Agenda Item	**15**
Report No	**EDI/27/18**

HIGHLAND COUNCIL

Committee:	Environment, Development and Infrastructure
Date:	17 May 2018
Report Title:	Inverness Greenhouse Gas Inventory Report
Report By:	Director of Development and Infrastructure

Purpose/Executive Summary

1.1 This report provides a summary of a report commissioned jointly by The Highland Council and Highlands and Islands Enterprise (HIE) to provide a greenhouse gas inventory for Inverness, as covered by the Inverness City Area Committee, and seeks support for a wider study for the whole Highland region to be undertaken.

Recommendations

1.2 Members are asked to:

- note the contents of the report;
- agree that funding opportunities should be explored to allow a greenhouse gas inventory to be prepared for the whole Highland region; and
- agree that a multi-agency Climate Change Working Group be established under the Highland Environment Forum to take forward priority actions identified in the Inverness GHG Baseline report.

2 Background

2.1 Following the establishment of the Carbon CLEVER initiative in 2013, which aims for a carbon neutral Inverness in a low carbon Highlands by 2025, a report was commissioned jointly by The Highland Council and HIE through the University of the Highlands and Islands (UHI) to provide a greenhouse gas (GHG) inventory for Inverness. The report, attached at **Appendix 1**, has calculated the net carbon balance for the area, and is the first such inventory produced specifically in Highland. Pages 4 – 13 of the report provide a detailed executive summary of the key findings and opportunities arising.

2.2 The baseline report, which estimates emissions generated in 2014, helps to identify areas where action is required in order to meet the 2025 target, and provides a methodology which can be utilised for a wider examination of greenhouse gas emissions for the whole Highland region.

3 Defining Carbon Neutrality

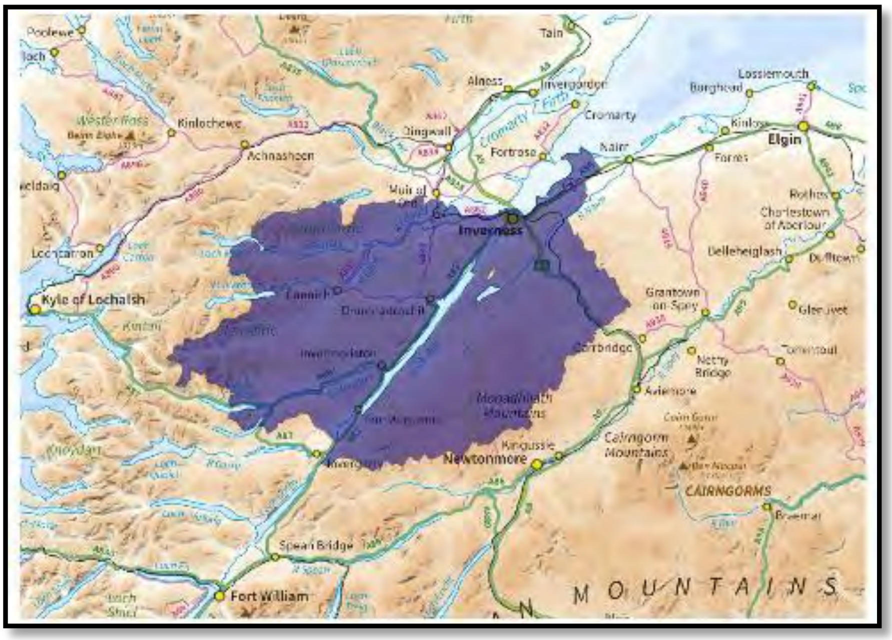
3.1 As per para 2.1 above, the key aspiration of the Carbon CLEVER initiative is to create a carbon neutral Inverness in a low carbon Highlands by the year 2025. In order to achieve this ambition, it is necessary to understand what is meant by carbon neutral, and to baseline the emissions of the region to allow progress to be measured. The following definition of carbon neutral is suggested by the report:

"Carbon neutral means making no net release of carbon dioxide to the atmosphere from the inventory area by reducing consumption, producing and using renewable energy, and offsetting emissions by planting trees."

3.2 Under the Climate Change (Scotland) Act 2009, the Council is legally bound to support the Scottish Government's ambition to reduce national greenhouse gas emissions by 42% against 1990 baseline levels by 2020, and by 80% by 2050. Whilst the Council can only directly control the emissions arising from its own estate, it is important for the organisation to be seen as leading from the front in terms of region-wide emissions reduction and to work with partners to help achieve national ambitions. Setting an aspirational target for Inverness provides an opportunity for local people and businesses to buy in to the vision and support the growing shift towards a low carbon economy. The definition above provides three key ways that stakeholders throughout the region can work together to identify projects and initiatives which support the overall vision.

4 Scope, Boundary and Methodology

4.1 The Inverness Greenhouse Gas Inventory report for 2014 provides baseline emissions data for the area below, which covers a total of 2,903 square kilometres:



4.2 To provide a more comprehensive GHG assessment, the project adopted a broader boundary than simply the Inverness city boundary. This wider boundary allows a more accurate picture of the emissions baseline for Inverness to be generated, as it contains many businesses and recreational resources with key links to the city, as well as major infrastructure such as harbours, the airport and the trunk road network. In addition, the Inverness district boundary contains a significant volume of renewable electricity generation and forestry, which would be missed if a solely city-focussed study had been undertaken.

4.3 Emissions were considered from all relevant sources, including the use of stationary energy (in residential, commercial and institutional properties); transport (by road, rail and water); waste disposal and the treatment of waste water; industrial processes and product use; and emissions from agriculture, forestry and other land use.

4.4 Emissions analysis was drawn from national and local energy and GHG data sets. Local data was also accessed through primary research by requesting information from key private and public sector organisations. Other data were modelled using recognised approaches to disaggregate higher area statistics. Whilst this is the first such inventory to be produced for the region, its methodology is consistent with the Global Protocol for Community Scale Greenhouse Gas Emissions (GPC).

4.5 The approach adopted in developing this emissions inventory takes an integrated approach in identifying both emissions and positive contributions (i.e. carbon sequestration) through renewables production and forestry in the area, whilst also factoring in the negative impact that degraded peatland has on the overall footprint.

5 Emissions Baseline and Key Findings

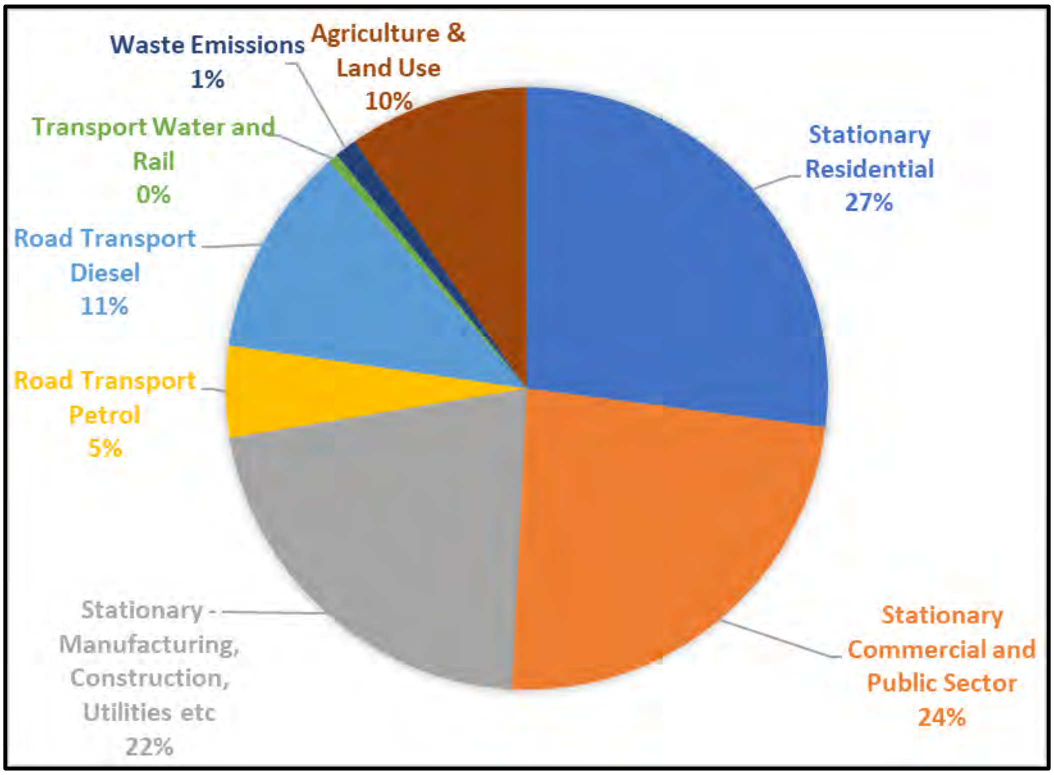
5.1 The emissions estimates per category are combined below to provide totals with and without an adjustment for net carbon sequestration from forestry (carbon is absorbed from the atmosphere by growing trees, and is also sequestered into the soil through accumulation of organic litter on the ground). Totals are given in tonnes of carbon dioxide equivalent (tCO_2e) for the following emissions scopes:

- Scope 1 – emissions from sources located within the inventory boundary e.g. direct emissions from burning fuel (gas, LPG, heating oil, petrol, diesel etc) .

- Scope 2 - emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the Inventory boundary.
- Scope 3 - all other emissions that occur outside the Inventory boundary but arising because of activities taking place within the area e.g. distribution losses from grid-supplied electricity.

	Scope 1	Scope 2	Scope 3	Total tCO_2e
Stationary Residential	88,981	91,043	7,432	**187,456**
Stationary Commercial and Public Sector	50,268	105,523	8,614	**164,405**
Stationary (Manufacturing, Construction, Utilities, etc)	74,142	69,741	5,693	**149,576**
Transport Petrol	34,077	0	0	**34,077**
Transport Diesel	78,313	0	0	**78,313**
Transport Water and Rail	3,712	0	0	**3,712**
Waste Emissions	2,440	0	5,760	**8,200**
Agriculture and Land Use*	67,140	0	0	**67,140**
Forestry				***-383,918***
Total, excluding Forestry Sequestration	**399,073**	**266,307**	**27,499**	**692,879**
Per Capita, excluding Forestry Sequestration				**8.6**
Total, including Forestry Sequestration				***308,961***
Per Capita, including Forestry Sequestration				***3.8***

5.2 The following chart illustrates the composition of the Inventory area emissions in 2014:



5.3 The gross emissions for the Inverness Greenhouse Gas Inventory area in 2014 were calculated to total 692,879tCO_2e. The area's population in 2014 was officially estimated at 79,728, giving a per capita figure of 8.6tCO_2e. The annual sequestration of carbon in the Inventory Area's woodlands was estimated as 383,918tCO_2e, which would reduce the Inventory Area's net emissions to 364,496 tCO_2e, the equivalent of 3.8tCO_2e per resident. This reflects the significant role the area's forests play in mitigating the overall climate change impact of the region, and supports increasing efforts to expedite forestry planting in appropriate locations.

5.4 The key findings from the report can be summarised as follows:

- Wide areas of peatland are under threat of damage and degradation. There is now greater awareness of the carbon storage role of managed peatland, and this is helping to reverse the historical passive management and commercial exploitation/extraction of peatland, thus improving its capacity for carbon storage. Support for peatland preservation and restoration should therefore continue.

- Stationary residential emissions from domestic energy use were the largest single contributor to the inventory area's overall GHG emissions, at 187,456tCO_2e, with emissions from grid-supplied electricity the largest proportion of this figure. The Scottish Government has designated energy efficiency as a national infrastructure priority in the form of the Scottish Energy Efficiency Programme (SEEP), and the Council will have a key role to play in its delivery, whilst tackling the effects of fuel poverty where possible. There are likely to be a range of ways that the Council and others can encourage increased domestic and business energy efficiency in the coming years.

- Cars are by far the biggest source of road transport emissions, and were responsible for 63,182tCO_2e in 2014 (roughly equivalent to the Council's total annual carbon footprint). There is growing interest in the promotion of low carbon and active transport, and this will receive continued policy support and funding. In addition, there will be an increasing reliance on electric vehicles and the sharing economy i.e. car clubs, in meeting local transport needs. The Scottish Government has committed to the phasing out of sales of new petrol and diesel cars by 2032. The Council can play a key role in supporting this vision by improving access to electric vehicle charging infrastructure both for its staff and the public whilst supporting the provision of access to shared electric vehicles in communities.

- Total renewable electricity produced in the Inventory Area in 2014 was 1,436,000,000kWh - nearly three times the amount of electricity consumed in the area. Renewable electricity production also exceeds the combined kWh consumption of grid supplied electricity and mains gas in the Inventory Area. From a theoretical perspective, if local renewable energy production displaced the consumption of grid electricity and mains gas (through the electrification of heat, for example), the annual carbon sequestration of the area's forests would be greater than the remaining emissions from stationary fossil fuel consumption and the emissions from waste, transport etc. This emphasises the important role that renewable energy can play in reducing emissions across the region.

- As tourism has grown, especially since the advent of the North Coast 500, the increased number of people in the area will have led to increasing emissions through their travel to and within the area, their overnight stays and other uses of buildings, and their consumption and related waste.

- Healthcare has an important role to play in contributing towards reduced operational emissions, as well as a requirement to adapt service delivery to meet the emerging challenges which will arise from the changing climate. Climate change is widely considered to be a "threat multiplier" in respect of global health, given that it can potentially amplify pre-existing health problems and inequalities.

- Whilst the inventory has been compiled using the best available data and methods, this is a new field where research is continually improving our understanding, and subsequent inventories should seek to build on the work undertaken and improve the accuracy, reliability, and coverage of data. Producing an emissions baseline for the Inverness area has required a review of the different sources of greenhouse gas emissions, and highlights where data are not adequate or available, or where further information is needed to inform policy and project interventions. A number of areas in the report are active foci of current research, including agricultural emissions factors, soil carbon under all forms of land use, the emissions and sequestration from peatland etc. It is important that work in these fields continues to be supported, given their important role in the overall emissions from the region.

6. Next Steps

6.1 The Inverness GHG Baseline report identifies a number of key recommendations (pp. 94 – 97) to take forward in order to further reduce the emissions profile of Inverness. The report recognises that achievement of carbon reduction targets is not simply a responsibility for, nor within the sole control of, The Highland Council – this will require actions from a range of stakeholders. As climate change is not explicitly mentioned in the Local Outcome Improvement Plan, a wide approach to emissions reduction becomes even more important. To this end, it is recommended that a multi-agency Climate Change Working Group should be established under the Highland Environment Forum to take forward priority actions identified in the Inverness GHG Baseline report.

6.2 As mentioned above, the Inverness GHG Baseline report is the first such inventory produced in Highland, and provides a detailed summary of the emissions footprint of the area for 2014. To understand what the picture looks like across the whole region, it is recommended that funding opportunities are explored to allow an inventory to be produced for the whole region for 2016, which is the most up-to-date reporting year from a data availability perspective. This would be of benefit in communicating with Highland residents and businesses about the region's climate change performance whilst identifying key areas of focus, going forward.

7 Implications

7.1 Resource – It is anticipated that the cost of producing a carbon baseline report for the whole Highland region would be in the region of £20,000. If the aspiration is supported, the Climate Change team will explore opportunities with partners to secure this funding, with a view to commissioning the report later in 2018.

7.2 Legal - The Council has a legal duty to assist Scotland achieve its national carbon emission reduction targets as set out by the Climate Change (Scotland) Act 2009. The Council is required to mandatorily report to the Scottish Government on action taken to tackle climate change. The reporting covers action taken within the Council's own estate, but also action taken by the Council to work with its partners and communities to tackle climate change. The Inverness Greenhouse Gas Inventory Report identifies key opportunities to work with communities to mitigate against climate change impacts.

7.3 Community (Equality, Poverty and Rural) – The Inverness GHG Baseline report identifies a number of ways in which climate change and carbon emissions reduction can have equality, poverty and rural impacts. If supported, the Climate Change Working Group will identify key ways to mitigate these impacts.

7.4 Climate Change/Carbon CLEVER – this report provides the first step in measuring the climate change impact of Highland, and identifies key measures which should be taken forward to reduce this impact over the coming years. Many of these support the *Local Voices, Highland Choices* priority to work with communities and partners to mitigate against and adapt to climate change whilst raising awareness around sustaining and improving our natural, built and cultural environment.

7.5 Risk – Climate change is now recognised as a Corporate Risk, and it is therefore important that efforts are made to reduce its impacts - the report outlines several key action areas which need to be addressed to minimise risk to service delivery.

7.6 Gaelic – no implications arising from this report.

Designation: Director of Development and Infrastructure

Date: 30 April 2018

Author: Keith Masson, Climate Change Officer

APPENDIX 1

University of the Highlands and Islands
Oilthigh na Gàidhealtachd agus nan Eilean

INVERNESS GREENHOUSE GAS INVENTORY 2014

February 2018

Draft Report

Table of Contents

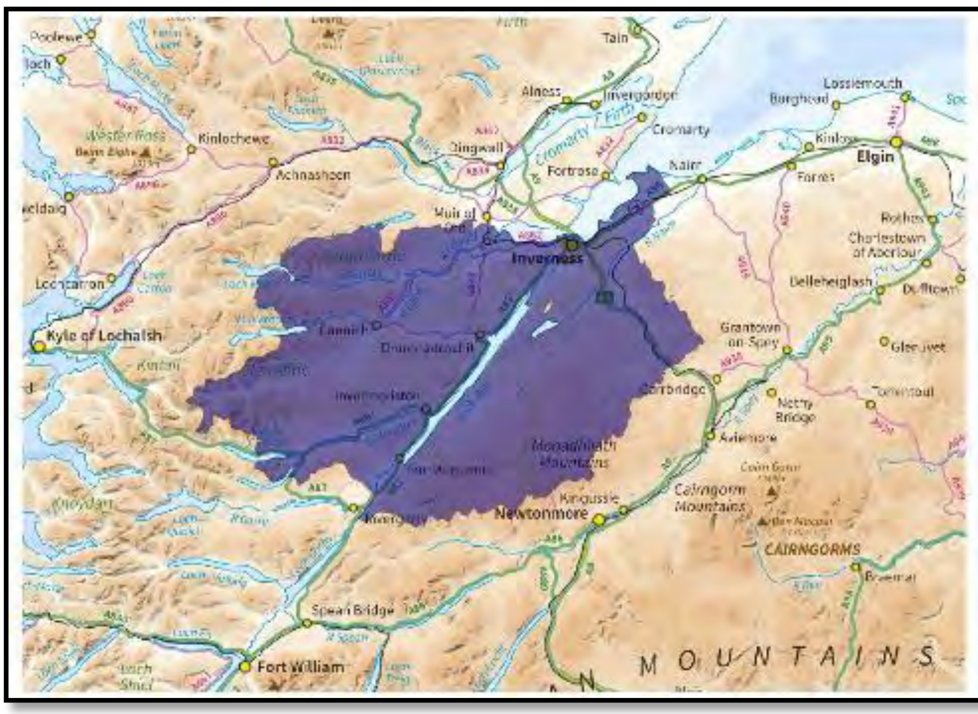
Tables and Figures

Executive Summary

The Scope of the Report

This report was commissioned by Highland Council and Highlands and Islands Enterprise to provide a greenhouse gas inventory for Inverness and enable the net carbon balance for the area to be assessed. For the purposes of the study, the “Inverness” area was taken as the former Inverness District (i.e. including both the city and its surrounding area), and the data collated and analysed related to 2014 – the most recent year for which the core information was available when our research was undertaken.

The report provides a baseline Greenhouse Gas (GHG) Inventory for 2014 for the Inventory Area (see below), covering 2,903 sq km. It is the first such Inventory to have been produced specifically for this area and is consistent with the Global Protocol for Community Scale greenhouse gas emissions (GPC). The findings will inform work that Highland Council has been progressing through its Carbon CLEVER initiative and policy initiatives of other organisations, and provide a baseline to enable future progress in reducing emissions by category to be tracked.



We considered emissions from all relevant sources, including the use of stationary energy (in residential, commercial and institutional properties); transport (by road, rail and water); waste disposal and the treatment of wastewater; industrial processes and product use; and emissions from agriculture, forestry and other land use.

Analysis drew on national and local energy and greenhouse gas emission data sets, and where official data were available for the specific Inverness District area, this was used. Local data were also accessed through primary research by requesting information from key private and public sector organisations, with several public sector data sources contacted for specific data. Other data were modelled using recognised approaches to disaggregate higher area statistics.

Emissions were calculated for the 'basket' of six Kyoto Greenhouse Gases, reported as carbon dioxide equivalent (CO_2e) and categorised by 'scope'. Scope 1 emissions are directly emitted within the boundary of the area under consideration (often referred to as territorial emissions); Scope 2 emissions are indirect and arise from the consumption of grid supplied electricity, heat, steam & cooling within the area; and Scope 3 emissions are indirect and arise beyond the area's boundary because of activities taking place within the area.

Our approach takes an integrated climate change perspective in identifying both emissions and positive contributions through renewables production and carbon sequestration through forestry in the area; taking also into account the negative impact of degraded peatland.

Whilst this inventory has been compiled using the best available data and methods, this is a new field where research is continually improving our understanding; and subsequent inventories should seek to build on the work undertaken and improve the accuracy, reliability, and coverage of data. Producing an emissions baseline for the Inverness area has required a review of the different sources of greenhouse gas emissions, and highlights where data are not adequate or available, or where further information is needed to inform policy and project interventions.

Emissions by Category

The estimates per emission category, the sources of which are described in detail in the full report, are combined below to give totals with and without an adjustment for net carbon sequestration in the year from forestry. In the table below, an adjustment is not made for renewable energy generation (but see Page 10 below). Emissions are given in tonnes of carbon dioxide equivalent (tCO_2e).

	Scope 1	**Scope 2**	**Scope 3**	**Total tCO_2e**
Stationary Residential	88,981	91,043	7,432	**187,456**
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*Includes land management sequestration of -15,266 tCO_2

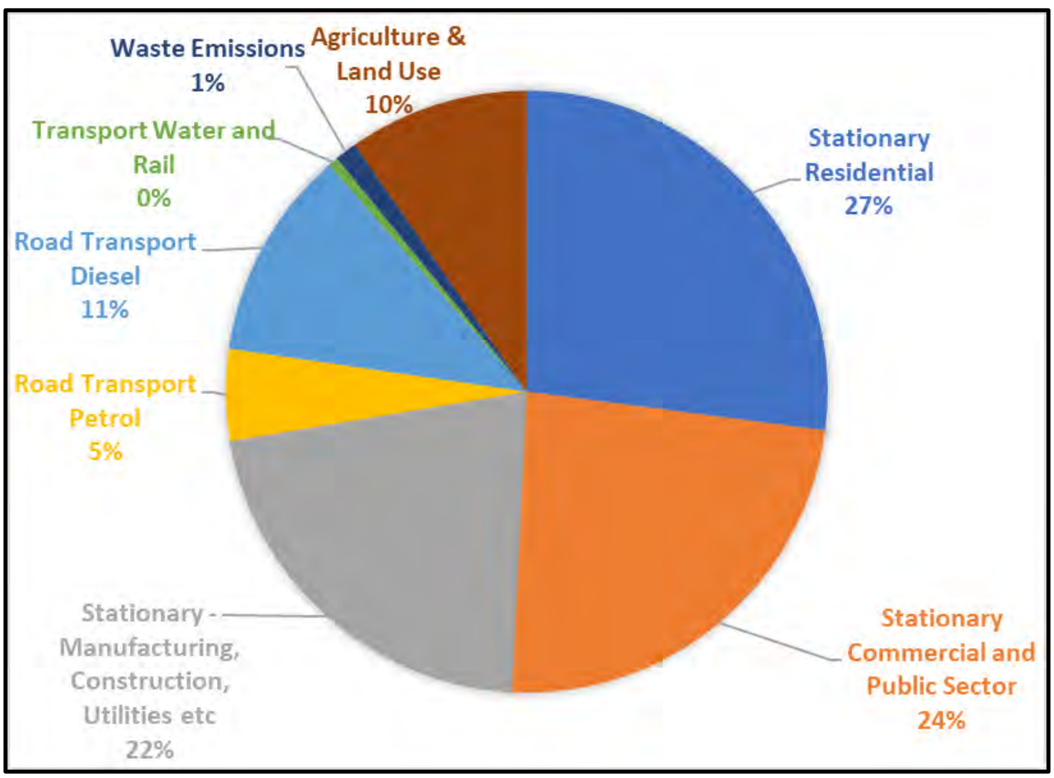
The gross emissions for the Inverness Greenhouse Gas Inventory area in 2014 were calculated to total 692,879 tCO_2e. The area's population in 2014 was officially estimated at 79,728, giving a per capita figure of 8.6 tCO_2e. The annual sequestration of carbon in the Inventory Area's woodlands was estimated as 383,918 tCO_2e, which would reduce the Inventory Area's net emissions to 364,496 tCO_2e, the equivalent of 3.8 tCO_2e per resident.

This figure per resident does not take into account the presence of tourists in the area. In 2014, there were approximately 7,500,000 bednights in Highland according to VisitScotland statistics on UK and overseas tourist visits (including people staying with friends and relatives) – of which perhaps 3 million were spent in the Inverness area as defined for this report. If the 80,000 people normally resident in the area spent an average of 350 nights in the area over the year, this would give 28 million bednights. Thus, tourism might add around 10% to the area's "population" on average over the year. Tourists, on average, will tend to travel more by car per day while in the area than the average resident; although most visit during times of year when heating costs will be relatively low.

Also, the area will attract more day visits for work, shopping and leisure by people resident outwith the area (including other parts of Highland) than the number of day visits made by the area's residents outwith the area.

Greenhouse gas emissions for Scotland, reported annually as part of the implementation of the Scottish Climate Change Act, were 56.9 million tCO_2e in 2014, excluding forestry sequestration. With the Scottish population estimated at 5,346,120 in 2014, per capita emissions totalled 10.6 tCO_2e. This average emissions per head figure is higher than the Inverness Inventory Area total – in part due to the national figures including all of the country's energy supply, including oil refineries, nuclear fuel production and coke and gas production. With forestry sequestration included, the figure for Scotland falls to 46.7 $mtCO_2e$, the equivalent of 8.74 tCO_2e per capita.

The following chart illustrates the composition of the Inventory Area emissions in 2014:



Emissions arising from energy use in residential, commercial and industrial properties are a consequence of using grid supplied electricity, burning mains gas, and using heating oil/LPG. These emissions represented 72% of the overall Inverness Inventory Area emissions, the equivalent of 501,437 tCO_2e.

Stationary residential emissions from domestic energy use were the largest single contributor to the Inventory Area's overall GHG emissions, at 187,456 tCO_2e, with emissions from grid supplied electricity the largest proportion of this stationary emissions figure. In the coming years there will be a range of ways that Highland Council and others could encourage increased domestic and business energy efficiency. The Scottish Government has also identified significant funding available to address emissions over the next few years, including reducing energy use in commercial properties, manufacturing and construction activities, etc.

The transport emissions that we were able to identify and attribute represented 16.7% of all Inventory Area emissions, totalling 116,103 tCO_2e, with road transport producing 97.4% of these emissions. Of interest is the significant proportion of this generated by diesel powered internal combustion engines, 78,313 tCO_2e. Cars are by far the biggest source of road transport emissions, and were responsible for 63,182 tCO_2e. There is growing interest in the promotion of active transport, and this will receive continued policy support and funding. However, being realistic, this will only make marginal impacts on reducing overall area transport emissions in the near future.

It was not possible to access figures for air travel from Inverness Airport, which is located in the east of the Inventory Area – although the proportion of flight miles that are in the Inventory area will be very small, and attributing all miles associated with flights to and from the airport would not be appropriate as the airport serves a much wider catchment area than the Inventory area including transits. Whilst emissions from air travel in Scotland have grown in recent years, this growth has been significantly slower than the growth in the number of passengers. This is the type of reduction in carbon intensity required for sectors to become more carbon efficient. Air travel emissions will be included in Scotland's future Inventories, and it would be good practice, therefore, to include air travel emissions in future Inverness or Highland emission inventories (appropriately attributed).

Rail and water transport, including leisure activity on Loch Ness and freight moving into and out of Inverness harbour, were estimated to have generated a very small volume of emissions, 3,712 tCO_2e. There will be increasing interest, however, in how the marine transport sector can reduce emissions, both when boats are travelling and when they are moored in harbours and ports.

Waste emissions are declining across Scotland – a consequence of increased levels of recycling and the diversion of organic waste from landfill. This report estimates emissions attributable to the Inverness Inventory area from solid waste landfilled at 5,760 tCO_2e, composted waste at 1,844 tCO_2e, and from waste water treatment at 556 tCO_2e – giving a total of 8,200 tCO_2e. This is an emerging area of GHG Inventory analysis. Scottish Water would be interested in contributing to any future reviews of the waste water emissions in the Inverness Inventory Area.

There is growing awareness of the role that plants and soil play in retaining carbon. Land and animal management are evolving and facing a period of uncertainty as the UK withdraws from the Common Agricultural Policy. Agricultural emissions in the area in 2014 were 82,406 tCO_2e. Woodland growth produced a net sequestration of 383,918 tCO_2e (unadjusted for felling). Peatland is an important carbon reserve in the Inverness Inventory Area. Due to inadequate peatland and upland management, however, an estimated 73,803t CO_2e was lost in 2014 from this potential reserve.

There could be more consideration of land use and carbon sequestration in the Inventory Area as well as in the wider Highlands. Intensive conifer tree plantations established in the second half of the 20th century are mainly responsible for the significant carbon sequestration now occurring in the Inventory Area as well as in the wider Highlands. A significant proportion of these plantations are being or will be harvested in the coming years, however, and this will significantly reduce the benefit from forestry carbon sequestration in the area. Planting for the creation of new woodland in Scotland has consistently failed to reach the targets that would allow the forestry sector to make this important carbon sequestration role consistently in the coming years. To catch up on lost planting, the Scottish Government has increased annual planting targets to 15,000 a year by 2025. The move towards more natural and mixed woodland planting has reduced the potential for carbon sequestration as a result, with implications for future forestry carbon sequestration in the Inverness and wider Highland areas. Without the sequestration benefit of forestry, net per capita emissions in the Inventory Area would nearly double.

A report for Scottish Natural Heritage estimates that wide areas of peatland are under threat of damage and degradation. There is now greater awareness of the carbon storage role of managed peatland, and this is helping to start reversing the historical passive management and commercial exploitation/extraction of peatland, improving its capacity for carbon storage.

This report identifies the growing interest in carbon neutral cities and regions. Areas aspiring to be carbon neutral are allowing a long period of time – up to 2050 – to achieve this target. A key original aspect of the Council's Carbon CLEVER initiative was the aspiration of creating a carbon neutral Inverness by 2025. The Carbon CLEVER initiative did not define carbon neutral, but to help the area move towards this aspiration, the following definition is suggested:

Making no net release of carbon dioxide to the atmosphere from the Inverness Inventory Area by reducing consumption, producing and using renewable energy, and offsetting emissions by planting trees.

Total renewable electricity produced in the Inventory Area in 2014 was 1,436,000,000 kWh, which was nearly three times the amount of electricity consumed in the area. From purely an electricity consumption perspective, it could be suggested that the Inventory Area is already carbon neutral as more electricity was produced than consumed in the Inventory Area in 2014 (taking into account that the carbon intensity of the mains electricity factor used in the report has already reduced because of local renewable energy production being supplied to the national grid).

Renewable electricity production also exceeds the combined kWh consumption of grid supplied electricity and mains gas in the Inventory Area. From a theoretical perspective, if local renewable energy production displaced the consumption of grid electricity and mains gas (through the electrification of heat), the annual carbon sequestration of the area's forests would be greater than the remaining emissions from stationery fossil fuel consumption and the emissions from waste, transport etc. This would mean that the Inventory Area has already met the carbon neutral definition given above.

The approach to carbon neutrality in this report adopts some simplified assumptions for practical purposes. For example, the variable production of renewable electricity in relation to periods of peak consumption of grid supplied electricity has not been matched. This approach does however show theoretically that areas can move towards being carbon neutral by combining renewable energy production and carbon sequestration. The challenge for areas with suitable land areas will be to develop a consistent supply of renewable energy through a production mix and suitable storage as well as expanding the carbon sequestration in woodland.

Findings for Other Areas

Measuring emissions for a defined city or other area is an emerging area of analysis, which is being informed and improved by constant development in methodologies and data availability. A report was prepared for Aberdeen City and Aberdeenshire in 2010 using the Greenhouse Gas Regional Inventory Protocol to develop an emissions account for the two local authority areas for 2005. This identified total emissions of 6,020,000 tCO_2e (12.30 tCO_2e per head). A broader assessment was carried out for Glasgow and the Strathclyde region which focussed on consumption based emissions, and a number of Scottish community organisations have attempted carbon assessments. A study close in methodology to the one we adopted was made by the Greater London Authority, using the BSI Specification 2070 for assessment of greenhouse gas emissions from a city, which gave a basic figure of 5.51 tCO_2e per capita for the use of energy, but 10.05 tCO_2e per capita when also taking into account transport, waste and water use, and an estimate of supply chain emissions associated with food and construction materials.

A greenhouse gas inventory study was undertaken in Lochaber in 2012 using the GPC methodology. To provide a broadly comparable set of figures to our Inverness area, the two large industries in Lochaber (the aluminium smelter and the aggregate quarry) were excluded; and this gives a total of 275,221 tCO_2e for emissions, equating to 13.8 tCO_2e per capita. Forestry and other land use was responsible for sequestering 480,990 tCO_2e in 2012, however, making Lochaber carbon negative, with a net emissions total of -205,769 tCO_2e, the equivalent of -10.3 tCO_2e per capita. This highlights the valuable carbon reduction role played by the region's extensive forestry.

Trends

Over the last twenty years, a range of commercial, development, social and environmental factors have had both positive and negative impacts on GHG emissions in the Inventory Area. Trends have included the following:

- Population growth has increased the level of emissions produced in the area – a combination of residential, other stationary and transport emissions. It is important to keep trends in emissions per capita under review as well as total emissions in the Inventory and wider Highland Council area.

- New urban housing has created an increased demand for electricity and gas. There is a more diverse mix of space heating in rural properties. As the thermal performance of housing improves, however, emissions from heating should decline.

- Changing economic activity has impacted on the sources and levels of emissions. Economic activity in the Inventory Area is now less reliant on manufacturing and heavier industry, having moved towards more service based activity, which requires lower energy consumption with a reduction in emissions.

- As tourism has grown (especially in recent years), nevertheless, the increased number of people in the area will have led to increasing emissions through their travel to and within the area, their overnight stay and other uses of buildings, and their consumption and related waste.

- Increased incorporation of renewable energy technologies in domestic and commercial properties, as well as continued political support for the broader development of renewable energy, will continue to reduce the carbon intensity of grid electricity. There is concern, though, that the rate of reduction will fall as less lower carbon electricity will be produced until planned new nuclear power stations in the UK start generating.

- Increased segregation and treatment of waste is helping to reduce emissions. Banning the disposal of organic material in landfill has significantly helped to reduce emissions.

Recommended Actions

The report identifies a range of actions (summarised below) that Highland Council and other organisations and businesses could consider to help reduce future emissions, with significant public funding available to support these interventions.

Stationary Energy

Reflecting Scottish Government priorities and funding, Highland Council and other stakeholders should continue to support the trend of declining residential emissions in the Inverness Inventory and wider Council areas. Key interventions might include:

- Ensuring there is a rolling programme of domestic energy efficiency, renewable heat, district heating initiatives and pilot projects eligible for national funding as the availability of this evolves.

- Liaising with other agencies and initiatives to capitalise on the benefits of the UK Government's commitment to offer smart meters to every household and business by 2020.

- Continuing to support developments to access the District Heating Loan Funding, which helps address the financial and technical barriers to district heating projects.

- Considering opportunities/projects that would be eligible for support through the Heat Network Partnership.

Industry, Commercial and Non-Domestic Buildings

Scotland's industrial sector has already substantially reduced emissions, and this is likely to continue in the coming years. Specific recommendations to help the industrial sector in the Inverness and wider Highland areas to continue emission reductions include:

- Ensuring that the Business Gateway service is familiar with the policy rationale for and mechanisms to help businesses reduce emissions.
- Collaborating with other local authorities and the Scottish Government on the development of a successor programme to the non-domestic Renewable Heat Incentive, with continuing support for low carbon heating.

- Liaising with relevant organisations, for example Resource Efficient Scotland, to ensure that businesses in Council and other public sector owned industrial, office and retail properties are aware of support to reduce emissions.

- Monitoring the Scottish Government's production of SEEP (Scotland's Energy Efficiency Programme) Route Map in 2018 and tapping into the supporting £500 million funding.

- Ensuring that all tenants in Highland Council small and medium sized non-domestic premises are aware of the programme of smart meter roll-out and ensuring that meters are fitted to appropriate properties by 2020.

Transport

The most significant transport emission reductions that could be encouraged relate to road transport, and opportunities include:

- Liaising with the Scottish Government to incentivise more rapid uptake of electric and ultra-low emission cars and vans.

- Continuing engagement with ChargePlace Scotland to maximise the opportunity for enhancing the electric vehicle (EV) charging network in the area.

- Engaging with the area's taxi firms to determine the interest in and potential uptake of ultra-low emission vehicles.

- Monitoring the introduction of statutory requirements for the provision of EV charging points/wiring in new residential and commercial developments.

- Continuing to promote the opportunity for active travel in the Inventory Area and wider Highlands.

- Encouraging and facilitating more use of public transport and vehicle sharing, and cycling for short journeys.

Waste

Ways of reducing waste emissions include:

- Sustaining and improving current waste reduction, recycling and landfill diversion facilities.

- Ending landfilling of biodegradable municipal waste by 2020 and reducing all waste sent to landfill to 5% by 2025.

- Sustaining and increasing the collection of food waste in the area.

Land Use and Land Use Change

This report shows that agriculture in the Inverness district is highly varied, that forestry has provided a highly valuable carbon sink, and that poorly managed peatland can be an emissions source as significant as agriculture. Actions for consideration to encourage carbon friendly land management include:

- Reviewing the Marginal Abatement Cost Curve assessment completed by SRUC for the Committee on Climate Change which listed 24 potential mitigation measures to reduce emissions in agriculture.

- Liaising with the Forestry Commission, private woodland owners and other private landowners about future planting options and their impact on emission mitigation.
- Increasing understanding of peatland carbon storage and the ways in which it is threatened.

- Making the results from this GHG Inventory available to planners and to the Highland Land Use Strategy group.

To help take forward these policy interventions and programmes, a small group might be established, comprising Highland Council and the main agencies active on environmental issues to oversee progress. This GHG Inventory could then inform a series of meetings on emissions and mitigation in the different sectors identified, with participation from the relevant groups for each area. For instance, in the case of transport, stakeholders could include HIE, HITRANS, Energy Saving Trust/Transport Scotland, community councils, community environmental groups and electric car retailers. With respect to stationary emissions, the Council and other public bodies now have considerable experience in developing innovative programmes to help reduce energy consumption – comprehensively measuring and reporting on results.

In the case of wastewater, where emission allocation and identification are more technical, consultation would be appropriate with Scottish Water, local contractors such as Veolia, and electricity companies. In the case of agriculture and land use, it would be useful to examine all land uses and all mitigation options in an integrated way, bringing together farmers, landowners, foresters, game hunters, conservationists, walkers and other recreational users of land and local communities. Initial meetings might take place within a specified period (e.g. during 2018) to determine what actions could be taken to achieve a carbon neutral Inverness and how the inventory could be improved, shared and kept as up-to-date as possible.

Alternatively, action might span the whole of the Highland Council area – either initially or after a pilot in the Inverness area.

The above measures would help Scotland to move towards achieving its 2050 Vision as set out in the Scottish Government's Scottish Energy Strategy (December 2017).

Chapter 1 – Introduction

This report has been prepared by the University of the Highlands and Islands to provide a review of greenhouse gas emissions (GHG) in 2014 for the city of Inverness and the surrounding area. This area has been defined as the former Inverness District boundary. Throughout this report, the term Inventory Area has been used.

Our analysis provides a baseline for 2014 which will inform Highland Council's Carbon Clever programme. The report estimates all GHG emitted as a result of activities throughout the Inventory Area including stationary energy, transport, industrial processes, waste, agriculture and forestry. The report also identifies how different organisations are evolving their operations to reduce their GHG emissions.

Since pre-industrial times, atmospheric abundance of GHGs has risen. While influenced by natural factors, this increase is also linked to emissions related to human activity[1]. Globally, there has been a 70% increase in GHG emissions from 1970 to 2004 alone[2]. Growing population, intensified agricultural practices, increase in land use and deforestation, industrialisation and associated energy use derived from fossil sources have all led to the increased growth rate of atmospheric GHG in recent years.

Figure 1 – Atmospheric Carbon Dioxide (CO_2)

Source: National Oceanic and Atmospheric Administration

[1] Greenhouse Gas Bulletin No 12 – October 2016 World Meteorological Organisation and Global Atmosphere Watch.

[2] http://www.eea.europa.eu/themes/climate/faq/what-are-the-current-trends-in-greenhouse-gas-emissions

The UK Government's Stern Review[3] published in 2006 concluded that scientific evidence is overwhelming: climate change is a serious global threat, requiring an urgent global response. Using results from economic models, the Stern Review estimated that if no action were to be taken, the overall costs and risks of climate change would be equivalent to losing at least 5% of global GDP each year, indefinitely. If a wider range of risks and impacts are considered, the estimates of damage could rise to 20% of GDP or more.

Recognising this challenge, there is a growing portfolio of international regional and domestic approaches to managing and reducing GHG emissions. The following paragraphs identify some of the more local activity and progress towards reducing emissions.

1.1 Scottish Context and Activity

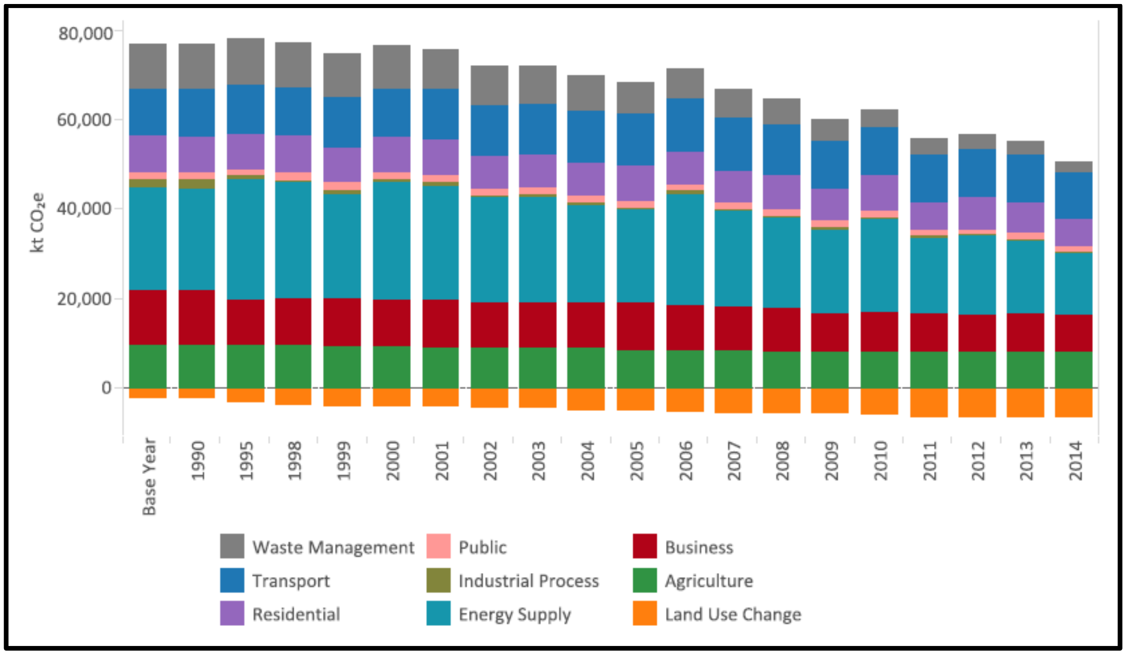
The Scottish Government passed ambitious climate change legislation – the Climate Change (Scotland) Act in 2009. The Act provides the policy, legislative and investment frameworks to support reduction in the country's GHG emissions. There has been a specific charge on public sector bodies to reduce their own emissions as well as engage the wider public in GHG emissions reduction[4].

Comprehensive data collection and analysis has been established to help monitor progress in emission reduction. The following chart illustrates how sector emissions have declined over the 25 years between 1990 and 2014.

[3] http://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/stern_review_report.htm

[4] Public Sector Sustainability Reporting – Guidance on the Preparation of Annual Sustainability Reports. Scottish Government

Figure 2 – Total Greenhouse Gas Emissions 1990 – 2014, Scotland[5]



Changes in emissions have been driven by a range of factors:

- increased energy efficiency of appliances and improved insulation in homes, helping to reduce energy consumption;
- the switch from burning oil and coal for electricity production to gas;
- the diversion of waste from landfill and increased recycling, which reduces levels of waste related methane production, and;
- reducing energy consumption in the business sector (a combination of a smaller manufacturing sector which uses less energy and the growth of more service activity which consumes less energy), as well as installing more energy efficient machinery and equipment.

The following chart illustrates how energy consumption, one source of Scottish GHG emissions, has declined over the last decade.

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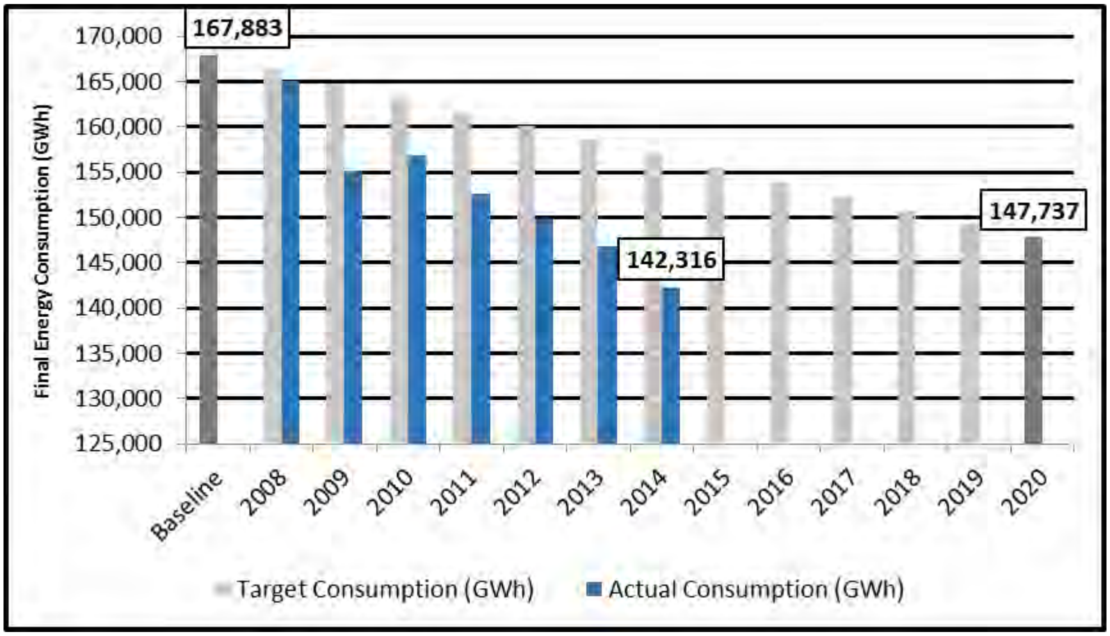
[5] Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2014, Department of Energy and Climate Change, The Scottish Government, The Welsh Government, The Northern Ireland Department for Agriculture, Environment and Rural Affairs.

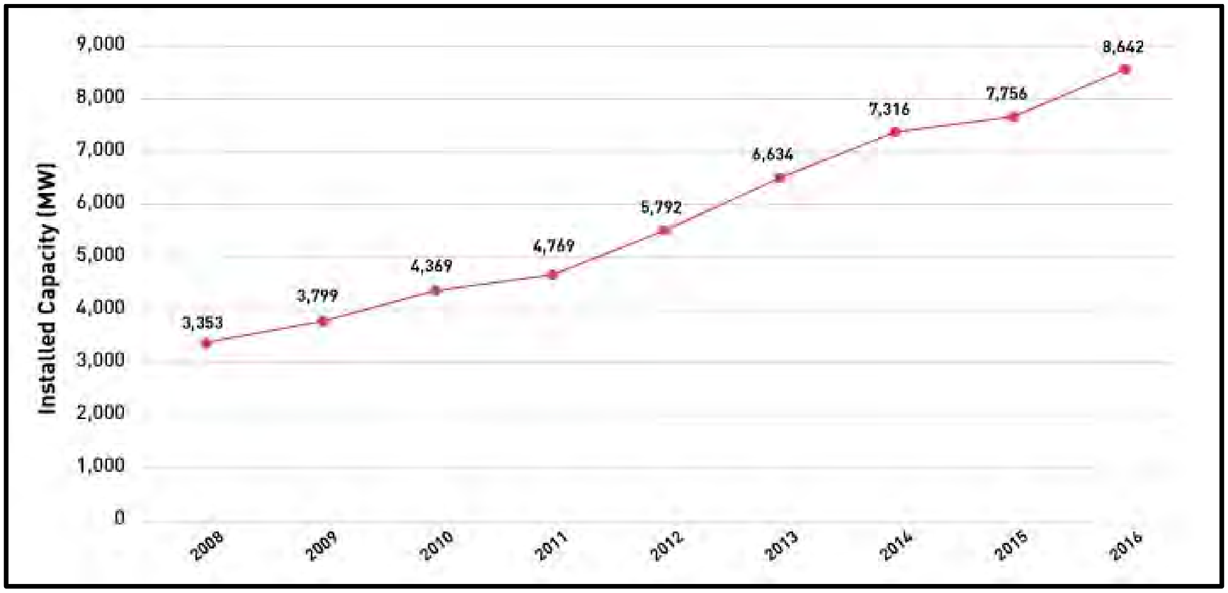
Figure 3 – Final Energy Consumption (GWh), Scotland, Baseline (2005-2007) - 2014[5]



Coupled with this decline in energy consumption is sustained support to increase the generation of renewable, low carbon energy in Scotland. There has been considerable change over the past 15 years in the production of electricity in Scotland. The power sector has become increasingly decarbonised as renewable energy and low carbon generation has replaced traditional fossil fuel powered generation. In 2015, renewables represented Scotland's biggest source of electricity production (42%) and served the majority of Scottish needs alongside the two remaining nuclear plants in Scotland (35% of generation). There has also been increases in the development of small scale and domestic installations of renewable energy from solar, biomass and hydro power[6].

[6] Scottish Energy Strategy: The future of energy in Scotland, Scottish Government. 2017

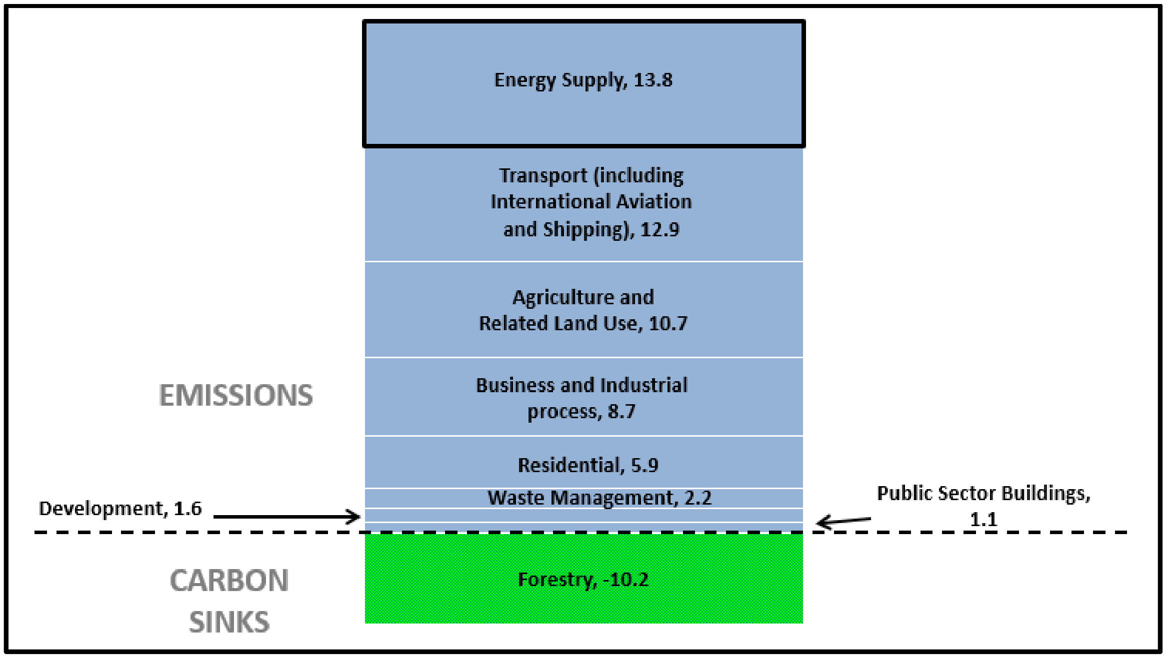
Figure 4 – Total Installed Capacity of Renewable Electricity in Scotland, 2008-2016[7]



The following chart identifies the sources and values of GHG emissions for Scotland in 2014. A key aspect of this chart is the carbon sink provided by forestry, which is explained in more detail later in this report. An important characteristic of the area used in this research is a high level of peatland. Acting in a similar way to trees, peatland which is not degraded absorbs and stores carbon. Again, this is discussed in more detail later in this report.

[7] Scottish Renewables. Renewables in Numbers http://www.scottishrenewables.com/sectors/renewables-in-numbers/

Figure 5 – Sources of Scottish Greenhouse Gas Emissions, 2014. (Values in million tonnes CO_2e[8])



A key aspect of this decline in energy use has been sustained effort to improve energy efficiency in domestic and work environments. For example, increased levels of home insulation reduce the rate at which heat is lost from a property, requiring less energy to be consumed for heating. The transition of lighting from inefficient incandescent to energy efficient LED is an example of technological advances reducing energy consumption.

In their 2016 Progress Report[9], the Committee on Climate Change identified that Scotland is performing well, especially compared to other countries in the UK and the UK as a whole. Key findings from the report include:

- The annual legislated target to reduce Scottish emissions for 2014 was met: emissions in 2014 were 45.8% lower than 1990 levels.
- Scotland performed better than the UK as a whole in 2014: since 1990, gross Scottish emissions have fallen nearly 40%, compared to nearly 33% at a UK level.
- Scotland has made good progress in several areas and is often leading the UK. There has been good progress in deploying renewable electricity generation capacity, helping to meet the 2020 target for 500 MW of capacity early.
- The Government is aiming for an integrated approach to reducing emissions by reducing demand, improving energy efficiency, installing low-carbon heat, and reducing waste.

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[8] Energy in Scotland 2017, Scottish Government
[9] Reducing emissions in Scotland: 2016 Progress Report, Committee on Climate Change

To provide a policy environment that continues this good practice, in January 2017 the Scottish Government published their draft Energy Strategy[10] and Climate Change Plans[11] for consultation. These documents signal further financial and policy support for energy efficiency and the decarbonisation and decentralisation of the country's energy supply.

1.2 City Context

In their 2015 report[12], the New Climate Economy identified some of the issues facing cities and their interaction with GHG emissions.

"Cities are crucial to both economic growth and climate action. Urban areas are home to half the world's population, but generate around 80% of global economic output and around 70% of global energy use and energy-related GHG emissions. Cities are growing at an unprecedented rate, particularly in the developing world, with 1.4 million people added to urban areas each week".

By 2030, around 60% of the global population will live in cities. Over the next two decades, nearly all the world's net population growth is expected to occur in urban areas. By 2050, the urban population will increase by at least 2.5 billion, reaching two-thirds of the global population".

As a result, interest in the carbon footprint of cities and regions is growing. 3,000 delegates attended the World Mayors Summit on Climate (WMSC) held in November 2010 in Mexico City. This enabled mayors from different regions of the world to sign a voluntary Pact (the Global Cities Covenant on Climate "the Mexico City Pact"). This sent a clear message to the international community on the strategic importance of cities in the struggle against climate change.

On June 22, 2016, city mayors from across the world announced the new Global Covenant of Mayors for Climate & Energy. This single initiative created the largest global coalition of cities committed to climate change leadership, building on the commitments of more than 7,100 cities from 119 countries and six continents, representing more than 600 million inhabitants and over 8% of the world's population.

1.3 Scotland's Cities

Closer to home, the Scottish Cities Alliance is the collaboration of Scotland's seven cities (Aberdeen, Dundee, Edinburgh, Glasgow, Inverness, Perth and Stirling) and the Scottish Government. This is being facilitated by the Scottish Council for Development & Industry to create the conditions for growth and to attract inward investment. The Alliance partners were brought together following the launch of the Scottish Government's Agenda for Cities in December 2011.

The Agenda for Cities recognises the role Scotland's cities play in the transition to a low carbon economy in a way which maximises the economic benefits for Scotland as a whole. The Scottish Cities Alliance have assisted in creating individual reviews for each city and produced the "Low Carbon Resilient Cities Report[13] " highlighting the collaborative opportunities for investment across the cities. Collectively these

[10] Scottish Energy Strategy: The Future of Energy in Scotland, Scottish Government, 2017
[11] Draft Climate Change Plan The draft third report on policies and proposals, 2017-2032
[12] Seizing the Global Opportunity - Partnerships for Better Growth and a Better Climate. The 2015 New Climate Economy Report
[13] Low Carbon Resilient Cities: Investment Opportunities for 'Better' Growth, Jacobs 2015

prioritised actions were estimated to require investment in the region of £340 million over a 5 to 10-year programme. The direct target benefits from this investment were:

- Economic output of £682 million;
- Gross Value Added of £251 million;
- 4,885 full time equivalent jobs;
- Revenue saving of £21 million per year, largely realised by the Local Authorities; and
- A reduction of almost 64,000 tCO_2 per year, equivalent to c10% of emissions from council activity.

Recognising the role for cities in managing and reducing GHG emissions, Scottish Renewables held their first ever Low-Carbon Cities Conference in 2017[14]. The Conference explored opportunities for Scotland's cities to embrace the transition to a sustainable, clean, green economy; reducing energy costs and tackling fuel poverty, while attracting low-carbon investment and jobs, and building Scotland's industries of the future. Key opportunities identified at the conference included:

- Use of renewable energy technologies, for example district heating, especially where provided by biomass, and the use of waste to produce fuel and energy.

- Alternative fuels: hydrogen, biofuels and their role in reducing transport generated GHG emissions.

- The rate at which disruptive technology, demographic trends and city population growth will challenge traditional policy approaches to behaviour change.

Through this greater focus on Scottish cities, there is growing support for and development of multipurpose, strategic and multi partner projects which will create the foundation for strong emission reduction activity in the coming years.

1.4 Inverness City

Inverness core city area has a population of 38,000, while the wider Inventory area had almost 80,000 residents in 2014[15]. Inverness is a service centre and hub for those exploring the wider Highlands.

In 2014, Highland Council launched its Carbon CLEVER initiative with a target of a carbon neutral Inverness in a low carbon Highlands by 2025. Whilst other cities across Europe have adopted similar initiatives, they tend to have an almost entirely urban city-based focus. As the fortunes of Inverness and the Highlands are so closely linked, the Carbon CLEVER approach was to adopt two targets, where the objective for one will reinforce that of the other. Achieving such ambitious targets requires the combined efforts of a wide range of organisations across the private, public, and third sectors, residents and communities.

The vision of a Carbon CLEVER Highlands was given as:

"By 2025, the Highlands will be a region where its residents and visitors can move around easily by low carbon and sustainable forms of transport. The region is well connected both in terms of transport links and through digital connectivity. Buildings across the region will have been energy renovated, and new

[14] https://www.scottishrenewables.com/events/sr-low-carbon-cities-conference-2017/
[15] Mid Year Estimates

buildings are energy efficient. The growing majority of buildings in rural areas will be heated by renewable sources. Electricity will be generated from a range of renewable sources, and excess energy can be transmitted to surrounding regions through smart grids, or stored efficiently. Land and resources across the Highlands are utilised for optimal economic, social, and environmental gains. Communities across the region are engaged, are highly active, more healthy and empowered."

The Carbon CLEVER initiative was to deliver actions and direction via five key strategic themes:

- Economy
- Energy
- Land Use and Resources
- Transport
- Engagement Strategy

This report provides a GHG emissions baseline for 2014 that will help inform the context and targets of future energy efficiency and emission reduction projects.

Chapter 2 – Calculating and Reporting City Greenhouse Gas Inventories

Creating a regional GHG inventory is an emerging discipline. Previous regional GHG Inventory reviews often adopted different boundaries and methodologies. These inconsistencies have created challenges in comparing results over times from individual studies. To address this common weakness an internationally recognised protocol has been established to enable a consistent methodology when preparing regional GHG inventories.

The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) provides guidance on preparing regional GHG inventories. It supports communities/cities to measure and disclose a comprehensive GHG emission inventory. It was developed with the following objectives:

- Help cities prepare a comprehensive and credible emission inventory.
- Help cities develop effective strategies for managing and reducing their emissions through an understanding of impacts from their human activities.
- Support consistent and transparent public reporting.
- Harmonise existing international protocols and standards for city level emission inventories.
- Support cities' ability to demonstrate the global impact of collective local actions, and to measure collective progress credibly over time.
- Support emission accounting, reporting, and trading schemes at the local/subnational/national level.
- Facilitate access of local governments to climate finance opportunities.

2.1 Greenhouse Gas Inventory – Five Key Principles

To support this best practice approach, inventory preparation methodology is adopting the five key principles now expected in GHG measurement and analysis[16]:

Relevance: Reported emissions reflect those occurring as a result of activities and consumption patterns of the inventory area. The principle of relevance applies when selecting data sources, and determining and prioritising data collection improvements.

Completeness: Analysis accounts for all required emissions sources within the inventory boundary. Any exclusion of emission sources shall be justified and clearly explained.

Consistency: Calculations are consistent in approach, boundary, and methodology. Using consistent methodologies for calculating GHG emissions enables meaningful documentation in changes of

[16] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, World Resources Institute, 2014 Pages 25 & 26

emissions over time, trend analysis, and comparisons between cities. Calculations follow the methodological approaches provided by the GPC.

Transparency: Activity data, emission sources, emission factors, and accounting methodologies are documented to enable verification. All exclusions shall be clearly identified, disclosed and justified.

Accuracy: The calculation of emissions shall not systematically overstate or understate emissions. Accuracy should be enough to give decision makers and the public reasonable assurance of the integrity of the reported information. Uncertainties in the quantification process shall be reduced to the extent that it is possible and practical.

2.2 Greenhouse Gas Emission Scopes

To provide consistent GHG measurement for different areas, the descriptive term "Scopes" is used. The GPC distinguishes between emissions that physically occur within the inventory area (Scope 1), from those that occur outside the inventory area but are driven by activities taking place within the area's boundaries (Scope 3), and from those that occur from the use of electricity, steam, and/or heating/cooling (Scope 2). Scope 1 emissions may also be termed "territorial" emissions, because they are produced solely within the territory defined by the geographic boundary[17]. A methodological question that arises where only one part of a country is being assessed for its emissions is that its Scope 1 emissions might be Scope 3 emissions for another area – i.e. if the whole country were being covered by a regionalised analysis, it would be necessary to adjust across areas to avoid double counting.

Table 1 – Greenhouse Gas Emission Scopes

Scope Definition	Definition
Scope 1	Emissions from sources located within the inventory boundary
Scope 2	Emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the Inventory boundary
Scope 3	All other emissions that occur outside the Inventory boundary because of activities taking place within the area

Data collection was fundamental in preparing the inventory. For this report, data were obtained from a variety of sources, and in several cases, was adapted for our purpose. The GPC recognises the challenges of data availability and management and sets out good practice data collection principles.

When collecting emissions data, it is important to establish first whether a source exists, and then the data availability and quality[18]. Emissions used in this report were classified into six main sectors:

- Stationary energy use
- Transportation
- Waste
- Industrial processes and product use (IPPU)
- Agriculture, forestry, and other land use (AFOLU)

[17] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, Page 11
[18] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, Page 27

- Any other emissions occurring outside the geographic boundary as a result of city activities (collectively referred to as Other Scope 3).

Emissions from these sectors were sub-divided into subsectors, and where beneficial, into sub-categories. Sectors define the topmost categorisation of city-wide GHG sources, distinct from one another, that together make up the city's GHG emission sources activities. Sub-sectors are divisions that make up a sector – for example transport modes such as aviation or on-road. These can be divided into sub-categories where appropriate to provide more detail.

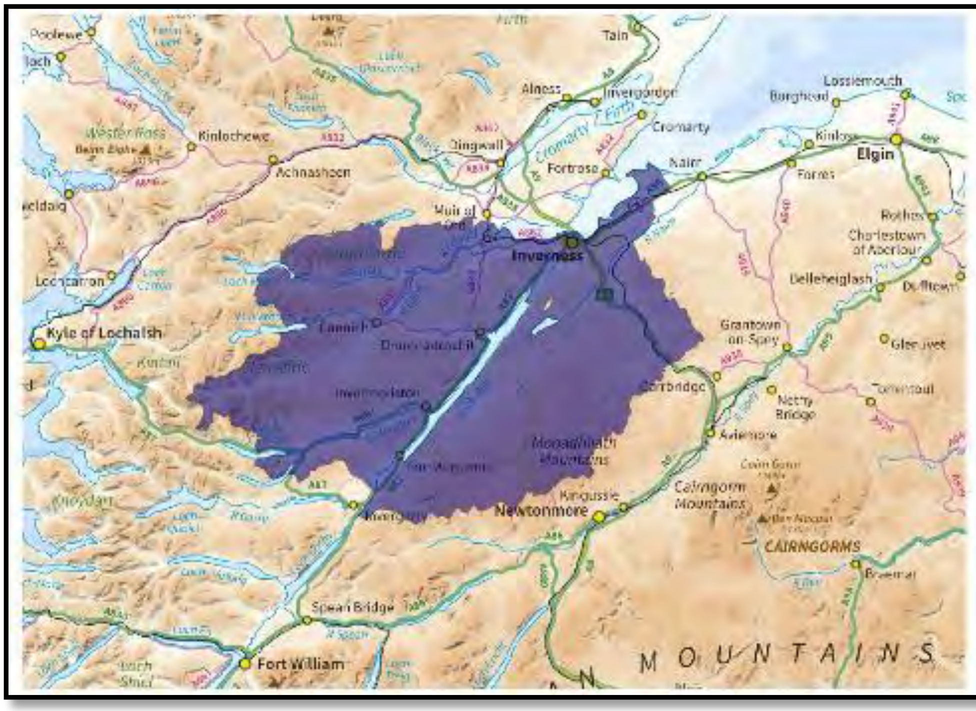
Table 2 – Greenhouse Gas Inventory Sectors

Sectors and sub-sectors
STATIONARY ENERGY
Residential buildings
Commercial and institutional buildings and facilities
Manufacturing industries and construction
Energy industries
Agriculture, forestry, and fishing activities
Non-specified sources
Fugitive emissions from mining, processing, storage & coal transportation
Fugitive emissions from oil and natural gas systems
TRANSPORTATION
On-road
Railways
Waterborne navigation
Aviation
Off-road
WASTE
Solid waste disposal
Biological treatment of waste
Incineration and open burning
Wastewater treatment and discharge
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)
Industrial processes
Product use
AGRICULTURE, FORESTRY AND Other LAND USE (AFOLU)
Livestock
Land
Aggregate sources and non-CO2 emission sources on land
OTHER SCOPE 3

Chapter 3 – Study Area and Data

The core Inverness City is relatively compact, home to just under 38,500 residents and with a narrow economic base. To provide a more comprehensive GHG assessment, this project adopted a broader boundary, reflecting the former Inverness District boundary. This wider area contains many businesses and recreational resources as well as major infrastructure such as harbours and the region's main airport. It also provides major routes into the core City area.

Figure 5 Inverness GHG Inventory Boundary



The following table summarises key socio-economic data for the Inventory Area.

Table 3 – Inverness GHG Inventory Area Information

	Inventory Area Information
City Name	Inverness
Country	Scotland
Inventory year	2014
Geographic boundary	Former District Boundary
Land area (km^2)	2,903 km^2
Resident population (2014)	79,728
Composition of economy	Just over a third of the Inventory Area's 49,000 employees work in the public sector (including health, education, administration), and tourism is the principal private sector employer.

The following table identifies the number of employees in the Inventory Area in 2014, comparing this to the wider Highland Council area. Accommodation and food services relate largely to tourism, which is an important source of work and income in the area. The relatively small level of primary sector employment reflects the extensively managed upland areas that characterise much of the area (as well as the wider Highlands), and the exclusion of proprietors and the self-employed from the figures.

Table 4 – Employment by Industry, 2014, Inverness GHG Inventory Area and Highland

	Inverness		Highland
	Employees	%	%
Agriculture, forestry & fishing	200	0.4	1.4
Mining, quarrying & utilities	1,000	2.1	2.7
Manufacturing	2,100	4.2	6.6
Construction	2,400	4.9	6.1
Motor trades	1,600	3.3	2.1
Wholesale	1,500	3.0	2.7
Retail	5,600	11.5	10.5
Transport & storage (inc postal)	3,000	6.0	5.3
Accommodation & food services	4,100	8.3	10.9
Information & communication	1,300	2.7	2.0
Financial & insurance	600	1.2	0.9
Property	400	0.9	1.0
Professional, scientific & technical	2,500	5.1	5.4
Business administration & support services	3,300	6.8	5.6
Public administration & defence	2,600	5.2	5.8
Education	2,900	6.0	7.0
Health	12,200	24.9	19.3
Arts, entertainment, recreation & other services	1,700	3.5	4.6
Total	**48,900**		

Source: Business Register and Employment Survey 2014. Figures are rounded to the nearest 100

3.1 Data Availability

The collection and analysis of relevant data was critical in developing the Inverness GHG inventory. Our analysis involved use of both national and regional statistics, as well as the collation of primary data from key businesses. National and regional statistics were primarily sourced from publications and analysis produced by the UK Government's Department for Business, Energy and Industrial Strategy (BEIS). Electricity use was collected for specific meter points. Our analysis based on electricity consumption has a high degree of accuracy. Gas consumption is also recorded by specific meter points and cross-referenced with volumes of gas distributed by national and major transporters.

Road transport fuel estimates were modelled, with estimates based on data from a number of different information sources. As a result, the estimates are subject to potential modelling inaccuracies.

We have included more commentary about data availability, modelling etc, in the subsequent sections of this report, with a more detailed explanation of the process used to provide sectoral energy use in Appendix 1.

Chapter 4 – Sources of Emissions and Inventory Calculations

In addition to the GPC, the Inverness GHG Inventory has been informed by the process for emission calculations described in the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. The IPCC guidelines provide three levels of methodological complexity for the calculation of each emission source.

- Tier 1 is the basic calculation method, designed to use readily available national or international statistics in combination with the provided default emission factors.
- Tier 2 is an intermediate approach, applying more sophisticated emission calculations and emission factors.
- Tier 3 is the most demanding in terms of complexity and data requirements.

In general, Tier 1 emissions are estimated based on the activity data and the use of a default emission factor. Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period, for example the volume of gas or kWh or electricity consumed, kilometers driven, or tonnes of solid waste sent to landfill. Tier 2 emissions calculations require more detailed activity data and national/regional specific emissions factors. Tier 2 analysis has been used where possible. Calculating emissions according to Tier 3 requires even more detail and specific information on combustion technology, control technology, etc.

We have used Tier 1 to calculate the majority of GHG emissions for the Inventory Area, and Tier 2 methodology to calculate some Agriculture, Land Use and Waste GHG emissions. Emission factors are produced for the UK annually[19], and emission factors for 2014 have been used in our analysis.

4.1 Stationary Energy

Within the Inverness GHG Inventory area, Stationary Energy emissions arise from residential, commercial and industrial buildings and facilities, as well as onsite use of fossil fuels in plant and equipment, etc.

- Scope 1 emissions include all direct emissions from burning fuel (gas, LPG, heating oil etc).
- Scope 2 emissions include emissions associated with the consumption and generation of electricity which may be generated within or outside the Inventory boundary.
- Scope 3 emissions include distribution losses from grid-supplied electricity.

To inform analysis of Stationary Energy GHG emissions, data produced by the Department of Energy and Climate Change (subsequently renamed the Department for Business, Energy & Industrial Strategy) was used. Data are available for all UK Local Authorities as well as lower Layer Super Output Areas which correspond in Scotland to Data Zones.

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[19] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2014

To facilitate detailed analysis and reflecting guidance from the GPC, the Stationary Energy sector was divided into the following sub-sectors:

- Residential buildings
- Commercial buildings
- Institutional buildings and facilities
- Manufacturing industries
- Construction
- Energy industries/utilities
- Agriculture, forestry and fishing activities
- Non-specified sources

A small volume of emissions from the energy sector frequently arise as fugitive emissions, which typically occur during extraction, transformation, and transportation of primary fossil fuels. Small amounts of liquids and gases can be lost during this process. As there is limited fossil fuel extraction, transformation and transportation in the Inverness GHG Inventory area, it was excluded from our analysis.

The following fuels are consumed in properties in the Inverness GHG Inventory area and subsequently release emissions:

- Natural gas is used primarily in the settlement of Inverness. Gas is consumed mainly for heating in the domestic sector, influenced by external temperatures and weather conditions. It is distributed in Inverness by Scotia Gas Networks, delivering to around 23,105 domestic and 311 non-domestic gas meter points in the city. Gas consumption data was obtained from DECC for 2014.

- 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. Collecting information on consumption can be challenging[20]. Information has been obtained from DECC on fuel oil for domestic central heating in 2014.

- Coal is primarily used to provide space and water heating in domestic and commercial properties that do not have access to mains gas. Domestic and non-domestic coal consumption was obtained from DEFRA/DECC for the 2014 base year.

- Biomass is an increasingly used fuel in domestic, commercial and institutional properties such as healthcare, education etc. One large manufacturing facility in the Inventory Area uses biomass and their emissions have been included in this report. More comprehensive records of installations and output are now being produced by the Department for BEIS, which would facilitate a review in future years.

To avoid double counting of emissions already captured, only emissions associated with the generation of grid-supplied electricity imported into the Inverness GHG Inventory area are included in Scope 2. Consumption of grid supplied electricity was identified from the DECC sub national electricity consumption and number of customers for 2014.

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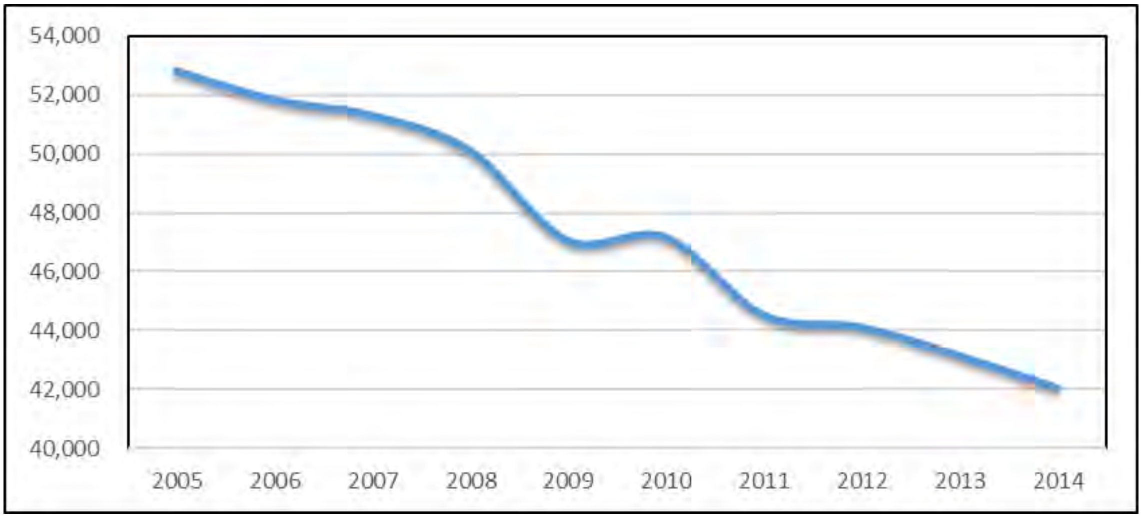
[20] Highland Council Heat Map - Final Report Highland Council, April 2011, Appendix 2

4.1.1 Residential Buildings

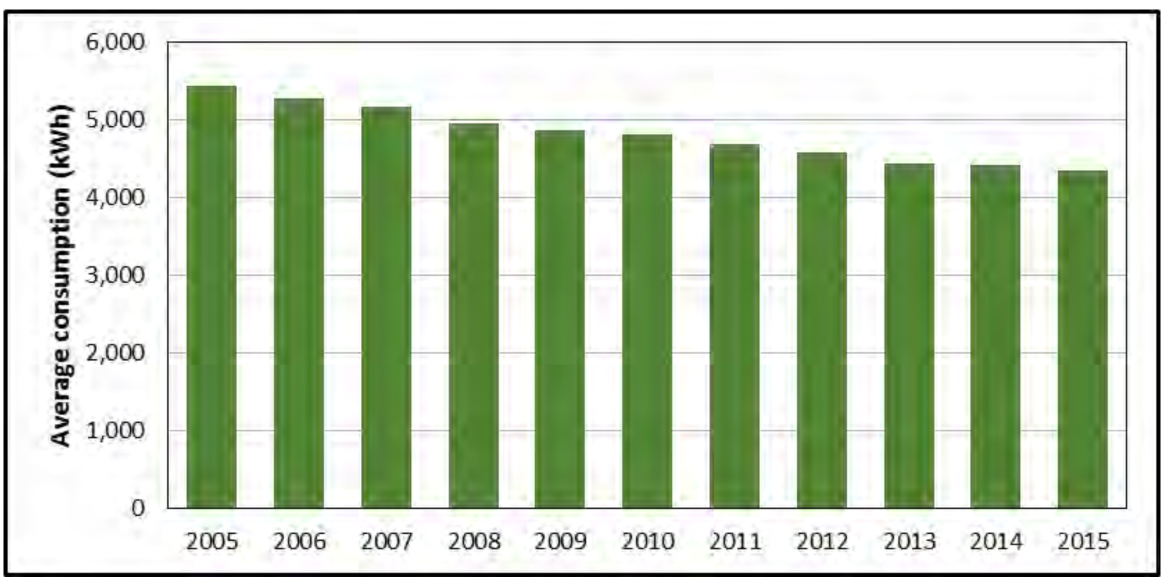
Greenhouse gas emissions from residential buildings have been consistently declining since 1990, accounting for 13% of total emissions in Scotland in 2014.

Figure 6 – Residential Energy Consumption (GWh), Scotland, 2005 - 2014[21]



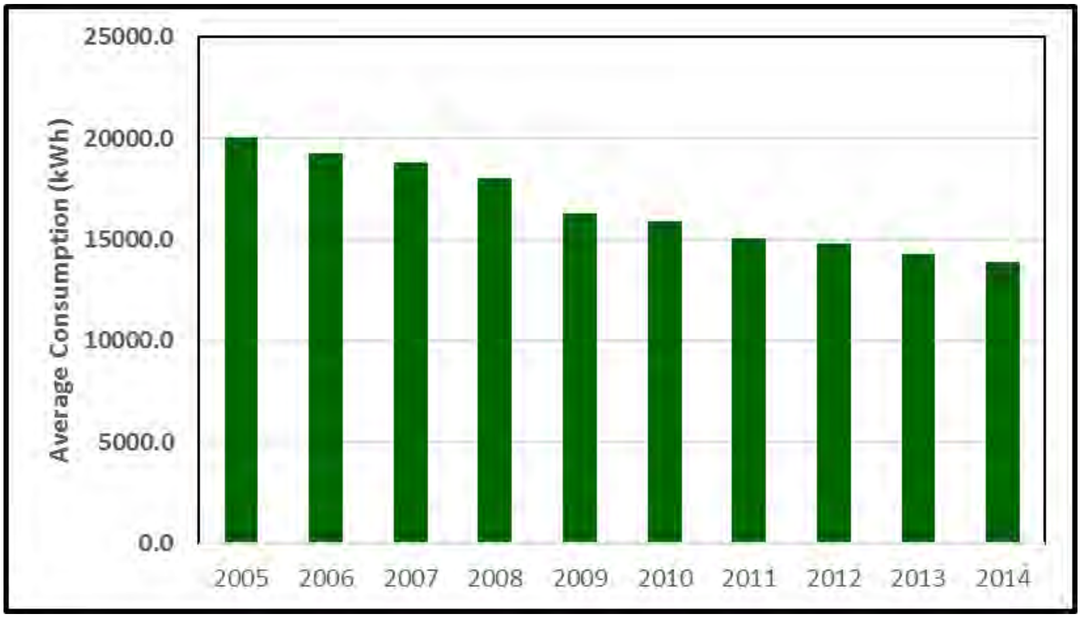
Two primary sources of energy are used in urban residential properties – electricity and mains supplied gas. The latter is primarily used for heating in residential properties. The former can provide heating as well as powering appliances etc.

Figure 7 – Average Residential Electricity Consumption in Scotland (kWh), per Household, 2005-2015[22]



[21] Energy in Scotland 2017 Scottish Government
[22] http://www.gov.scot/SESO/DatasetSearch.aspx?TID=197

Figure 8 – Average Domestic Gas Consumption per Consumer, Scotland, 2005 - 2014[20]



The Scottish Government has historically prioritised the reduction of energy use in the residential sector. The consultative Scottish Government Climate Change Plan published in January 2017 contained several commitments to continue supporting the reduction of residential energy use.

There is a mixture of energy consumption and subsequent GHG emission production in the Inventory Area. In the core city area, access to the gas grid provides cheap space and water heating. In properties outside the core city area, space and water heating can be provided by electric, coal, LPG and oil heating systems.

Table 5 – Households by Central Heating Type, 2011

	Inventory Area		Highland		Scotland
	Number	% of households	Number	% of households	% of households
All households	34,353		102,091		
No central heating	886	2.6	3,215	3.1	2.3
Gas central heating	20,010	58.2	35,247	34.5	74.2
Electric central heating	7,214	21.0	25,169	24.7	13.4
Oil central heating	3,958	11.5	25,193	24.7	5.7
Solid fuel central heating (wood and coal)	574	1.7	5,746	5.6	1.1
Other central heating	321	0.9	1,546	1.5	0.7
Two or more types of central heating	1,390	4.0	5,975	5.9	2.6

Source: 2011 Census of Population. Other central heating includes solar, liquefied petroleum gas (LPG) or other bottled gas.

As the gas network only distributes gas around the Inverness city, a low proportion of Inventory Area households have gas central heating compared to Scotland.

The following table identifies the domestic energy use and subsequent emissions for the Inventory area. Electricity and gas consumption figures have been derived from national statistics which are collected for each meter point. They are therefore reasonably robust for the Inventory area. Coal, heating oil and manufactured fuels have been allocated on a percentage of central heating type, informed by Highland Council area data.

Table 6 – Inverness GHG Inventory Area Residential Emissions

	Residential kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	185,802,393		91,043		91,043
Natural Gas	334,862,317	60,275			60,275
Heating Oil	96,052,170	23,053			23,053
Coal	11,850,970	4,029			4,029
Manufactured Fuels	4,640,370	1,624			1,624
T&D Losses				7,432	7,432
Total	633,208,220	88,981	91,043	7,432	187,456

Notes on Table 6 Methodology

Electricity – Figures for domestic electricity usage by LLSOA are published in the sub-national consumption database. There is no unallocated usage for Highland; and therefore the figure of 185,802,393 kWh is sourced directly from national statistics.

Natural Gas – Figures for domestic gas usage by LLSOA are published in the sub-national consumption database. Aggregating together the relevant LLSOAs in the study area provided a total of 334,120,143 kWh. Where it is not possible to allocate consumption to a specific meter, for example where an incorrect postcode has been allocated to a meter, this is recorded as unallocated and included in the wider Local Authority figures. There is a total unallocated figure for Highland of 888,831 kWh, of which 83.5% were allocated to the study area (the proportion of the gas pipelines in Highland which are in the study area). This gives a total figure of 334,862,317 kWh of gas consumption in the study area in 2014.

Heating Oil – Domestic petroleum use in Highland in 2014 was 52,567 tonnes of oil equivalent. From the Census figures in Table 5, 15.7% of oil central heated households in Highland were in the Inventory Area. Applying this ratio to the total Highland figure and without correcting for regional weather characteristics we can apply to overall domestic petroleum use in Highland to arrive at a total of 8,259 tonnes of oil equivalent in the study area (96,052,170 kWh).

Coal – Domestic coal use in Highland in 2014 was 10,198 tonnes of oil equivalent. From the Census figures in Table 5, 10.0% of solid fuel central heated households in Highland were in the Inventory Area. Although solid fuel central heating includes both wood and coal, we can assume that a similar ratio applies to coal only. Therefore, domestic coal use in the Inventory area can be estimated at 1,019 tonnes of oil equivalent (11,850, 970 kWh).

Manufactured Fuels (such as barbecue fuel, coal briquettes and firelighters) – Relatively insignificant, Highland figures (1,166 tonnes of oil equivalent) were allocated to the Inventory area by proportion of population, resulting in 399 tonnes of oil equivalent (4,640,370 kWh) being allocated to the Inventory area.

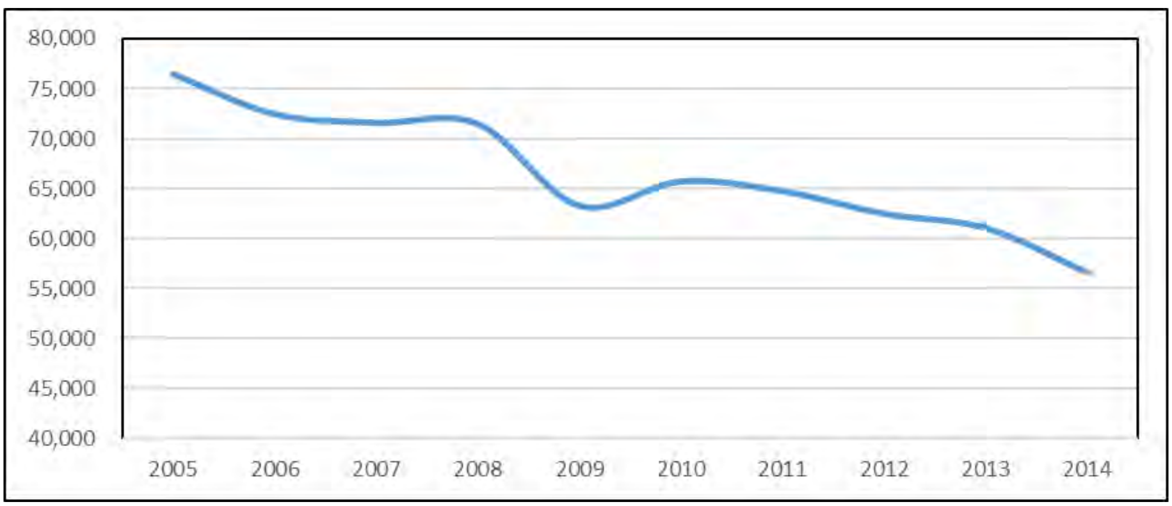
T&D Losses – Transmission and distribution (T&D) factors are used to report the Scope 3 emissions associated with grid losses (the energy loss that occurs in getting the electricity from a power plant to the consumer). It is derived by multiplying the purchased units of electricity by the appropriate TAD emission factor for that specific year.

Repeating this work in the future will identify a contribution from renewable energy, biomass, solar thermal water heating and solar PV produced electricity. It was not possible to collect detailed data on these installations for 2014, although we identified 321 households with solar central heating or bottled gas in 2011 (see Table 5). More comprehensive recording of onsite renewable energy systems is now in place nationally which will facilitate more accurate analysis in future work.

4.1.2 Commercial Buildings

Commercial building energy consumption has also declined in recent years. Whilst the energy efficiency of equipment in commercial buildings has improved, there are also several structural issues which have helped to reduce commercial building energy use. For example, greater levels of renewable energy (especially heat) are being used in off gas grid properties. In addition, there is an impact of restructuring economic activity where buildings are now used to deliver more service related activity. There is also a weather-related impact, with milder winter temperatures reducing the amount of energy required for heating.

Figure 9 Industry and Commercial building energy consumption (GWh), Scotland, 2005 – 2014[23]



There is a mixture of commercial buildings within the Inventory Area; including retail outlets, shopping complexes; office buildings; and institutional buildings, such as schools, hospitals, police stations and regional Government administration offices.

[23] Energy in Scotland 2017 Scottish Government

Detailed commercial sector energy use is not available for the Inventory Area. To provide this level of detail, energy intensity per employee for the UK ratios were identified and then applied to sectors in the Inventory Area in Table 7 below. This facilitated the modelled energy use profile for different sectors in the Inventory Area. More details of this process are contained in Appendix 1.

Table 7 – Inverness GHG Inventory Area Commercial Building Emissions

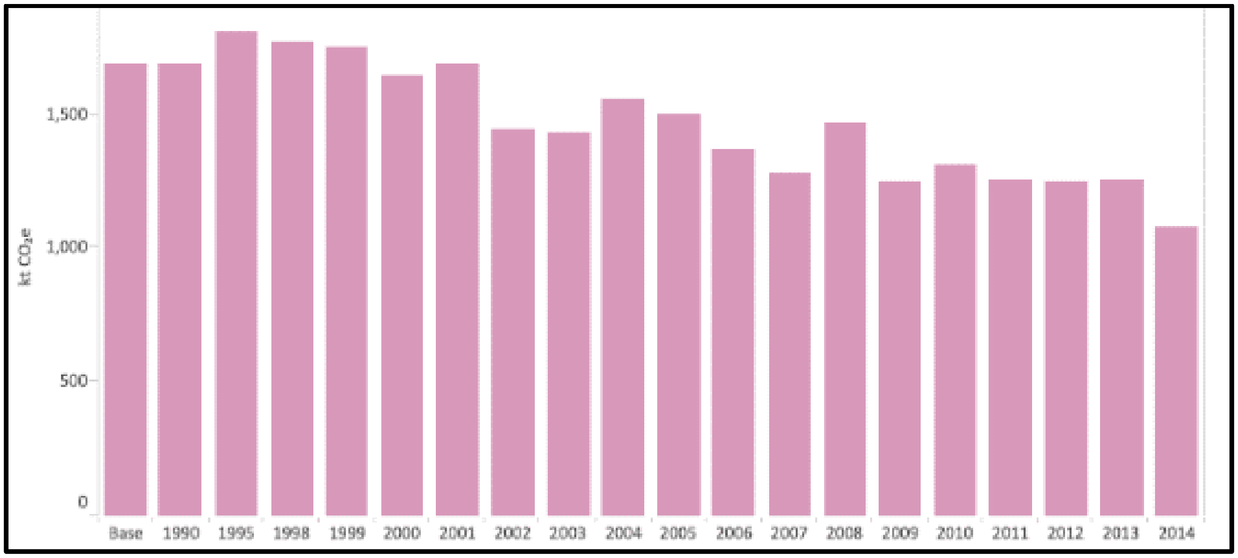
	Tonnes Oil Equivalent	Commercial Building kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	13,498	156,981,740		76,921		76,921
Natural gas	7,689	89,423,070	28,615			28,615
Petroleum	1,346	15,653,980	3,913			3,913
Coal	13	151,190	48			48
T&D Losses					6,279	6,279
Total	22,546	262,209,980	32,577	76,921	6,279	115,778

Note: Non-domestic fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Section 3.1 for more detailed analysis of non-domestic emissions. The distribution of national employment by sector facilitated more detailed sub-sectoral emissions analysis.

Institutional Buildings and Facilities

Several public-sector organisations have major regional administration offices in the Inventory area. Highland Council have several offices as well as service and waste collection facilities in Inverness, and the region’s main hospital is also located in the city at Raigmore. There are several local medical practices, and there is a significant healthcare research and teaching facility located next to the main hospital. The newly established Inverness Campus area accommodates new buildings for Inverness College, HIE and others, and the site has 14.5 hectares for 17 fully serviced development plots with planning permission granted for 55,000m^2 of development.

Figure 10 – Total Greenhouse Gas Emissions from the Scottish Public Sector, 1990 – 2014[24]



The following table identifies the emissions arising from public sector and institutional buildings and facilities in the Inventory Area. There has been sustained activity over the last decade, throughout the public sector, to measure, manage and reduce greenhouse gas emissions. Carbon Management Plans (CMPs) had been produced and identified how to reduce operational emissions. These CMPs introduced carbon measurement and management and absolute emission reduction targets. This helped organisations such as the Highland Council to reduce total emissions from 66,579 tCO_2e in 2011/12 to 63,843 tCO_2e in 2014/15. These previous figures are for the whole Highland Council estate while the following figures have been estimated for the Inventory area.

[24] Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2014 Department of Energy and Climate Change, The Scottish Government, The Welsh Government, The Northern Ireland Department for Agriculture, Environment and Rural Affairs

Table 8 – Inverness GHG Inventory Area Institutional Buildings and Facilities Emissions

	Tonnes Oil Equivalent	Institutional Buildings and Facilities kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	5,019	58,370,970		28,602		28,602
Natural Gas	7,315	85,073,450	15,313			15,313
Petroleum	769	8,943,470	2,236			2,236
Coal	38	441,940	141			141
T&D Losses					2,335	2,335
Total	13,141	152,829,830	17,691	28,602	2,335	48,627

Note: Non-domestic fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Appendix 1 for a detailed methodology. It has not been possible to identify the source of c800 TOE of heat being sold from the Institutional Sector and this was excluded from this Inventory.

The Climate Change (Scotland) Act 2009 places duties on public bodies relating to climate change. In 2015, the Scottish Government introduced an Order requiring all 150 Public Bodies who appear on the "Major Player" list to report their GHG emissions annually. Reports and analysis are publicly available, increasing accountability and transparency.

The first mandatory "Major Player" reports were submitted on 30 November 2016, although many of the relevant "Major Players" have an estate that extends beyond the current Inverness GHG Inventory Area. This reporting now creates the opportunity to identify specific "Institutional" emissions and the programmes and initiatives being undertaken to reduce them.

Table 9 – Inverness GHG Inventory Area Major Player Emissions

Organisation	Year	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Highland Council	Financial 2014/15	20,847	38,722	4,274	63,843
NHS Highland	Financial 2014/15	3,287	14,463	1,626	19,377
Highlands & Islands Enterprise	Financial 2014/15	112	585	287	984
University of the Highlands and Islands	Academic Aug-July	48	135	214	397
Highlands & Islands Transport Partnership	Financial 2014/15		5	11	16

Buildings occupied by Scottish Natural Heritage and the Forestry Commission/Forest Enterprise are excluded above.

Highland Council, the largest institutional producer of GHG emissions in the Highland area, undertakes a rolling programme of internal activity to reduce these emissions and is also evolving its service delivery to nurture and develop lower emission activity. An example is Highland HERO (Heat Energy & Renewable Opportunities). This project is identifying how more renewable heat can be supplied to and consumed in the area. Core themes are:

- Affordability
- Economic development
- Sustainability
- Energy security

The two primary outputs from this work are:

1. HERO Map – an interactive GIS based map of the Highland energy landscape
2. HERO Strategy – a long-term energy strategy for Highland Council

The Highland Council will use these outputs to help inform the direction for heat network and energy projects at a local level over the longer term. The built environment will be at the core of this approach, focussing on:

- Energy efficiency
- Heat, including district (community and communal heating) and individual and bespoke heating solutions
- Renewable energy
- Energy storage

To underpin the HERO work, the Council is completing a rolling programme of technical, social and community appraisals. This will stimulate ideas and discussion among stakeholders and attract HERO project investment proposals and accelerate project delivery in the Highland area. Different locations favour particular renewable energy uses and this is largely dependent upon geographical, meteorological and demographical factors. Using the HERO approach, Highland Council will assess their local environment to identify options to generate renewable power.

By accelerating the momentum of successful energy project implementation, Highland Council will continue to lead by example by delivering and supporting robust and locally engaged energy and sustainability solutions for the region.

Table 10 – Specific Examples of Anticipated Highland HERO Actions

Title	Purpose
Socio-economic modelling development	Enable fully informed local and community project benefit analysis
Renewable Energy Potential – Solar PV – Hydro – Wind	Predict potential and identify opportunities at an early stage
Energy from Water Scoping Exercise	Identify opportunities at an early stage for water sources (i.e. sea lochs, coastal and sea inlets, canals and waterways)
Energy from Waste Products	Explore alternative waste management options
Electrification Options	Appraise options for best use of electricity at local level
Hydrogen	Prepare for potential early adoption in the longer term
District/Community Heating	Identify viable schemes
Energy Storage	Exploit opportunities to incorporate storage systems into heat and power solutions
Scotland's Energy Efficiency Programme (SEEP)	Maximise opportunities for combining Highland energy projects with national programmes (including funding streams)

4.1.3 Manufacturing Industries

Scotland's industrial sector accounts for over half the country's exports and total business research and development expenditure, sustaining a significant number of high-value jobs. Reducing the use of energy in manufacturing is critical to helping achieve the country's climate change targets. As a result, "Energy Efficiency and Decarbonisation" is a key priority in Scotland's Manufacturing Action Plan.[25]

[25] A Manufacturing Future for Scotland, https://www.scottish-enterprise.com/knowledge-hub/articles/insight/scotlands-manufacturing-action-plan

Table 11 – Inverness GHG Inventory Area Manufacturing Industries

	Tonnes Oil Equivalent	Manufacturing kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	9,179	106,751,770		52,308		52,308
Petroleum	9,285	107,984,550	26,996			26,996
Natural gas	6,618	76,967,340	13,854			13,854
Coal	2,619	30,458,970	9,747			9,747
Manufactured fuel	2,176	25,306,880	8,857			8,857
Gas oil	445	5,175,350	1,397			1,397
Fuel oil	224	2,605,120	677			677
Burning oil	23	267,490	64			64
LPG	3	34,890	7			7
T&D Losses					4,270	4,270
Total	**30,572**	**355,552,360**	**61,601**	**52,308**	**4,270**	**118,179**

Note: Manufacturing Industry fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Appendix 1 for a detailed methodology.

*For more detail see Section 4.3.

4.1.4 Construction

In 2014, there were a range of construction projects underway in the Inventory Area, including the Inverness Royal Academy, Inverness College relocation and other Inverness Campus developments, and River Ness Flood Protection Scheme. Nearly £70m was spent on these projects in 2014.

Construction emissions arise from site preparation, construction installation, building completion, and the operation of construction equipment.

Table 12 – Inverness GHG Inventory Area Construction

Construction	Tonnes Oil Equivalent	Construction kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	315	3,663,450		1,795		1,795
Natural gas	702	8,164,260	1,470			1,470
Gas oil	309	3,593,670	970			970
Coal	10	116,300	37			37
Fuel oil	11	127,930	33			33
T&D Losses	-				147	147
Total	**1,347**	**15,665,610**	**2,510**	**1,795**	**147**	**4,452**

Note: Construction sector fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Appendix 1 for a detailed methodology.

4.1.5 Energy Industries and Utilities

Energy industries include three basic types of activities:

- Primary fuel production (e.g., coal mining, and oil and gas extraction).

- Fuel processing and conversion (e.g., crude oil to petroleum products in refineries, coal to coke and coke oven gas in coke ovens).

- Energy production supplied to a grid (e.g., electricity generation and district heating) or used on-site for auxiliary energy use.

There are an increasing number of renewable energy generation facilities in the Inverness GHG Inventory area. Large hydro schemes established in the 1950s and 1960s are now complemented with new pumped hydro and wind generated electricity. A desk review of these developments identified that on-site electricity consumption, where occurring, was not a significant source of emissions.

A large landfill site was operated on the outskirts of Inverness until 2003. Following its closure and capping, over 2 million m^3 of methane was flared from the site; $284.3m^3$ per hour, running for approx. 8,400 hours in 2014.

In early 2017, a 50kW turbine was installed to produce energy from burning the methane. A main by-product of this flaring is the production of CO_2 which has a lower global warming impact. The methane emissions for 2014 are included in the waste section of this report. Where waste is used to generate energy, emissions are counted as Stationary Energy sources. This includes energy recovered from landfill gas or waste combustion.

It was possible to identify a Utilities allocation within the Inverness Inventory emissions. Employment within this sub sector includes energy as well as water. The following table identifies emissions in this sector:

Table 13 – Inverness GHG Inventory Area Utilities

Utilities	Tonnes Oil Equivalent	Utilities kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	1,743	20,271,090		9,933		9,933
Natural gas	78	907,140	163			163
Gas oil	36	418,680	113			113
T&D Losses					811	811
Total	**1,857**	**21,596,910**	**276**	**9,933**	**811**	**11,020**

Note: Utilities sector fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Appendix 1 for a detailed methodology.

4.1.6 Agriculture, Forestry and Fishing Activities

This sub-sector covers emissions from direct fuel combustion in primary sector activities, including plant and animal cultivation, afforestation and reforestation activities, and fishery activities. These emissions are typically from the operation of farm machinery, generators to power lights, pumps, heaters, coolers, boat engines etc.

Table 14 – Inverness GHG Inventory Area Agriculture, Forestry and Fishing

Agriculture, Forestry and Fishing	Tonnes Oil Equivalent	Agriculture, Forestry and Fishing kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Petroleum	2,841	33,040,830	8,260			8,260
Electricity	364	4,233,320		2,074		2,074
Natural gas	61	709,430	128			128
T&D Losses					169	169
Total	**3,266**	**37,983,580**	**8,388**	**2,074**	**169**	**10,632**

Note: Agriculture, Forestry and Fishing sector fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Appendix 1 for a detailed methodology.

4.1.7 Non-specified Sources - Miscellaneous

This subcategory includes all remaining emissions from Stationary Energy sources that are not specified elsewhere.

Table 15 – Inverness GHG Inventory Area Miscellaneous Emissions; Mining and Quarrying

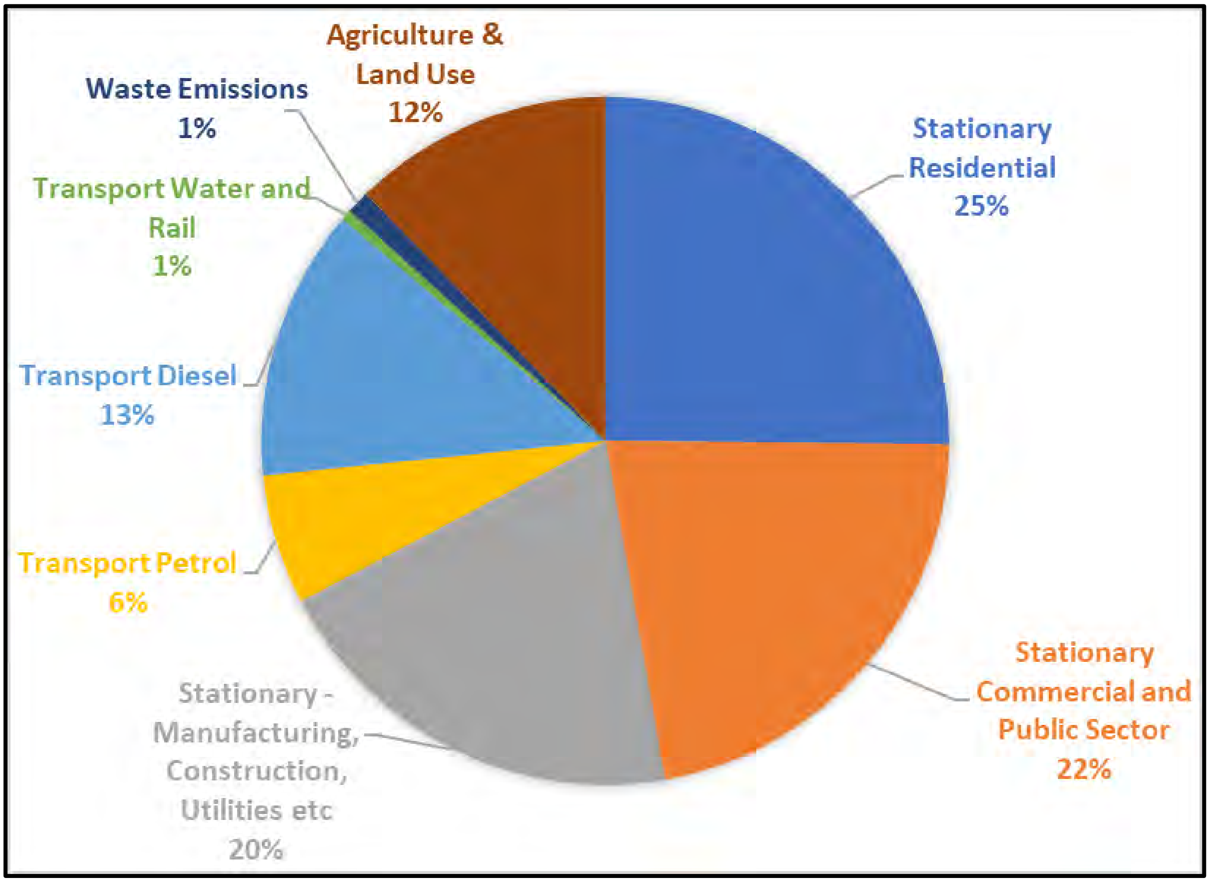
Miscellaneous, Mining and Quarrying	Tonnes Oil Equivalent	Miscellaneous kWh	Scope 1 TCO_2e	Scope 2 TCO_2e	Scope 3 TCO_2e	Total TCO_2e
Electricity	637	7,408,310		3,630		3,630
Petroleum	470	5,466,100	1,367			1,367
T&D Losses					296	296
Total	**1,107**	**12,874,410**	**1,367**	**3,630**	**296**	**5,293**

Note: Mining and Quarrying sector fuel and electricity consumption data for 2014 were obtained from DECC and disaggregated – see Appendix 1 for a detailed methodology. This analysis has not been able to review in detail the 57 TOE of heat sold from this sector.

4.1.8 Summary

The following chart illustrates the distribution of Stationary GHG Emissions across the key subsectors in 2014. Total Stationary emissions were 501,437 tCO_2e. Residential activity was responsible for 25% of all stationary emissions. Emissions from commercial and institutional properties accounted for 22% of the overall sector's emissions. Manufacturing was responsible for 20% of emissions.

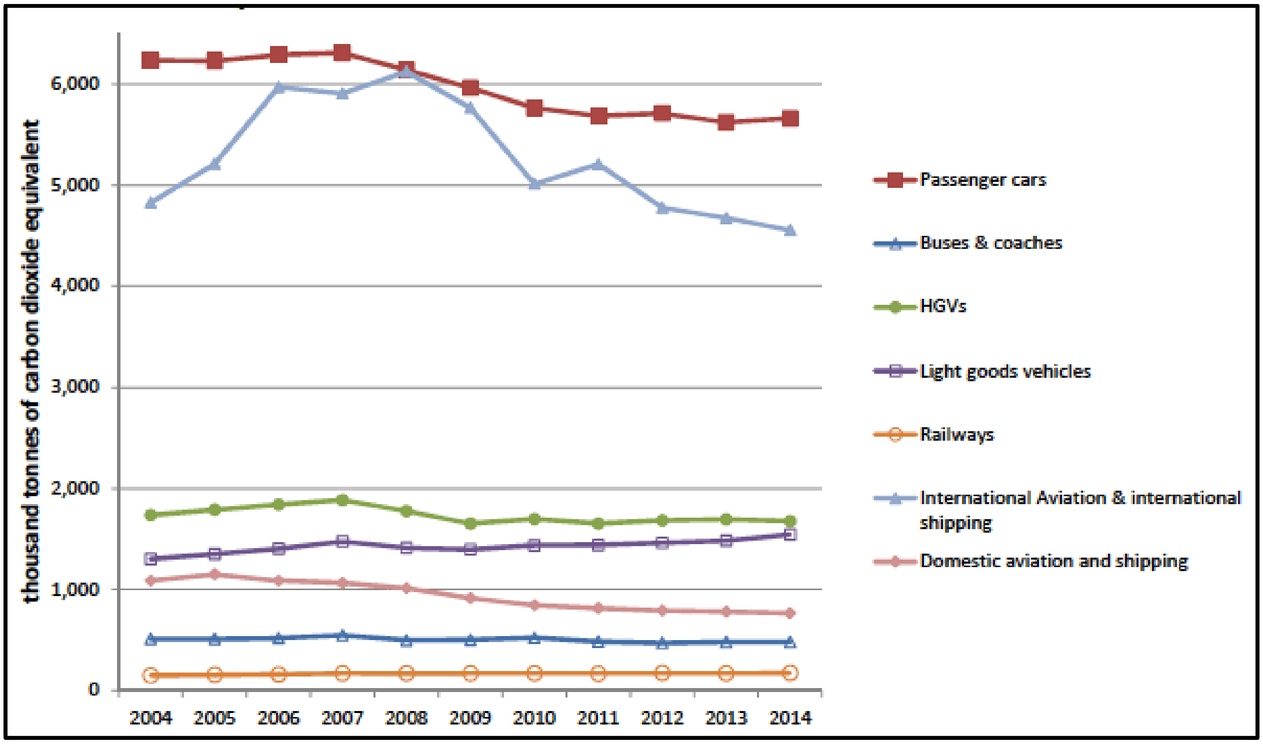
Figure 11 – Distribution of Inverness Inventory Area Stationary GHG Emissions 2014



4.2 Transport

Transport vehicles and mobile equipment produce GHG emissions directly by combusting fuel or indirectly by consuming grid-delivered electricity. Transport emissions accounted for 28% of Scotland's total GHG emissions in 2014, with passenger cars the biggest source of transport emissions. Air travel, especially domestic flights, tends to be the highest source of emission per kilometre travelled. Coaches and rail have the lowest source of emissions per kilometre travelled per person/passenger.

Figure 12 – Greenhouse Gas Emissions Attributed to Scotland by Mode of Transport[26]



The GPC defines emissions from road transport as all emissions associated with 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.

A key challenge for estimating transport related GHG emissions for the Inverness GHG Inventory relates to the issue of cross-boundary travel. The GPC divides transport emissions into in-boundary trips (Scope 1) and cross-boundary trips (Scope 3).

Scope 1 – Scope 1 includes all GHG emissions from the transport of people and freight occurring within the Inventory boundary.

Scope 2 – Scope 2 includes all GHG emissions from the generation of grid-supplied electricity used for electric-powered vehicles.

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[26] Scottish Transport Statistics No 35: 2016 Edition

Scope 3 – Scope 3 comprises emissions from the portion of transboundary journeys occurring outside the Inventory boundary, and transmission and distribution losses from grid-supplied energy for electric vehicle use. This includes the out-of-Inventory portion of all transboundary GHG emissions from trips that either originate or terminate within the Inventory boundary.

To facilitate detailed analysis and reflecting guidance from the GPC, the Transport Sector was divided into five sub-sectors:

- On-road transportation
- Railways
- Water transport
- Aviation
- Off-road transportation

4.2.1 On-road Transportation

Nationally available BEIS published fuel consumption data for local authority areas was used to calculate road transport emissions. Local Inventory Area emissions were derived by local road use counts (for locations see Appendix 2, Map 4).

The following text summarises the approach used to calculate road transport emissions.

Critique of Data Sources and Allocation to Highland

<u>Sub-National Road Transport Consumption Data</u>

Fuel consumption by road vehicles is calculated by the methodology used to estimate total UK emissions for road transport in the National Atmospheric Emissions Inventory (NAEI) and Greenhouse Gas Inventory (GHGI), and is consistent with internationally agreed procedures and guidelines for reporting emission inventories.

The methodology for calculating fuel consumption combines traffic activity data (from Department for Transport's national traffic census) with fleet composition data and fuel consumption/emission factors.

The base map of the UK road network is derived from the Ordnance Survey Meridian 2 dataset, which provides locations of all roads in Great Britain. The base maps and traffic flow census count data were combined in order to map vehicle movements, and fuel consumption factors were then applied to map overall fuel consumption, as well as consumption in regions and local authority areas.

The estimates are therefore based on where the fuel was consumed rather than where it was purchased. Road fuel purchased abroad and consumed in the UK is included whereas road fuel purchased in the UK and consumed abroad is excluded.

This dataset covers road transport consumption of petrol and diesel only – Biofuels, LPG and electric cars are excluded.

The DUKES and ECUK figures derive fuel consumption based on fuel sales. The difference between sub-national and DUKES and ECUK figures varies year by year but the difference is considered well within the uncertainty of the factors used to derive the fuel consumption from traffic activity. The DUKES and ECUK fuel consumption figures are not available below the UK level.

For more information see:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/609332/Sub-national_Methology_and_Guidance_Booklet_2016.pdf

Traffic Counts

The frequency and accuracy of counts is another consideration for the robustness of this data. In the Inventory area, traffic on three of the A Roads was counted (manually or automatically), and 23 were estimated from previous years or nearby links. For B and Minor Roads, the three counts were taken manually, although, as discussed later in this Section, more count points are needed. In the Highland area, 13 A Roads were counted in 2014 (10 automatically and three manually) and 192 were estimated from nearby links or by estimating from previous years' counts, although all 16 of the B and Minor roads were manually counted.

The following table contains a detailed disaggregation of road use for the Highland Council area. This was sourced from BEIS produced figures for road transport energy consumption at local authority level.

Table 16 – Consumption of Fuel on Roads in Highland, TOE, 2014

Mode		Highland (TOE)
Buses	A roads	7,265
	Minor roads	2,541
	Total consumption	**9,806**
Diesel Cars	A roads	36,303
	Minor roads	10,457
	Total consumption	**46,760**
Petrol Cars	A roads	42,461
	Minor roads	11,791
	Total consumption	**54,251**
Motorcycles	A roads	1,124
	Minor roads	165
	Total consumption	**1,289**
HGV	A roads	34,285
	Minor roads	3,135
	Total consumption	**37,421**
Diesel LGV	A roads	22,723
	Minor roads	6,685
	Total consumption	**29,407**
Petrol LGV	A roads	952
	Minor roads	301
	Total consumption	**1,253**
Personal		**112,107**
Freight		**68,081**
Total		**180,188**

Source: BEIS Road Transport energy consumption at regional and local authority level, 2014

Notes: There are no motorways in the Highland area.

Petrol cars, motorcycles and petrol LGV are petrol consuming vehicles, while buses, diesel cars, HGV and diesel LGV are diesel consuming vehicles.

These figures were allocated to the Inventory Area using traffic counts. For A roads, there were 26 traffic counts in the Inventory Area in 2014, and 205 in Highland overall[27] For B and minor roads, there were only three traffic counts in the Inventory Area in 2014 and 16 in Highland overall. Traffic counts in the Inventory Area were compared to traffic counts for the whole Highland Council area to establish an "increased usage ratio," identified in more detail below.

[27] https://www.dft.gov.uk/traffic-counts/area.php?region=Scotland&la=Highland

Increased Usage Ratio

Traffic count figures identified that roads in the Inventory Area have higher traffic counts than in Highland overall. This is linked to the higher population density in the Inventory Area. For example, there were an average 7,054 cars per day per A Road counting point in the Inventory Area, which compares with an average of 2,584 cars per day in the wider Highland Council area. Daily vehicle flow on the Inventory Area A roads was more than twice the flow (increased usage ratio of 2.2) on roads in the wider Highland Council area. For B and minor roads, this higher use was even greater.

	Highland (Average Annual Daily Flow)	Inventory Area (Average Annual Daily Flow)	Increased usage factor - A Roads
Motorcycles	54	103	1.9
Cars/Taxis	3,151	7,054	2.2
Buses/Coaches	56	99	1.7
Light Goods Vehicles	655	1,415	2.2
All HGVs	271	481	1.8
All Motor Vehicles	**4,183**	**9,150**	**2.2**
			B & Minor Roads
Motorcycles	22	65	2.1
Cars/Taxis	1,854	7,893	2.9
Buses/Coaches	36	139	2.6
Light Goods Vehicles	320	1,139	2.4
All HGVs	48	141	2.0
All Motor Vehicles	**2,280**	**9,377**	**2.8**

Incorporating these increased road use figures has facilitated a more realistic assessment of traffic in the Inventory Area.

Table 17 – Proportion of the Highland Road Network and Proportion of the Highland Total Traffic in the Inventory Area

	% of Highland Road Network in the Inventory Area	% of the Highland Total Traffic in the Inventory Area
Cars		
A roads	10	22.4
Minor roads	17	50.0
Motorcycles		
A roads	10	18.9
Minor roads	17	36.5
Buses		
A roads	10	17.5
Minor roads	17	43.8
LGV		
A roads	10	21.6
Minor roads	17	41.4
HGV		
A roads	10	17.8
Minor roads	17	48.2

Analysis identified that the proportion of Highland Council area traffic in the Inventory Area is greater than the Inventory Area's share of the road network. This reflects both the status of the Inventory Area as the capital of the Highlands and its higher population density.

The population density of the Inventory Area was 27.5 people per km^2 in 2014, although this increases to 165.5 people per km^2 if the five largest datazones are excluded (with a total population of 5,000). This is significantly higher than the population density in Highland overall (9.1 people per km^2) and leads to greater congestion on the roads. Fuel consumption tends to increase when vehicles are idling or in slow moving traffic, although there is increasing use of stop start systems in cars to reduce emissions when engines are idling. There are also road characteristics in the wider Highland Council area, including frequent stopping for passing places, number of significant gradients etc, that challenge road internal combustion engine fuel efficiency. It would be very difficult to try to assess the GHG emission releases that arise from these different road and driving conditions, and they have therefore been excluded from this work, which is based purely on allocation by traffic count data.

Applying the proportion of Highland traffic in the Inventory Area in Table 17 to the fuel consumption in Highland in Table 16 identified the following fuel use by category.

Table 18 – Proportion of Traffic and Tonnes of Oil Equivalent in Highland and the Inventory Area

	% of the Highland Total Traffic in the Inventory Area	Highland TOE	Inventory Area TOE
Cars			
A roads	22.4	78,764	17,633
Minor roads	50.0	22,248	11,132
Motorcycles			
A roads	18.9	1,124	213
Minor roads	36.5	165	60
Buses			
A roads	17.5	7,265	1,269
Minor roads	43.8	2,541	1,114
LGV			
A roads	21.6	23,675	5,111
Minor roads	41.4	6,986	2,895
HGV			
A roads	17.8	34,285	6,091
Minor roads	48.2	3,135	1,512
Total		**180,188**	**47,032**

Overall, an estimated 26% of the total fuel consumed on roads in Highland was consumed in the Inventory Area.

Table 19 shows the split by petrol/diesel, with cars and LGV split by the same proportion as the overall fuel consumption in Highland.

Table 19 – Fuel Consumption in Inventory Area, by Vehicle and Fuel Type

	Petrol tCO_2e	Diesel tCO_2e	Total tCO_2e
Cars	43,846	40,871	84,717
Motorcycles	775	0	775
Buses	0	7,314	7,314
LGV	928	23,572	24,500
HGV	0	23,336	23,336
Total	**45,549**	**95,093**	**140,642**
Out of Scope	**1,498**	**2,301**	

Critique of Method and Suggested Improvements for Future Studies

A challenge when using this methodology is the allocation of Highland data (deemed to be relatively robust) to the study area through traffic counts, especially due to the small number of traffic counts for the B and minor roads. Obtaining good coverage of traffic counts on a variety of representative points in the study area would improve the robustness of the figures. Alternatively, approaching the creators of the Sub-National Road Transport Consumption Data with a custom geography to derive results directly from their model would be another avenue to explore.

An adjustment could be made for increased emissions due to congestion in the Inventory area, which may be more than in the wider Highland area due to a higher population density and visitor numbers. However as previously highlighted, advances with stop start systems will reduce emissions during congestion. Analysis also has to consider the more challenging and less fuel efficient journey characteristics of travelling on many rural roads.

For the increased usage factor, an average of annual average daily flow figures was used. Taking an average of averages is not ideal, but as this is only approach to derive the increased usage factor, it is deemed acceptable.

Drawing on the DUKES data to examine fuel sales in the area would be an alternative method. However data are currently only produced at the UK level, so additional work would be required to provide this data for a smaller area.

The approach outlined in the previous critique identified petrol and diesel use to be 16,000 TOE and 30,982 TOE respectively by vehicles travelling on roads in the Inventory area in 2014. The Scope 1 emissions that arise from the consumption of these fuels are calculated to equate to 45,539 tCO_2e for petrol and 95,000 tCO_2e for diesel.

Scope 2 emissions arise from the provision of electricity for charging electric vehicles. In 2014, there were just over 15,000 new electric vehicle registrations in the UK, up from just under 4,000 the previous year. The Inverness Inventory area has 0.12% of the UK population. Using this ratio to allocate a share of electric vehicle registrations would result in 23 vehicles being registered and used in the Inverness Inventory area. Scope 2 emissions would therefore be minimal and are also likely to have been picked up in domestic and non-domestic electricity use – i.e. they would be double counted if they were included here. Total registrations have increased substantially since 2014, however, and therefore will be worth considering in the future. Transport related Scope 2 emissions will also arise in future Inventories following the introduction of five electric buses to the Inverness City bus fleet in 2015.

The data provided through road counters is not sufficient to allocate road transport emissions to Scope 3 emission sources. All road transport emissions are therefore allocated to Scope 1.

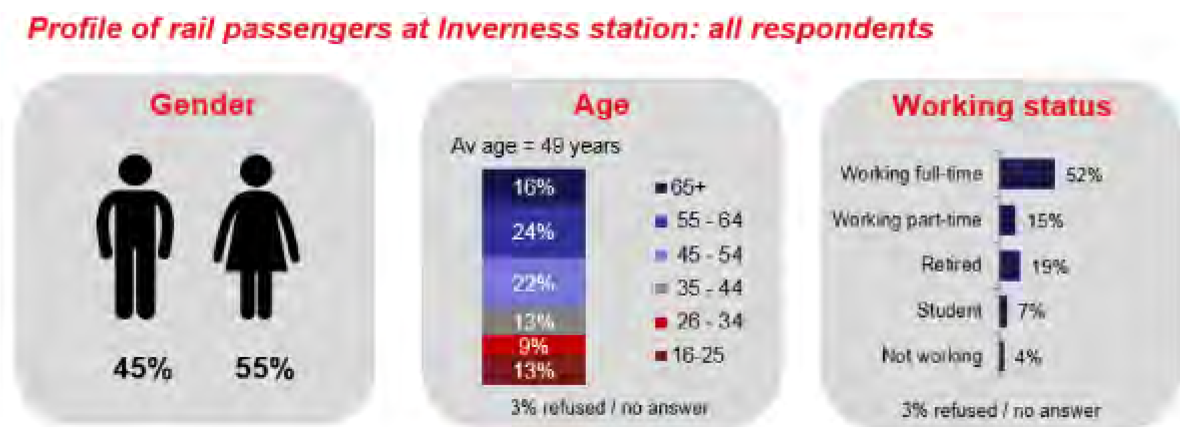
4.2.2 Railways

The rail network is an important aspect of Highland transport infrastructure, and the number of passengers travelling through all Highland railway stations increased from 3.0 million in 2007/08 to 3.6 million station entries and exits in 2014/15, representing a growth of 21%. This compares to 19% growth through all UK stations over the same period. Passenger growth at the Inverness city railway station was 25% over this period.

This station provides links to the north and west of the wider Highland region, with 75.9 km of railway line in the Inventory area, just over 11% of the Highland network. Beauly is the only other rail station within the Inventory Area (though with a station planned at Inverness Airport).

Work commissioned by HITRANS (the area's local Transport Authority) in 2015[28] identified that the average age of passengers travelling through Inverness station was 49 years. Over two thirds were employed (full or part-time) with 18% being retired. Almost two thirds of station users were travelling for leisure purposes, although a core of 17% were using the station for commuting. Almost a third of passengers were using the station on a regular basis, although a greater proportion were infrequent passengers, with almost a quarter using Inverness station for the first time.

Figure 14 – Profile of Rail Passengers at Inverness[29]



[28] Inverness station passenger experience, December 2015 HITRANS
[29] Inverness station passenger experience, December 2015 HITRANS

Data Sources

Figures for petroleum use in rail by local authority are published in the Residual Fuel Consumption dataset by BEIS.

UK total rail emissions are compiled for three journey types: freight, intercity and regional. The emissions were spatially disaggregated using data from the Department for Transport's Rail Emissions Model (REM), which provided emission estimates for each strategic route in Great Britain for passenger and freight trains. The most recent year in REM was 2009/10, and therefore the emissions for each strategic route have had to be scaled appropriately, as described in the national inventory reports (e.g. Wakeling et al, 2016), using trends from national statistics on fuel consumption by rail operators. These were then distributed across Great Britain with the use of GIS data provided by Network Rail

All rail power units are fuelled by diesel, and in 2014, 3,230 tonnes of oil equivalent (TOE) was used by these trains in the Highland area.

In order to allocate this to the study area, a detailed analysis of the rail network and train frequency was conducted using Network Rail's Working Timetable (WTT). The WTT shows all movements on the rail network including freight trains, empty trains and those coming in and out of depots. The analysis found that, per week, passenger trains travelled 13,673km in the Inventory Area and 50,711km in the rest of Highland. Therefore, trains in the Inventory Area travelled 21.2% of the total distance travelled in Highland.

Allocating 21.2% of the total Highland emissions to the Inventory Area provides 685 TOE. An emissions uplift of 20% has also been applied on the Inverness – Perth and Inverness – Aberdeen lines as more carriages are added due to the increase in passengers and freight between the different locations. This results in an estimated 28.5% of all rail traffic in Highland in the Inventory Area, equating to 922 TOE scope 1 emissions.

As there is no electrification of the railway network in Inverness or the wider Highlands, Scope 2 emissions will be the result of electricity use in Inverness Station (which is already accounted for in Stationary Energy).

Rail Scope 3 emissions can be calculated by identifying the number of city residents disembarking at each out-of-boundary stop (relative to the total passengers on the out-of-boundary stops). HITRANS commissioned a Rail Passenger survey in Autumn 2010[30] 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, and Scope 3 emissions have therefore been excluded from this report.

[30] HITRANS Rail Passenger Survey April 2011

Critique of Methodology

National Figures

The Department for Transport's Rail Emissions Model was last updated in 2009/10, and emissions are distributed across Great Britain using GIS data. The methodology given does not robustly explain the process, and therefore it is difficult to evaluate the robustness of the data.

Allocation to the Inventory Area

Highland figures were allocated to the Inventory area by taking a proportion of the overall rail traffic in Highland, calculated by applying distances to Network Rail's Working Timetable (WTT), which includes passenger trains, freight trains and empty trains and trains coming in and out of depots. We used the 2017 WTT as the timetable wasn't available for 2014. This method doesn't account for greater emissions from trains with more carriages (due to increased passenger and freight moving between cities), and therefore trains going between Inverness and Aberdeen and Inverness and Perth were increased by 20%. This estimate of 20% could be improved through additional research and consultation.

4.2.3 Water Transport

The Port of Inverness is one of the major water transport gateways for the Scottish Highlands and is located within the Inventory area. It is one of Scotland's most sheltered natural deep-water harbours, and as a result the Port can offer ships almost guaranteed access irrespective of the weather.

Discussions with the Harbour manager identified:

- Fuel used in pilot boats which meet inbound ships to escort them in and out of the Port.
- Electricity used in the Port's office and warehouse buildings (included in Stationary Energy).
- Limited fuel use in forklift vehicles. Operated by a third party, they have been excluded from this report.
- Fuelling of pleasure craft that take visitors dolphin watching in the Moray Firth. This fuel is provided by a third party who confirmed there was no activity in 2014.
- Of the freight that departed from the Port in 2014, none originated in the Inverness Inventory area. To simplify reporting in this first Inventory area, only emissions for freight generated in the Inventory area were to be included.

In addition to freight water transport emissions, there are several sources of recreation and tourism related water transport GHG emissions, including:

- A 150-berth marina, constructed in 2009, is located adjacent to the Port and two further marinas are located on the Caledonian Canal at Dochgarroch and Seaport. Emissions from these facilities are not included. Detailed primary research would help identify fuel consumption in boats moored in the marina. It is anticipated the majority of emissions would be Scope 1, with a smaller proportion being Scope 2.

- Motor cruisers that are rented for travel along the Caledonian Canal and Loch Ness. Primary research would help to identify fuel sales and the level of consumption within and outwith the Inventory area.

- Cruise businesses that transport passengers on Loch Ness. Two companies, one operating at the north and one at the south, provided fuel use data for 2014.

Combined, these water transport operations consumed just under 300,000 litres of fuel in 2014. Using the standard ratio, combustion of this fuel will have resulted in the release of 801 tCO_2e.

4.2.4 Aviation

In 2014, Scottish aviation emissions stood at 1.9 MtCO2e, or 15% of total transport emissions. This compares with 1.4 MtCO2e in 1990. Passenger numbers in that period increased from just over 10 million to 24 million. The growth in demand of 134% was thus associated with a significantly lower growth in emissions of 38%, reflecting effective efficiency improvements, including increased load factors.

It was not possible to access suitable data from the local airport to review aviation emissions for the Inventory Area.

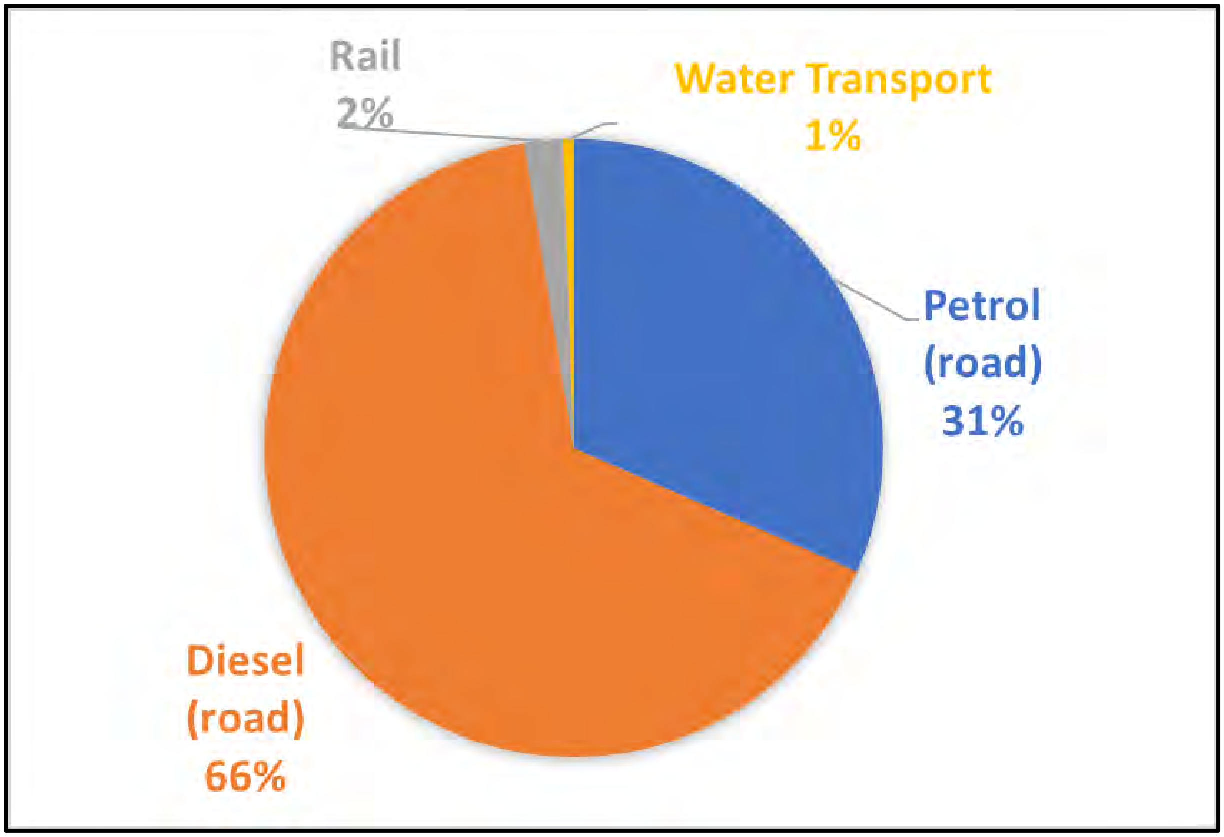
4.2.5 Off Road Transport

This has been excluded from analysis due to the lack of information on airport operations – off road transport involves moving baggage trailers and the use of pushback tractors or tugs to move planes away from terminal buildings. Also, undertaking primary research to identify fuel consumption on or in farms, fish farms, quarries, warehouses and building sites would be very challenging and time consuming.

4.2.6 Transport Emissions Summary

The following chart illustrates the distribution of Inventory Area transport GHG emissions that we have identified (noting the exclusions above). Road transport and the resulting consumption of petrol and diesel was responsible for 97% of the transport emissions.

Figure 15 – Percentage Distribution of Transport Emissions in the Inverness GHG Inventory Area



4.3 Industrial Processes and Product Use (IPPU)

Nationally, industrial processes can produce a number of non-energy related emissions, including:

- Production and consumption of mineral products such as cement, lime and soda ash.
- Production of metals such as iron and steel, aluminium, zinc and lead.
- Chemical production (e.g. ammonia, petrochemicals and titanium dioxide).
- Consumption of petroleum products in feedstocks and other end-uses.

A desk review of key sources of potential emissions involved assessing the Scottish Environmental Protection Agency's Scottish Pollutant Release Inventory (SPRI). This is a database of annual mass releases of specified pollutants to air, water and land from SEPA regulated industrial sites. It also provides information about off-site transfers of waste.

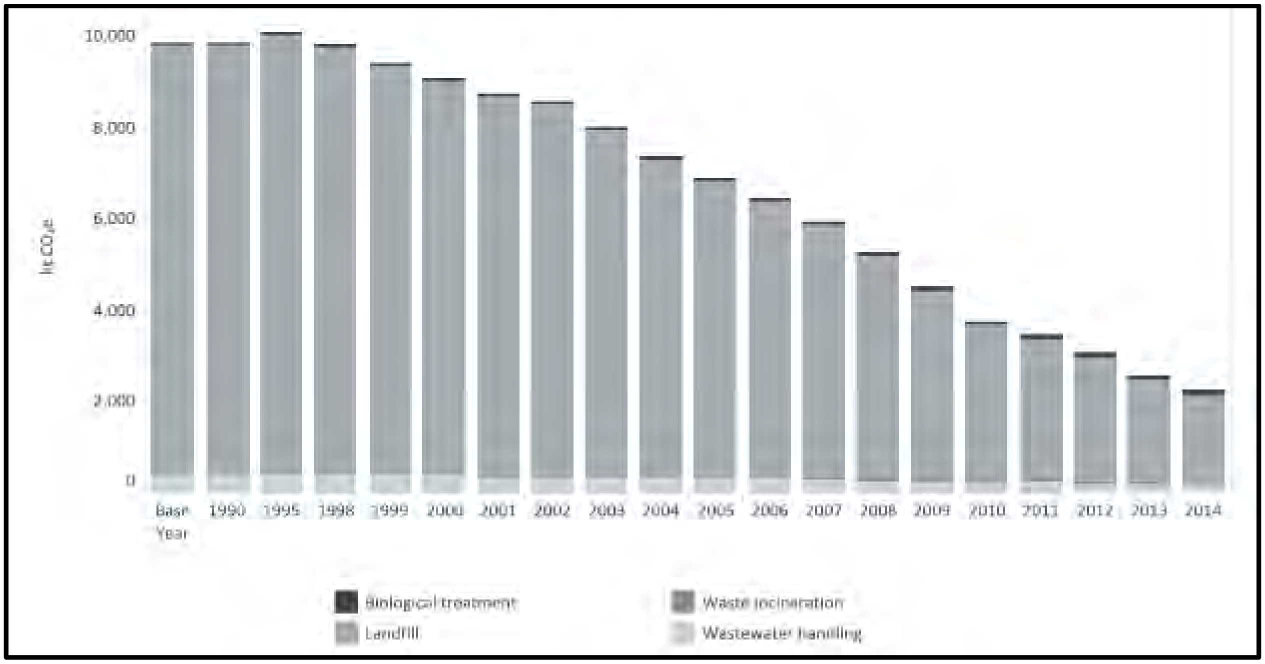
The SPRI provides emission values and waste transfers when they are over the reporting thresholds and indicate if a site releases a pollutant below the threshold. Analysis for 2014 identified one pertinent entry on the SPRI, Norbord Ltd at Morayhill, which manufactures veneer sheets and wood-based panels. The main two pertinent GHG's recorded in the SPRI were 97,200 tonnes CO_2 and 216 tonnes of nitrogen oxides. Discussions with the company identified that these emissions are recorded at the plant stack, with 96% arising from the combustion of large volumes of biomass. Only 4% of the CO_2 emissions arise from the consumption of gas.

The biomass element of these emissions are excluded from this inventory, with fuel derived emissions included in Section 4.1.3.

4.4 Waste

A range of waste material emanates from the Inventory Area. This can be disaggregated into solid waste and wastewater that will be disposed of and/or treated at facilities inside the Inventory Area, or transported elsewhere for treatment. Waste disposal and treatment produces GHG emissions through aerobic or anaerobic decomposition, or incineration.

Figure 16 – Total Greenhouse Gas Emissions from Waste Management in Scotland, 1990 - 2014[31]



The waste management sector constituted 5% of all GHG emissions in Scotland in 2014, and was the second largest source sector for methane emissions, representing 29% of total methane emissions in 2014. Emissions from this sector in 2014 were dominated by methane from landfill (85% of total GHGs from the waste management sector), with a smaller contribution from emissions of methane and nitrous oxide from wastewater treatment (10%).

Emissions from the waste management sector in Scotland have been steadily declining; by 77% since 1990 as illustrated in the above chart. This has been driven by reductions of emissions from landfill, achieved by the progressive introduction of methane capture and oxidation systems within landfill management.

There has been an increasing focus on the amount and types of waste being generated in Scotland, supported by the Government's Scotland Zero Waste Plan[32]. This established targets to increase recycling and reuse, reduce waste being sent to landfill and improve data available on waste volumes.

[31] Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2014 Department of Energy and Climate Change, The Scottish Government, The Welsh Government, The Northern Ireland Department for Agriculture, Environment and Rural Affairs

[32] Scotland's Zero Waste Plan 2010, Scottish Government

To assess detailed waste analysis in this report, the following guidelines were adopted:

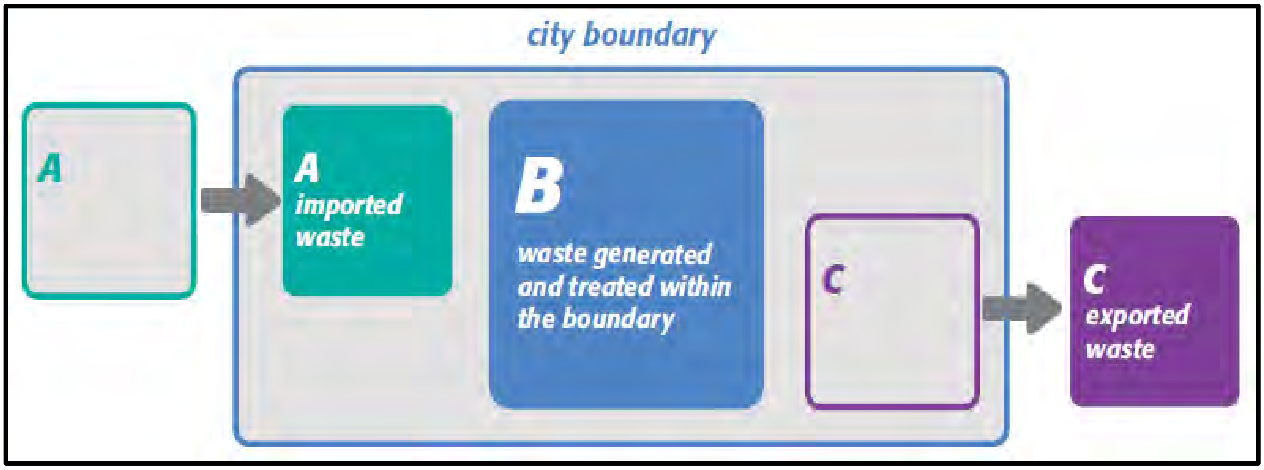
Scope 1: Emissions from waste treated inside the Inventory area. This includes all GHG emissions from treatment and disposal of waste within the Inventory area regardless of whether the waste was generated within or outside the city boundary.

Scope 2: Emissions arising from grid supplied electricity consumed in waste treatment facilities within the city boundary are reported under Scope 2 in Stationary Energy, commercial and institutional buildings and facilities.

Scope 3: Emissions from waste generated by business, residents and visitors in the Inverness Inventory area, but treated at a facility outside the city boundary.

The following figure summarises boundary considerations for emission sources in the waste sector.

Figure 17 – Overview of Inverness GHG Inventory Waste Emissions Boundary



- A in Figure 17 illustrates waste generated outside of the city boundary and treated within the boundary – this will primarily be wastewater and sewage.

- B illustrates waste generated and treated within the city's boundary, primarily wastewater and sewage.

- C illustrates waste generated inside the boundary and treated outside of the boundary, predominately solid business and domestic waste.

To help inform this report, commercial waste figures were obtained from Scottish Environmental Protection Agency[33], with Highland Council data on non-commercial waste available online[34]. Our estimate of waste for the Inverness Inventory area was based on the per capita average of Highland Council domestic waste. For commercial waste, data for the Highland Council area was obtained from SEPA. Employment by different sectors was then used to identify appropriate shares of this Highland Council area waste for the Inverness Inventory area, giving an estimate for the Inverness Inventory area

[33] https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/business-waste-data/
[34] http://www.environment.scotland.gov.uk/get-interactive/data/household-waste/

of 28,070t of landfilled waste, of which 23,465t was domestic and 4,605t commercial. A composition study for Highland Council by Resource Futures in November 2014 provided a basis for the estimate of degradable organic carbon content (DOC).

4.4.1 Solid Waste Disposal

There is no active landfill site in the Inventory Area. The Longman landfill site was closed over a decade ago with waste transported to other landfill sites in Highland or to the Central Belt. Major improvements at the Seater landfill site near Wick have reduced the need for reliance on landfill capacity outside the Council area but no solid waste is now landfilled in the Inventory Area.

Methane that is captured and used for energy generation or methane that is flared are both reduced to CO_2 in the process, and this emission is considered a natural process and not part of the GHG inventory[35]. This Inventory includes the methane that escapes to the atmosphere from landfill sites. Methane is still emitted from the closed Longman landfill site and this is monitored.

Emissions from landfill can be calculated through a First Order Decay model or a methane commitment model. The IPCC recommends the FOD model, and this is used to develop the UK Inventory. However, this approach requires records of waste management from the 1950s. It has not been possible to reproduce these for the Inventory Area. An alternative approach is to adopt the methane commitment model which gives the total emissions produced by material sent to landfill over the time that it decays. It is different from other elements of the Inventory which reports emissions within the year. An annual figure would require modelling the history of material sent to landfill for up to 50 years to indicate ongoing emissions. This is an area for potential future work.

Table 20 – Composition of Domestic and Commercial Solid Waste Produced in the Inverness Inventory Area, 2014

Item	Percentage	Tonnes
Food	30.6	8,589
Garden waste	4	1,123
Paper	11.4	3,200
Wood	0.7	196
Textiles	4.7	1,319
Industrial	48.6	13,642
Total	**100**	**28,070**

Waste composition is used to identify the degradable organic content (DOC) of the landfilled material and this in turn to identify the methane generation potential of the material – in this case 11.4% and 4.6% respectively. Emissions for the 28,070t sent to landfill would be 230.4tCH_4. Methane is a far more potent GHG than CO_2 in terms of its warming impact in the atmosphere. It is recognised as having a global warming potential (GWP) 25 times greater (over a 100-year period) than a similar volume of

[35] UK Greenhouse Gas Inventory 1990 to 2014: Annual Report for submission under the Framework Convention on Climate Change, DECC 2016, Page 414

carbon dioxide[36], which converts to 5,750t CO_2e. As there is no landfill capacity in the area this should register as a Scope 3 emission.

4.4.1 Biological Treatment of Waste

Methane and nitrous oxide arise through aerobic and anaerobic composting processes. In Inverness, garden waste is shredded at the Longman site and transferred to Nairn for composting in windrows in an aerobic process. In 2013/14 the Highland Council Waste Statistics recorded 9,950t garden waste processed at Longman. This has helped to inform our calculations for the emissions arising from treatment of this waste as follows:

- Methane = 9,950t x 4g/kg x 10-3 – 0 = 39.8t CH_4. Considering methane's GWP, this equates to 995t CO_2e.

- Nitrous Oxide = 9950t x 0.3g/kg x 10-3 = 2.985t N_2O. Nitrous Oxide has a 100 year GWP 298. This equates to 889tCO_2e.

The total emissions arising from the biological treatment of waste are thus calculated as 1,884 CO_2e. This is a Scope 1 emission.

4.4.3 Incineration and Open Burning

No municipal waste is incinerated within the Inverness area. There is a small volume of clinical waste (c 9 tonnes) that is incinerated. As this is such a low volume, it was excluded from this Inventory.

4.4.4 Wastewater Treatment and Discharge

Waste water treatment gives rise to methane and nitrous oxide from the storage, settlement, processing and spreading of sewage sludge. Scottish Water carries out a greenhouse gas assessment of all their operations and those of their contractors in the private sector, using software developed by the UK Water Industry Regulator (UKWIR), and they have calculated the emissions for the Inverness area population as 63.5kg CO2e/person/year (personal communication). This total includes emissions for all company activities and is dominated by the use of electricity, while the waste water process emissions are 11% of the total. These figures applied to the study area population of 79,728 give a total of 556.9t CO_2e.

For future revisions of the Inventory, Scottish Water have offered to assist in identifying measures of water processed in the area which would allow a fuller estimate to be developed.

4.4.5 Waste Emissions Summary

Calculating waste emissions for the Inverness GHG Inventory area has required different methodologies from those used to determine, for example, stationary energy and transport emissions. This is an emerging area of analysis, informed by developing understanding of a range of biological processes. The following table summarises the source of waste GHG emissions.

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[36] https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

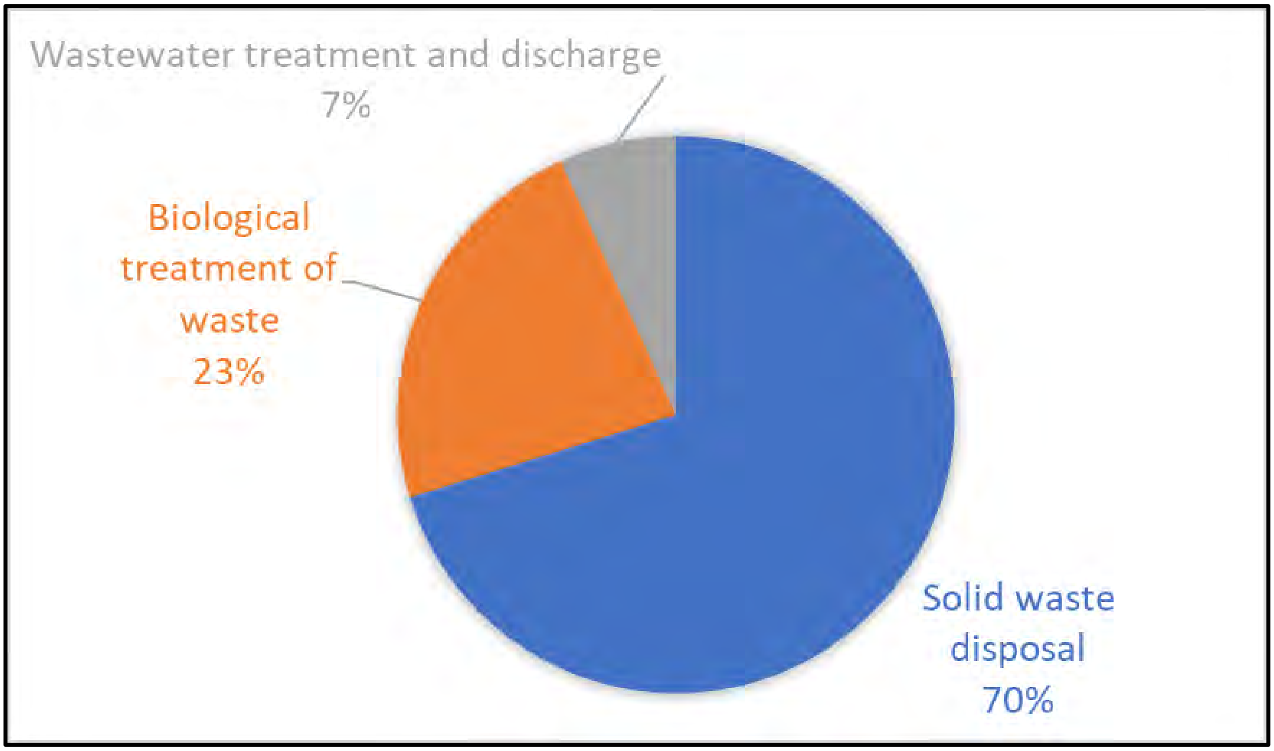
Table 21 – GHG Emissions from Waste Produced in the Inventory Area

	tCH_4	tN_2O	tCO_2e
Waste to Landfill	230.4		5,760
Waste composted	39.8		995
Waste composted		3	889
Waste Water Treatment			556
Total			**8,201**

There is interest in how waste emissions can be managed and reduced, and the Committee on Climate Change has provided a useful summary of the steps available to reduce GHG arising from waste treatment[37].

The following chart illustrates the percentage distribution of the 19,819 tCO_2e arising from waste treatment associated with the Inverness GHG Inventory Area.

Figure 18 – Percentage Distribution of Waste Treatment Emissions in the Inverness GHG Inventory Area



[37] https://www.theccc.org.uk/wp-content/uploads/2013/04/Waste-factsheet.pdf

4.5 Agriculture, Forestry and Other Land Use

Emissions in the Agriculture, Forestry and Other Land Use (AFOLU) sector also differ from other parts of the Inverness GHG Inventory which are dominated by the use of fossil fuels. In the AFOLU sector, biological processes are the main source of emissions. Land use and changes in land use are dominated by emissions due to the loss or accumulation of carbon in the soil.

- Agriculture gives rise to emissions from livestock, crops and soil. Livestock produce methane emissions from enteric fermentation and from manure and nitrous oxides from manure management. The artificial fertilisers applied to crops give rise to nitrogen emissions, as does the application of livestock manure and sewage, the incorporation of crop residues, and the deposition of manure by grazing animals.

- Forestry gives rise to large removals of carbon through photosynthesis by growing trees – although this is offset by harvesting, the loss of soil carbon due to planting and nitrogen emissions from fertiliser application.

A particularly important aspect of soil carbon in the Inverness GHG Inventory area is that of emissions and sequestration in peatland soils. This has not historically been included as part of the National Inventory Report though that is gradually changing, with the publication by the IPCC of a supplement on reporting for wetland emissions in 2013[38]. Peatland can sequester carbon in a healthy state, but generate emissions if disturbed or degraded.

This Inverness GHG Inventory has been informed by data sourced from the June Agricultural Census (JAC), the National Forest Inventory (NFI) and the SNH Carbon and Peatland Map. Emissions are calculated as specified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, with UK specific factors from the National Inventory Report (NIR). Activities and conditions specific to Scotland and the Highlands have been incorporated where possible from advice from local professionals.

The estimation of emissions due to land use and land use change depends on developing a matrix of land use on an annual basis. This has not been possible for the present study, but the use of JAC data has enabled a partial account to be developed for the twenty-year period 1994-2014.

For preparing the emissions for the Inverness GHG Inventory area, the following guidelines have been adopted:

Scope 1. Emissions from agricultural activity, land use and land use change within the Inventory boundary.

Scope 2. Emissions from use of grid-supplied energy in buildings and vehicles in farms or other agricultural areas, which are reported in Stationary Energy and Transportation respectively.

Scope 3. Emissions from land-use activities outside the Inventory boundary (e.g., agricultural products imported for consumption within the area) are not included in this analysis.

[38] http://www.ipcc-nggip.iges.or.jp/public/wetlands/pdf/Wetlands_Supplement_Entire_Report.pdf

4.5.1 Agriculture Overview

The Inverness GHG Inventory area covers a total of 283,764ha. Data are recorded for agricultural parishes, twelve of which lie wholly within the area. There are others that overlap the area and where this is less than 5% of the area of any parish, they have been excluded from the calculations, leaving two (Croy at 8% and Urray at 18%) where data has been included in proportion to the land area included in the study. The total agricultural area is 188,231ha, 66% of the whole area and 9% of the total agricultural area in Highland.

The James Hutton Institute Map of Land Capability for Agriculture identifies the land as mainly suitable for rough grazing (Class 6) with some areas providing improved grassland (Class 5.2 and 5.3). Census returns record land used for crops, improved grassland, rough grazing and woodland. For six of the 14 parishes in the Inventory area, the rough grazing land stands at over seventy percent, indicating farming characterised primarily by extensive hill grazing stock.

The total area of crops and fallow land in 2014 stood at 5,136ha, of which 3,702ha (72%) was cereals, 399ha (8%) fodder crops, and 609ha (18%) crops for human consumption. The Economic Report for Scottish Agriculture 2015[39] shows cereals in Highland at 83% of crop production land, and the lower rate in the study area is due to the comparatively high level of vegetable production in the area.

Table 22 – Cropping Activity in the Inverness Inventory Area

Crops	Ha	Crops	Ha
Cereals		**Fodder crops**	
Wheat	625	Peas and beans	96
Barley	2,794	Turnip and swede	147
Oats	236	Kale and cabbage	18
Mixed grain	44	Rape	36
		Other crops	100
		Fallow	427
Crops for human consumption			
Oilseed rape	183	Orchard fruit	0.5
Seed potatoes	112	Soft fruit	4
Ware potatoes	41	Other crops	89
Vegetables	176		
Total	**5,136**		

Emissions from soils arise from synthetic fertiliser, manure application, nitrogen in crop residues, lime application and dung dropped on pasture and hill by grazing animals. Fertiliser rates were sourced from

[39] http://www.gov.scot/Resource/0047/00478588.pdf

UK NIR[40], crop yields from the SAC Farm Management Handbook (FMH[41]), and crop residue factors from IPCC Volume 4 table 11.2. Because of the wide variation in agricultural activity, the estimate was based on a division of parishes into low intensity, medium intensity and high intensity agriculture.

Table 23 – Activity Intensity in the Inverness GHG Inventory Agricultural Parishes

Farm type	Parishes	Description
Low intensity	Boleskine and Abertarff, Urquhart and Glenmoriston, Croy (part), Daviot, Moy and Dalrossie	Extensive hill stock farming, low rate of housing, low proportion of crops and no silage
Medium intensity	Kilmorack, Kiltarlity, Dores Croy (part) and Urray	Upland stock farming, high level of winter housing, moderate level of crops and silage on 30% good grass
High intensity	Kirkhill, Ardersier, Inverness and Petty	Lower level of stock production, housed during winter, high level of crops and vegetable production

Separate calculations were made for each group of parishes, with differing assumptions about housing, silage production and the maintenance of pasture ground.

4.5.2 Livestock

In common with elsewhere in the Highlands, livestock is dominated by cattle and sheep. Emissions consist of methane from enteric processes and manure and nitrous oxide from manure. The quantities of manure that need to be managed depend on the levels of animal housing. Manure can be managed in slurry systems or through straw bedding, and calculations have assumed a predominance of the latter.

Table 24 – Livestock Numbers in the Inventory Area

Animal	Number
Dairy cattle	339
Beef cattle	14,788
Sheep	95,724
Pigs	1,091
Deer	523
Horses	604
Goats	52
Poultry	8,381

[40] UK Greenhouse Gas Inventory 1990 to 2014: Annual Report for submission under the Framework Convention on Climate Change, DECC 2016

[41] https://www.sruc.ac.uk/info/120376/farm_management_handbook

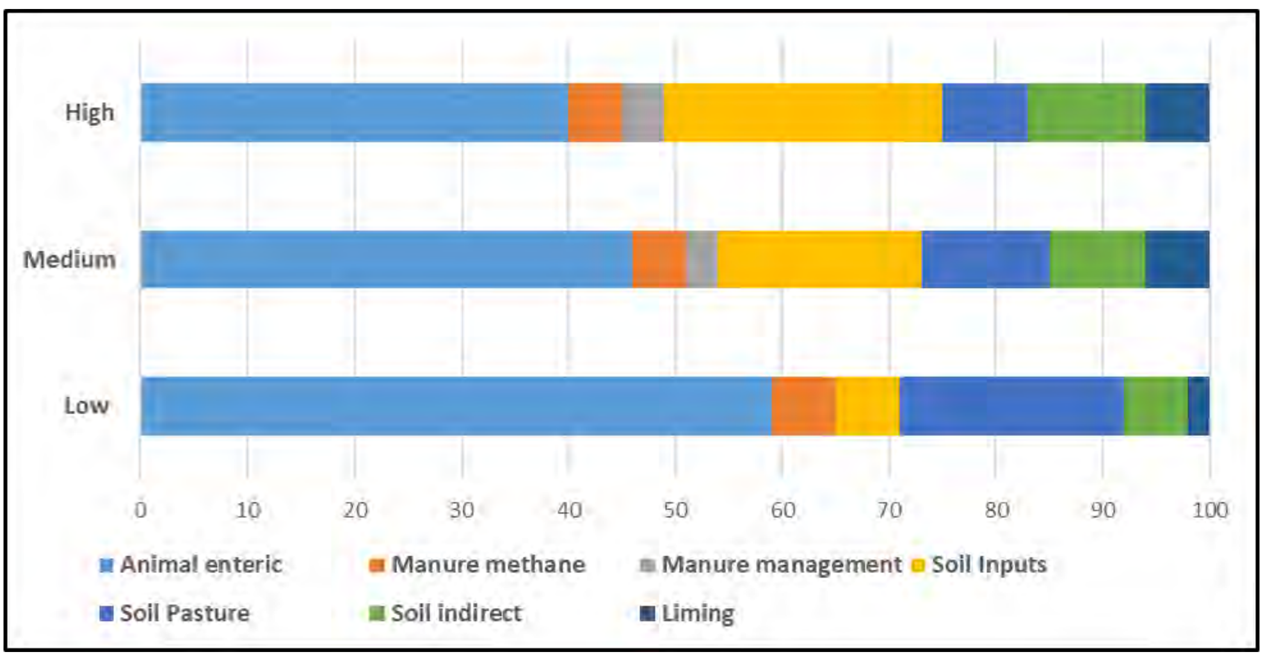
The total emissions from agriculture for 2014 amount to 82,406t CO_2e, with the following distribution:

Table 25 – Distribution of Agriculture Emissions

Agricultural emissions 2014	t CO_2e	% Distribution of Emissions
Animals		
Enteric	40,697	49
Manure methane	4,558	6
Manure management	1,845	2
Soils direct		
Soil Inputs	13,266	16
Soil Pasture	11,260	14
Soils indirect		
Soil indirect	6,947	8
Liming	3,833	5
Total	**82,406**	

This overall picture varies when farm types are considered. Areas dominated by crops have a larger proportion of nitrous oxide emissions from soil, while extensive hill farmland shows an increase in enteric methane. A comparison of the estimates for the three farm types defined in Table 23 shows the percentage contribution of enteric methane rising to 59% in the extensive hill farms and falling to 40% in the more intensively cropped parishes, while emissions from soil (direct and indirect) stand at 12% in the low intensity parishes compared with 37% in the intensively farmed parishes.

Figure 19 – Percentage Distribution of Agriculture GHG Emissions under Different Management Profiles



This clearly observed variance in the composition of agricultural emissions underlines the need to consider specific farming practices when considering emissions reduction.

4.5.3 Forestry and Land Use Change

The National Forest Inventory (2014)[42] has been mapped to the Inverness GHG Inventory area and shows a total of 68,374ha of woodland of which 47,477ha was conifer plantation and 20,897ha broadleaf woodland. The split between public and private ownership was 41% Forestry Commission (FC) and 59% private for conifers, and 12% FC and 88% private for broadleaves. The conifers are mainly composed of sitka spruce, scots pine and lodgepole pine; and the broadleaves are dominated by birch as shown in the category SAB (sycamore ash and birch), with oak and alder the next largest species. The age and species of trees are taken from the split reported in the NFI report and broken down in the following table. The growing of Christmas Trees is excluded.

Table 26 – Age and Species for Inverness Inventory Area Conifers and Broadleaves

Conifers Age	Sitka Spruce (SS) (ha)	Scots Pine (SP) (ha)	Hybrid Larch (HL) (ha)	Lodgepole Pine (LP) (ha)	Douglas Fir (ha)	Total (ha)
0-10	1,263	997	166	831	66	3,323
11-20	1,804	1,424	237	1,187	95	4,748
21-40	8,119	6,409	1,068	5,341	427	21,365
41-60	5,232	4,130	688	3,442	275	13,768
61-80	902	712	119	593	47	2,374
81-100	361	285	47	237	19	950
100+	361	285	47	237	19	950
Total	**18,041**	**14,243**	**2,374**	**11,869**	**950**	**47,477**
Broadleaf Age	**Oak (ha)**	**Beech (ha)**	**SAB (ha)**	**Willow/Poplar (ha)**	**Total (ha)**	
0-10	251	334	3,511	84	4,179	
11-20	176	234	2,457	59	2,926	
21-40	263	351	3,686	88	4,388	
41-60	326	435	4,564	109	5,433	
61-80	138	184	1,931	46	2,299	
81-100	50	67	702	17	836	
100+	50	67	702	17	836	
Total	**1,254**	**1,672**	**17,553**	**418**	**20,897**	

[42] https://www.forestry.gov.uk/inventory

Carbon is absorbed from the atmosphere by growing trees. Forestry Commission yield tables[43] give the volume of growth for different species and ages and yield class. Yield data are adjusted for overall biomass growth above and below ground and converted to mass using a density ratio. The carbon content is assessed at 0.51tC/t for conifers and 0.48 tC/t for broadleaves, and this gives the annual sequestration from growing trees.

Carbon is removed when trees are harvested. The Forestry Commission Scotland Strategic Plan[44] proposed a target harvest of 200,000m^3 per year. Assuming this is taken from the conifer forest gives a rate of 5m^3/ha/year and this rate has been applied to the full conifer forest in the Inverness Inventory area. It should be noted that this rate is lower than the 9.2m^3/ha/year in the NFI softwood timber 25-year forecast. The lower rate is due to the fact that much of the ground is managed as minimal intervention, partly due to a move towards the promotion of natural woodland habitat and partly due to the difficulty of extraction in areas where the slope is too steep or access too costly (personal communication). It has been assumed, that following harvest, a significant proportion of the trees would remain on site, including 10% stemwood, 50% of the above ground biomass and 100% of below ground biomass.

Carbon is sequestered into the soil through the accumulation of organic litter on the ground[45]. This has been calculated using data from Forest Research which assumes a differing rate of sequestration for three different growth periods during the life of conifers, and these factors have been applied to the Inverness conifer woodland.

Carbon is lost when soils are drained for planting and the UK NIR assumes that this loss continues for an average of 100 years. Given the steep slopes and peaty soils of the area, it is assumed that all conifer forests have been subject to drainage, resulting in an annual loss of 0.3tC/ha[46]. There is also a loss of nitrogen from drained soils, and this has been calculated based on the underlying soil types for the conifer land as shown on the SNH Priority Peatland map.

Fertiliser application is largely not practiced by Forestry Commission Scotland (FCS), but private sector productive forestry is assumed to make two applications to trees under 10 years old of 150kgN/ha/year, giving an average application for these trees of 30kgN/ha/year. Figures for the proportional split between FCS and private conifers have been derived from FCS reports which show 67% of the trees under ten years old to be in the private sector forests.

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[43] Edwards, PN, Christie, JM, 1981, Yield Models for Forest Management, Forestry Commission Booklet no 48, FC, Farnham, Surrey

[44] http://scotland.forestry.gov.uk/images/corporate/pdf/scottish-forestry-strategy-2006

[45] Understanding the carbon and greenhouse gas balance of forests in Britain, Forestry Commission, 2012

[46] Webb et al, 2013, UK Greenhouse Gas Inventory 1990 to 2011, annex p634

Table 27 – Forestry Associated Emissions in the Inverness GHG Inventory Area

Forest GHG Emissions, Inverness District 2014	t CO_2e
Biomass	
Biomass growth	-565,495
Wood removals	324,473
Harvest residue	-133,126
Dead organic matter	-10,771
Soils	
Drainage	53,191
Fertiliser	313
Total	**-331,416**

4.5.4 Other Land Use

Emissions are considered separately for land that is subject to a change of use, conventionally considered as a twenty-year period before the present, and land that remains in the same use. For land remaining in the same use, emissions are considered separately for mineral soils and for organic soils. Following the UK NIR, mineral soils are interpreted as including organo-mineral and thus constitute nearly the whole area. The proportion of land with each type of soil has been analysed using the SNH Carbon and Peatland map, which blends data on land cover with soil data.

Table 28 – Inverness GHG Inventory Land Use Change, 1994-2014

To\From	Forest	Crops	Improved grass	Rough grass	**Total 2014**
Forest	4,411		4,456	15,242	**24,109**
Crops		5,136			**5,136**
Improved Grass		920	16,539		**16,539**
Rough grass			4,456	129,664	**135,040**
Total 1994	**4,411**	**6,056**	**25531**	**145,826**	**180,824**

Emissions are based on a series of factors intrinsic to the land use itself and arising from different forms of management and inputs. In the case of cropland, ground subject to continuous tillage is given a factor of 0.69 to reflect soil degradation and of 1.11 for a medium level of inputs. Improved grass is assumed subject to a high level of inputs and is given a factor of 1.11. Forest land is regarded as unity and not subject to change, though it should be noted that research continues to understand better the long term effects of forestry on soil carbon.

For land use change, a soil database was used (Bradley, 2005), which gives different soil carbon equilibrium values for forest land, crop land, pasture land and semi natural land. These are long slow changes, and it is currently estimated that carbon losses take place over an average of 75 years (UKNIR A 3.4.15) before a new equilibrium is established, while gains are over an average period of 525 years.

The total greenhouse gas impact of other land use in 2014 is calculated at 15,266 tCO_2e. The estimate for land use change shows a total annual sequestration of 3,626 tCO_2e/year as the changes have led to conversion of soils to land uses where the carbon intensity is due to rise. Land remaining in the same use shows an annual sequestration of 11,640 tCO_2e/year, with soil carbon losses in cropland of 8,817 tCO_2e/year balanced by gains in improved grassland of 20,457 tCO_2e/year.

It should be noted that these estimates are very sensitive to the underlying assumptions. If it were assumed that the improved grassland was not receiving a high level of inputs, this would have the effect of annulling the sequestration and leaving an overall emission of 8,817 tCO2e from land use. This is an area of focus for research at present, and all estimates are currently subject to a wide margin of error. These data should therefore be seen as illustrative of the need for attention to soil carbon.

4.5.5 Peat

The SNH digital map of carbon rich soils has been mapped to the area and this enables a rough estimate to be made for emissions from peatland soils. It should be stressed that there is still considerable uncertainty about all aspects of peat soils: their full depth and area, the rate at which they lose carbon, and the rate at which they accumulate it. Estimates here have been taken from work done by Scottish universities, especially for the ClimateXChange briefings and for the SNH publication on managing and restoring blanket bogs[47]. The area of blanket bog in the Inverness GHG Inventory area is 40,507ha. It is estimated that across Scotland 30% of the peat is in good condition and sequestering carbon at 0.76t CO_2e/ha/year, 20% is degraded losing carbon on average at 2.75t CO_2e/ha/year, and 50% damaged losing carbon on average at 3t CO_2e/ha/year. These values have been applied to the Inventory Area.

Table 29 – Blanket Peat and Carbon Sequestration

Condition	**Good (ha)**	**Degraded (ha)**	**Damaged (ha)**	**Total (ha)**
Blanket Peat Area	12,152	8,101	20,253	40,507
	tCO_2e/ha/yr	tCO_2e/ha/yr	tCO_2e/ha/yr	
Carbon emissions	-0.7	2.7	3	
	tCO_2e/yr	tCO_2e/yr	tCO_2e/yr	tCO_2e/yr
Total carbon emissions tCO_2e/yr	-9,235	22,278	60,760	73,803
t CO_2e/yr with restoration		**-6,157**	**-15,392**	**-21,549**

This rough estimate indicates that the potential emissions from peatland are 73,803t CO_2e, which represents 95% of the 82,406t CO_2e estimated for all agricultural activity. The figures in the table underline the fact that restoration, while it offers benefits at a potential annual removal of 21,549t

[47] Managing and restoring blanket bog to benefit biodiversity and carbon balance – a scoping study. Scottish Natural Heritage Commissioned Report No. 562, 2014

CO_2e, has less impact than the losses from damaged and degraded peatland. Any action that can be taken to avoid losses offers the greatest benefit in terms of minimising greenhouse gas emissions.

Chapter 5 – The Wider Study Area Issues: Upland Management, Forestry & Renewable Energy

Our analysis has adopted an Inventory Area boundary that extends beyond the core city/urban centre. By relating to this broader area, our analysis has incorporated a more comprehensive review of local GHG emissions and issues than focusing just on Inverness city would have entailed.

These broader aspects include:

- With appropriate woodland and peatland management, the surrounding land provides a carbon storage resource, sequestering carbon through forestry/woodland growth and upland management.

- The development of renewable energy by 2014 had comprised 9 large windfarms and with another 2 planned, and 13 large hydro schemes as well as an increasing number of micro renewable energy installations; solar PV and thermal, biomass and micro hydro.

These are discussed in this Chapter.

5.1 Upland Management

The distinction between upland and lowland habitats can often be blurred as there is no precise dividing line between the two. A common boundary used is the 250m contour, providing an edge to upland and lowland. However, in reality, this succinct boundary does not exist, and the two merge through a broad band of transitional vegetation and land management. As highlighted in the previous chapter, there is growing recognition of the significant roles that land management and upland areas play in relation to GHG emissions.

Upland farms and estates support a range of habitats that are important for their wildlife interest and landscape value. These habitats have been created and/or managed by farmers and estates over many generations. Most of these habitats need a level of grazing or other management, muirburn and trampling to maintain their wildlife interest and to prevent natural succession to other habitat types. Some habitat types require very low levels of grazing or no grazing at all. Other vegetation types require relatively high levels of grazing and are vulnerable to under-grazing, with a range of vegetation types that fit somewhere between these two extremes.

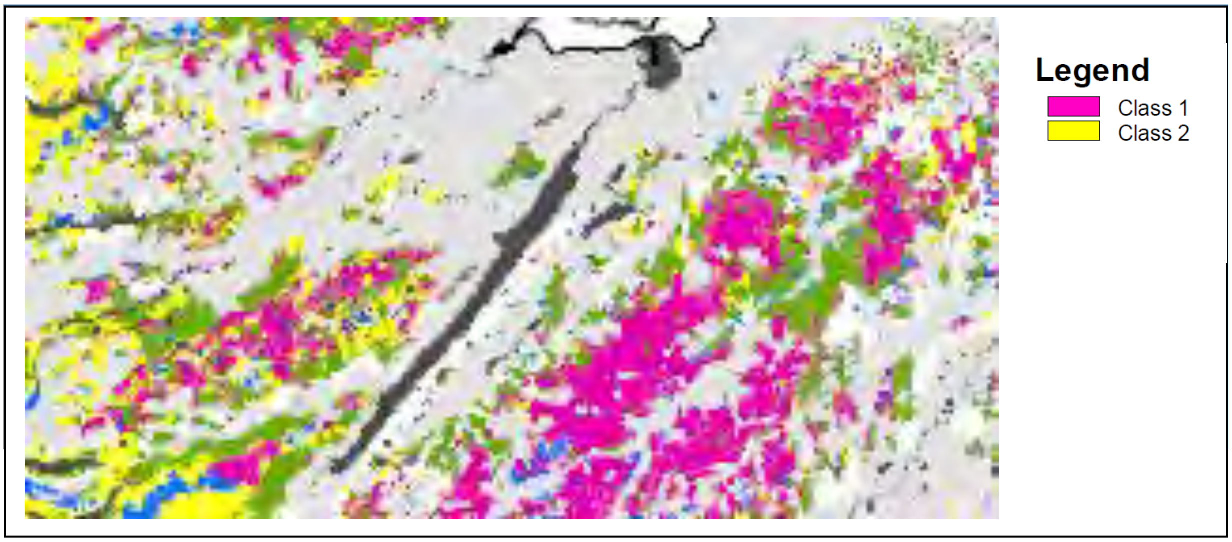
Peatlands cover more than 20% of Scotland's land area. Scotland also has about 10-15% of the total global area of blanket bog, making it one of the most important international locations for this habitat. Blanket mire is found in cool, wet, typically oceanic climates, where it can cover whole landscapes. Peat accumulates slowly over many years and can reach depths exceeding 5m, although 0.5-3m is more typical. Upland areas in the Inverness GHG Inventory area provide significant stores of carbon that help to address climate change. The amount of carbon stored in UK peatlands has been estimated to be equivalent to at least three years of the UK's total greenhouse gas emissions. An assessment of soil carbon in Lochaber alone by the James Hutton Institute in 2015 gave a result of 199,283ktC. The management of habitats with highly organic soil influences whether they add to this carbon store, or release the stored carbon, which is of major importance for climate change.

The following illustration from the SNH Carbon and Peatland map highlights areas of carbon-rich soil, deep peat and priority peatland habitat. The top two classes (1 and 2) taken together identify this nationally-important peatland.

- Class 1 are nationally important carbon-rich soils, deep peat and priority peatland habitat and areas likely to be of high conservation value.

- Class 2 are nationally important carbon-rich soils, deep peat and priority peatland habitat and areas of potentially high conservation value and restoration potential.

Figure 20 – Important Peatland Resources in the Inverness GHG Inventory Area



Source SNH[48]

The upland Inverness GHG Inventory area also provides a special and unique environment that supports a range of economic activity, from traditional land management such as farming and estate activity to locations for renewable energy and outdoor recreation and tourism. When well managed and in good condition, they help provide a range of natural benefits: storing and cleaning water that provides supplies for the area's residents, acting as a buffer to slow the rate of runoff, and reducing flood risks.

As land use changes in this area, there is growing recognition of the need to consider the environmental benefits traditionally being provided by uplands. Inappropriate drainage ditches and forestry plantations will remove water from surface layers of the bog and ultimately lower the bog surface, favouring plants which grow in drier conditions. In recognition of this, the FC have discouraged afforestation on deep peat and are conducting research into the impacts of forestry on soil carbon[49].

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[48] http://www.snh.gov.uk/planning-and-development/advice-for-planners-and-developers/soils-and-development/cpp/

[49] Forest Research, 2010, Understanding the GHG implications of forestry on peat soils in Scotland

Scottish Government as part of the work on the first Land Use Strategy[50] organised two land use pilot studies in North East Scotland and the Scottish Borders with the aim of testing the integration of the consideration of ecosystem services into land use planning. The Aberdeenshire pilot ran for two years concluding in March 2015 and produced a report on land use opportunities and a series of maps recording eco systems services for the area. Scenarios for changes in land use were developed in pursuit of policies on agriculture, local development, water and biodiversity, with measurement for ecosystems services quantified as sediment export, nitrogen retention and carbon sequestration; and a prototype tool was developed to help support decision making on land use on six policy areas. In the Scottish Borders, land use issues have been pursued through the Tweed Forum, an organisation with a focus on land use within the catchment area of the River Tweed, which has carried out projects to encourage tree planting, wetland restoration and flood management.

Reflecting this growing awareness, the Scottish Government has also produced an information note[51]. This has provided guidance and example of how wider ecosystem services can be accommodated in upland management and development. Key issues to consider include drainage, afforestation by exotic conifers, development, agricultural improvement, muirburn and erosion.

The Scottish Land Use Strategy has provided greater commitments to consider the role of upland management in areas such as the Inverness Inventory area, identifying one of the principles for sustainable land use:

"Where land is highly suitable for a primary use (for example food production, flood management, water catchment management and carbon storage) this value should be recognised in decision-making"[52].

As awareness of the role of upland areas in carbon sequestration and ecosystem services has developed, there is now a greater obligation on developers to consider the wider impact of their projects. There are also now specific initiatives and programmes being established to consolidate and improve the sequestration and storage of these high value land classes. Peatland ACTION, for example, is supporting activity with £8 million to spend on continuing Scotland-wide peatland restoration in 2017/18**.**

5.2 Forestry

Forests and woodlands in the UK contain around 150 million tonnes of carbon, and every year they remove about four million tonnes of carbon from the atmosphere. As a result, the forest carbon sink is offsetting about 3 per cent of annual carbon dioxide emissions. Forests affect the carbon cycle:

- Negatively through deforestation which results in a permanent loss of forest cover and a large release of carbon dioxide into the atmosphere.

- Positively through planting fast-growing trees to absorb carbon dioxide from the atmosphere.

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[50] Getting the best from our land. A land use strategy for Scotland. Scottish Government. March 2011

[51] Applying an ecosystems approach to land use - Information Note, Scottish Government, March 2011

[52] Page 12, Getting the best from our land. A Land Use Strategy for Scotland 2016 – 2021, Scottish Government March 2016

The rate of carbon sequestration is relatively high because most of the UK's forests are young and still growing, though in the Highlands many plantations were established in the 1970s and are therefore due for harvest. The Woodland Carbon Code[53] is the voluntary standard for UK woodland creation which provides guidance on the rate of carbon sequestration by species, woodland management regime, tree age etc. Independent validation and verification to this standard provides assurance about the carbon savings of sustainably managed woodlands.

As forests grow older, the rate of carbon removal declines. This will be a key challenge for large areas of woodland in the Inverness GHG Inventory area which are reaching maturity and being felled. However, this harvest creates opportunities for fresh planting which will allow trees to enter their maximum rate of carbon sequestration in the coming decades. Recent priorities for native woodland planting will result in less sequestration from future forests, however.

The National Forest Inventory[41] includes a fifty-year forecast of timber availability which shows that, while these removals are currently very large, they are likely to be subject to considerable fluctuation as the current forests planted in the 1970s are coming to maturity without the same level of planting having been maintained in subsequent decades.

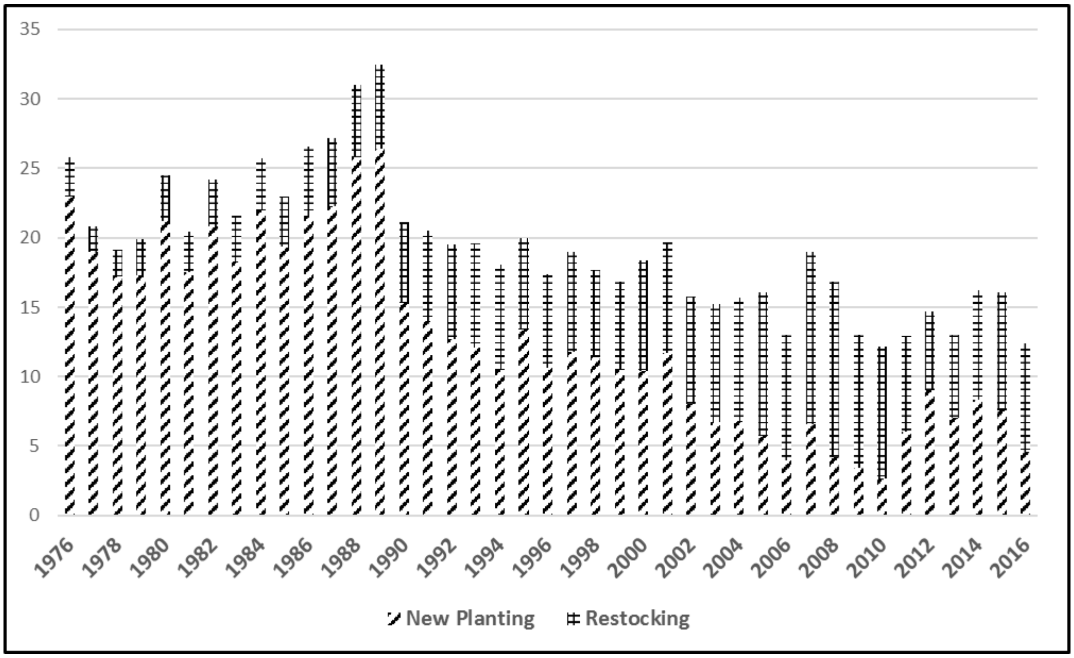
This pattern is repeated across Scotland and as a consequence the Scottish Government Climate Change Plan anticipates that the land use sector will move from being a net sink to a net emissions source from 2026 rising to 2030 before the effects of new planting are experienced.

The Scottish Forest Strategy[54] aimed to raise the area of forested land to 25% of the total Scottish land area by planting new woodlands on 10,000ha per year from 2015 to 2022 and then falling to 7,636ha/year thereafter. However, as the following chart illustrates, new planting rates have been below that target since 2002.

Figure 21 – New Planting and Restocking Rates (000 Ha) in Scotland, 1976 - 2016

[53] https://www.forestry.gov.uk/forestry/infd-863ffl

[54] http://scotland.forestry.gov.uk/images/corporate/pdf/scottish-forestry-strategy-2006.pdf



Source Forestry Commission[55]

The Scottish Government has identified how it plans to reverse this trend[56]:

1. By increasing the long term annual woodland creation target from the current target of 10,000 hectares per year to:
    - 12,000 hectares per year from 2020/21
    - 14,000 hectares per year from 2022/23
    - 15,000 hectares per year from 2024/25
2. By increasing the use of Scottish wood products in construction from the current level of 2.2 million metres^3 to:
    - 2.6 million metres^3 by 2021/22
    - 2.8 million metres^3 by 2026/27
    - 3.0 million metres^3 by 2031/32

These targets could be achieved through a combination of new and increased support, with, for example improved grant application processes, increased downstream timber demand from the construction sector and improving the planning and development of new forest areas.

Due to the timescales involved between planning, planting and the subsequent harvest of woodlands, the forestry sector is at the forefront of addressing the implications of climate change. This has been reviewed in several comprehensive publications[57 58].

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[55] https://www.forestry.gov.uk/forestry/infd-7aqknx
[56] Draft Climate Change Plan, The draft third report on policies and proposals 2017-2032, Scottish Government January 2017
[57] Climate Change Risk Assessment for the Forestry Sector, DEFRA January 2012
[58] Combating Climate Change – A role for UK Forests. The Stationery Office 2009. Also known as "The Read report"

To adapt to a changing climate, a three-way approach has been established in the forestry sector: consideration of the tree species being grown; the sites they are growing on; and anticipated climate change; and the Forestry Commission has established an ecological site classification to predict which sites will be particularly sensitive to current and future climate change.

5.3 Renewable Energy

The Scottish Government's recently published Energy Strategy[59] updates the ambitious targets for transitioning to increased renewable energy in Scotland. It describes the priorities for an integrated approach to delivering a low carbon energy system and considers both the use and the supply of energy for heat, power and transport.

The 2050 Vision in the Strategy is built around the following six priorities:

- Consumer engagement and protection – including protecting consumers from excessive or avoidable costs, and promoting the benefits of smarter domestic energy applications and systems.
- Energy efficiency – improving the use and management of energy in Scotland's homes, buildings, industrial processes and manufacturing.
- System security and flexibility – maintaining secure and reliable energy supplies as Scotland's energy transition takes place.
- Innovative local energy systems and networks, which the Scottish Government will support.
- Renewables and low carbon solutions – meeting needs and helping to achieve Scotland's ambitious emissions reduction targets.
- Investment, innovation and diversification across Scotland's oil and gas sector.

The Inventory area was the location for Scotland's first large scale pumped storage hydro facility at Foyers. A century later, it is the location of Scotland's newest pumped storage hydro facility at Glendoe. Pumped storage has been complemented with the exploitation of wind, hydro and at a smaller scale, solar energy resources.

Over the past 15 years, the power sector has become increasingly decarbonised. Scotland's last coal-fired power station closed in 2016. In 2015, renewables represented the biggest source of electricity production (42%) and served the majority of Scottish needs alongside the two remaining nuclear plants in Scotland. The Scottish Government has been a passionate supporter of the development of renewable energy in Scotland. The latest proposals for supporting the transition to renewable energy and promoting greater energy efficiency were contained in the draft Energy Strategy, published for consultation in January 2017[58]. Renewables generated the equivalent of 59.4% of Scotland's electricity requirements in 2015, up from just over 10% in 2001. Most of this growth can be attributed to onshore wind, complementing the existing post-war investment in large-scale hydro.

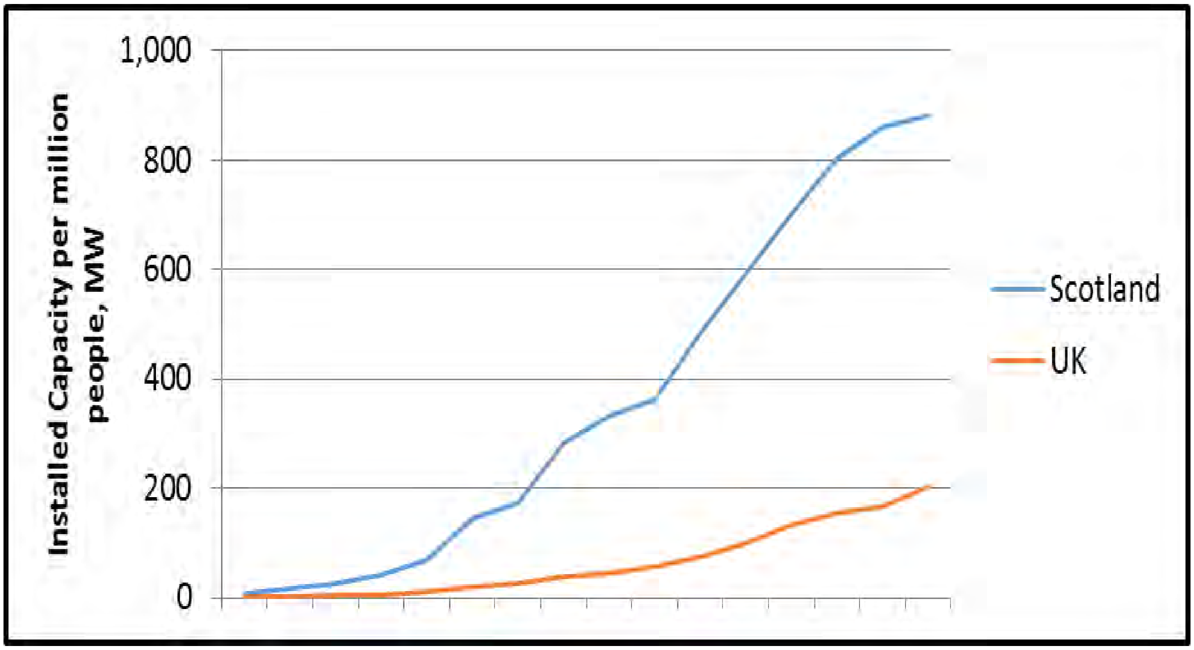
As a result of the increasing contribution of renewable energy, the emissions intensity of electricity generation has fallen substantially in recent years. Official figures[60] show that the average carbon intensity of electricity generated in Scotland has fallen below 250 grams of carbon dioxide for every

[59] Scottish Energy Strategy: Scottish Government, December 2017

[60] https://www.theccc.org.uk/wp-content/uploads/2014/03/1871_CCC_Scots_Report_bookmarked.pdf

kilowatt hour generated in 2011 and 2012. The grid electricity emission factor in the June 2017 release of the UK Government conversion factors for Company Reporting was 0.35kgCO2e/kWh – 28% below the emission factor used in the calculations for this 2014 Inventory.

Figure 22 – Renewables Installed Capacity, per million people, Scotland & UK, 2000—2015[61]



Recent years have seen a growth in small scale installations of renewable energy from solar, biomass and hydro power, aided by the UK Feed in Tariff (FiT) which supported renewable generation schemes under 5 megawatts (MW). Scotland's renewable energy success is built on the consistent support of the Scottish Government and a UK-wide support regime.

Table 30 – Production from Main Renewable energy Installations in the Inverness GHG Inventory Area in 2014.

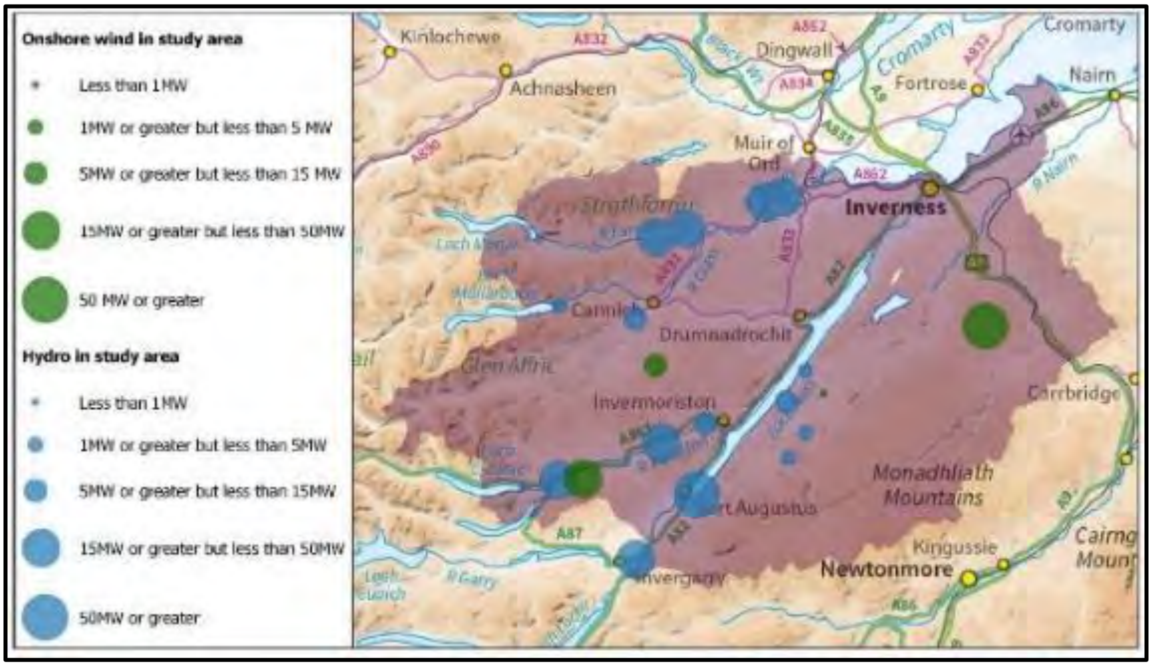
	Installed Capacity MW	Load Factor (hourly) %	Electricity Generated GWh
Onshore Wind	167.5	26.4	387
Small Hydro	13.4	39.6	46
Large Hydro	300.8	39.1	1,030
TOTAL	**481.7**		**1,464**

The following illustration identifies the location of the larger renewable energy installations in the Inventory area. The absence of any significant developments in the south east of the Inventory area is notable, although, as highlighted in Figure 20, this location contains significant areas of Class 1 peat soils. While this designation does not prevent development, it does require consideration of how impacts on the land and soils will be minimised. This reflects a maturing debate about land use and

[61] https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes

broader development which may release of GHG and which has to take account of the impacts of climate change.

Figure 23 – Locations of Renewable Energy Production in the Inverness GHG Inventory Area in 2014 (excluding micro installations)



Source. Renewable Energy Planning Database and Digest of UK Energy Statistics.

Future renewable energy activity in the Inventory area is likely to involve a combination of large and small-scale projects. Work for Scottish Renewables[62] highlighted the value of pumped storage hydro in providing a resource that balances out energy supply and demand. Several new pumped storage hydro schemes have been proposed in the area.

At a more local level and involving smaller scale generation, there will be continuing engagement with micro renewable energy systems. Figures are now being collected by the Department for Business, Energy and Industrial Strategy to show the level of small scale renewable energy systems installed in domestic and commercial properties. Changes in the support for smaller scale systems have challenged installation rates and financial returns. However, there are now reducing manufacture and installation costs, which is helping to maintain the attractiveness of micro renewable energy installations.

While the previous paragraphs have focused on renewable electricity, there is increasing support to produce renewable heat. Section 4.1.2 provided a local example of how this is being progressed by Highland Council. This reflects the emphasis the Scottish Government has put on renewable heat, with a target of 11% of heat to come from renewables by 2020.

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[62] The Benefits of Pumped Storage Hydro to the UK, Scottish Renewables, August 2016

5.4 Carbon Neutrality

As awareness of climate change increases, there is growing interest in how cities and countries can become carbon neutral. The Carbon CLEVER initiative was established with a target of "a carbon neutral Inverness in a low carbon Highlands by 2025", though it did not indicate how carbon neutrality would be defined.

Carbon neutral is normally defined as:

"Making no net release of carbon dioxide to the atmosphere, especially through offsetting emissions by planting trees".

Sweden, for example, has committed to becoming carbon neutral by 2050. It already gets 83 per cent of its electricity from nuclear energy and hydropower, and to achieve carbon-neutral status, the country will focus on reducing emissions from transport by increasing the use of biofuels and electric vehicles. It plans to cut domestic emissions by at least 85 per cent, and offset remaining emissions by planting trees or investing in projects abroad.

The Carbon Neutral Cities Alliance is a new collaboration of international cities committed to achieving aggressive long-term carbon reduction goals. The Alliance aims to address what it will take for leading international cities to achieve deep emissions reductions and how they can work together to meet their respective goals more efficiently and effectively. Cities striving for carbon neutrality recognise that averting the worst impacts of climate change will require cutting GHG emissions by at least 80% by 2050. Because urban areas account for nearly three-quarters of humanity's emissions, reaching this goal will depend in large part on the ability to develop new ways that promote economic prosperity, social equity, enhanced quality of life, and climate resilience.

Both these examples indicate the magnitude of the transition that will be required, with a target date of around 2050 (which compares with the Carbon CLEVER target of 2025). The following text identifies key factors for consideration when assessing the area's progress towards carbon neutrality.

The Contribution from Forestry

This baseline review has, for the first time, identified the level of emissions in the Inventory Area, and has also identified the carbon being absorbed and stored by forestry plantations. The forest estate identified in this review was responsible for the sequestration of 331,000 tCO_2e in 2014, which could reduce net Inventory Area emissions from 745,204 tCO2e to 413,788 tCO2e, a reduction of 44%. It is important to note that this sequestration figure will fluctuate in response to levels of tree planting and tree age. As noted earlier, tree planting rates in Scotland have been consistently below the levels required to sustain and increase the future sequestration of carbon.

The report has also highlighted the role of well managed and maintained peatland in storing and retaining carbon.

The Contribution from Renewable Energy production

The fuel mix used to produce electricity in the UK fluctuates in response to requirements in UK power stations and the increasing proportion of renewable energy being used to power the country.

The emission factor for grid supplied electricity has been reduced as more renewable electricity is exported to the grid and the amount of high carbon fossil fuels, for example coal, are burnt in power station also declines. It is worth noting that the electricity conversion factor just released by DBEIS and DEFRA for use from 2017 onwards is 28% lower than the emission factor used in preparing this baseline Inventory. If there were similar electricity consumption in the Inventory Area in 2017, this reduced emission factor would result in a decline of 76,000 tCO_2e from the original 2014 baseline.

The rate of decline of carbon in grid electricity is expected to slow down in the coming years at a time that the rate of decarbonising the UK's electricity supply stalls – a consequence of new nuclear power stations coming onstream more slowly than originally expected. With the electricity conversion factor based on historical (previous two years') fuel mix, this electricity generation transition will potentially slow in the future.

There is a growing degree of renewable energy production in the Inventory Area, generating electricity that feeds into the national grid and helps to reduce the overall UK electricity emission factor. The following table illustrates the disproportionate amount of renewable energy per capita being produced in the Inventory Area – just over 18 times more than for the UK as a whole. This demonstrates that the area is significantly contributing to the UK's transition towards a reduced emission intensity for grid supplied electricity.

Table 31 – Renewable Energy Generated per Capita, Inverness Inventory Area and the UK

	Electricity Generated GWh	Population	kWh Per Capita
Inverness Inventory Area	1,436	79,728	18,011
UK	64,398	64,610,000	997

Chapter 6 – Greening Health Care

Healthcare has a responsibility to contribute towards reducing operational emissions and also a requirement to adapt service delivery to meet the new challenges emerging from a changing climate.

Climate change has been identified as 'the biggest global health threat of the 21st century[63] , and is considered to be a "threat multiplier," amplifying pre-existing health problems and inequities. Without urgent action to reduce greenhouse gas emissions, disease patterns will change, the frequency of extreme weather events will increase, and demand for clinical services will rise across all social groups, both locally and globally.

In their 2016 report, the Joseph Rowntree Foundation[64] identified the following climate change impacts on health and wellbeing in the UK:

- **Heat**: In August 2003, over 2,000 people died in the UK because of an intense period of heat. Summers as hot as 2003 could be considered 'normal' by 2050. By this time, the effect of rising mean temperatures in the UK is projected to increase heat-related deaths from the current level of 2,000 to 7,000 per year.

- **UV radiation and skin cancer**: Around 2,000 people die from melanoma each year in the UK. Climate projections for the UK point to an increase in UV radiation.

- **Disease**: While it is hard to quantify future changes resulting from climate change, it is likely that the activity of many ticks and mosquitoes will increase, and new pathogens could potentially be introduced to the UK.

- **Flooding**: As flooding increases with a changing climate, the number of deaths from flooding could increase. The effects of flooding on mental health and wellbeing are thought to be significant. The 2007 floods in the UK, led to a two to five fold increase in mental health symptoms.

- **Air quality**: Between six and nine million people currently suffer from chronic respiratory conditions that make them sensitive to poor air quality. Population growth and ageing are likely to increase this number. As average temperatures rise, the concentration of ground level ozone and air pollution is also expected to rise. This has been linked to increased premature death from heart disease, strokes, pulmonary disease, respiratory disease and lung cancer.

The report also identified some of the possible health benefits of climate change and mitigation measures.

- **Energy efficient homes**: Domestic energy is responsible for more than a quarter of energy use and emissions in the UK. Homes that are well insulated and ventilated can be more energy efficient, with a lower carbon footprint, while providing a healthier living environment and reducing fuel bills.

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[63] Breaking the Fever; Sustainability and climate change in the NHS, Royal College of Physicians 2017
[64] Public health in a changing climate, Joseph Roundtree Foundation, 2016

- **Active travel:** Transport accounts for 28% of greenhouse gas emissions in Scotland. Road transport is the most significant source of emissions in this sector. Promoting more active forms of travel, including walking and cycling, holds not only the potential to reduce emissions, but also to promote health.

- **Green space:** Access to green space is associated with high levels of physical activity and lower levels of obesity. Moreover, the increased levels of physical activity associated with green space also have mental health benefits.

- **Sustainable food system and diet:** Buying food that is grown locally helps to reduce emissions from transportation. Making minor changes to diet by cutting down on meat consumption can also reap both climate and health benefits.

- **Renewable energy:** The current energy mix has a profound impact on human health. As well as exacerbating climate change, fossil fuels are already causing poor health through air pollution. Reducing reliance on carbon intensive forms of energy will contribute to a healthier population and a reduction in emissions.

As this list acknowledges, current climate risks and future climate change are likely to have wide-ranging and varied impacts for the delivery of health services. Many hospital and care homes are already at risk of overheating; with the Adaptation Sub-Committee's most recent progress report[65] identifying that the types of hospital ward that are vulnerable to overheating currently make up 90% of the total stock across the UK. In addition, during the summer heatwave of 2003, the majority of additional deaths in England were within care homes[66].

6.1. Health Care in the Highlands

NHS Highland is one of the fourteen regions of NHS Scotland, and the largest Health Board in terms of geographic area, covering an area of 32,500 km² from Kintyre in the south-west to Caithness in the north-east. The Board serves a population of 320,000 people.

In the Inverness GHG Inventory Area there are a range of healthcare facilities. The region’s main hospital in Inverness is complemented by local medical practices, the management of which is evolving. This is creating opportunities for individual medical practices to progress their own carbon reduction activity, which in turn has implications for procurement and emissions “ownership” and subsequent reporting.

As identified in Chapter 4, there is a statutory responsibility for public bodies to reduce operational greenhouse gas emissions. NHS Highland has developed a suite of programmes and initiatives – including a Property Asset Management Strategy and a 10-year Operational Implementation Plan to help improve the energy efficiency of the estate and reduce reliance on fossil fuels and their subsequent

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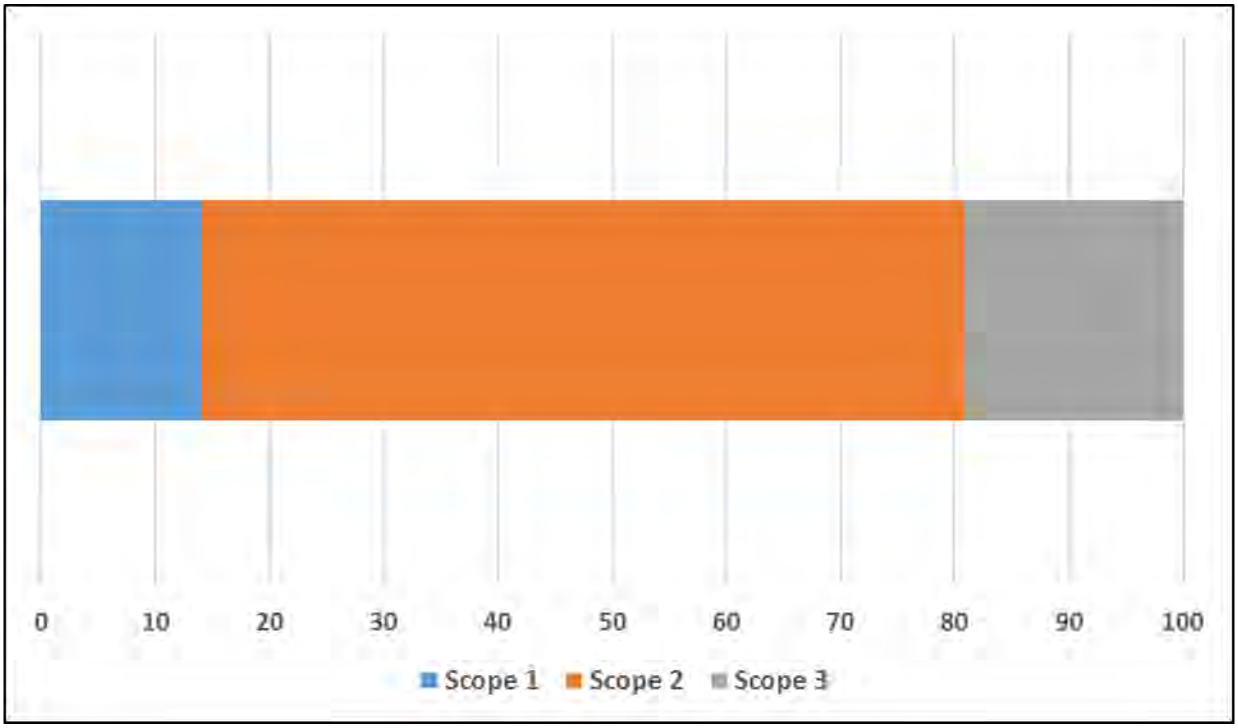
[65] Committee for Climate Change (2014) Managing climate risks to well-being and the economy: ASC progress report 2014
[66] NHS England (2014) Heatwave Plan for England: Supporting Vulnerable People Before and During a Heatwave - Advice for Care Home Managers and Staff

emissions. The installation of twenty biomass heating systems is an example of the implementation of these strategies and plans.

6.2 Operational Emissions

The following chart illustrates the sources of the different emissions generated by NHS Highland in 2014.

Figure 24 – Distribution of Greenhouse Gas Emissions in NHS Highland Estate, 2014



Scope 1 emissions arise from staff related travel and the provision of onsite space and water heating. The installation of biomass heating systems is an example of the steps being taken to reduce Scope 1 emissions. In the past, onsite incinerations (see Scope 3 emissions text) could produce local steam for distribution around the hospital estate, and the reduction of incineration has almost eliminated this associated heat resource.

Scope 2 emissions arise from the use of electricity and purchased heat and steam in various premises. Large healthcare facilities have a constant demand for electricity and heat. While there can be some localised scope to use onsite solar PV to produce renewable low carbon electricity, it is likely that establishments will have a high consumption of grid electricity for the immediate future. There is scope to install more energy efficient equipment, however, for example LED lighting refits. Such improvements are being facilitated through the NHS Highland's Property Asset Management Strategy.

Scope 3 emissions primarily result from the disposal of waste. In the past, it was common for healthcare facilities to operate their own incinerators to dispose of waste. These facilities could also produce steam/heat which would then provide space heating throughout the hospital estate. Changing attitudes to waste, how it can be reduced, recycled and reused, as well as concerns about operational efficiency and incinerator emissions, has resulted in the closure of virtually all onsite hospital incinerators. This has resulted in the transport of waste offsite to specialised treatment facilities located elsewhere in Scotland or the north of England.

6.3 Adapting to the Impacts of Climate Change

NHS Boards have a legal requirement to prepare for climate change, with specific duties set out in Part 4 of the Climate Change (Scotland) Act. These specify requirements to contribute to the delivery of the Act's emissions reduction targets and deliver statutory adaptation programmes in a sustainable way.

To help meet requirements and identify how healthcare will evolve in response to climate change, NHS Highland has undertaken several strands of activity. At a site-specific level, 22 flood risk assessments have been completed. These identify how particular healthcare properties will be at risk form changing precipitation that is already a physical manifestation of climate change in the area.

Further analysis has been supported in specific Climate Change Impact Assessments[67] for the organisation's estate. These have identified some of the climate related opportunities and threats that will affect healthcare in the coming years. Climate change-related opportunities will include:

- Potential for reduced winter-related illness and deaths, although as colder weather becomes less frequent, there is a risk that impacts will increase due to lack of preparedness.
- More outdoor sports and activity to reduce overweight/obesity and increase physical and mental well-being.
- Increase of green areas, which can increase a patient's mental well-being.

Future climate threats include:

- Increased risk of morbidity and mortality from extreme weather events.
- Drier summers interspersed with heavy rain and likely to increase risk of raw water contamination, especially in private water supplies (PWS).
- The Highlands has the highest incidence of Lyme Disease in the country, and with climate change, ticks that carry Lyme Disease have become increasingly widespread and may increase further.
- Heavy rain and flooding reduces mental health, including injuries and deaths.
- Flooding increases self-reported illnesses, particularly relating to skin, respiratory and gastro-intestinal conditions[68].

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[67] Climate Change Impact Assessment for the NHS Estate, October 2015
[68] The Highland Council. http://www.highland.gov.uk/downloads/file/3584/adapting_to_climate_change

- Toxic algal blooms could threaten public health, particularly if they occur at a time when there are increased water sports.

- Increasing exposure to injury – increased need for mountain rescue teams (increase in summer hillwalking).

- Growing proportion of older people and therefore increased patient demand for health and social care services.

- Very hot weather and heatwaves leading to associated illnesses and worsening of pre-existing illnesses, especially cardiovascular and respiratory illnesses.

- Warming climates increase the likelihood of vector-borne diseases, mosquito-borne diseases, tropical diseases and pandemics.

- Lack of public awareness about these threats.

To help address these threats and capitalise on emerging opportunities, the following might be considered:

Table 32 – Climate Change-related Opportunities for Healthcare

Opportunity	Themed Activity
Awareness and Training – developing an awareness programme to ensure that managers and staff are aware of the key climate risks now and in the future.	- Raise awareness of Lyme Disease - Raise awareness of the importance of testing and treating private water supplies - Increase road safety awareness - Use information from Scottish Mountain Rescue to promote safety in the outdoor environment - Raise awareness of climate change and extreme weather events within vulnerable communities, approaching adaptation through community adaptation planning
Partnership Working – working with the Local Resilience Partnership and stakeholders to consider climate change impacts, awareness and potential actions for areas that affect the NHS, but are outside of its control	- How transport infrastructure could be affected and impact on patient and staff travel and access - How affected transport corridors could create difficulties for the healthcare supply chain in the area - How disruption to transport and power supplies could affect more rural properties where there is a need for regular face to face support or medical equipment is operating
Flood Risk Management – determining which local areas are most vulnerable to flooding/surface water and creating or updating an emergency response strategy and flood risk management plan and strategy.	- Review asset flood maps and determine next steps (e.g. comparisons with future on-site developments, discussions with wider stakeholders, discussions with estate teams, procurement of detailed flood risk assessments). - Asset management planning
New and Existing Buildings – during new developments or renovations, considering how the planning, design and building of facilities should incorporate innovative and sustainable solutions to adapt to climate change.	- Sustainable drainage - Passive cooling – orientation, ventilation and vegetation - Greywater harvesting. - Install resilience measures
Supply Chain – considering how supply chains could be affected by severe weather risk	- Identify contingency plan should key providers be affected.
Transport Strategy/Action Plan	- Build consideration of climate risks into broad Travel Strategy/Action Plan.

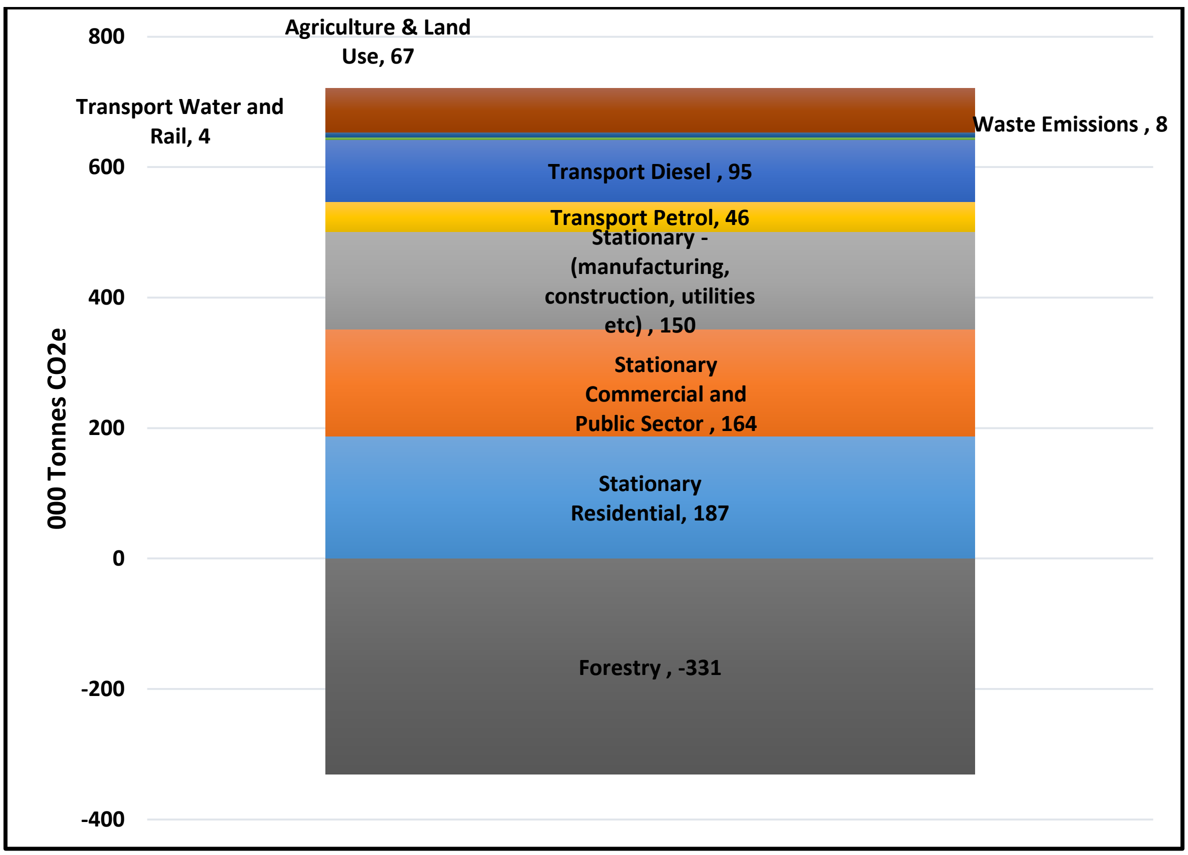
Chapter 7 – Findings and Recommendations

The primary objective of this report was to produce a transparently calculated and disaggregated baseline of GHG emissions for the Inverness area for 2014. This would provide a comprehensive and disaggregated measure of GHG emissions – identifying key emission sources for reduction, setting priorities for mitigation, and providing a baseline for tracking progress on emission reduction policy initiatives. Our analysis has been guided by the international protocol on Global Protocol for Community-Scale Greenhouse Gas Emission Inventories.

The total emissions for the Inverness GHG Inventory area in 2014 have been calculated at 721,161 tCO_2e, and the counterbalancing sequestration of carbon in the Inventory Area's forestry plantations at 331,416 tCO_2e. This has the potential of reducing the Inventory Area's net emissions to 389,745 tCO_2e, which is equivalent to 4.88 tCO_2e per resident.

The following chart illustrates the contribution made by different GHG emission producers in the Inventory area.

Figure 25 – Distribution of Emissions in the Inverness GHG Inventory area in 2014



Stationary residential energy use is the largest contributor to the Inventory Area's overall GHG emissions. The consumption of gas and heating oil and electricity for space and water heating and to power appliances are the main sources of residential emissions. In the coming years, there will be sustained investment across Scotland to help reduce residential energy use and emissions. There will be scope for Highlands Council to apply for this funding and to develop local projects. There will also be sustained support to help the commercial and public sectors to reduce their emissions.

Transport throughout the Inventory Area was responsible for the production of 140,642tCO_2e. Road transport is a significant source of transport emissions. Analysis for this report only focused on the emissions arising for journeys being undertaken in the Inventory Area. Figures would have been higher if fuel sales in the Inventory Area for travel elsewhere in the Highlands had been included. Unfortunately, it was not possible to access figures for air travel from the airport located in the east of the Inventory Area. While emissions for air travel in Scotland have grown in recent years, this growth has occurred at a significantly slower rate than the growth in the number of passengers flying. This is the type of reduction in carbon intensity reduction that is required for sectors to become more carbon efficient.

The use of fuel in water transport; leisure on Loch Ness and pilot boats guiding the transport of freight moving into and from Inverness harbour generated a very small volume of GHG emissions; 801 tCO2e. Current Scottish Government proposals are to work with port authorities to identify the potential costs and benefits of cold ironing (the use of shore power by ships whilst in harbour) and other low emission measures to ship owners and operators.

Waste emissions are shown for landfill and composting. These emissions are declining across Scotland, a consequence of increased levels of recycling and the diversion of organic waste from landfill. This report has included an estimate of the emissions arising from the treatment of waste water, sewage etc generated in the Inventory area and treated at a major facility to the east of Inverness. Emissions from solid and liquid waste treatment from the Inventory area were 8,190 tCO_2e. This is an item rarely recorded in small area GHG Inventory analysis. Scottish Water would be interested in contributing to any future reviews of the waste water emissions in this Inverness Inventory Area.

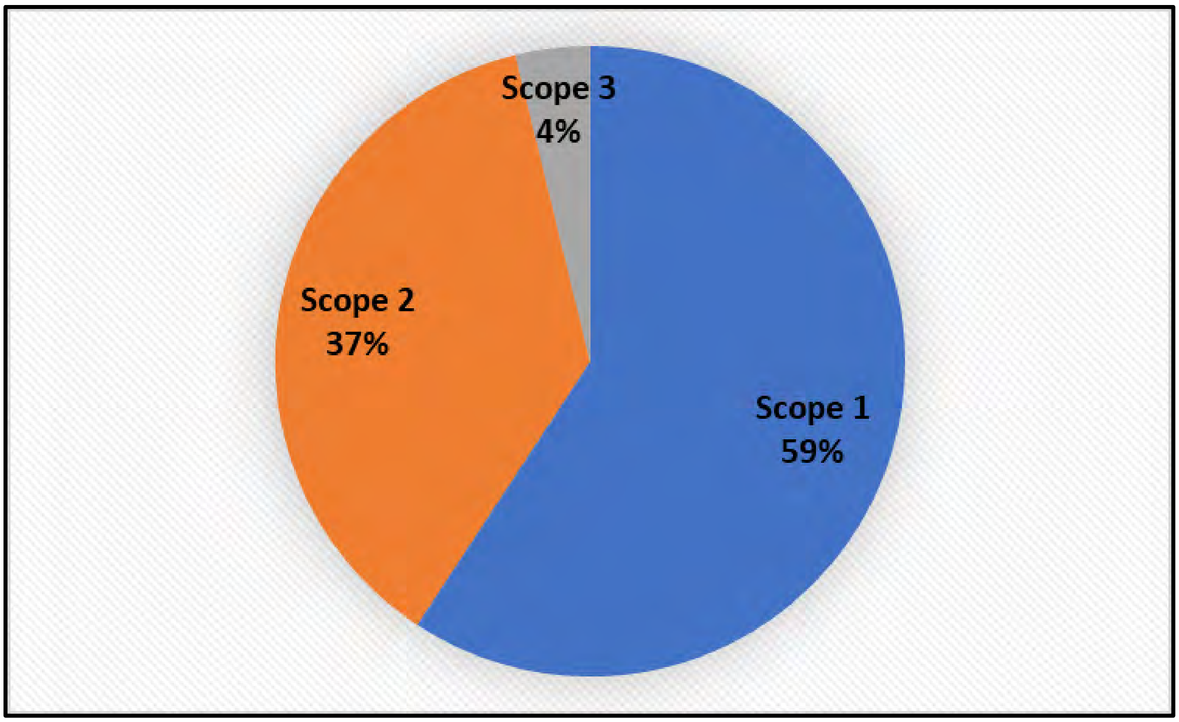
Land use emissions in the area were 67,180 tCO_2e. A key aspect of this land use analysis was the role of forestry and peatland in absorbing and storing carbon. This woodland carbon sink was responsible for the storage of 331,416 tCO_2e.

There is a growing portfolio of renewable electricity production; hydro and wind turbines located in the Inventory Area. In 2014, it was estimated 1,464,000,000 kWh were produced by this technology.

The following figure illustrates the Scope of emissions. Scope 1 emissions arise from the use of fossil fuels in the Inventory area. As a result, they are often referred to as “territorial emissions”. Scope 2 emissions are a consequence of the consumption of grid supplied electricity. It is worth noting that between 2014 and 2017, the conversion factor for grid electricity declined from 0.49kgCO_2e/kWh to 0.35kgCO_2e/kWh. Should electricity consumption remain the same in the Inventory Area in 2017, this reduced mains electricity emission factor would have the impact of reducing scope 2 emissions by 76,087 tonnes CO_2e. Scope 3 emissions are arising predominately because of transmission losses and disposal of waste in landfill, outside the Inventory area. These emissions would be significantly higher if a broader approach had been taken to collect data for transboundary transport emissions.

Another important aspect of GHG accounting is the assessment of emissions based on consumption, sometimes known as end-user emissions, taking account of the emissions embodied in the extraction, manufacturing, transport and distribution of goods consumed but not produced in an area. In recognition of the importance of this approach, the Scottish Government issued a report Scotland's Carbon Footprint 1998-2013, carried out an by Prof Barrett at Leeds University
http://www.gov.scot/Topics/Statistics/Browse/Environment/Publications/carbonfootprint9813.
This work is based on environmental extension of economic input-output tables and provides a valuable addition to understanding. It is likely to be particularly significant in an area like Inverness where much of our food, clothing and other goods are imported.

Figure 27 Emission Scopes for the Inverness GHG Inventory Area 2014



7.1 Recommendations

Highland Council, in response to the (Scotland) Climate Change Act 2009 in addition to setting the ambitious goal of reducing its own emissions by 3% a year, has taken the initiative to set aspirations for the wider community and to work towards a carbon neutral Inverness in a low carbon Highland. The achievement of this goal would mean the reduction or offsetting the remaining 389,745 tCO2e identified in this report (after the allowance for forestry sequestration) for Inverness and taking forward a discussion about what level of emissions would constitute a low carbon Highland.

The achievement of this wider ambition is not simply within the powers of the Council but will require the actions of a wide group of stakeholders. With the 2009 Act there is a legal requirement for public bodies to actively pursue emissions reduction and to act in a way considered sustainable and considerable work has been developed by many organisations in this context. In this context Highland

Council has signed Scotland's Climate Change Declaration and promoted its uptake within other organisations. New Carbon reporting was introduced for main public-sector organisations in 2016. In the private-sector there have been innovative voluntary efforts backed up by the CRC Energy Efficiency scheme which began in 2008 and driven reduction for large energy users with fines payable if targets are not met. In the voluntary sector, the Highland Environmental Network links the activities of third sector groups working on environmental issues and SCVO and Voluntary Action Scotland across Highland provide links with those active in other social sectors.

The following final paragraphs identify some specific recommendations for Highland Council that have been informed by both the experience of preparing this GHG Inventory report as well as the key themes and development opportunities identified in both the draft Scottish Climate Change Plan and Energy Strategy.

7.1.1 Stationary Energy

The residential sector covers all housing in the Inventory Area. Emissions in this sector are primarily linked to the amount of energy used by appliances and how homes are heated. Space heating and the provision of hot water typically account for over 75% of domestic energy consumption. Future national policy interventions will be primarily targeted at reducing the rate of heat loss from buildings and the adoption of low carbon heating including the electrification of heating.

The Scottish Government has committed to continue funding to help improve the thermal performance of residential buildings, targeting the greatest levels of support at those most exposed to high levels of domestic heating and energy use; – older occupants who spend more time each day in their home, young families which also spend more hours during the day at home.

Key recommendations for Highland Council to continue the declining trend of residential emissions in the Inverness Inventory Area will reflect the Scottish Government priorities and funding. These include;

- Ensuring there is a rolling programme of potential initiatives and pilot projects that could tap into the national funding being made available for energy efficiency improvement.
- Consider how the organisation can liaise with other agencies and initiatives to capitalise on the greater energy awareness that will arise from the UK Government commitment to offer smart meters to every household and business by 2020 UK.
- Consider how the organisation can continue to support developments to access the District Heating Loan Fund which provides low interest loans to help address the financial and technical barriers to district heating projects. This will be an increasing opportunity where there are groups of houses being built off the gas grid.
- Consider opportunities/projects that would be pertinent for support through the Heat Network Partnership. This is a collaboration of agencies focused on the promotion and support of district heating schemes in Scotland.

7.1.2 Industry, Commerce and Non Domestic Buildings

Scotland's industrial sector has already delivered substantial emissions reduction. There will be scope to make further decarbonisation in the coming years. Specific recommendations for Highland Council to help the industrial sector to continue emission reductions include;

- Ensure the Business Gateway service is familiar with the policy rationale for and mechanisms to help businesses reduce GHG emissions
- The non-domestic Renewable Heat Incentive which ends 2020/21 has been a valuable source of support for businesses in off gas grid areas to engage with biomass and renewable heating. There is scope for the organisation, to collaborate with other local authorities and the Scottish Government on the development of a successor programme to the RHI. This will continue support for a low carbon form of heating that is an alternative on off gas grid areas.
- Advice and support will be provided to Scottish industry to help organisations reduce their energy use etc. There may be opportunities for Highland Council to liaise with relevant organisations, for example Resource Efficient Scotland to ensure any businesses in its industrial, office and retail properties is aware of and able to access advice and pertinent support.
- Monitor the Scottish Government's production of the SEEP (Scotland's Energy Efficiency Programme) Route Map in 2018. This will be a major area of activity to reduce GHG emissions and will be supported with £500 million funding over the first four years of the programme.
- Ensure all tenants in Highland Council small and medium sized non-domestic premises are aware of the programme of smart meter roll out and ensure meters are fitted to appropriate properties by 2020

7.1.3 Transportation

The largest contributor to Scottish transport emissions is the road sector. Emissions from maritime transport have also been declining. Rail emissions have followed a generally rising trend over the period 1990 to 2014. Aviation emissions have also grown by 38% over the period 1990 – 2014. However this coincided with a growth in passenger numbers of 134%.

The most significant transport reduction interventions that Highland Council can be involved with are road transport related and include;

- Liaising with the Scottish Government to evaluate the scope for incentivising more rapid uptake of electric and ultra-low emission cars and vans, as through public procurement policies and preferential local incentives (such as access management and parking policies).
- If appropriate in the Inverness and wider highlands, liaise with the Scottish Government to evaluate the scope for urban-wide low emission zones with a specific focus on CO_2 emissions, as well as air pollution more generally.
- Continue engagement with ChargePlace Scotland to maximise the opportunity for enhancing the EV charging network in the area.
- Engage with the area's taxi firms to determine the interest in and potential uptake of ultra low emission vehicles.

- Monitor the introduction of statutory requirements for the provision of EV charging points/wiring in new residential and commercial developments.

7.1.4 Waste

This sector has witnessed the largest percentage fall in Scottish emissions between 1990 and 2014, a result of the progressive introduction of landfill gas being captured and used for energy and the reduction in biodegradable municipal waste going to landfill.

Specific opportunities for future waste emission reduction activity or Highland Council include;

- Sustain and improve current waste reduction, recycling and landfill diversion facilities.
- Ending landfilling of biodegradable municipal waste by 2020 and reducing all waste sent to landfill to 5% by 2025.
- Sustain and increase the collection of food waste in the area.

7.1.4 Land Use and Land Use Change

This study has shown that agriculture in the Inverness district is highly varied, that forestry has provided a highly valuable sink and that peatland could be an emissions source as significant as agriculture.

- Review the MACC assessment done for the Committee on Climate Change by SRUC[69] which listed 24 potential mitigation measures to reduce emission in agriculture.
- Liaise with the FC and private woodland owners and other private landowners about future planting options and their impact on emission mitigation.
- Develop understanding of peatland carbon storage and the ways in which it is threatened.

Highland Council could ensure that the results from this GHG Inventory are made available to planners and to the Highland Land Use Strategy. Key areas for Highland are the carbon storage in forestry and peatland. These are both areas of ongoing research and UHI could be at the forefront of this work. Links could be forged with research groups in SNH, FR, CEH and university departments including SRUC and James Hutton Institute.

To help take forward these policy interventions, programmes etc, a small group should be established composed of Highland Council and the main agencies active on environmental issues to oversee progress. This GHG Inventory should be used as the basis for a series of meetings on emissions and mitigation in the different sectors identified with participation from the relevant groups for each area. For instance in the case of transport stakeholders would include HIE who commissioned a study of

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[69] Eory, V., MacLeod, M., Topp, C.F.E., Rees, R.M., Webb, J., McVittie, A., Wall, E., Borthwick, F., Watson, C., Waterhouse, A., Wiltshire, J., Bell, H., Moran, D., 2015, Review and update the UK agriculture MACC to assess the abatement potential for the 5th carbon budget period and to 2050, Report to the Committee on Climate Change, SRUC and Ricardo-AEA

emissions in the transport sector in 2008[70], HITRANS who nearly a decade later have just commissioned work to help facilitate more uptake of electric vehicles, community councils, community environmental groups, electric car retailers and electric car owners. For stationary emissions, the Council itself, along with other public bodies, now has considerable experience in developing innovative programmes to help reduce energy consumption, comprehensively measuring and reporting on results. Individual businesses, especially SMEs are able to tap into support from for example Resource Efficient Scotland to reduce emissions.

In the case of wastewater where emission allocation and identification are more technical, consultation would be appropriate with Scottish Water, local contractors such as Veolia and electricity companies. In the case of agriculture and land use, it would be useful to examine all land uses and all mitigation options in an integrated way bringing together farmers, landowners, foresters, game hunters, conservationists, walkers and other recreational users of land and local communities. All these meetings should take place within a specified period (October 2017 – March 2018) to determine what actions could be taken to achieve a carbon neutral Inverness by 2025 and how the inventory could be improved, shared and extended.

Discussion should take place with UHI to develop expertise in Highland on the topics which are of particular importance locally i.e. peatland emissions and sequestration, the extent of and damage to peatland and its causes and possible solutions, conservation of peatland in good health, measures of soil carbon and changes experienced with different kinds of land use.

[70] Hill, N, Wagner, A, Graham, G, Li, Y, 2008, Transport Carbon Emissions in the Highlands and islands, AEA Energy and Environment, Oxford

Appendix 1 – Energy Consumption by Sector in the Inverness GHG Inventory Area.

As there were no specific sectoral energy use figures from official sources for the Inventory Area, the following methodology was used to provide sector energy use estimates.

Phase 1

Limited data are available at local authority level for non-domestic, non-transport energy use, and the figures below were estimated via survey collected figures on local/site specific consumption.

Non-Domestic Electricity Sales

	All non-domestic (GWh)	All non-domestic (TOE)
Highland	904	77,744

Source: BEIS - Sub-national electricity sales and numbers of customers 2005-2015. TOE is tonnes of oil equivalent

Non-Domestic Gas Sales

	All non-domestic (GWh)	All non-domestic (TOE)
Highland	605	52,029

Source: BEIS - Sub-national gas sales and numbers of customers 2005-2015

Non-gas, Non-electricity and Non-road Transport Fuel Use

		Highland (TOE)
Petroleum	Industrial	33,054
	Public Administration	3,252
	Commercial	1,212
	Agriculture	24,464
Coal	Industrial & Commercial	10,790
Manufactured Solid Fuels	Industrial	22
All Fuels		**72,794**

Source: BEIS - Energy consumption: sub-national estimates of non-gas, non-electricity and non-road transport

These figures provide a useful total of energy use for the Highland Council area in 2014; 203,000 tonnes of oil equivalent. However these figures are not disaggregated in a manner that enables further analysis.

A more detailed breakdown of energy use by sector is available at the UK level. The sectors and matching 2007 SIC codes are:

Sector	2007 SIC Codes
Agriculture, forestry & fishing	01,02,03
Mining, quarrying	05-09
Manufacturing	10-32
Construction	41-43
Utilities	35, 36, 37
Commercial	45-47, 52,53,55-56, 58-63, 64-66, 68, 69-75, 77-82, 90-99
Public Administration	84-88

Dividing the total energy use by sector by the total employees per sector gives the following energy use per employee in the UK[71].

Energy Use by Type per Employee by Industry

	Agriculture, forestry & fishing	Mining, quarrying	Manufacturing	Construction	Utilities	Commercial	Public Administration
Coal	-	-	1.3	0.0	-	0.0	0.0
Manufactured fuel	-	-	1.1	-	-	-	-
Natural gas	0.3	-	3.3	0.3	0.1	0.3	0.4
Electricity	1.5	2.3	3.4	0.1	1.7	0.4	0.2
Heat sold	-	0.3	-	-	-	0.0	0.0
Bioenergy and Waste	1.3	1.7	-	-	-	0.0	0.0
Petroleum	1.4	2.4	-	-	-	0.1	0.0
LPG	-	-	0.0	-	-	-	-
Gas oil	-	-	0.2	0.1	0.0	-	-
Fuel oil	-	-	0.1	0.0	-	-	-
Burning oil	-	-	0.0	-	-	-	-
Total	**4.5**	**6.7**	**9.5**	**0.5**	**1.9**	**0.8**	**0.7**

[71] For GB, employee numbers were taken from the Business Register and Employment Survey, and for Northern Ireland from the Quarterly Employment Survey

As a sense check, we applied these energy use by employee figures to the total number of employees by industry in Highland (excluding proprietors and the self-employed):

Energy Use (in tonnes of oil equivalent)

	Agriculture, forestry & fishing	Mining, quarrying	Manufacturing	Construction	Utilities	Commercial	Public Admin	TOE
Coal	-	-	8,974	27	-	27	76	9,104
Manufactured fuel	-	-	7,456	-	-	-	-	7,456
Natural gas	528	-	22,677	1,790	113	16,013	14,630	55,751
Electricity	2,288	1,220	22,941	586	1,847	20,503	7,321	56,705
Heat sold	-	151	-	-	-	37	1,766	1,954
Petroleum	2,153	1,235	11,865	-	-	2,804	1,538	19,595
LPG	-	-	10	-	-	-	-	10
Gas oil	-	-	1,527	788	52	-	-	2,367
Fuel oil	-	-	769	28	-	-	-	796
Burning oil	-	-	77	-	-	-	-	77
Total	4,968	2,605	76,297	3,219	2,012	39,384	25,332	153,816

The total energy use (154 thousand tonnes of oil equivalent) above is less than the figure obtained using Method 1 (203 thousand tonnes of oil equivalent). This is mainly due to discrepancies in petroleum and electricity, as discussed below.

- **Petroleum**
  61,982 in Method 1
  19,595 in Method 2 – giving 42,387 of difference

  Method 2 does not seem to have worked well for petroleum, significantly underestimating industrial use and use in agriculture. We adjusted these figures to account for this difference.

- **Electricity**
  77,744 in Method 1
  56,705 in Method 2 – giving 21,039 of difference

  These figures tell us that non-domestic electricity use in Highland is 27.1% higher per head than non-domestic electricity use in the UK. Given the colder temperatures and lack of critical mass in Highland, it seems reasonable to assume that this may be the case, and therefore have adjusted the Method 2 figures up by 27.1% to account for this.

If the adjustments suggested above were made to the previous table, the results for Highland would be as highlighted in the following table.

	Agriculture, forestry & fishing	Mining, quarrying	Manufacturing	Construction	Utilities	Commercial	Public Admin	TOE
Coal	-	-	8,974	27	-	27	76	9,104
Manufactured fuel	-	-	7,456	-	-	-	-	7,456
Natural gas	528	-	22,677	1,790	113	16,013	14,630	55,751
Electricity	3,137	1,672	31,453	803	2,532	28,110	10,038	77,744
Heat sold	-	151	-	-	-	37	1,766	1,954
Petroleum	24,464	1,235	31,819	-	-	2,804	1,538	61,860
LPG	-	-	10	-	-	-	-	10
Gas oil	-	-	1,527	788	52	-	-	2,367
Fuel oil	-	-	769	28	-	-	-	796
Burning oil	-	-	77	-	-	-	-	77
Total	28,128	3,058	104,763	3,436	2,697	46,991	28,048	217,121

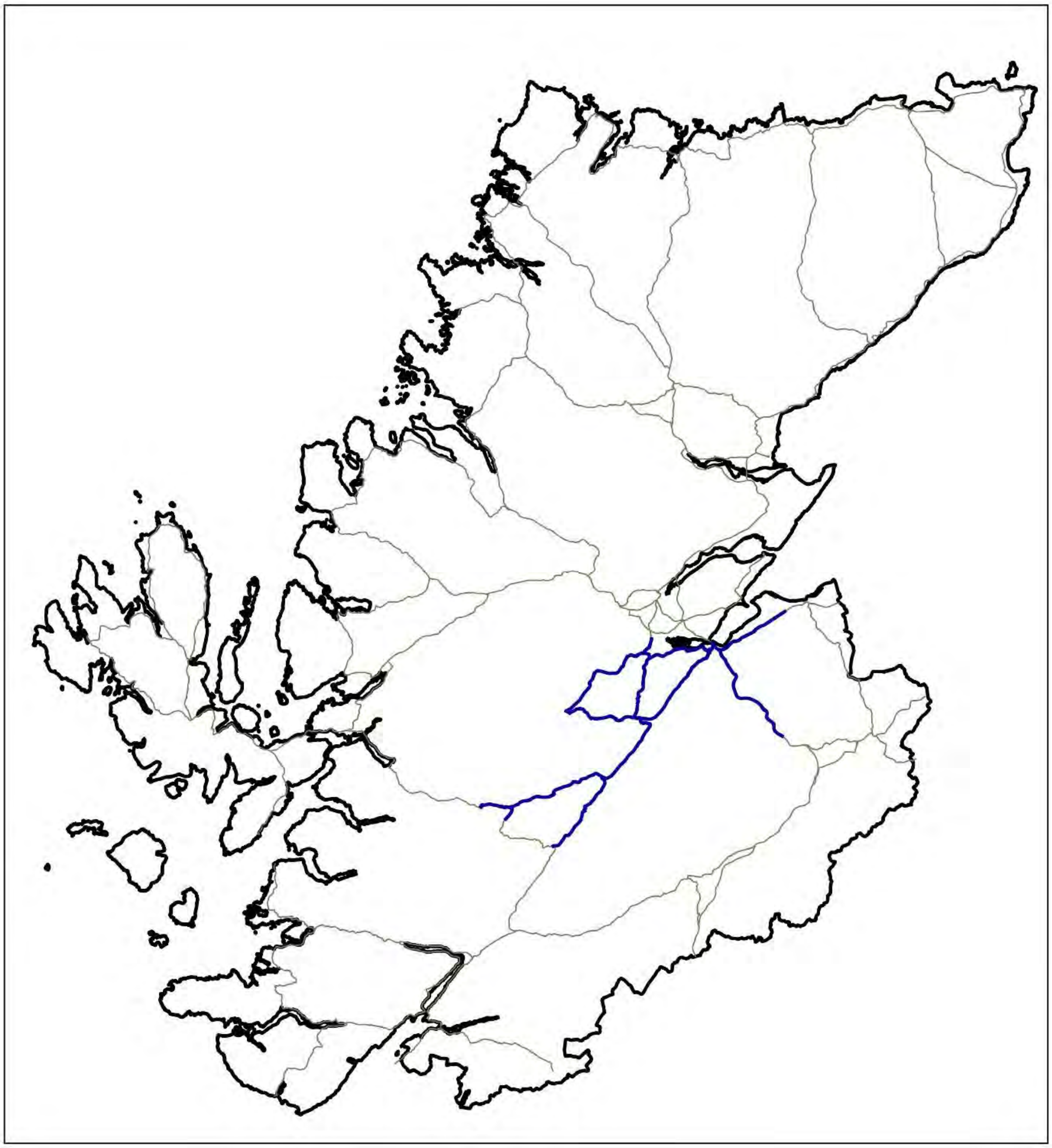
The difference in the two methods is now about 7%, and is considered to be within an acceptable margin.

Having estimated total figures for Highland, it was then possible to establish energy use by employee in different sectors in Highland, which could then be applied to employees in the study area. The following table gives energy use in tonnes of oil equivalent by sector in the Inventory area:

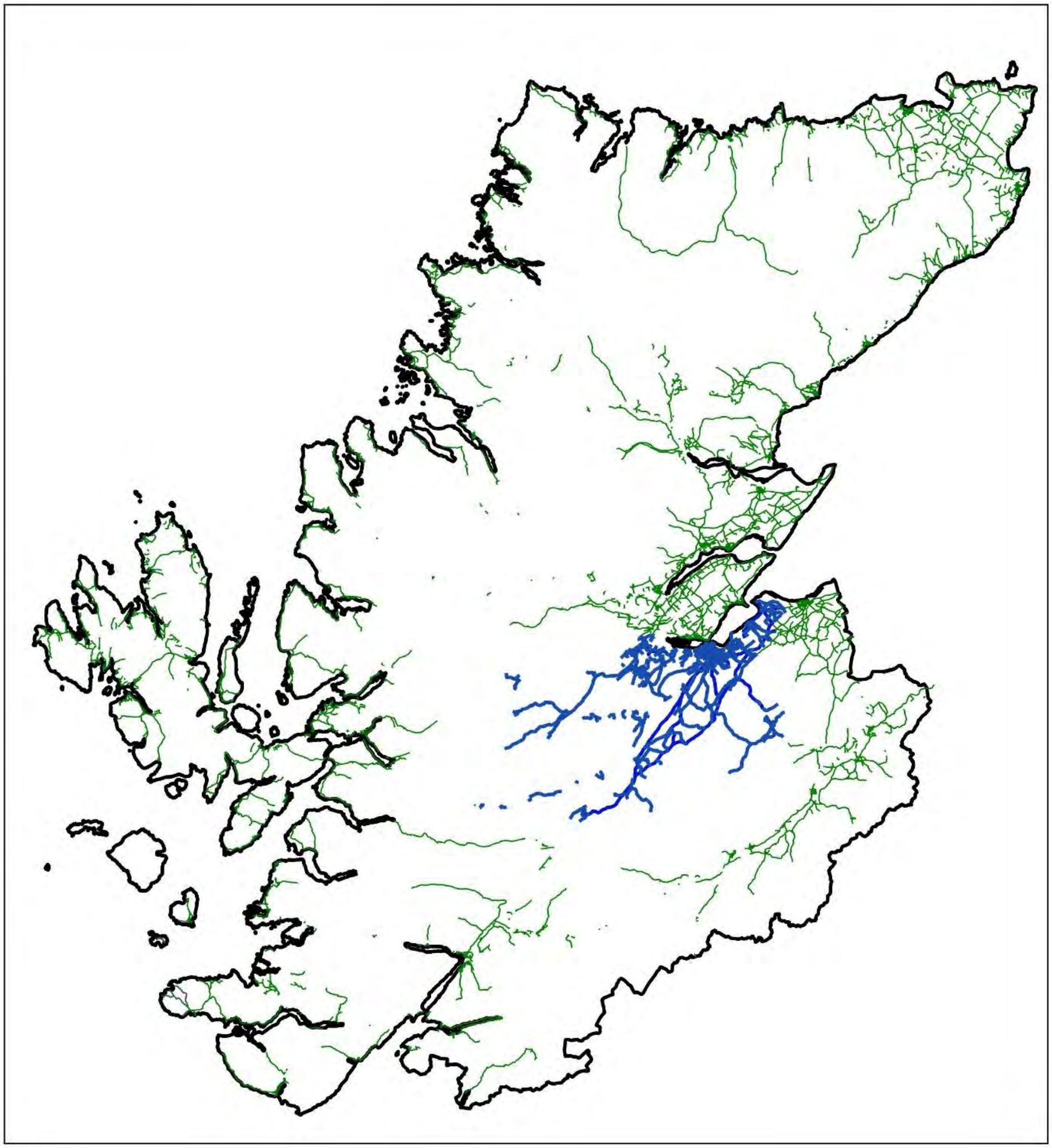
	Agriculture, forestry & fishing	Mining, quarrying	Manufacturing	Construction	Utilities	Commercial	Public Admin	TOE
Coal	-	-	2,619	10	-	13	38	2,680
Manufactured fuel	-	-	2,176	-	-	-	-	2,176
Natural gas	61	-	6,618	702	78	7,689	7,315	22,463
Electricity	364	637	9,179	315	1,743	13,498	5,019	30,755
Heat sold	-	57	-	-	-	18	883	958
Petroleum	2,841	470	9,285	-	-	1,346	769	14,712
LPG	-	-	3	-	-	-	-	3
Gas oil	-	-	445	309	36	-	-	790
Fuel oil	-	-	224	11	-	-	-	235
Burning oil	-	-	23	-	-	-	-	23
Total	3,266	1,165	30,572	1,347	1,857	22,565	14,024	74,796

Appendix 2 – Roads and Counting Points in Highland and the Inventory Area

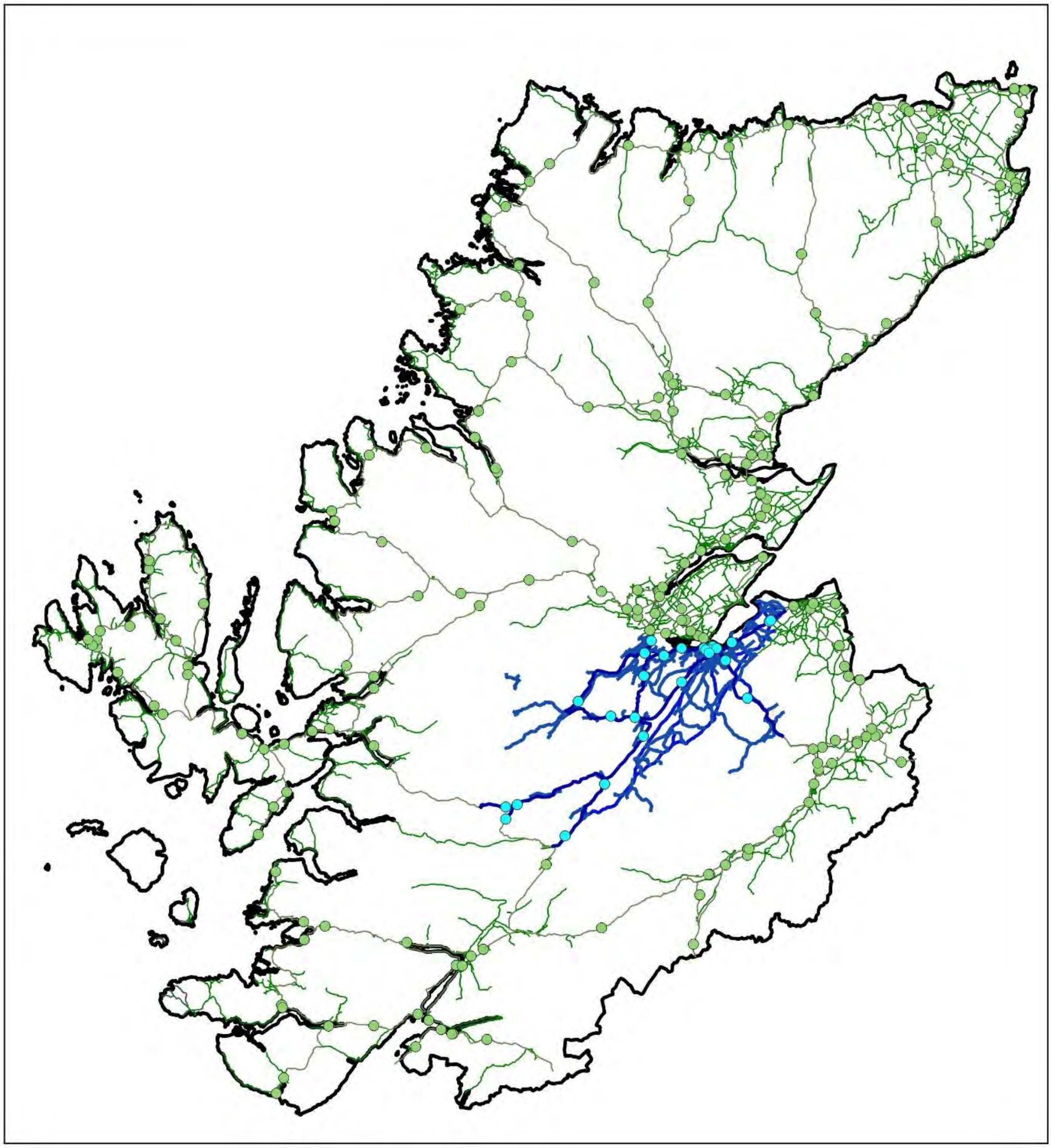
Map 1. A Roads in Highland and the Inventory Area



Map 2. Minor Roads in Highland and the Inventory Area



Map 3. All A Roads and Minor Roads and Traffic Counts in Highland



Map 4. All A Roads and Minor Roads and Traffic Counts in the Inventory area