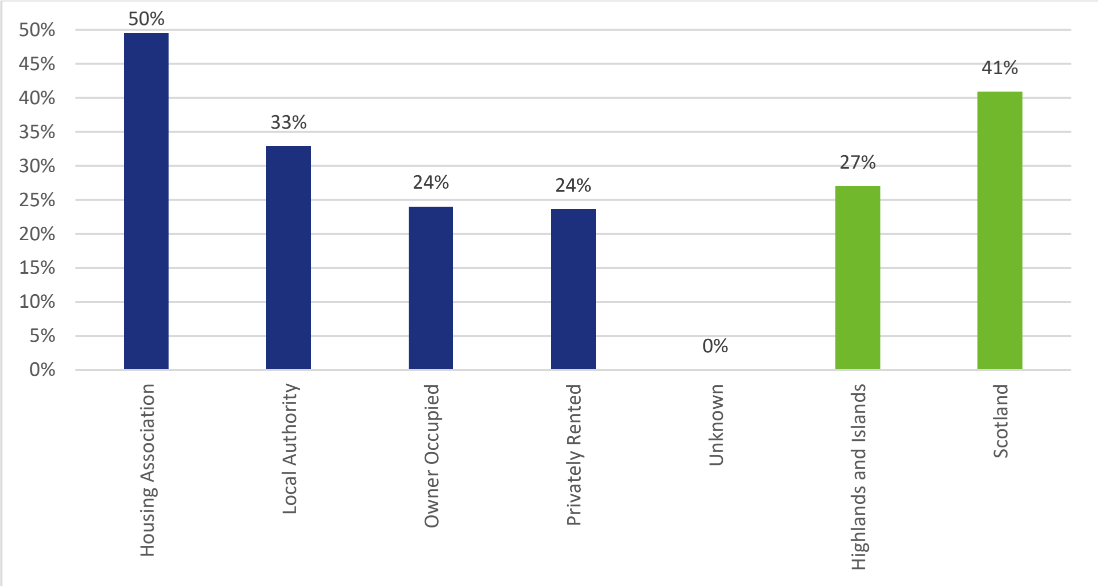
Source: Energy Saving Trust, 2023

5.36 Half of housing association dwellings had an EIR rating of at least a C, followed by a third of local authority tenures. Meanwhile, just under a quarter (24%) of both owner-occupied, and privately rented tenures had at least a C rating.

5.37 The more advanced energy efficiency of dwellings in the social sector in terms of average CO_2 emissions, SAP rating and EIR may in part reflect the standards that have been put in place by Government for the sector over the last decade. The Scottish Housing Quality Standard (SHQS), introduced in 2014, set a target for local authority landlords and registered social landlords to bring their housing stock up to SHQS standard by April 2015. The energy efficiency elements of SHQS were replaced by the Energy Efficiency Standard for Social Housing (EESSH) in 2014, with a milestone for social rented housing to have an Energy Performance Certificate (EPC) rating of 'C' or 'D' by December 2020.[85] The second milestone (EESSH2) requires all social rented houses to meet EPC Band 'B', or be as energy efficient as practically possible by the end of December 2032. As such, they are in a better starting point than owner-occupied dwellings and other properties. Analysis of responses to the Scottish Government's recent consultation on their proposed Heat and Buildings Bill[86] should soon be published. The consultation paper set out proposals to manage the transition of domestic and non-domestic buildings to net zero. For residential properties, this includes the potential introduction of a minimum energy efficiency standard for private landlords and owner-occupiers to be met by 2028 and 2033 respectively (although consideration is being given to variation or exemptions required based on dwelling characteristics etc).

[85] Energy efficiency in social housing - Home energy and fuel poverty - gov.scot (www.gov.scot)
[86] Delivering net zero for Scotland's buildings - Heat in Buildings Bill: consultation - gov.scot (www.gov.scot)

Figure 5.9: Environmental impact rating band C or above by property tenure



Source: Energy Saving Trust, 2023

SUMMARY DISCUSSION

As is evident from the analysis presented above, there are some specific retrofit challenges around the Highlands and Islands' housing stock and improving energy efficiency (and thus domestic carbon emissions), particularly in more rural and island locations. Table 5.12 summarises the factors around emissions arising from dwellings in the region. Typically, the retrofit challenges relate to the lack of suitability of many conventional retrofit approaches currently on offer.[87] A greater reliance on carbon intensive fuels and the nature and age of dwellings in the region mean that such approaches cannot easily be applied for many dwellings in the region, and therefore more bespoke or novel approaches need to be taken. This increases the complexity of the retrofit challenge for the Highlands and Islands, but also presents an opportunity for the region to position itself as a testbed for new retrofit approaches.

Anecdotal evidence suggests that there are additional challenges around the lack of a local supply chain (many retrofit and energy efficiency companies are based in the Central Belt), and thus a limited skills base in the region. Stimulating labour market demand for increased building capacity and skills development is critical going forward. A significant reduction in housing emissions will only result from improving the energy efficiency of owner-occupied dwellings which constitute 63% of total dwellings in the Highlands and Islands region.

[87] It is likely that all properties across the Highlands and Islands will require some form of intervention and that there's a clear need for a significantly expanded contractor base who can undertake non-traditional measures such as external wall insulation.

Table 5.12: Overview of emissions from residential dwellings and related factors

	% of detached dwellings	% of pre 1919 dwellings	% of dwellings with solid walls	% of dwellings with single glazing	% of dwellings with solid floors	% of dwellings with high carbon main fuel (LPG, oil, solid)	% of dwellings in very severe exposure zone	Mean tCO_2 emissions	% of dwellings at Environmental Impact Rating C+
Argyll and Bute	33%	30%	37%	10%	15%	21%	80%	6.0	24%
Highland	38%	17%	25%	7%	23%	35%	19%	5.8	28%
Caithness and Sutherland	41%	28%	38%	5%	26%	51%	7%	7.0	18%
Inner Moray Firth	36%	15%	21%	7%	23%	26%	0%	5.3	33%
Lochaber, Skye and Wester Ross	46%	16%	25%	5%	22%	51%	96%	6.6	19%
Moray	35%	23%	36%	5%	22%	19%	0%	5.2	31%
Na h-Eileanan Siar	63%	7%	31%	5%	21%	58%	99%	7.8	19%
Orkney Islands	55%	25%	36%	7%	52%	42%	63%	6.8	21%
Shetland Islands	55%	20%	28%	3%	16%	34%	97%	6.6	21%
Arran and Cumbrae	36%	50%	58%	8%	19%	28%	98%	7.6	11%
Island	52%	24%	37%	6%	28%	42%	91%	6.9	24%
Mainland	36%	20%	29%	7%	21%	27%	23%	5.7	33%
Other Urban Area	24%	12%	19%	8%	15%	1%	0%	4.3	36%
Small Towns	21%	19%	31%	6%	15%	13%	46%	5.2	26%
Accessible Rural	48%	19%	27%	5%	29%	40%	3%	5.5	38%
Remote Rural	54%	19%	37%	7%	27%	50%	61%	7.3	20%
Highlands and Islands	**40%**	**21%**	**31%**	**7%**	**22%**	**31%**	**39%**	**6.0**	**27%**
Scotland	**21%**	**18%**	**26%**	**8%**	**17%**	**8%**	**10%**	**4.3**	**41%**

Note: Areas with performance equal to or better than Scotland average have been highlighted.

6 REGIONAL RENEWABLE ENERGY GENERATION CAPACITY

Chapter summary

- The Highlands and Islands play a pivotal role in Scotland's renewable energy targets and strategy due to its extensive natural assets. Recognising this competitive advantage for the region, the creation of renewable energy schemes cuts across a range of regional and national policy objectives.
- The total installed and operational renewable energy capacity in Scotland in 2023 was around 12,500MW, with more than half of this (52%) within the Highlands and Islands (6,513MW). The renewable energy generation comes from a growing number of sources and technologies across the region. These are: wind, wave and tidal stream, solar, hydroelectricity (including pumped storage hydroelectricity), hydrogen, heat pumps, and biomass, biogas, and anaerobic digestion.
- If all pipeline activity is realised, capacity within the region is expected to increase substantially to over 33,000MW. Schemes in and around the Highland Council area are expected to drive the largest absolute capacity increase, while Shetland is expected to realise the largest percentage increase, albeit from a comparatively low base.
- Onshore Wind is currently the largest source of renewable energy generation within the Highlands and Islands, with a current capacity of around 2,900MW. This is expected to increase by over 5,000MW should all pipeline activity be realised.
- Offshore wind capacity is expected to increase to a far greater scale (+16,462MW) than other technologies, with the most recent ScotWind leasing rounds opening up the Highlands and Islands to more developments.
- There are currently two operational Offshore Wind farms within the Highland and Islands the Beatrice and Moray East Wind Farms. These are large sites with 84 and 100 turbines respectively.
- Tidal barrage and tidal stream energy technologies currently have a small role in installed capacity in the Highlands and Islands but one that is set to grow over the next few years.
- Currently, the Highlands and Islands has limited operational battery storage capacity, with a little over 3MW installed. However, capacity is anticipated to increase by around 1,300MW, substantially increasing the region's energy storage capacity.
- With the longstanding success of hydroelectric stations in the Highlands and Islands, there are a number of developments in the pipeline that will drastically increase energy generation capacity.
- Despite low capacity for biogas and biomass energy generation there is, however, considerable investment and planning being undertaken to increase the developments.
- Hydrogen technology presents a truly significant opportunity to transform energy generation, heating, transportation and storage in the Highlands and Islands.
- Key enablers to help realise this renewable energy generation potential include: development of skills to support the work required; harnessing academic expertise and facilitating industry academia collaboration; capitalising on the relative attractiveness of renewables over oil and gas for new entrants; and co ordinated lobbying of government to support development.

INTRODUCTION

6.1 The natural resources that are at the disposal of the Highlands and Islands place the region in an ideal position to generate renewable energy. This chapter considers the current generation capacity within the Highlands and Islands, across a range of generation technologies. It also gives some consideration to strategic factors that will influence the region's ability to realise its future potential in renewable energy generation.

RENEWABLE ENERGY IN THE HIGHLANDS AND ISLANDS

6.2 Sustainable energy development is a priority for Scotland and key to this is reducing the consumption of fossil fuels in all sectors and areas of activity. The Scottish Government has set the ambitious target of being a net zero nation by 2045 and is supporting a range of activities to address the climate emergency,[88] some of which have been reflected in recent Programmes for Government. The Just Transition Commission[89] provides scrutiny and advice on how to deliver a just transition to a low carbon economy in Scotland. The third update on the Climate Change Plan in 2018 and subsequent 2020 update identifies that Scotland is well placed to take advantage of opportunities in emerging industries, such as marine energy and offshore wind.[90] The most recent ambitions are to ensure that the electricity system is largely from renewable sources by 2032, as well as using smart grid technologies to improve connection to the national grid.

6.3 This is addressed in the Scottish Energy Strategy which supports the climate change ambitions and sets out a vision for a competitive local and national energy sector that delivers secure, affordable and clean energy by 2050.[91] It focuses on an inclusive transition to a low-carbon future with targets to increase Scotland's energy sourced from renewables, maximise the productivity of this energy use, and becoming a world leader in renewable and low carbon technologies.

6.4 The Highlands and Islands plays a pivotal role in Scotland's renewable energy targets and strategy due to its extensive natural assets. The region's abundant natural resources facilitate renewable energy generation through a number of approaches and technologies, making it an ideal location for harnessing clean and sustainable power. Whilst pivotal for meeting Scotland's energy and net zero targets, the development of renewable energy projects in the Highlands and Islands also creates significant potential economic opportunities.

6.5 Recognising this competitive advantage for the Highlands and Islands, the creation of renewable energy schemes cuts across a range of regional and national policy objectives. As Scotland reduces its reliance on fossil fuels it creates job opportunities - the Highlands and Islands being well positioned to benefit from this realignment. The development and subsequent operation of these renewable energy schemes creates opportunities throughout the lifecycle of the project and indirectly in the wider region. Renewable energy schemes vary greatly in scale, motive, and ownership. Local communities can benefit from renewable energy initiatives through direct employment, involvement in shared ownership or community schemes, and indirectly though greater local revenue generation. This empowers communities, strengthens social cohesion, and encourages more inclusive and sustainable development.

[88] Scottish Government (2021) Programme for Government 2021-22, A fairer, greener Scotland.
[89] https://www.justtransition.scot/
[90] Scottish Government (2018) Climate Change Plan. The Third Report on Proposals and Policies 2018-2032.
[91] Scottish Government (2021) Programme for Government 2021-22, A fairer, greener Scotland.

6.6 As the social and economic benefits are important for regional and national objectives, so too are the environmental benefits presented to the region. By transitioning to renewable energy sources, the region can mitigate the environmental impacts associated with fossil fuel use, such as air pollution, greenhouse gas emissions, and habitat destruction. On a more local scale, this presents an opportunity for greater protection of the unique natural heritage and in supporting sustainable tourism, which is vital for the region as a main employer in certain areas.[92]

6.7 Renewable energy schemes are not new to the Highlands and Islands with major Hydroelectric schemes being built across much of the region in the 1950s and 1960s.[93,94] However, an important development has been the proliferation of a wide range of technologies, developers, and scale of renewable energy developments across the region, with various approaches being adopted to capitalise on opportunities. An important element of the creation of renewable energy schemes in the Highlands and Islands is the ScotWind leasing round by Crown Estate Scotland, through which offshore wind developers can secure seabed leases for the development of large-scale offshore wind farms.[95] The leasing round aims to accelerate the development of offshore wind energy in Scotland, and the Highlands and Islands, and contribute to the country's renewable energy targets. It is a critical initiative in supporting the country's transition towards a low-carbon economy, while attracting investment, creating job opportunities and stimulating economic development. Leases were awarded to 20 commercial-scale offshore wind projects in 2022[96] that could create almost 25GW of installed capacity across Scottish waters in the next decade.[97] There are currently seven offshore wind farms operating in Scottish Waters with a total generating capacity of 1.9GW.[98] Recent awards have included Scottish Power Renewables and their Machair Wind development which is currently planned to have a capacity of 2000MW and is in the process of site investigations.[99]

6.8 This strategy, of delivering leasing rounds, has been successful, with the Crown Estate also opening up the Innovation and Targeted Oil and Gas (INTOG) leasing round, with the direct objective of reducing emissions from oil and gas production.[100] This targeted action offers developers the opportunity to build two types of offshore wind project, both small scale and innovative, as well as larger schemes directly addressing the decarbonisation of oil and gas production. With the North Sea Transition Sector deal influencing large areas of this leasing round, it demonstrates both the context and opportunities in which renewable energy targets and developments operate within.[101] The opportunities to develop renewable energy projects are an attractive proposition, from which an application and development process begins, creating a pipeline of projects at varying stages of development with varying timelines.

[92] https://www.gov.scot/publications/stronger-more-resilient-scotland-programme-government-2022-23/
[93] https://www.drax.com/about-us/our-sites-and-businesses/cruachan-power-station/
[94] In recent years there has been a resurgence of interest in Hydroelectric schemes.
[95] https://www.crownestatescotland.com/scotlands-property/offshore-wind/scotwind-leasing-round
[96] https://www.crownestatescotland.com/resources/documents/scotwind-briefing-november-2022
[97] https://www.crownestatescotland.com/news/scotwind-offshore-wind-leasing-delivers-major-boost-to-scotlands-net-zero-aspirations
[98] https://www.crownestatescotland.com/scotlands-property/offshore-wind/current-projects
[99] https://www.scottishpowerrenewables.com/pages/machairwind.aspx
[100] https://www.crownestatescotland.com/scotlands-property/offshore-wind/intog-leasing-round
[101] https://www.crownestatescotland.com/scotlands-property/offshore-wind/intog-leasing-round

CURRENT AND PIPELINE RENEWABLE ENERGY GENERATION CAPACITY

Regional generation capacity: current and pipeline

6.9 Analysis in this chapter uses data from the Renewable Energy Planning Database (REPD) published by the Department for Energy Security and Net Zero (DESNZ), information on schemes identified through the recent ScotWind and INTOG leasing rounds, and desk research on projects not currently in the REPD, to provide estimates of the current and pipeline renewable energy generation capacity within the region. It includes local authority data for the HIREP area, along with data for Arran and Cumbrae where it can be sourced.[102] The REPD contains data on schemes that are currently moving through the planning application and consulting process, under construction or in operation. Desk research has been undertaken to verify site location and capacity for some entries in the REPD – e.g. some sites have incorrect geographical or local authority locations, or contain incorrect/no information regarding generation capacity. As the REPD only includes projects over 150kW, the analysis may not capture smaller, community-based schemes taking place across the region.

6.10 The total installed and operational renewable generation capacity in Scotland in 2023 was approximately 12,576MW, with 52% (6,513MW) of this in the Highlands and Islands. The renewable energy generation comes from a growing number of sources and technologies across the region. These are: Wind, Wave and Tidal Stream, Solar, Hydroelectricity (including Pumped Storage Hydroelectricity), Hydrogen, Heat Pump, Biomass, Biogas, and Anaerobic Digestion.

6.11 Whilst there is a sizeable operational renewable energy capacity in the Highlands and Islands, there is also a pipeline of renewable energy generation sources which is expected to increase the region's renewable energy capacity significantly from 6,513MW to 33,205MW – an increase of 410% (26,692MW). It is important to highlight that throughout the pipeline of developments, there are a range of different stages in which each of the developments exist. Project development, application and consenting processes are lengthy, with revisions and changes in scale, ownership and technology remaining a consideration. Schemes may be delayed, withdrawn, or refused.

Table 6.1: Regeneration capacity in the Highlands and Islands: Operational and pipeline

	Highlands and Islands (MW)	Scotland (MW)	Highlands and Islands as % of Scotland
Operational	6,513	12,576	52%
Pipeline[103]	26,692	59,626	45%
Consented, awaiting construction, under construction	*5,420*		
Project planning, development and application process	*21,272*		
Total Operational and Pipeline	**33,205**	**72,203**	**46%**
Percentage increase	***410%***	***474%***	**-**

Source: DESNZ Renewable Energy Planning Database, 2023; Crown Estate Scotland, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding. Pipeline breakdown calculated for Highlands and Islands only.

[102] Data is limited for Arran and Cumbrae. The scale of renewables developments on the islands are typically small, community-based schemes, and are therefore unlikely to be under the minimum capacity threshold for inclusion in the REPD (150kW). However, two small hydro schemes, totalling 1MW in capacity, have been included.

[103] Pipeline includes schemes that are consented, awaiting construction or under construction, and also those in the project planning, development, or application process phase.

Generation capacity by local authority

6.12 Across the Highlands and Islands there is expected to be a significant increase in renewable energy generation. Schemes in and around the Highland Council area are expected to drive the largest absolute capacity increase, with more than 11,000MW expected to be added to the area's energy generation capacity. Shetland is expected to realise the largest percentage increase upon successful developments of proposed schemes, albeit from a comparatively low base.

Table 6.2: Generation capacity by local authority in the Highlands and Islands

	Operational MW	LA operational share (%)	Pipeline MW	LA pipeline share (%)	Potential increase (%)
Argyll and Bute	897.8	14%	3,558.6	12%	396%
Highland	5,099.5	78%	11,483.7	49%	284%
Moray	411.4	6%	1,126.1	4%	274%
Orkney Islands	49.8	1%	3,678.4	12%	7,386%
Shetland Islands	12.9	0%	3,543.9	12%	27,558%
Na h-Eileanan Siar	40.9	1%	3,301.2	11%	8,071%
Arran and Cumbrae[104]	1	<1%			
Highlands and Islands Total	**6,513.2**		**26,691.9**		**410%**

Source: DESNZ Renewable Energy Planning Database, 2023; Crown Estate Scotland, 2023; RenewableUK, 2023; ekosgen desk research

RENEWABLE GENERATION CAPACITY BY TECHNOLOGY

6.13 Across the Highlands and Islands there is an expected growth in the scale and capacity of renewable technologies. Offshore wind capacity is expected to increase to a far greater scale (+16,462MW) than other technologies, with the most recent ScotWind leasing rounds opening up the Highlands and Islands to more developments. However, significant increases in generation and supply/storage capacity are expected across nearly all renewable energy technologies. This is particularly the case for battery storage schemes, which seek to take advantage of curtailed energy and contribute to better load and demand management in local energy systems. A number of proposed pumped storage systems, which will increase the region's hydroelectric generation capacity, have also been announced in recent months.

[104] Data is limited for Arran and Cumbrae. The scale of renewables developments on the islands are typically small, community-based schemes, and are therefore unlikely to be under the minimum capacity threshold for inclusion in the REPD. However, two small hydro schemes, totalling 1MW in capacity, have been included.

Table 6.3: Generation capacity by technology in the Highlands and Islands

	Operational (MW)	*Technology operational share (%)*	Pipeline (MW)	*Technology pipeline share (%)*	Potential increase (%)
Offshore Wind (Fixed/Floating)	1,480.0	*23%*	16,461.9	*62%*	1,112%
Onshore Wind	2,914.6	*45%*	5,057.2	*19%*	174%
Hydro and Pumped Storage Hydro	2,066.1	*32%*	2,569.2	*10%*	124%
Battery storage	3.2	*<1%*	1,296.2	*5%*	40,506%
Tidal Stream	10.6	*<1%*	874.2	*3%*	8,247%
Wave			20.0	*<1%*	n/a
Biogas, Biomass and Anaerobic Digestion	37.9	*1%*	270.0	*1%*	712%
Solar Photovoltaics	0.6	*<1%*	92.5	*<1%*	15,417%
Hydrogen/Ammonia			50.8	*<1%*	n/a
Heat Pump District Heating	0.2	*<1%*			n/a
Total (Highlands and Islands)	**6,513.2**		**26,691.9**		**410%**
Total (Scotland)	**12,576.1**		**59,626.4**		**474%**

Source: DESNZ Renewable Energy Planning Database, 2023; Crown Estate Scotland, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

Offshore wind

6.14 Offshore Wind is a significant generator of renewable energy in the waters around the Highlands and Islands with a current generation capacity of around 1,480 MW. There are currently two operational Offshore Wind farms within the Highland and Islands – the Beatrice and Moray East Wind Farms. These are large sites with 84 and 100 turbines respectively. The Beatrice Offshore Wind Farm is a notable project located in the Outer Moray Firth, off the northeast coast of Scotland and is a joint venture between Scottish energy company SSE Renewables (40%), Copenhagen Infrastructure Partners (35%), and Red Rock Power Limited (25%). Construction of the wind farm began in 2017, and it became fully operational in 2019.[105]

[105] https://www.beatricewind.com/

Table 6.4: Operational and pipeline capacity in the Highlands and Islands – Offshore Wind

	Operational (MW)	Pipeline (MW)	Percentage Increase
Argyll and Bute		2,100.0	n/a
Highland	1,480	5,718.9	386%
Moray			
Orkney		3,008.0	n/a
Shetland		2,800.0	n/a
Na h-Eileanan Siar		2,835.0	n/a
Arran and Cumbrae			
Total	**1,480**	**16,461.9**	**1,112%**

Source: DESNZ Renewable Energy Planning Database, 2023; Crown Estate Scotland, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

6.15 However, there is a considerable pipeline of new offshore wind farm developments at varying stages, many of which are being driven through successful proposals through ScotWind leasing rounds. These developments are expected to increase the current capacity by over 1,100%, creating an additional operational capacity of 16,462MW. Ocean Wind Caledonia[106] and Machair Wind[107] are two of the largest of these proposed developments in the pipeline, both the result of the ScotWind leasing round, and each with an expected generation capacity of 2GW. Machair Wind, off the coast of Argyll, is the largest of the ScotWind and INTOG developments, with site investigations completed in November 2023 and project consent expected in the mid-2020s. Upon completion it is expected that this development will generate enough electricity to power the equivalent of more than 2 million homes across the UK, contributing to not only regional but Scotland and UK wide targets around energy and climate action.

6.16 While all existing operational offshore wind capacity is from fixed installations, the majority of pipeline activity is expected to come from floating offshore wind technologies (Table 6.5). A smaller proportion of pipeline capacity is expected to come through combined fixed and floating offshore wind installations (the West of Orkney project[108] proposed through the ScotWind leasing round).

Table 6.5: Operational and pipeline capacity by technology type in the Highlands and Islands – Offshore Wind

	Operational (MW)	Pipeline (MW)	Percentage Increase
Wind Offshore Fixed	1,480.0	5,790.0	391%
Wind Offshore Floating		8,671.9	n/a
Wind Offshore Combined Fixed & Floating		2,000.0	n/a
Total	**1,480.0**	**16,461.9**	**1,112%**

Source: DESNZ Renewable Energy Planning Database, 2023; Crown Estate Scotland, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

[106] https://www.oceanwinds.com/projects/caledonia/
[107] https://www.scottishpowerrenewables.com/pages/machairwind_project.aspx
[108] https://www.westoforkney.com/

Tidal and Wave energy

6.17 Tidal Barrage and Tidal Stream Energy technologies currently have a small role in installed capacity in the Highlands and Islands but one that is set to grow over the next few years. There is currently only 10.6MW of energy generated within the Highlands and Islands through these means, with all sources bar one, located in either the Shetland or Orkney Islands.

Table 6.6: Operational and pipeline capacity in the Highlands and Islands – Tidal and Wave energy

	Operational (MW)	Pipeline (MW)	Percentage Increase
Wave		**20**	**n/a**
Orkney Islands		*20*	*n/a*
Tidal (stream)	**10.6**	**874.2**	**8,247%**
Argyll and Bute		*30*	*n/a*
Highland		*392*	*n/a*
Orkney Islands	*10*	*437.2*	4,372%
Shetland Islands	*0.6*	*15*	2,500%
Moray			
Na h-Eileanan Siar			
Arran and Cumbrae			
Total Wave and Tidal	**10.6**	**894.2**	**8,436%**

Source: DESNZ Renewable Energy Planning Database, 2023; Crown Estate Scotland, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

6.18 There is currently around 894MW of proposed developments within the Highlands and Islands with varying sizes, with the vast majority of this (98%) relating to tidal stream rather than wave energy. Brims Tidal Array at Cantick Head in the Orkney Islands is currently in the application process but will significantly increase the capacity if the 200MW site is developed, though there is a degree of uncertainty in how the project, which is almost fully consented, will proceed following the liquidation of OpenHydro.[109] There are also significant developments awaiting construction such as the MeyGen Project Phase 2, with around 28MW, in addition to the pre-existing 6MW in the Inner Sound Phase 1 scheme operated by SIMEC Atlantis Energy (SAE). The MeyGen project is the largest planned tidal stream project in the world. Located in the Pentland Firth, the project is being delivered in collaboration with various partners and stakeholders, including the Scottish Government, Crown Estate Scotland, and others. The MeyGen development has several phases, with the initial phase involving the installation of four tidal turbines, known as the Atlantis AR1000 turbines, with a total capacity of 6 megawatts (MW). These turbines were successfully deployed and generated electricity, making it the world's first large-scale tidal energy array to deliver power to the grid in 2017. The long-term vision for the MeyGen development is to expand the project to its full capacity of 398MW, which could involve the installation of hundreds of additional tidal turbines in the Pentland Firth.[110]

[109] https://tethys.pnnl.gov/project-sites/brims-tidal-array
[110] https://saerenewables.com/tidal-stream/meygen/

Onshore Wind

6.19 Onshore Wind is currently the largest source of renewable energy generation within the Highlands and Islands, with a current capacity of around 2,900MW. The use of Onshore Wind turbines is noticeable in both its geographical spread across the region but also in the range of generation capacity. The largest operational Onshore Wind farm, Stronelairg near Fort Augustus, with a capacity of 228MW is operated by SSE Renewables.[111] The development was completed in 2018 and takes SSE's Scotland-wide onshore generation capacity to 2,143MW, with the Highlands and Islands playing a large part in their operational and future developments and plans. The Allt Dearg Wind farm in Argyll is an example of a community owned wind farm. The development operates in partnership with local landowners, specialist investors and the Ardrishaig Community. The success of Allt Dearg and its community ownership model has encouraged neighbouring communities of Tarbert and Skipness to the south, and Kilfinan on the east side of Loch Fyne to look at similar schemes.[112]

Table 6.7: Operational and pipeline capacity in the Highlands and Islands – Onshore Wind

	Operational (MW)	Pipeline (MW)	Percentage Increase
Highland	2,015.6	2,440.6	121%
Argyll and Bute	417.3	706.3	169%
Moray	385.8	602.8	156%
Orkney Islands	43.8	162.4	371%
Na h-Eileanan Siar	40.9	466.2	1,140%
Shetland Islands	11.2	678.9	6,062%
Arran and Cumbrae			
Total	**2,914.6**	**5,057.2**	**174%**

Source: DESNZ Renewable Energy Planning Database, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

6.20 This capacity is planned to greatly increase with over 5,000MW of Onshore Wind energy generation currently in the application and construction phase within the Highlands and Islands. The largest of these schemes is the Viking Wind Farm in Shetland, which is expected to have a generation capacity of 443MW upon completion in 2024, almost double that of Stronelairg. The Viking Wind Farm is a joint venture between SSE Renewables and the Shetland Charitable Trust. The project is owned and operated by Viking Energy Limited, a company established to oversee the development and construction of the wind farm. This project emphasises the importance of SSE Renewables to the Highlands and Islands in terms of development creation but also the ability of the region to meet the needs of SSE in generating large quantities of renewable energy.[113]

Battery storage

6.21 Battery storage has gained considerable attention in recent years, both as a means to manage load demand across local energy systems (e.g. for island communities, such as the Isle of Rum,[114] which is not on the national grid) and for maximising the potential of curtailed energy, where renewable energy generated (for example by community wind farms) is in excess of demand and would otherwise be wasted.

[111] https://www.sserenewables.com/news-and-views/2018/12/completion-of-228mw-stronelairg-onshore-wind-farm/
[112] https://www.lochfynewindfarms.com/
[113] https://www.sserenewables.com/onshore-wind/in-development/viking/
[114] http://www.windandsun.co.uk/case-studies/islands-mini-grids/isle-of-rum.aspx

6.22 Currently, the Highlands and Islands has limited operational storage capacity, with a little over 3MW installed. However, almost 1,300MW of battery storage projects are in the development pipeline, with most in Highland and Moray as part of Onshore Wind development schemes. This would substantially increase the region's energy storage capacity, particularly when the cost of curtailment – where the National Grid pays wind farms to shut down to avoid exceeding grid capacity – is in sharp political focus.[115] A recent battery storage scheme was proposed by Inverness Caledonian Thistle FC in Inverness.[116] Planning Permission for the scheme was refused, but it is understood that the decision has been appealed. The scheme would have potentially developed storage capacity of up to 50MW.

Table 6.8: Operational and pipeline capacity in the Highlands and Islands – Battery storage

	Operational (MW)	Pipeline (MW)	Percentage Increase
Highland	0.2	686.4	312,000%
Shetland Islands	1.0	50.0	4,921%
Argyll and Bute		112.5	n/a
Moray		447.3	n/a
Orkney Islands	2		n/a
Na-h-Eileanan Siar			
Arran and Cumbrae			
Total	**3.2**	**1,296.2**	**40,506%**

Source: DESNZ Renewable Energy Planning Database, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

Hydro-electric

6.23 There are a range of different types of hydro-electric (hydro) energy generators, including smaller hydro schemes to larger pumped storage. Currently, these combined sources generate an estimated 2,066MW across the region, with the largest being Cruachan Pumped Storage Hydroelectric Station generating 440MW.[117] Hydroelectricity has been a long standing and important source of energy in the Highlands and Islands with the Cruachan Station opening in 1965. Whilst there are only four pumped storage stations in the entire UK, smaller hydro stations are found throughout the region with smaller community owned stations such as Knockando generating 0.05MW in Moray.[118]

Table 6.9: Operational and pipeline capacity in the Highlands and Islands – Hydro-electric

	Operational (MW)	Pipeline (MW)	Percentage Increase
Highland	1585.5	1964.4	124%
Moray	0.05		n/a
Shetland			
Orkney			
Argyll and Bute	479.5	604.8	126%
Na-h-Eileanan Siar			
Arran and Cumbrae	1.0		n/a
Total	**2,066.1**	**2,569.2**	**124%**

Source: DESNZ Renewable Energy Planning Database, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

[115] https://www.power-technology.com/news/scottish-first-minister-calls-for-increased-energy-storage-following-curtailment-costs/
[116] https://www.bbc.co.uk/news/articles/czvzerj82x5o
[117] https://www.drax.com/about-us/our-sites-and-businesses/cruachan-power-station/
[118] https://www.pressandjournal.co.uk/fp/news/moray/1125861/hydro-plan-for-speyside-village-could-be-blueprint-for-others-to-follow/

6.24 With the longstanding success of hydroelectric stations in the Highlands and Islands, there are a number of developments in the pipeline that will drastically increase energy generation capacity. The combined renewable energy generation within the proposed developments is around 2,569MW, which would increase the overall hydro capacity to 4,635MW across the Highlands and Islands. The flagship development is the Coire Glas Pumped Storage developed by SSE, which would be the first of its kind built in 40 years. Using similar technology to Cruachan, the station will double the UK's ability to store energy, with a generation capacity of 1,500MW or 1.5GW and energy storage capacity of 30GWh.[119] Gilkes Energy recently announced two potential pumped storage projects, both of which could exceed Coire Glas in scale. The Earba Storage project[120] anticipates a generation capacity of 1,800MW and an energy storage capacity of 40GW while the Fearna Pumped Storage Hydro scheme[121] also anticipates up to 1,800MW installed capacity and 37GW of stored energy.

Solar

6.25 There are currently very few sites of Solar energy generation in the Highlands and Islands with current operational capacity around 0.6MW - Lochaber High School contributing 0.3MW of that total.[122] There are, however, a considerable number of projects at various stages along the application and development process that will increase the energy generation capacity of solar energy in the Highlands and Islands by around 93MW. The largest is the proposed development on Milltown Airfield in Moray which will be expected to generate 50MW upon completion. The development is one of 18 developments across the UK owned by Scottish Power Renewables. This makes the portfolio the largest to be delivered in the UK's post-subsidy market, demonstrating the key role that solar and the Highlands and Islands will play in both the UK and Scotland's renewable energy targets.[123]

Table 6.10: Operational and pipeline capacity in the Highlands and Islands – Solar

	Operational (MW)	Pipeline (MW)	Percentage Increase
Argyll and Bute		5.0	n/a
Highland	0.5	17.5	3,492%
Moray		70.0	n/a
Na-h-Eileanan Siar			
Orkney			
Shetland Islands	0.1		n/a
Arran and Cumbrae			
Total	**0.6**	**92.5**	**15,417%**

Source: DESNZ Renewable Energy Planning Database, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

[119] https://www.coireglas.com/
[120] https://earbastorage.co.uk/
[121] https://fearnastorage.co.uk/
[122] Intelligence suggests that REPD data underestimates the solar generating capacity by focusing on installations requiring planning permission. Anecdotal evidence indicates that Highland Council has more than 0.5 MW of installed capacity itself without factoring in other generation across the region; however, it is likely that much of this and other solar PV generation capacity has been installed under permitted development (PD) rights. Such schemes are typically small-scale or domestic in nature. In the absence of data on solar PV and other generation technologies installed under PD rights, we have focused on available data through REPD for solar PV.
[123] https://www.scottishpowerrenewables.com/pages/milltown_solar_pv_scheme.aspx

Biogas, biomass and anaerobic digestion

6.26 This includes biomass, biogas, energy from waste (EfW) incineration and waste energy projects. Whilst making up a smaller share of overall renewable energy generation within the Highlands and Islands, these technologies and sites offer opportunities for greater variation in the overall renewable capacity. The current capacity is around 38MW, with biomass making up the largest share (75%), Speyside Renewable Energy Partnership CHP Power Plant being the largest contributor (up to 15MW).[124]

6.27 There is, however, considerable investment and planning being undertaken to increase the developments and capacity of biogas and biomass style energy generation in the Highlands and Islands. The Upper Bighouse Biomass Boilers in Sutherland is in the application stage, with a proposed development which would see a generation capacity of around 264MW.[125] Alongside other projects, there is an expected generation capacity of 270MW in the pipeline for the Highlands and Islands. This considerable growth is due to the targeted investment of one company, highlighting the opportunities for specialist and innovative companies to benefit from in the Highlands and Islands.

Table 6.11: Operational and pipeline capacity in the Highlands and Islands – Biogas, biomass, and anaerobic digestion[126]

	Operational (MW)	Pipeline (MW)	Percentage Increase
Argyll and Bute	1.0		n/a
Highland	11.5	264.0	2,296%
Moray	25.6	6.0	23%
Na-h-Eileanan Siar			
Orkney			
Shetland			
Arran and Cumbrae			
Total	**37.9**	**270.0**	**712%**

Source: DESNZ Renewable Energy Planning Database, 2023; RenewableUK, 2023; ekosgen desk research. Figures and percentages may not sum due to rounding.

Hydrogen

6.28 Hydrogen technology presents a truly significant opportunity to transform energy generation, heating, transportation and storage in the Highlands and Islands. Natural gas is the principal fossil fuel used for domestic heating in the UK and reducing its use will undoubtedly make a significant contribution to reducing UK and Scottish Government targets of carbon reduction. Hydrogen may also provide a solution to heating supply in areas not currently served by the gas mains network.

6.29 There are several projects that are currently underway relating to hydrogen as an alternative energy source throughout the Highlands and Islands area, though it should be noted that due to the exploratory and pilot nature of these projects, they are not counted in the overall renewable energy capacity figures set out above. In particular, the Orkney Islands have a distinct track record with regards to delivering hydrogen projects. This is evidenced through projects such as HySeas III,[127] a European

[124] https://www.speysiderenewableenergy.co.uk/
[125] https://gmgenergy.co.uk/pages/our-sites
[126] As above regarding solar PV, we have focused on available data through REPD for biogas, biomass, and anaerobic digestion generation capacity. This may underestimate to total generation capacity for these technologies.
[127] https://www.hyseas3.eu/

Union (EU) Horizon 2020 project that is testing whether or not fuel cells may be successfully integrated with a proven marine hybrid electric drive system (along with the associated hydrogen storage and bunkering arrangements required to facilitate this). The project aims to use knowledge gained to build a hydrogen-fuelled ferry capable of travelling from Kirkwall to Shapinsay in Orkney.

6.30 Another project based on Orkney relating to hydrogen is the Community Energy Scotland Surf 'n' Turf[128] project, which is also an EU Horizon 2020 project. Surf 'n' Turf aims to use power from the Eday Renewable Energy community wind turbine to produce hydrogen using the European Marine Energy Centre's (EMEC) electrolyser based in Eday (which, in itself, is part of an EU INTERREG project[129]). This hydrogen can then be stored and shipped to Kirkwall, where a hydrogen fuel cell is housed on Kirkwall Pier. The fuel cell converts hydrogen back into electricity by mixing it with oxygen from the air. It is intended that this electricity will be able to power facilities in the Kirkwall Harbour area, and ferries when docked.

6.31 Building on the foundations made in the Surf 'n' Turf project, the BIG HIT[130] project utilises two proton exchange membrane (PEM) electrolysers (situated near renewable generation assets on Eday and Shapinsay) to turn electricity into hydrogen to act as an energy-storage medium, that can then later be converted back into power and heat for buildings and vessels in Kirkwall harbour, as well as for hydrogen fuel cell road vehicles within the Orkney Islands Council fleet.

6.32 Outside of Orkney, other projects are currently under development in the Highlands and Islands. This includes one in the Western Isles, led by Comhairle nan Eilean Siar, PlusZero Ltd and University of the Highlands and Islands North, West and Hebrides. It aims to create a Hydrogen Skills and Innovation Centre at Creed Park in Stornoway, creating new facilities for both hands-on hydrogen technology training and next generation electrolyser research and field testing. Another example of hydrogen hub development can be seen in Argyll and Bute, where the Machrihanish Airbase Community Company (MACC) Hydrogen Futures project has been awarded funding from the Community Renewable Fund.[131] The project will investigate potential consumer markets for green hydrogen in the Argyll and Bute region, as well as how to implement the production and distribution of green hydrogen on the MACC site.

6.33 Hydrogen may also be ideally suited to meeting the energy needs of high energy consumers such as distilleries. For example, Moray's mean non-domestic gas consumption per meter is the second highest in Scotland (3.53 million kWh per meter)[132] as a result of its many distilleries. Shifting to hydrogen as a fuel source could drive a significant reduction in carbon.

6.34 One significant example of this development with regards to distilleries being serviced by hydrogen in the Highlands and Islands area is the Cromarty Hydrogen Project,[133] which aims to develop a green hydrogen production hub in the Cromarty Firth region. It revolves around the local distilleries forming the baseload demand for early phases of the project, thereby enabling them to decarbonise in line with their own ambitions and sector targets.

[128] https://communityenergyscotland.org.uk/projects-innovations/surf-n-turf/
[129] https://www.emec.org.uk/projects/hydrogen-projects/iteg/
[130] https://www.bighit.eu/about
[131] http://www.machrihanish.org/news-details.php?id=1243
[132] DESNZ (2024) Subnational gas consumption, Great Britain, 2005 – 2022, at: https://www.gov.uk/government/statistics/regional-and-local-authority-gas-consumption-statistics
[133] https://www.cromartyhydrogenproject.co.uk/project-background/

6.35 Another distillery project is the HySpirits project,[134] which is exploring the potential development of a thermal fluid heater system to operate with hydrogen as the combustion fuel within the distilling process. Funded by the Department of Business, Energy and Industrial Energy's (BEIS) Industrial Fuels Switching Competition, this project is based at The Orkney Distillery and is led by the EMEC in partnership with Orkney Distilling Ltd (site owners) and Edinburgh Napier University (assessing the distillery site and designing the hydrogen system).

Bruichladdich Distillery: HyLaddie project

The Bruichladdich Distillery is a Scotch whisky distillery situated near Port Charlotte on the Isle of Islay in Scotland. In recent years, the distillery has taken a number of measures to reduce its carbon footprint. This has included the installation of a circulatory heating system to recycle hot wastewater and switching to 100% renewable energy to power their operations.[135]

Bruichladdich have also implemented a range of energy efficiency and waste reduction measures at their distillery, as well as responsibly sourcing organic barley, as a means to reduce their carbon footprint. Over half of the distillery's barley is grown on Islay from a total of 19 farmers. This is supplemented by Bere barley grown on Orkney, organic barley grown in the North East of Scotland, and barley grown on a biodynamic certified and carbon negative farm in England, which sequesters ten times more carbon than it emits.[136] These measures, along with a project to plant around 7,500 trees around its warehouses[137] and making bottle gift tins optional,[138] form part of the company's overall sustainability strategy.

This approach has earned the Bruichladdich distillery recognition including being awarded The Energy Institute Environment Award, achieving 100% Green Electricity and becoming the first whisky and gin distillery in Europe to be a certified B Corporation.[139]

As part of a long-term commitment to reduce their carbon footprint and create positive energy infrastructure for its distillery, Bruichladdich is delivering a number of projects. One of these is HyLaddie, a BEIS Green Distilleries Competition-funded project that aims to make distillation on-site carbon-free by 2025. The project is being delivered in partnership with ITP Energised and Protium Green Solutions and Deuterium Heating.

Following a successful Phase 1 feasibility study,[140] Phase 2 of the HyLaddie project has secured £2.65 million of funding to investigate and demonstrate a viable solution for the decarbonisation of the distillery's heating requirements using green hydrogen. This will see the installation of an on-site Dynamic Combustion Chamber (DCC™).[141] The DCC3000 hydrogen boiler, patented by Hydrogen Technologies LLC, can produce enough process steam to drive a steam turbine with up to 3MWe capacity. The technology, the first of its kind in the UK, is the only zero-emission, closed loop boiler that generates high temperature steam, using oxygen and hydrogen that is reacted in a vacuum. Hydrogen is produced via an electrolyser which is supplied by Bruichladdich's renewable grid connection. This eliminates any emissions of CO_2, NO_x and SO_x.[142]

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[134] https://www.orkneydistilling.com/blogs/news/hydrogen-powered-gin-our-sustainable-vision
[135] https://uk.bruichladdich.com/blogs/philosophy/energy
[136] https://www.heraldscotland.com/life_style/food_and_drink/latest/23134223.spirit-sustainability-reaches-new-heights/
[137] https://uk.bruichladdich.com/pages/milestone
[138] https://www.thespiritsbusiness.com/2021/02/bruichladdich-makes-gift-tins-optional/
[139] https://uk.bruichladdich.com/blogs/philosophy/milestones
[140] https://assets.publishing.service.gov.uk/media/607eb5c0e90e076aaf0a31e0/HyLaddie_Phase_1_Feasibility_Report.pdf
[141] https://www.itpenergised.com/portfolio/green-hydrogen-feasibility-study-beis-green-distilleries-competition-project-hyladdie/
[142] https://www.theengineer.co.uk/content/news/distillery-to-install-dcc-hydrogen-boiler-to-produce-green-spirits

The HyLaddie project will see the DCC3000 run in isolation from the existing thermal heating system to create a zero-emission distillation process and, in turn, the world's first zero-emissions whisky.[143] Bruichladdich hopes to demonstrate the capability of hydrogen within the distillation process to encourage commercialisation across Islay, and more widely.

Other distilleries, including the Arbikie distillery near Montrose and Beam Suntory Ltd. (owners of Bowmore and Laphroaig (also on Islay), Ardmore and Glen Garioch), are also benefitting from BEIS Green Distilleries competition funding to transition from traditional distilling processes that burn fossil fuels, instead using zero-carbon green hydrogen generated on site.[144]

6.36 Other applications of hydrogen are also being developed. This includes the development of an ammonia plant at Hammars Hill wind farm in Orkney, which will convert electricity, water and air into ammonia (NH_3), as an effective form of energy (hydrogen) storage. The process to form the ammonia can also be reversed, which enables the supply of hydrogen for use in fuel cells, including ferries.[145]

SUMMARY DISCUSSION

The potential impact of the scale of renewable energy generation in the Highlands and Islands cannot be understated. The development of a new, clean energy industry, and provision of clean carbon-free energy to homes and communities, and to high consumption industries, across the region, Scotland and the rest of the UK is a transformational opportunity. There are clear links with the Scottish Energy Strategy in terms of decarbonisation, and in contributing to a decentralised energy and heating supply network, ultimately improving energy security. Renewable energy generation is also central to delivering against the Scottish Government objectives for Just Transition, Net Zero and the ambitions of the National Strategy for Economic Transformation (NSET).

The Highlands and Islands is at the vanguard of renewable energy activity in Scotland. The current renewable energy capacity of the region is significant, and there is potential to increase capacity even further. This can be seen most clearly in respect of offshore wind, but also in generation and supply/storage across nearly all renewable energy technologies, particularly in projects that seek to capture and store carbon emissions through Carbon Capture and Storage (CCS) systems. While the recent award of UK Government funding for the Acorn CCS project at St Fergus in North East Scotland[146] does not directly impact on the Highlands and Islands region, it is a signal of intent with regards to the development of clusters in Scotland that are focused on reduction of carbon. Lessons could be potentially learned with regards to storage and utilisation of carbon, to be used in tandem with renewable energy generation as part of the pathway to net zero.

In order to capitalise on the potential of the region in renewables generation, there are certain enablers that are required to be considered, that will help realise the economic and environmental opportunities presented within the region.

[143] https://www.gov.uk/government/publications/green-distilleries-competition/green-distilleries-competition-phase-2-demonstration-successful-projects
[144] https://www.gov.uk/government/publications/green-distilleries-competition/green-distilleries-competition-phase-2-demonstration-successful-projects
[145] https://hammarshillenergy.co.uk/
[146] https://www.gov.uk/government/news/hundreds-of-new-north-sea-oil-and-gas-licences-to-boost-british-energy-independence-and-grow-the-economy-31-july-2023

One of the most vital enablers for realising these benefits is the development of skills to support the work required. As such, there is a need to understand the current skills landscape, to better identify current and emerging skills gaps and training requirements. This requires scaling up, aligning and targeting provision of education and learning to the relevant opportunities available to anchor skills development in the region, and addressing both replacement and expansion demand in the labour market. This, alongside upskilling the existing workforce to keep pace with new processes and developments, is a key issue in driving economic development.

Academic engagement also acts as a key enabler in the region, with a wealth of academic expertise and academic institutions based in the Highland and Islands. There is considerable research capacity in the diverse and specialised UHI partner colleges. This includes the Scottish Association for Marine Science (SAMS), which has world-leading expertise in marine systems science, algal biotechnology and marine renewables. NAFC Marine Centre UHI in Shetland has renowned expertise in fisheries, shellfish and marine spatial planning. The Environmental Research Institute, based in Thurso, works across carbon, water and climate, ecological health, environmental contamination and renewable energy. In addition, other universities have a base and conduct research in the region through collaboration, institutes and campuses. Orkney's Research and Innovation Campus (ORIC) is a centre for the island's clean energy and low carbon expertise, housing Heriot-Watt University's International Centre for Island Technology (ICIT) in Orkney, as well as Robert Gordon University. The University of Stirling's Institute of Aquaculture operates the Marine Environmental Research Laboratory (MERL) at Machrihanish. There is a need to ensure that collaboration between industry and academia is targeted at specific industry need, and there is evidence of this occurring through the research and development partnerships currently underway exploring hydrogen potential, linking industry, government and research institutions partners.

There is also an opportunity for strategic stakeholders to capitalise on the relative attractiveness of renewables over oil and gas for new entrants, and in establishing more proactive communications with potential 'shifters' from oil and gas and other mature energy sectors. Renewable energy is seen as an attractive career, particularly for younger generations, though for some segments of the workforce there remain some challenges around the perception of the sector in terms of quality of employment, cleaner working conditions, the range of jobs/roles available, etc. The sector needs to be understood in terms of it not just involving external work in a challenging environment, but in a wider range of supporting roles – involving digital technologies, data analytics, remote operation of unmanned vehicles, and such like.

In order to enable the development of further renewable energy generation capacity, stakeholders have a role to play in lobbying respective government and public bodies to facilitate this development. This can be through application to funds that are cognisant of the opportunity (e.g. the Community Renewal Fund helping to fund feasibility studies) or through lobbying groups such as Scottish Renewables who campaign for actions that result in growth of the renewable sector in Scotland.[147] Lobbying has also been a potential avenue for cross-governmental bodies to consider, and has been applied by the Scottish Government in their pressing of the UK Government for the Acorn Project to be given a "go-ahead".[148]

[147] https://www.scottishrenewables.com/about/our-mission
[148] https://www.gov.scot/news/uk-government-urged-to-end-carbon-capture-scheme-delays/

7 REGIONAL CARBON SEQUESTRATION POTENTIAL

Chapter summary

- Carbon sequestration is the process of capturing, securing and storing carbon dioxide from the atmosphere. Stabilising carbon in solid and dissolved forms reduces its warming effects on the atmosphere. The process can help to reduce society's "carbon footprint." There are three main types of carbon sequestration: biological, geological and technological.
- The UK Woodland Carbon Code is a quality assurance standard that is applied to woodlands in the United Kingdom to ensure that the carbon units prescribed to woodlands are independently verifiable. The Peatland Code, similarly, helps organisations to market the climate benefits of natural assets.
- Around half of Scotland's woodland and forestry is in the Highlands and Islands. Both Highland and Argyll and Bute have a significantly higher forestation coverage than other parts of the region, though in terms of proportion of land coverage, forestry and woodland coverage is highest in Moray and Argyll and Bute (c.28%).
- Peat and peaty soils constitute a significant part of the Highlands and Islands' area over half overall, but highest proportion wise is Na h Eileanan Siar where over three quarters of the land is covered by peat and peaty soils. However, much of this peatland is degraded at least to some extent, requiring restoration to enhance and maintain its capacity to store carbon.
- The Scottish Government has set targets to restore 250,000 hectares of peatland by 2023 and to expand woodland cover in Scotland to 21% by 2032.
- Peatland restoration and afforestation are significant carbon sequestration opportunities for the region. Along with capturing carbon, they offer significant economic and environmental benefits. However, the suitability of land for forestry or restoration as well as existing land use and management need to be considered.
- The region accounts for 71% of land in Scotland capable of supporting rough grazing only, and 66% of land that is classed as being of limited agricultural value. If only a small portion (2.5%) of the latter was converted to forestry, it is estimated that around 1.5m CO_2 units could be sequestered in the region over a 30 year period.
- Should the current rate of peatland restoration activity in the region be maintained, it is estimated that around 15.0 million additional CO_2e units could be sequestered in the Highlands and Islands by 2030, rising to 18.8m CO_2e units if the rate of restoration increased by 25%.

INTRODUCTION

7.1 This chapter examines the carbon sequestration potential in the Highlands and Islands. It is intended to provide a high-level consideration of the scale of potential sequestration through terrestrial biological sequestration processes, and specifically peatland restoration and woodland creation. The approach taken looks at theoretical capacity within the region. The subsequent discussion outlines broad considerations for sequestration approaches in the Highlands and Islands going forward.

CARBON SEQUESTRATION IN THE HIGHLANDS AND ISLANDS

7.2 Carbon sequestration is the process of capturing, securing and storing carbon dioxide from the atmosphere. Stabilising carbon in solid and dissolved forms reduces its warming effects on the atmosphere. The process can help to reduce society's "carbon footprint." There are three main types of carbon sequestration: biological, geological and technological. Carbon storage and sequestration has gained prominence in Scotland in recent years. Scotland has not only the storage capacity but also the geographical context and know-how to become a major hub for CO_2 transport and storage in Europe.[149]

7.3 Biological carbon sequestration involves storing carbon dioxide in vegetation, for example grasslands or forests, and soils and oceans. This is a natural process. Areas that sequester carbon are referred to as carbon sinks.

7.4 Geological carbon sequestration is the process of storing carbon dioxide in underground geologic formations, or rocks. Carbon dioxide processed through geological carbon sequestration typically arises from industrial sources, energy related sources, or natural gas processing facilities and is injected into porous rocks for long-term storage.

7.5 Technological carbon sequestration typically refers to sequestration activity that falls outwith biological or geological sequestration. Innovative techniques are being developed to remove carbon dioxide from the atmosphere using scientific techniques and new technologies.

7.6 The Highlands and Islands hosts a large portion of Scotland's rural environment and land capable of carbon sequestration.[150] Information on regulated carbon sequestration activity can be found through the UK Land Carbon Registry which acts as the database that stores and publicly displays data about the status of Woodland Carbon Code and Peatland Code projects and ownership and use of carbon units.[151] Carbon sequestration projects are searchable through the registry and details on the type of sequestration, the developer(s) involved, the status of the project and the project location are available. Carbon calculations and site maps are often available alongside other project-specific information.

7.7 The UK Woodland Carbon Code is a quality assurance standard that is applied to woodlands in the United Kingdom to ensure that the carbon units prescribed to woodlands are independently verifiable. It is an internationally recognised accreditation system for high standards of forest management and carbon management.[152] It allows organisations to reduce net emissions and claim carbon neutrality. The scheme regulates, verifies, and validates how landowners can participate in projects that use part of their woodland for carbon sequestration and credit trading. The carbon sequestration from these projects is translated into carbon units which can be used only once. The carbon units can either be used against the buyer's own emissions or can be sold to a third party to compensate for their emissions.[153]

[149] https://carbcap.geos.ed.ac.uk/website/publications/regionalstudy/CO2-JointStudy-Full.pdf
[150] Biological sequestration in particular but also geological sequestration.
[151] https://woodlandcarboncode.org.uk/uk-land-carbon-registry
[152] https://woodlandcarboncode.org.uk/
[153] https://www.woodlandcarboncode.org.uk

7.8 Woodland Carbon Code projects produce verified[154] and validated[155] units. Verified carbon units can be used against current year's emissions, while validated ones are available for sale for future vintages and can be used for future net zero plans. In both cases 1 unit corresponds to 1 tonne of carbon dioxide sequestered, either currently or in the future.

7.9 The Peatland Code[156] is the certification standard for peatland restoration in the UK, offering the assurance to voluntary carbon market buyers that greenhouse gas mitigation claims are validated and verified by an independent body, and that the climate benefits being sold are real, quantifiable, additional, and permanent.[157] The code safeguards the integrity of its project's carbon credits and, through the generation and sale of these units, provides land managers undertaking peatland restoration with a source of revenue.

7.10 The Peatland Code was set up to help facilitate restoration of the UK's extensive peatlands, the majority of which are estimated to be in a degraded state.[158] This is a result of land use change and drainage for grazing. Degraded peatlands are a significant source of GHG emissions, and in the UK alone are contributing 23 million tonnes of CO_2e emissions each year,[159] almost 3.5% of the country's total carbon footprint.[160]

7.11 Another carbon market code that is somewhat emerging in the carbon credit sector is the hedgerow carbon code. The UK Government's Department for Environment, Food, and Rural Affairs is working on the development of a hedgerow carbon code to support habitat enhancement activities and measurement of carbon sequestration.[161] This would monetise hedgerow growing by calculating the carbon that hedgerows sequester and validating the associated carbon credits.

7.12 Blue carbon is another carbon sequestration initiative, the term being used to describe the carbon stored in coastal and marine ecosystems. The Blue Carbon Initiative, for example, currently focuses on carbon in coastal ecosystems – mangroves, tidal marshes, and seagrasses – which sequester and store large quantities of blue carbon in both the plants and the sediment below.[162]

7.13 The ocean plays a vital role in the removal of atmospheric CO_2. The Highlands and Islands has extremely valuable but currently underused marine environmental resources, particularly in relation to natural resources like seaweed and microalgae. With almost two thirds of the UK's coastline, the Highlands and Islands is a valuable innovation and test area for developing marine environmental services and associated technologies. With its access to the largest portion of Scottish waters, it also has the opportunity of becoming a leader in marine biotechnology applications of carbon sequestration through seaweed, seagrass, or shellfish, as well as in saltmarshes and seabed sediments: sediments in sea lochs in particular are the largest store of marine organic carbon in the region.[163]

[154] Referred to as Woodland Carbon Units (WCU)
[155] Referred to as Pending Issuance Units (PIU)
[156] https://www.forestcarbon.co.uk/certification/the-peatland-code
[157] https://www.iucn-uk-peatlandprogramme.org/peatland-code/introduction-peatland-code
[158] IUCN, UK Peatlands: Peatland Programme. Available at: https://www.iucn-uk-peatlandprogramme.org/about-peatlands/uk-peatlands
[159] Smyth, M-A. et al. (2017) Implementation of an Emissions Inventory for UK Peatlands. Available at: https://www.researchgate.net/publication/333056609_Implementation_of_an_Emissions_Inventory_for_UK_Peatlands
[160] IUCN (2021), Peatland addition to the UK GHG inventory adds 3.5% to national emissions. Available at: https://www.iucn-uk-peatlandprogramme.org/news/peatland-addition-uk-ghg-inventory-adds-35-national-emissions
[161] https://www.gov.uk/government/news/innovative-nature-projects-awarded-funding-to-drive-private-investment
[162] https://www.thebluecarboninitiative.org/
[163] SAMS Enterprise (2022) Optimising carbon sequestration opportunities in Argyll and Bute

FORESTATION SEQUESTRATION

Scope of assessment

7.14 To support the fulfilment of the Scottish Government's commitments on climate change and biodiversity, the Scottish Government has set a target to increase woodland cover from around 18% to 21% by 2032.[164] This is reflected in Scotland's Forestry Strategy for 2019-29, which sets out the long-term framework for the expansion and sustainable management of Scotland's forests and woodland.[165]

7.15 Recognising the importance and relative scarcity of good quality agricultural land in the region, land considered for potential forestation sequestration activity within this report was constrained to land capable of supporting rough grazing only – that is, comparatively poor or marginal agricultural land – using the Land Capability for Agriculture in Scotland rating system. Based on this system, classes 6.1-6.3 and 7 were considered in scope. It should be noted that though this system ranks land based on its potential productivity and cropping flexibility, it does not take into account other factors, such as existing land management and uses.

Land coverage in the Highlands and Islands

7.16 Land capable of supporting rough grazing only is categorised into four classes: 6.1, 6.2, 6.3, and 7. Class 6.1 is of high grazing value whereas class 7 is of very limited agricultural value. The Highlands and Islands is home to 71% of all land in Scotland capable of supporting only rough grazing and 66% of land that is of very limited agricultural value (class 7) (Table 7.1).

Table 7.1: Area of land (hectares) in LCA Classes 6.1-3 and 7 (capable of supporting only rough grazing) in the Highlands and Islands by local authority

	Area in Hectares					
Area	**Class 6.1**	**Class 6.2**	**Class 6.3**	**Class 7**	**Total**	**% of Scotland total**
Argyll and Bute	54,379	74,846	379,469	7,776	516,469	13%
Arran and Cumbrae	-	-	-	-	-	-
Highland	29,584	206,719	1,534,350	142,631	1,913,284	47%
Moray	658	1,723	43,435	14,745	60,560	2%
Orkney Islands	0	2,637	22,066	936	25,639	1%
Shetland Islands	439	11,192	89,641	2,098	103,370	3%
Na h-Eileanan Siar	5,447	5,212	232,653	1,917	245,229	6%
Highlands and Islands	**90,507**	**302,328**	**2,301,614**	**170,103**	**2,864,551**	**71%**
Scotland	**161,114**	**552,988**	**3,064,223**	**256,697**	**4,035,022**	**100%**

Source: The James Hutton Institute. Data available at local authority level only, and so excludes Arran and Cumbrae.

7.17 Table 7.2, below, outlines the area, in hectares, of woodland and forestry in the Highlands and Islands by local authority area. Both Highland (31%) and Argyll and Bute (14%) have a significantly higher forestation coverage than other parts of the region, though in terms of proportion of land coverage, forestry and woodland coverage is highest in Moray and Argyll and Bute (c.28%). However, it is worth noting that data regarding forestry and woodland coverage by area is inconsistent at best.

[164] Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3) - gov.scot (www.gov.scot)
[165] Introduction - Scotland's Forestry Strategy 2019–2029 - gov.scot (www.gov.scot)

Table 7.2: Area of woodland and forestry by Highlands and Islands' local authority[166]

Area	Native Woodland (ha)	Forestry (ha)	Total (ha)	% of Scotland total[167]	Source
Highland	310,000	130,000	440,000	31%	Highland Council Forest and Woodland Strategy, 2018
Argyll and Bute	33,100	165,000	198,100	14%	Argyll and Bute Council Woodland and Forestry Strategy, 2011
Arran and Cumbrae	-	-	-	-	-
Moray	-	-	62,441	4%	Moray Council Woodland and Forestry Strategy, 2017
Na h-Eileanan Siar	-	-	2,418	<0.3%	Forestry Commission National Inventory of Woodland and Trees: Western Isles, 2001
Orkney	-	-	130	<0.1%	Natural Scotland Native Woodland Survey of Scotland: Orkney and Shetland, 2011
Shetland	-	-	38	<0.01%	Natural Scotland Native Woodland Survey of Scotland: Orkney and Shetland, 2011
Total, Highlands and Islands				**50%**	

7.18 Though Table 7.2 does not include estimates for Arran and Cumbrae, both have areas of woodland/forestry. Forestry and Land Scotland estimate that around a quarter of Arran is forested.[168] The Cumbrae Community Climate Action Plan identifies that LULUCF was a carbon sink for Cumbrae, with the majority of removals attributed to forest land. However, given data limitations, quantification is not possible/available, and therefore Arran and Cumbrae are not included in the estimates of potential sequestration through forestation set out in Table 7.3.

Forestation and woodland sequestration

7.19 Land identified as being able to support only rough grazing in the Highlands and Islands[169] has the potential to support carbon sequestration activities. If the land were to be transformed into woodland, then the number of carbon units per hectare could theoretically be calculated.

7.20 The number of carbon units per hectare that can be achieved varies by woodland age and type, whereby mature woodland sequesters more carbon than new woodland. Based on available data and ranges of carbon units per hectare, a reasonable average is 350 CO_2e units per hectare over a period of approximately 30 years.[170]

7.21 Table 7.3 below outlines the potential quantity of sequestered carbon, over a period of approximately 30 years, at an average rate of 350 CO_2e units per hectare, if 2.5%, 5% or 7.5% of land identified as being able to support only rough grazing were to be transitioned to woodland creation and carbon sequestration activities in the Highlands and Islands. Around 25 million CO_2e units could potentially be sequestered over a 30-year period in a scenario where 2.5% of rough grazing land is converted for sequestration forestation.

[166] Disaggregated data unavailable for Moray, Na h-Eileanan Siar, Orkney and Shetland at time of reporting.
[167] https://www.gov.scot/publications/scotlands-forestry-strategy-20192029/pages/4/
[168] https://forestryandland.gov.scot/visit/forests-on-the-isle-of-arran
[169] See Table 7.1.
[170] ekosgen, for HIE (2022) Optimising Carbon Sequestration Opportunities in Argyll and Bute: Economic Impact

Table 7.3: Potential sequestration through forestation of identified suitable rough grazing land (Classes 6.1-3 and 7) in the Highlands and Islands by local authority

Local Authority	CO_2e units at 350 per hectare		
	2.5%	**5%**	**7.5%**
Argyll and Bute	4,519,100	9,038,200	13,557,300
Arran and Cumbrae	-	-	-
Highland	16,741,200	33,482,400	50,223,700
Moray	529,900	1,059,800	1,589,700
Orkney Islands	224,300	448,600	673,000
Shetland Islands	904,400	1,808,900	2,713,400
Na h-Eileanan Siar	2,145,700	4,291,500	6,437,200
Highlands and Islands	**25,064,800**	**50,129,600**	**75,194,400**

Source: ekosgen modelling based on NatureScot/Peatland ACTION (2023) data.
Note: Given data availability, modelling was not possible for Arran and Cumbrae.

7.22 However, recent evidence indicates that there may be a reluctance amongst landowners – and tenants – to give up agricultural land of any quality to sequestration activity.[171] With this in mind, there is value in considering the sequestration potential of Class 7 land only (that of very limited agricultural value) (Table 7.4). In this instance, around 1.5 million CO_2e units could potentially be sequestered over a 30-year period in a scenario where 2.5% of Class 7 rough grazing land is converted for sequestration forestation. Assuming a similar rate of emissions going forward, this could potentially equate to around 0.1% of national emissions or 0.8% of regional emissions over the 30-year period.

Table 7.4: Potential sequestration through forestation of identified suitable rough grazing land (Class 7 only) in the Highlands and Islands by local authority

Local Authority	CO_2e units[172] at 350 per hectare		
	2.5%	**5%**	**7.5%**
Argyll and Bute	68,000	136,000	204,100
Arran and Cumbrae	-	-	-
Highland	1,248,000	2,496,000	3,744,000
Moray	129,000	258,000	387,000
Orkney Islands	8,100	16,300	24,500
Shetland Islands	18,300	36,700	55,000
Na h-Eileanan Siar	16,700	33,500	50,300
Highlands and Islands	**1,488,400**	**2,976,800**	**4,465,200**

Source: ekosgen modelling based on NatureScot/Peatland ACTION (2023) data.
Note: Given data availability, modelling was not possible for Arran and Cumbrae.

PEATLAND RESTORATION SEQUESTRATION

Scope of assessment

7.23 A number of factors were taken into consideration for the assessment of potential carbon sequestration through peatland restoration. This included the total area of peat and peaty soils in the region and the known area of restored peatland to date through Peatland ACTION[173] projects.[174] Within this, the rate of restoration through Peatland ACTION projects was considered.

[171] ekosgen, for HIE (2022) Optimising Carbon Sequestration Opportunities in Argyll & Bute: Readiness Evaluation
[172] Sequestration is measured in units of CO_2e, particularly in schemes such as Peatland ACTION. One unit is equal to one tonne of CO_2.
[173] Peatland ACTION funding, from Scottish Government, primarily supports on-the-ground peatland restoration activities and is open for applications from eligible land managers who have peatlands that would benefit from restoration.
[174] https://www.nature.scot/climate-change/nature-based-solutions/peatland-action/peatland-action-what-we-do

Peatland coverage in the Highlands and Islands

7.24 Figure 4.8 in Chapter 4 illustrated the extent of peat resource in the Highlands and Islands. This is reflected in Table 7.5 which outlines the area, in hectares, of peatland in the region. This includes all peatland, including both peat in its natural state, and also degraded peatland. Around three quarters of all Scotland's peatland is located in the Highlands, with over half (56%) of the region's land covered by peat and peaty soils.[175] Within the region, coverage is highest proportion-wise in Na h-Eileanan Siar where over three quarters of the land is covered by peat and peaty soils. It is worth noting that all soil classifications set out below (as well as Class 4, which includes mainly mineral soils), may be suitable for peatland restoration.[176]

Table 7.5: Area of total peatland by soil classification, in hectares, in the Highlands and Islands[177]

	Area in Hectares					
	Class 1	Class 2	Class 3	Class 5		
Local Authority	Peat soil	Peat soil with occasional peaty soil	Mainly peaty soil with some peat soil	Peat soil with no peatland vegetation recorded	Total Peatland (Class 1, 2, 3, 5)	% of total area
Argyll and Bute	60,314	127,119	41,070	187,036	415,539	58%
Highland	515,422	549,644	85,650	393,434	1,544,150	58%
Moray	26,590	2,340	2,074	19,970	50,973	23%
Orkney Islands	9,485	-	1,438	5,225	16,148	15%
Shetland Islands	52,759	1	8,449	32,381	93,589	56%
Na h-Eileanan Siar	132,472	77,166	24,253	18,099	251,991	77%
Arran and Cumbrae	6,420	140	1,186	11,030	18,776	42%
Total, Highlands and Islands	**803,462**	**756,410**	**164,120**	**667,175**	**2,391,166**	**56%**
Total, Scotland	**1,002,232**	**858,238**	**312,581**	**994,449**	**3,167,500**	**39%**
Highlands and Islands % of Scotland	**80.2%**	**88.1%**	**52.5%**	**67.1%**	**75.5%**	

Source: Carbon and Peatland Map 2016

Peatland restoration

7.25 Peatlands are by far the world's most efficient terrestrial carbon store.[178] Scotland has 13% of the world's blanket bog. The huge reserves of peatlands in the Highlands and Islands, in their natural state, are a vitally important carbon store. The Flow Country in Caithness and Sutherland is a vast area of deep peat and extends to 494,210 acres (200,000 hectares). The wider Caithness and Sutherland area contains over 4,000km^2 of blanket bog, which makes it the largest expanse in Europe. It holds about one quarter of the UK's soil carbon (understood to be twice the amount of the UK's woodlands). These reserves are Scotland's largest terrestrial carbon store, holding around 1.6 billion tonnes of carbon.[179]

[175] Peat soils are often more than 1 m deep and can occasionally be more than 10 m deep. When soil has an organic layer at the surface less than 50 cm thick and overlies mineral layers, it is known in Scotland as a peaty soil. See: https://soils.environment.gov.scot/media/1460/180319_definitions-of-carbon-rich-soil_agreed-text-for-website.pdf

[176] https://soils.environment.gov.scot/resources/peatland-restoration/

[177] Table 7.5 presents data on all classifications of peat and peaty soils, to illustrate the extent to which peat and peaty soils exist in the region, and in Scotland. As noted in the text, all soil classifications presented may be suitable for peatland restoration. It should be noted that this may differ from other analysis of 'peatland' due to the inclusion of 'peaty soil' classifications.

[178] https://www.unep.org/news-and-stories/story/peatlands-store-twice-much-carbon-all-worlds-forests

[179] https://www.theflowcountry.org.uk/

7.26 Over time, land use practices have caused them to degrade and coupled with climate change, there is a risk that many areas in Scotland may not be able to support peatlands in the near future. The potential losses of carbon have been calculated and show that more than half of the carbon currently stored in Scottish blanket bogs will be at risk of loss as emissions arising from peatland degradation.[180]

7.27 Some estimates indicate that around 80% of peatland in Scotland is degraded to at least some degree.[181] It is therefore vital that the carbon they currently hold is secure and that steps are taken to avoid their degradation, and thus prevent emissions (typically due to their drying out).

7.28 There is an opportunity to restore the peatlands to enhance their capacity to maintain carbon stocks. Degraded peatland has significant carbon sequestration potential, and the Scottish Government's Climate Change Plan has set a target to restore 250,000 ha of degraded peatlands by 2030.[182] Scottish Natural Heritage (SNH) has kick-started the restoration challenge with the 'Peatland ACTION' project.[183]

7.29 Since the commencement of its delivery in 2012/13, Peatland Action has restored over 193,000 hectares of Peatland across Scotland. Some 70% of this is within the Highlands and Islands, with the majority in the Highland Council area. Almost 11,000 hectares per annum has been restored in the region over the period (median), equivalent to around c.0.5% of total peatland in the Highlands and Islands each year.

Table 7.6: Area of restored peatland, in hectares, in the Highlands and Islands

	Area in Hectares				
Area	**Total Hectares restored**	**% Scotland restored peatland**	**% LA/region peatland restored**	**Median ha per annum restored**	**Median % per annum restored**
Argyll and Bute	8,342	4%	2%	661	0.16%
Highland	124,219	64%	8%	8,415	0.54%
Moray	1,914	1%	4%	115	0.23%
Orkney Islands	0	-	-	-	0.00%
Shetland Islands	481	<1%	<1%	38	0.04%
Na h-Eileanan Siar	105	<1%	<1%	20	0.01%
Arran and Cumbrae	987	<1%	5%	61	0.32%
Highlands and Islands	**136,048**	**70%**	**6%**	**10,736**	**0.45%**
Scotland	***193,081***	***100%***	**-**	***12,825***	**-**

Source: Peatland ACTION, 2023; Carbon and Peatland Map 2016
Figures may not sum due to rounding

7.30 The number of carbon units per hectare that can be sequestered by degraded peatland varies due to the nature of the peatland, however, a potential of c.200 CO_2e units per hectare can be assumed for theoretical purposes.[184] This is in line with work undertaken for Highlands and Islands Enterprise, considering the potential of carbon sequestration opportunities in Argyll and Bute.[185]

[180] https://www.researchgate.net/publication/335104075_Potential_carbon_loss_from_Scottish_peatlands_under__climate_change
[181] https://soils.environment.gov.scot/resources/peatland-restoration/
[182] Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3) - gov.scot (www.gov.scot)
[183] https://www.nature.scot/climate-change/nature-based-solutions/peatland-action-project
[184] Conservative estimates based on: http://publications.naturalengland.org.uk/publication/5101422143340544; and https://www.gov.scot/publications/national-development-plan-crofting/pages/11/
[185] ekosgen, for HIE (2022) Optimising Carbon Sequestration Opportunities in Argyll & Bute: Economic Impact

7.31 Table 7.7 below, outlines the potential annual quantity of sequestered carbon if the current median rate of restoring degraded peatland in each area of the Highlands and Islands is maintained, assuming a typical 200 CO_2e units per hectare of restored peatland. In the absence of completed Peatland ACTION restoration projects in Orkney, median restoration rates per annum have been estimated for Orkney based on restoration rates for Shetland and Na h-Eileanan Siar, and reflect future potential restoration and sequestration of carbon.

7.32 Overall, around 2.1 million CO_2e units could be realised across the region on an annual basis; if an increase in the rate of restoration is realised, then between c.2.3 million and c.2.7 million CO_2e units could be sequestered on an annual basis if the restoration rate were to increase by between 10% and 25% in each area.

Table 7.7: Potential sequestered CO_2e units (at 200 CO_2e units per hectare) at median rate of existing restoration, plus rate uplift for comparison

	CO_2e Units		
Area	**Median restoration rate per annum**	**+10% above median rate**	**+25% above median rate**
Argyll and Bute	132,240	145,464	165,300
Highland	1,683,021	1,851,323	2,103,776
Moray	23,000	25,300	28,750
Orkney Islands	*5,205*	*5,725*	*6,506*
Shetland Islands	7,565	8,321	9,456
Na h-Eileanan Siar	3,946	4,341	4,932
Arran and Cumbrae	12,139	13,353	15,174
Highlands and Islands	***2,144,177***	***2,358,595***	***2,680,221***

Source: Consultant calculations based on NatureScot/Peatland ACTION (2023) data. The Highlands and Islands estimate is based on the median restoration rate for the region overall. Therefore columns do not sum to the total of the sub-regional estimates.

7.33 By 2030, between c.15.0 million and c.18.8 million of additional CO_2e units could be sequestered in the Highlands and Islands, assuming these scenarios (current median rate, +10%, +25%). Taking the lower estimate of 15 million additional CO_2e units, this could potentially equate to 8.0% of regional emissions or 1.2% of national emissions over the 30-year period that the CO_2e units would need to be sequestered for, assuming a similar rate of emissions going forward.

CONSIDERING THE REGION'S MARINE RESOURCE FOR SEQUESTRATION

The region is home to extremely valuable but underused marine environmental resources that could potentially support marine-based carbon sequestration activity in future. With almost two thirds of the UK's coastline, the Highlands and Islands is well-positioned to act as a valuable innovation and test area for marine environmental services and related technologies, including carbon sequestration.

However, the capacity of natural marine habitats to sequester and store carbon is not supported by management and ownership models equivalent to those of the terrestrial environment. This is due to the nascent nature of the marine biotechnology and marine environmental services sectors. However, this may develop as sequestration approaches mature.

SUMMARY DISCUSSION

The scale of the region's natural assets presents an opportunity for the area with regard to carbon sequestration activity. Terrestrial biological approaches – such as through forestation or peatland restoration – are the most feasible sequestration approaches currently. However, it is worth noting that the extent of the region's marine carbon assets mean that marine-based sequestration opportunities may also be realised in future.

Along with capturing carbon, a number of wider benefits can also be realised, including:

- Improved biodiversity and habitat creation, through peatland restoration or through appropriate planting,[186] and also through increasing the amount of deadwood available in a given habitat;[187]
- Flood risk mitigation and water management arising from increased water interception, infiltration and retention in river basins, resulting in reduced water run-off[188] and thus reduced risk of flooding in communities.[189] Woodlands[190] and restored peatland[191] can also have a positive effect on water quality, by acting as a water filter;
- A reduction in soil erosion and better management of soil nutrients through reduced run-off, limiting the erosive damage from wind and rain;[192,193]
- Creation and maintenance of woodlands and peatland restoration projects generate the need for skilled jobs, for example specialist skills required when managing ancient and veteran trees.[194] Such projects can also encourage greater levels of community engagement and have a positive impact on environmental education and community development, e.g., through volunteering or school projects;
- For woodland creation in particular, this can also contribute to community wealth building, through creation of a number of different capitals in community-owned woodland creation schemes: new financial capital (from carbon trading or timber revenues), social capital (co-operation, new capacity, and associations), individual capital (jobs), natural capital (generating ecosystem services) and built capital (if designing trails, recreational facilities or campsites).[195]

These additional social and environmental benefits can be 'stacked' on top of the primary carbon benefit of sequestration activity. However, they are not currently reflected in Carbon Codes. Thus, there is no scope for varying the price of carbon credits that can be purchased/sold through such schemes according to the wider social or environmental benefits that can secured. Carbon sequestration, and by extension, emissions reduction, is only one factor when considering potential

[186] https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/
[187] https://www.woodlandtrust.org.uk/blog/2020/07/biodiversity-and-native-woods/
[188] https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/
[189] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078625/The_Case_for_Trees_WEB_May_2022.pdf
[190] e.g. see: https://acsess.onlinelibrary.wiley.com/doi/10.2134/jeq2019.01.0020
[191] https://www.iucn-uk-peatlandprogramme.org/about-peatlands/peatland-benefits/water-quality
[192] https://carbonstoreuk.com/publications/the-wider-benefits-of-woodland-creation/
[193] https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-11/COI%20Peatlands%20and%20NFM.pdf
[194] https://www.gov.uk/government/news/woodland-projects-across-england-to-receive-funding-for-jobs-training-and-increasing-tree-cover
[195] Lyman, M, Grimm, C & Evans, J, 2014. *Community forests as a wealth creation strategy for rural communities* in Community Development Vol. 45.

land use, and the best way to articulate these benefits would be to find a way to monetise them – such as through the current development of biodiversity net gain (BNG) credits, arising from the UK Environment Act 2021.[196]

Recent research[197] has also identified a degree of information asymmetry and misunderstanding of sequestration amongst landowners and communities, helping to create a degree of resistance to sequestration schemes, particularly with regard to woodland creation. Cultural factors, including long-standing practices, ties to the land and a 'moral obligation' amongst landowners to maintain current modes of farming and land management, financial necessity, etc. also act as barriers to the consideration and implementation of sequestration schemes. A further issue is the limited understanding of the extent to which existing land use and management practices already sequester carbon. This may restrict woodland creation and planting to more marginal or peripheral areas of land, and constrain the extent to which such schemes, and thus carbon sequestration levels, can be realised.

Local capacity to deliver is a challenge. Given the location of many sites suitable for afforestation or reforestation, or areas of peatland in need of restoration, the (lack of) population density in these areas necessarily means that there is not a critical mass of the skills required to deliver such schemes. The availability of skills nationwide does not necessarily mean that they can be accessed either. For example, anecdotal evidence suggests that whilst there may be in the region of approximately 100 contractors able to undertake peatland restoration activity in Scotland, only a fraction typically get involved in Peatland ACTION restoration contracts (though the reasons for this and barriers to engagement are unclear). Further, there is often insufficient capacity within host communities to support such schemes, given the issues around information asymmetry and understanding discussed above.

Other challenges also exist. For example, the geography of the Highlands and Islands may either serve to constrain the extent to which sequestration may be achieved or cause existing land use and activity (e.g., agriculture) to be displaced. With particular regard to woodland sequestration, the ideal conditions are found on flatter land, and thus in direct competition with grazing. The constraining effect of the structural inequalities and associated challenges arising from the region's particular geography is also a critical factor in realising the uptake and expansion of carbon sequestration activities. The realisation of any impacts and benefits, both economic, social and environmental, would therefore be reliant on the regional economy's ability to support increased levels of sequestration activity, and a nascent industry to develop.

Realising the carbon and wider benefits of sequestration activity in the region will require a proactive and coordinated approach by public sector actors. In order for sequestration schemes to be viable, the carbon market in the region needs to be stimulated, and a critical mass of activity nurtured, to develop the required trade in carbon credits. Alongside this, ways in which social, community, environmental benefits can be maximised for local landowners and communities need to be explored – along with ways to achieve longer-term strategic ambitions including agricultural efficiency improvements, the creation of multi-purpose forests, or more transformational ambitions around re-wilding, or the restoration of the Atlantic rainforest, for example.

[196] The Environment Act 2021 makes provision for the Secretary of State to set up a system of statutory biodiversity credits that will be invested in habitat creation. The credits can be bought by developers as a last resort when onsite and local offsite provision of habitat cannot deliver the BNG required.
[197] ekosgen, for HIE (2022) Optimising Carbon Sequestration Opportunities in Argyll & Bute: Readiness Evaluation

In addition, current targets around afforestation (expanding woodland cover in Scotland to 21% by 2032) and peatland restoration (restoring 250,000 hectares by 2030) can be considered unattainable at current rates of progress. One reason for this is the over-reliance on public sector funding. Given recent inflationary pressures, allocated public sector budgets for afforestation and peatland restoration are unlikely to cover all associated costs. This is an area that the Scottish Government is currently exploring options for. There is evidence to suggest that private enterprises are more than willing to make financial investments in sequestration activity, if clearer and stronger links can be made between spend and outcomes – in carbon terms, but also in terms of wider benefits. Therefore, there is a need for – and an opportunity to – lever in greater involvement of the private sector to support the achievement of shared outcomes.

There is a need for a whole economy or whole system approach when considering carbon sequestration. It needs to be framed within the context of a low carbon economy, and the Scottish Government's ambitions for Net Zero and the objectives of the National Strategy for Economic Transformation (NSET). This could be through consideration of approaches including the Landscape Enterprise Networks (LENs) model that has been adopted by Nestle in their UK and Ireland Sustainable Growth Agreement, with regards to activity in the South of Scotland. The LENs model brings together private, public and third sectors within regional communities around shared interests which benefit the environment, communities, and business. The emphasis is on identifying common interests and how best to make activity work for these interests, for the benefit of all involved. An additional approach worthy of consideration is the Plan Vivo Standard. The Plan Vivo Foundation is a charity organisation that is focused on empowering communities to make best use of their resources, as they see fit. Projects that are delivered by and through the Plan Vivo Foundation are held to this Standard, ensuring that benefits are provided to both communities and the environment, as well as providing assurances to buyers of Plan Vivo certificates that emission reductions are real, additional and verifiable environmental benefits, and that there are wider community benefits being realised as a result.[198]

[198] https://www.planvivo.org/

8 CONCLUSIONS

INTRODUCTION

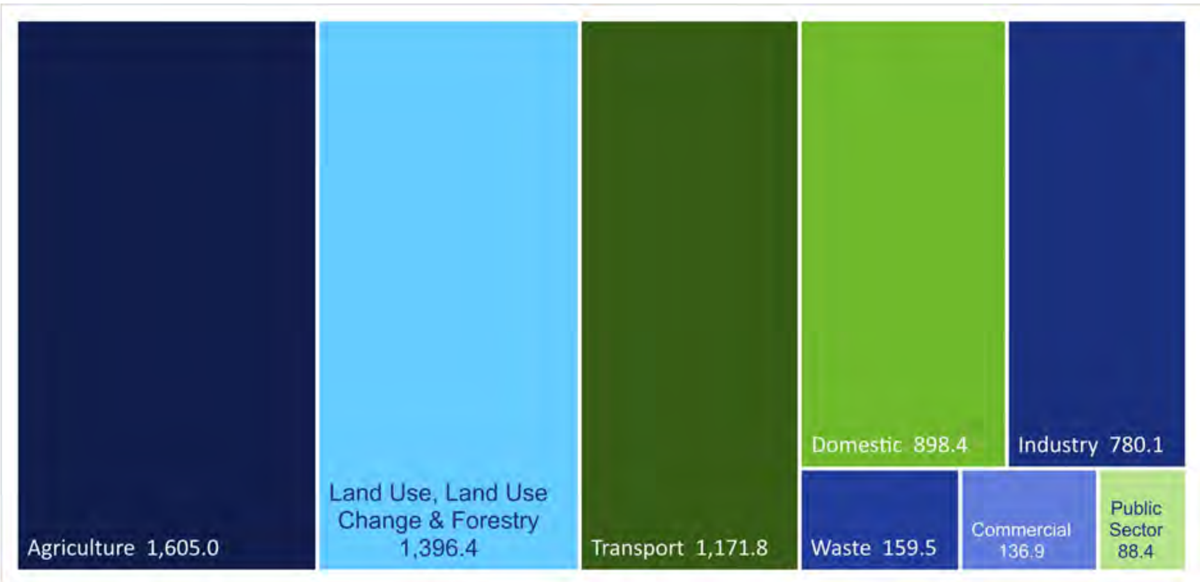
8.1 The preceding chapters in this report have given consideration to a range of data and other evidence relating to the greenhouse gas (GHG) emissions in the Highlands and Islands, to establish a GHG baseline for the region, with the baseline year being 2019. Given the nature of the various data and evidence sources drawn upon, the baseline is a composite one. The process of and approach to assessing GHG emissions is relatively new in comparison to, for example, analysing socio-economic characteristics or appraising economic impacts; a number of the data sources and modelling approaches involved are experimental, and even more established approaches are subject to ongoing revision and methodological improvements. Nevertheless, each chapter presents an overarching picture of GHG emissions, and related factors such as renewable energy generation and carbon sequestration potential. This chapter sets out the initial conclusions for this report, some observations on priorities for addressing GHG emissions, and potential next steps.

CONCLUSIONS

8.2 The region has an estimated carbon footprint of 6,236 kt CO_2 in territorial emissions. This accounts for around 15% of Scotland's total GHG emissions. A variety of factors including population density, land use, sectoral make-up and industrial activity, and building fabric and energy efficiency influence the level of emissions at the local authority level. Emissions at the regional level are decreasing, but at a slower rate than for Scotland as a whole.

8.3 Agriculture and land use, land use change and forestry constitute the largest components of regional territorial emissions, together accounting for just under half of all emissions. They are followed by transport (excluding aviation and water-based transport), industry and domestic emissions. These are the same top five for Scotland overall, however the order and extent of contribution varies (transport, domestic, industry, agriculture and land use, land use change and forestry for Scotland).

Figure 8.1: Territorial kt CO_2e emissions estimates by key sources, 2019



Source: UK Local authority and regional greenhouse gas emissions national statistics: 2005-2021. DESNZ, 2023

8.4 Constraints on data and modelling of emissions at the sectoral level even in UK Government-produced datasets limits detailed disaggregation of emissions data. Nevertheless, a reasonably clear pattern of emissions sources can be seen.

8.5 Agricultural emissions are the largest source of GHG emissions in the Highlands and Islands – without addressing this, we are unlikely to make a substantial shift in the region's emissions profile. Change will involve consideration of land use and agricultural practices, but with competing options for land use, there is undoubtedly a balance to be struck in terms of lower emissions, maintaining biodiversity and maintaining desirable outputs such as food production. Agritech has a role to play in the latter.

8.6 Land can be both a source and sink of GHG, contributing both positively and negatively to emissions. LULUCF is currently a substantial net contributor to the region's and Scotland's GHG emissions, largely reflecting the extent of peatland degradation and absence of large forestry plantations in some areas, particularly island areas. The region has significant opportunities to redress the balance, and with this brings economic opportunity.

8.7 Road transport emissions account for the greatest share of all transport emissions and have increased in recent years, by 12% between 2012 and 2019. This is particularly the case for diesel cars (+30%) and LGVs (+37%) – the latter following the trend for increased local deliveries associated with increased online retail and e-shopping. Whilst there has been an increase in rail passengers in recent years, emissions from rail travel have decreased overall, despite the lack of electrification and reliance on diesel power units on the region's rail network. Emissions from air travel (and specifically movement of aircraft) and ferry transport make up a relatively small proportion of regional emissions overall. However, emissions will typically be higher per passenger than other modes of transport. There is also a gap in understanding of emissions for water transport other than for ferries in the region.

8.8 Emissions from residential dwellings are considerably higher per dwelling than elsewhere in Scotland. Mean emissions per dwelling are 6.0 tCO_2 in the Highlands and Islands versus 4.3 tCO_2 per dwelling in Scotland overall. The age, nature, and condition of the housing stock, as well as differences in main fuel and heating systems make a significant contribution to the higher residential emission rates in the region. This is compounded by the proportion of dwellings in island and/or more remote areas – just under two thirds (65%) of the region's residential dwellings are in remote areas (either in remote towns (20%) or remote rural areas (45%)), making roll-out or uptake of energy efficiency or sustainability measures more difficult to achieve at scale. This also means that many of the region's dwellings are in exposed or very exposed locations – and their exposure to wind driven rain is an influencing factor in their energy consumption and energy efficiency.

8.9 There is a disproportionate reliance on fossil fuels in the region, particularly in island and rural locations. This is at least in part a result of lack of mains gas connection, but also reliability of energy sources – for example, many dwellings rely on carbon intensive fuels as a primary or secondary fuel source.

8.10 Consequently, many of the factors that distinguish the Highlands and Islands from the rest of Scotland mean that by comparative measures, it has a higher GHG emissions footprint: namely, a disparate population; its geography and remoteness; climate and greater exposure to wind driven rain; reliance on carbon intensive fuels; more energy intensive industries in certain areas (e.g. whisky distilling); older, more traditional residential dwellings and other buildings; greater dependency on higher-carbon forms of transportation; and lack of mains connection for gas. These factors underline the scale of the challenge in tackling GHG emissions.

8.11 However, many of these factors put the Highlands and Islands in a strong position to respond to tackling GHG emissions and contribute to a Just Transition to Net Zero. For example, the region has a disproportionately high share of Scotland's current and future renewable energy generation capacity. The total installed capacity is around 6,500 MW across a range of technologies. This equates to around half of Scotland's total (52%), versus around 9% of Scotland's population, and 13% of Scotland's business base. Based on known pipeline developments, this is expected to increase by over 410% to more than 33,000 megawatts. In thinking about ways in which the region's emissions can be offset or balanced, the region's current and potential capacity for renewable energy generation should thus be borne in mind. The scale of the opportunity that renewable energy generation presents cannot be understated, since the region is ideally positioned to maximise its renewables potential to offset a considerable amount of its territorial emissions.

8.12 In addition to this, the region is also leading the way in the implementation of low carbon technology such as heat pumps at the domestic level. This is a regional strength, and such activity will play a key role in decarbonisation efforts in the Highlands and Islands.

8.13 Terrestrial carbon sequestration approaches can also contribute to net zero ambitions within the region. Peatland restoration in particular has the potential to make sizeable annual contributions to net decreases in greenhouse gas emissions through Peatland ACTION-supported projects and other similar activities. Afforestation also has a key role to play, and if even a small proportion of the region's vast rough grazing is used for forestry, significant gains can be made. As with renewable energy generation, carbon sequestration offers the region a considerable opportunity to reduce and offset carbon emissions, as well as providing other ecosystem services. The Scottish Government is currently working to better understand the requirements to meet its own target of 250,000 hectares of peatland restored by 2030. A target of increasing woodland cover from around 18% to 21% by 2032 has also been set.

CONSIDERATIONS AND EMERGING PRIORITIES

8.14 Although there are clear local differences, the overall nature of the region's emissions profile means **a pan-regional, co-ordinated approach is needed to tackle the GHG emissions challenge**. This is reflected in the HIREP's draft Regional Economic Strategy which recognises that climate change adaptation, decarbonisation and energy transition are significant drivers of change for the region. Within this collaborative regional approach, a number of key considerations and emerging priority areas emerge, as outlined below:

- Shifting the dial regionally will only happen by **addressing the emissions challenges associated with agriculture and LULUCF**. Influencing some of the measures implementing the Scottish Government's Agriculture and Rural Communities Bill and subsequent policy and funding decisions is critical to this.
- **Supporting sustainable transport and transport decarbonisation** and stimulating investment and action to enable this will be key to lowering transport emissions. Encouraging modal shift along with targeted investment in sustainable transport infrastructure will be vital in this regard, whether for road transport (e.g., increasing provision of electric vehicle charging points), or for rail transport (e.g., supporting rail electrification plans set out in the National

Transport Strategy 2). Continuation of ground-breaking innovation such as that epitomised by the SATE project and adoption of greener fuel sources in the ferries replacement programme will also be critical.

- **Addressing carbon emissions and energy efficiency within residential dwellings and communities** will be essential for driving down domestic emissions. Doing so must include influencing homeowners and private rental landlords to adopt energy efficiency measures, transition away from the use of carbon intensive fuel sources and encourage the adoption of renewable technologies (where possible) for space heating and insulation. However, cost and capacity are significant barriers, particularly in terms of retrofit solutions.
- **Investment in the region's electricity and gas networks** is important to increase access to more reliable and lower carbon forms of energy, including green hydrogen. It will also enable the development of decentralised and local energy networks. This can contribute to greater realisation of benefits within local communities from investment in renewable energy generation, thus aiding community wealth building at local and regional levels.
- Supporting businesses to **increase awareness and understanding of net zero and its implications** for them, and influencing decarbonisation activity at the enterprise and sectoral levels will be a key component of efforts to reduce the regional GHG footprint. This will extend to energy efficiency of premises, energy transition, and lowering of emissions within operations.
- Regional transformational opportunities around marine energy, green hydrogen and offshore wind, as well as new hydroelectric schemes, are critical to decarbonisation efforts. Continuing to **support the region's renewables industries** will help **to realise the pipeline of renewable generation capacity** and contribute to a reduction in GHG emissions arising from electricity generation and consumption.
- **Carbon sequestration** can contribute to a reduction in the region's net emissions. There is already scope to achieve this through peatland restoration and afforestation, with other terrestrial approaches being explored along with the potential for marine sequestration. Carbon sequestration can also bring with it a wide range of other ecosystem services.
- **Skills development** to support the implementation of measures to address the region's carbon emissions is vital. This includes skills to support the roll-out of domestic retrofit for energy efficiency and implementation of low carbon heating technology, as well as skilled workers to maximise the potential for new forms of energy generation, including hydrogen. Without the right skills in the required volume, the Highlands and Islands will not be able to realise this potential.

8.15 The study has identified key areas where the region has an opportunity to significantly reduce its GHG emissions, notably in agriculture, land use, land use change and forestry, as well as in transport, housing and industry. The HIREP has a significant role to play in ensuring that across these policy areas, reducing emissions is central to strategic planning and implementation. It is also critical that the HIREP takes industry and communities along on the journey to net zero.

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