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Environmental Standards Scotland

Baseline Evidence Review – Climate Change

(Strategy and Analysis)

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Contents

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Version	Author	Purpose	Date
1.0	ESS	Baseline evidence review of public sources accessed up to August 2022.	30/09/2002

Executive summary

This baseline evidence review provides a high level summary of key published information about the current position, recent trends and performance and progress towards relevant targets and standards in the area of climate change in Scotland.

Background

A series of rapid reviews of key evidence sources were undertaken to support the identification of environmental issues of most concern, where Environmental Standards Scotland (ESS) proposes to focus its initial analytical work.

Eight reviews were produced, covering the environmental categories of air; biodiversity and ecosystem resilience; climate change; cross-cutting environmental governance; land and soil; population, human health and cultural heritage; resource use and waste; and water.

These categories are primarily intended to help Environmental Standards Scotland organise, manage and prioritise its work and are based on those used in the Strategic Environmental Assessment and the Environmental Impact Assessment processes. Considering the evidence within each category provides a structure for our assessment.

There will be overlaps amongst these categories and to minimise duplication, topics have been covered under what was considered to be the most relevant category. For example, we have considered the issue of impacts of climate change to ecosystems in the ‘Biodiversity and Ecosystem Resilience’ review.

Rapid reviews were undertaken in each topic area, with a narrow scope of identifying key data sources and summarising what they tell us about how the environment is changing in Scotland. The focus was on National or Official Statistics and Annual Reports and their related data, mainly from Government and other national organisations, to obtain a high-level summary of current environmental conditions and to ensure confidence in the quality of the information.

The approach started with the data, considering whether Scotland is on track to achieve its current environmental targets and objectives. The reviews are not intended to be

detailed explorations of individual issues e.g. specific policies to meet broad targets. Similarly, they are not intended to provide exhaustive lists of relevant legislation.

If a topic is not included, it is because it is covered in another review or relevant published data was not found within the scope of our review at this point. However, the topic will still form part of ongoing horizon scanning activity and could be explored in the future with relevant organisations.

Future stages of analysis will consider whether performance trends relate to any issues of compliance with, or effectiveness of, environmental legislation and scrutinise the detail underpinning trends identified.

Our monitoring and analysis work will progress through a series of stages. This will include horizon scanning to identify high-level areas of concern, through to a deepening analysis and understanding of how things are changing, the causes of this, and how policy and regulatory decisions affect this.

All of the monitoring and analysis work will be focused on identifying areas where further investigation or use of ESS' powers may be necessary, then supporting active investigations, and assessing whether the changes that have been made in response to our recommendations or use of powers are having the desired impact.

As the analytical priorities are taken forward, it is likely that some will quickly be identified as not having any compliance or effectiveness issues that merit further analysis or investigation at this stage. These can then be returned to horizon scanning in case an issue arises in the future, and a new issue can be added to the list of those subject to more detailed analysis.

The list of analysis priorities is expected to be dynamic and regularly updated. The evidence reviews, however, are a snapshot in time as of August 2022 and there is no plan for these to be updated on a regular basis.

Summary of key baseline evidence review findings

Greenhouse gas emissions

Using the Climate Change Committee (CCC)'s recommended reporting method, Scotland has met the 2020 greenhouse gas (GHG) emissions reduction target of a 56% reduction from the 1990 baseline. Since 1990, decreases in greenhouse gas emissions have been driven by improvements in the energy supply sector. Domestic transport is now reported as the largest source of GHG emissions in Scotland.

This should be interpreted with caution given that Scotland missed the 2019 target and the COVID-19 pandemic is likely at least partly responsible for the large decrease in emissions seen between 2019 and 2020. Therefore, further monitoring of emissions will be needed to determine whether the reductions seen between 2019 and 2020 are sustained during the recovery from the COVID-19 pandemic.

The Climate Change Plan set targets for the emissions intensity of residential buildings and from the industrial and services sectors to reduce by 30% on their 2015 baselines by 2032. There has been some progress in reducing emissions intensity in the services sector and slower progress in the residential sector. However, emissions intensity in industry has increased since 2015.

Overall, global emissions are increasing and so Scotland may be seen as performing relatively well as emissions are decreasing. Similar trends are also seen at a UK level, but Scotland may be performing better than the rest of the UK due to the decarbonisation of the energy sector.

Energy use

Although energy use itself is not necessarily an environmental condition factor, the ways in which we use energy and the sources it comes from have important environmental implications e.g. in terms of reducing emissions. Scotland met its target to reduce total final energy consumption by 12% by 2020, seven years early.

The majority of energy is consumed by the 'industrial, commercial and other' sector, and used for heat. There has been progress against the target for the energy intensity of

residential buildings. However, there has been limited progress in improving energy productivity in the services sector.

COVID may have impacted on progress towards the target to increase energy productivity across the Scottish economy by 30% by 2030 from a 2015 baseline. In 2020, energy productivity was lower than 2015 levels though this is likely to have been affected by the impact of COVID on the economy.

Further work will be needed to reduce reliance on non-renewable heating sources to meet emission reduction targets.

Energy sources

In terms of the sources of the energy consumed in Scotland, petroleum was the fuel type responsible for the largest share, followed by electricity. There has been an increase in the percentage of energy that Scotland uses that is from renewable sources, however the target for 30% by 2020 was missed. Further work will be needed to meet the 50% target for 2030.

Of the electricity that Scotland consumed in 2021, 84.5% came from low carbon sources, with over half from renewable sources. Scotland only very narrowly missed its 2020 target to generate the equivalent of 100% of Scotland's own electricity demand from renewable sources. This is a largely positive result, however renewable generation decreased slightly in 2021.

The target for the percentage of Scotland's heat demand met by renewable sources was also missed. Nonetheless, there are positive trends, with the capacity of renewable electricity generation experiencing large increases and the share of electricity generation from low carbon sources is increasing.

It remains the case that the majority of energy Scotland produces is from oil and gas sources, and the amount produced increased between 2019 and 2020. The majority of energy produced in Scotland is also exported. This shows that while Scotland is seen to be performing relatively well on the amount of renewable energy produced and consumed, Scotland still contributes a large amount to fossil fuel production. Similar trends are seen in other countries. It should be noted that Scotland is reported to have a

higher percentage of consumption of electricity from low carbon and renewable sources than England and Wales.

Energy efficiency

There have been improvements in the energy efficiency ratings of domestic buildings. However, more work will be needed to meet the target of all housing being rated as equivalent to EPC C or better by 2033 where technically and legally feasible and cost effective. The Scottish Government's Climate Change Plan Monitoring currently assesses this target as 'too early to say'.

Of the homes owned by social landlords, 89% met the Energy Efficiency Standard for Social Housing in 2020/21 missing the target of 100%. Nonetheless, this is much better than owner occupied homes where only 41% were at EPC C and private rented homes where 40% were at EPC C in 2019. In the non-domestic sector, only 13.5% of buildings have an EPC rating of C or above.

There have been increases over time in the measures implemented to improve energy efficiency in homes such as installing insulation and boilers. Similar trends have been seen in England, including the trend of better energy efficiency for social housing compared to private housing.

Therefore, while Scotland's energy efficiency and decarbonisation policies are regarded as ambitious, it is likely that more work is needed to reach the goals.

Climate change mitigation

Scotland's climate change mitigation plans, including the Net Zero by 2045 target, are regarded as ambitious, and there has been some progress in implementing policies to expand mitigation efforts. Despite this, further work is required to ensure policies are implemented effectively to deliver emission reduction ambitions.

In addition, while reductions in GHG emissions in Scotland have historically been from the energy supply sector, Scotland will likely now have to find opportunities in other sectors. Some potential areas for further exploration are nature-based solutions.

Similar conclusions can be made about the UK, with it being ranked seventh of all countries on climate change performance but the CCC's recent assessment stating that current plans will not deliver Net Zero by 2050 without further development.

Climate change adaptation

Despite some positive findings that Scotland's adaptation to climate change programme is making progress, the most recent assessment by the Climate Change Committee states that progress has stalled.

A similar picture is seen elsewhere. For example, in the EU, where there has been progress in implementing actions in some areas, but more is needed. According to the CCC, England still has a particularly long way to go in implementing climate change adaptation processes.

Impact of climate change on the natural environment / people and the built environment

Climate change is already impacting people and the environment both in Scotland and worldwide. In Scotland, for example, temperature rises and changes in rainfall patterns will affect most aspects of the environment and people's lives such as through increased flooding and changes in species distribution.

These impacts are very likely to increase and intensify over time, however the extent of the impact will be dictated by global progress in reducing greenhouse gas emissions. It is important to note that the impact of climate change on people will be unequal, with vulnerable people most likely to be affected and least able to adapt.

Scotland appears to be performing comparatively with the other countries in the UK in terms of the number of climate risks that require action. However, in all countries the CCC assesses that around half of the issues identified will require more action, which suggests a large amount of action will be required.

Conclusions for initial ESS analytical priorities

This baseline review identified a wide range of possible issues for further analysis, including missed targets for emissions, progress towards energy efficiency targets, further analysis of energy sources and stalling of progress on adaptation.

However, for the purposes of our initial analytical priorities, ESS will focus on:

- Progress against greenhouse gas emission targets.
- Progress on climate change adaptation, including planning for extreme weather events.

ESS' proposed Strategic Plan describes how issues will be prioritised for further analysis according to a range of criteria, including:

- Importance – the size and risk of the potential effect on the environment and/or public health; the urgency with which improvement is required;
- Nature and Scope – recent trends in environmental performance; whether the issue of concern appears to be systematic and/or longstanding;
- Neglect – whether there has been action taken on the issue of concern, or further action is planned in the near future; and
- Added-value – the contribution we could make, considering whether other monitoring, oversight or scrutiny bodies are planning to take, or could take, action to address the issue of concern.

These priorities in the area of climate change account of that scheme. They recognise the importance of reducing emissions and adapting to climate change for their cross-cutting influence in many environmental and social areas such as for agriculture, biodiversity and human health. They also consider the missed targets on emissions and stalled progress on adaptation. In keeping with the prioritisation process, the contributions of other actors and the added value that ESS can bring to an area will also be considered, in deciding where to focus future work.

Although ESS intends to focus on two issues in the first instance, other issues will be retained on a list for potential future analysis and horizon scanning in line with the stages of monitoring and analysis work set out in the strategic plan.

Climate Change Baseline Evidence Review

1. Introduction

In April 2019, Scotland's First Minister acknowledged that we are facing a global climate emergency[1]. In May of that year, the UK Parliament was then the first in the world to pass a motion declaring an 'environment and climate emergency'.[2]

There are a variety of legislation and policies relevant to climate change. The Climate Change (Scotland) Act 2009[3] is a key piece of overarching legislation. It is an Act of the Scottish Parliament which set targets for the reduction of greenhouse gas emissions. The Act set a target for Scotland to reach net zero emissions by 2050, an interim target for the year 2020 and required Scottish Ministers to set annual targets according to specified criteria.

The Act also confers powers to Ministers to impose climate change duties on public bodies and to make further provisions about the mitigation of and adaptation to climate change, such as on energy efficiency and the reduction and recycling of waste.

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019[4] is an Act of the Scottish Parliament to amend the Climate Change (Scotland) Act 2009. Amongst its changes is to bring the net zero target date forward to 2045, setting interim targets for 2020, 2030 and 2040, revising annual emissions reduction targets and making provision about advice, plans and reports in relation to those targets. The objective of the legislation is for Scotland to contribute appropriately to the world's efforts to deliver on the Paris Agreement reached at the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change.

The Climate Change Plan sets out Scotland's approach to tackling climate change, including setting targets for a range of sectors. It was first published in 2018 and was updated in 2020[5].

2. Methodology

A rapid review of key evidence sources has informed this report. This has focussed on scanning across the topic area, identifying key data sources and summarising what they tell us about how the environment is changing in Scotland and whether environmental targets and objectives are on track to be achieved.

The scope of the work was deliberately narrow and was intended to provide a snapshot of the evidence rather than a fully comprehensive picture. Where ESS' initial assessment of the evidence has identified potential concerns or issues that warrant further scrutiny, more detailed monitoring and analysis will be considered.

The work focused on published analytical reports and datasets, searching for relevant evidence by:

- using the terms: 'greenhouse gas emissions', 'energy use', 'energy sources', 'energy efficiency', 'climate change mitigation', 'climate change adaptation', 'impact of climate change on the natural environment', 'impact of climate change on people and the built environment'.
- where necessary these terms were combined with 'Scotland', 'UK' or 'International' to search for comparisons with other countries.

These terms were derived from ESS' environmental categories and sub-categories. Specific searches of key organisations' websites were also undertaken, based on knowledge and understanding of those active in the area. For climate change, this focussed on Scottish Government, the Climate Change Committee and NatureScot. There is some subjectivity in the choice of terms and organisations which may have an impact and were somewhat mitigated by consulting with key stakeholders on sources.

The focus of the reviews was on National or Official Statistics and Annual Reports and their related data, mainly from Government and other national organisations, to obtain a high-level summary of current environmental conditions with a tight scope which allowed the reviews to be completed in time to inform strategic plan development.

Only publicly available information was considered. Individual research reports or grey literature on specific, detailed areas of the topic were not within scope.

Evidence of issues relating to compliance with or effectiveness of environmental legislation was also not the focus at this stage. It is envisaged that this will form part of future analysis activity on priority analytical areas.

The approach started with the data, considering whether Scotland is on track to achieve its current environmental targets and objectives in this area. They are not intended to be detailed explorations of individual issues. Similarly, they are not intended to provide exhaustive lists of relevant legislation.

Baseline evidence reviews have been undertaken in each of the ESS Environmental Categories and there are naturally some topics which could fall across a number of reviews. For example, we have considered the issue of impacts of climate change to ecosystems in the ‘Biodiversity and Ecosystem Resilience’ review.

If a topic is not included, it is because it is covered in another review or no relevant published data was found within scope. However, the topic is likely to still form part of future horizon scanning activity and could be explored in the future with relevant organisations.

Initial drafts of the evidence reviews were shared with the ESS Board and with key identified analytical stakeholders to provide proportionate check that no key sources had been missed and no information had been misinterpreted. Going forward into more detailed analytical projects and undertaking further horizon scanning, ESS expects to engage a wide range of experts, including academics and specialist organisations.

3. Baseline evidence for environmental areas

Greenhouse gas emission

Greenhouse gases (GHG) are a group of gases contributing to global warming and climate change.

The Kyoto Protocol, an environmental agreement adopted by many of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 to curb climate change, covers seven GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

These are often converted to carbon dioxide equivalents to compare them and determine their individual and total contributions to climate change[6].

Overall emissions

Scotland's Climate Change (Emissions Reduction Targets) (Scotland) Act 2019[4] set a target to achieve net-zero emissions of GHGs by 2045, meaning emissions would be 100% lower than the baseline. It also set out interim targets that emissions would be at least 56% lower than the baseline by 2020, 75% lower by 2030 and 90% lower by 2040. The baseline year is 1990 for carbon dioxide, methane and nitrous oxide and 1995 for hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride[7].

The most recent statistics published in June 2022 showed that there had been a 51% reduction in greenhouse gas source emissions between 1990 and 2020, with 40.0 million tonnes of carbon dioxide equivalent (MtCO2e) from the basket of seven greenhouse gases emitted in 2020[7]. Source emissions data can be used to compare with other countries.

In 2017 the Climate Change Committee (CCC) recommended[8] that, due to international obligations to change greenhouse gas emission reporting to include new sources of emissions, Scotland should use a new method of reporting to assess progress against targets. It recommended that this should apply from the June 2020 statistical publication (relating to 2018 data) onwards. This is known as the GHG account[7] and it will limit the

effect of the new international obligations on reporting against targets. Under the GHG account method of reporting, emissions reduced by 58.7% between 1990 and 2020, meeting the target of 56.0%[7]

While the meeting of the 2020 target is positive, the success should be interpreted with caution. The CCC's 2021 report on Scotland's progress in reducing GHG emissions predicted that there would be a drop in GHG emissions in 2020 due to the COVID-19 pandemic[9]. Indeed, there was a 12.0% reduction in GHG emissions between 2019 and 2020[7], a much larger difference than has been recorded between previous consecutive years. For example, between 2018 and 2019 there was a 2.3% decrease. Furthermore, the target for 2019 of a 55% reduction in GHG emissions on baseline levels was missed by a significant margin at 51.5%[9,10]. The targets for 2017 and 2018 were also missed by a large margin[9].

The CCC also predict that there will be some rebound in GHG emissions levels in 2021 and 2022, which may lead to missed targets. However it is expected that some reductions will be sustained, for example due to increased homeworking[9]. Therefore, analysis of the GHG emissions in 2021 and 2022 will be needed to determine whether the drop in GHG emissions and meeting of GHG emissions targets seen in 2020 will be sustained.

Emissions by sector

Summary overall

In 2020, Domestic transport (excluding International Aviation and Shipping) (9.5 MtCO2e) was the largest source of net emissions[a], followed by Business (7.8 MtCO2e), Agriculture (7.4 MtCO2e), Residential (6.0 MtCO2e) and Energy Supply (5.3 MtCO2e)[7].

[a] For each sector, there will be an equilibrium whereby some GHGs are emitted and some are removed. Therefore, when referring to emissions by sector, these will be net emissions. Negative emissions are net sinks.

Carbon dioxide was the main greenhouse gas emitted from most sectors except Agriculture, Waste Management, and Land Use, Land Use Change and Forestry (LULUCF) where methane was the main net gas emitted[7].

Between 2019 and 2020, the main sectors contributing to the decrease in GHG emissions overall were Domestic Transport (-2.5 MtCO2e), International Aviation and Shipping (-1.1 MtCO2e), and Energy Supply (-0.8 MtCO2e). All other sectors saw decreases in GHG emissions except Residential, which had a 0.1 MtCO2e increase.

As with the overall emission figures, caution should be exercised when interpreting the data on changes between 2019 and 2020 sources of GHG emissions due to the effects of the COVID-19 pandemic. Indeed, while there have been relatively large reductions in domestic transport emissions and international aviation and shipping between 2019 and 2020[7], these were thought to be some of the biggest sectors slowing the reduction in GHG emissions in 2019[9]. As a result, analysis of the 2021 and 2022 GHG emissions will be needed to determine whether these reductions have been sustained.

To get a better understanding of the trends in GHG emissions by sector, the trends since 1990 were explored. The energy supply sector was historically the largest contributor to GHG emissions but has experienced large decreases since 1990 and is now the fifth largest contributor. Domestic transport has been the sector with the highest level of emissions since 2016 when it overtook the energy supply sector. Emissions from business, agriculture and residential have also now overtaken the energy supply sector in terms of their total GHG emissions[7].

Reductions in emissions from energy supply have made the largest contribution to reductions in Scotland's GHG emissions since 1990. Further information can be found in the Energy Sources section of this review.

Between 1990 and 2020, the most significant contributors to the overall reduction in GHG emissions were:

- a 75.2% reduction (16.1 MtCO2e) in Energy Supply emissions (such as power stations);

- a 91.8% (5.6 MtCO2e) reduction in emissions from LULUCF (due to methodological changes these are now classified as a net sink of emissions between 2011-2014, but was a net emitter in other years[8]);
- a 39.1% (5.0 MtCO2e) reduction in Business emissions; and
- a 76.9% (4.5 MtCO2e) reduction in Waste Management emissions[7].

Agriculture and land use

The agriculture sector has seen a 1.3 MtCO2e (14.9%) decrease in net emissions between 1990 and 2020. Between 2019 and 2020 there was a decrease of 0.2 MtCO2e (2.9%)[7].

Under the Kyoto Protocol, countries must report emissions by sources and removals by sinks of CO_2 and other GHGs from LULUCF, including from related activities such as forestry[11]. LULUCF was a net source of emissions in Scotland in 2020, emitting 0.5 MtCO2e, a decrease from 6.1 MtCO2e in 1990, but an increase from 2011-2014 when LULUCF were a net-sink of GHG emissions[7].

In 2020, the CCC produced an in-depth report advising the UK on how agricultural and land use policies should be used to meet net zero targets[12]. The report concluded that a transformation of land use is needed across the UK. For example, it suggest that the UK needs to increase tree planting, encourage low-carbon faming, restore peatlands, encourage bioenergy crops, reduce food waste and reduce the consumption of carbon-intensive foods[12]. However, it does note that different measures will be needed in different countries of the UK. For example, it suggests that in Scotland, there should be a high proportion of expenditure on forestry and peatland restoration (with high benefit-cost ratios), but a lower proportion of expenditure on hedgerows compared to other countries[12].

In 2021, the Scottish Government published its third land use strategy which it hopes will help Scotland meet its climate change targets through sustainable land use[12,b].

[b] More detail can be found in the Land and Soil baseline evidence review

Agricultural policy is currently being reformed in Scotland after the EU exit and the CCC have noted that it is crucial that the replacement for the Common Agricultural Policy and the Agriculture Bill in 2023 provides a framework to deliver climate mitigation and adaptation as well as wider environmental objectives[9].

ClimateXChange, a research centre, commissioned a rapid evidence assessment to explore the factors behind adoption of climate-friendly farming practices. This found that personal, institutional, farm characteristics and sociodemographic factors influenced adoption of climate friendly farming practices. It is likely that policies to encourage climate friendly agriculture will need to account for these factors[13].

Business and industrial processes

The business sector saw a 5.0 MtCO2e (39.1 per cent) decrease in emissions between 1990 and 2020, with over two fifths of the reduction occurring in the period to 1995 (2.2 MtCO2e reduction). The GHG reporting suggests that this is 'linked to a decline in emissions from manufacturing and the iron and steel industry over this time period'. There was then a smaller decrease between 2008 and 2009 (1.1 MtCO2e decrease), coinciding with the recession. Between 2019 and 2020 emissions were stable[7].

Emissions from industrial processes have seen a 1.5 MtCO2e (78.4 per cent) decrease from 1990 to 2020. However, the emissions have been relatively stable in recent years, with most of the decrease in this sector between 1990 and 1995, being associated with decreased emissions in the nitric acid production industry and processes associated with the iron and steel industry[7].

Energy

Further information on energy use, sources and efficiency can be found in later sections. While the energy supply sector has historically been a large source of GHG emissions, there has been progress in reducing emissions in recent years.

Electricity emissions - GHG emissions associated with electricity generation have fallen 88.5%, from a high of 19.7 MtCO2e to 1.7 MtCO2e in 2020. The proportion of total energy related (electricity, heat, industry and transport) emissions coming from electricity generation has also fallen greatly, from 24.7% in 2000 to 4.2% in 2020[14].

Displaced emissions - In 2019, energy from renewable sources displaced approximately 13.5 MtCO2e assuming that the same amount of electricity would have been generated by fossil fuels, equivalent to 28% of Scotland total GHG emissions for that year.

Between 2000 and 2019 energy from renewable sources displaced approximately 151 million tonnes of CO2 across the system in Great Britain[14].

Electricity grid intensity – The Climate Change Plan[5] set a target that electrical grid intensity would stay below 50 grams of carbon dioxide equivalent per kilowatt hour ($gCO2e\ kWh^{-1}$) by 2020. This target was reached in 2017.

In 2019, each kilowatt hour of electricity generated in Scotland added an estimated 40.9 grams of carbon dioxide into the atmosphere ($gCO2e\ kWh^{-1}$), a large decrease from 319.4 $gCO2e\ kWh^{-1}$ in 2010[14]. The decrease was driven by an increase in low carbon renewable energy generation and the closure of Scotland's last coal power stations. However, there has been an increase in grid intensity since 2017 due to a rise in the use of gas to generate electricity as a result of a fall in nuclear generation.

All emissions associated with energy – While the sections above discussed emissions associated with electricity generation, in 2020 the equivalent of 74.3% of Scotland's total greenhouse gas emissions are associated with energy (at any stage of the energy cycle and including Transport, Industry and Heat). This is similar to the 74.6% share in 1990 although overall emissions and energy-related emissions have reduced.[14]

Public sector

The main source of emissions from the Public sector is the use of natural gas for heating public buildings. There has been a 1.0 MtCO2e (51.4 per cent) fall in emissions from public sector buildings between 1990 and 2020. However, emissions over the last few years have been relatively stable, with a value of 0.9-1.0 MtCO2e between 2014 and 2020.[7]

Under the Climate Change (Duties of Public Bodies: Reporting Requirements) (Scotland) Order 2015[15] public sector bodies must report annually against their duties to

contribute to the delivery of the Net Zero target and Scotland's adaptation programme, and how they are acting sustainably.

Sustainable Scotland Network collates these reports. In the 2020-21 analysis report[16], it is stated that emissions and energy consumption from the public sector are decreasing. Specifically, for the reporting period 2020/2021, emissions from heating, transport and electricity decreased by 5.8% since the last reporting period and by 32.6% since mandatory reporting began for 2015/16[16]

Residential

Emissions from the residential sector largely come from direct fuel combustion in households. These emissions have decreased by 25.5% between 1990 and 2020, largely due to a switch away from using less efficient solid and liquid fuels to natural gas for heating, and improvements in energy efficiency. However, residential emissions increased very slightly between 2019 and 2020 from 5.9 MtCO2e to 6.0 MtCO2e (1.4% increase). This marginal increase was possibly driven by more people working from home during the COVID-19 lockdown despite a relatively warmer latter part of 2020 compared to 2019[7]

Further information on the climate impact of the residential sector can be found in the energy use and efficiency sections.

Transport

Domestic transport has consistently made up a large proportion of Scotland's emissions, and was the largest sector in 2020. However, between 2019 and 2020, there was a larger reduction than in previous years associated with the COVID-19 behavioural restrictions[7].

Emissions from international aviation and shipping have decreased by 0.5 MtCO2e (38.7%) between 1990 and 2020. Between 2019 and 2020 there was a substantial decrease of 1.1 MtCO2e (57.7%), largely due to the COVID-19 lockdown.

In isolation, international aviation emissions reduced by 67.7% between 2019 and 2020 with international shipping reducing by 15.5%[7].

Emissions intensity

The Climate Change Plan[5] set a target for the emissions intensity[c] of residential buildings (MWh per hour) to fall by 30% from 2015 levels by 2032. It also set a target for emissions intensity from the industrial and services sectors to reduce by 30% on a 2015 baseline by 2032.

Between 2015 and 2019 emissions intensity in the residential sector decreased by just 1.1% to 2.49 tons of carbon dioxide per household a year[14].

In 2018, industrial emissions intensity increased by 2.9% from 2015, suggesting that the situation is getting worse, rather than improving. However, this represents a 4.4% decrease from 2017[14].

In 2018, emissions intensity from the services sector decreased by 7.2% since 2015, due to a drop in emissions and an increase in gross value added (GVA) in this sector[14].

Nitrogen balance sheet

On 15 December 2021, the Scottish Government set out legislative proposals for establishing an economy and environment wide Scottish Nitrogen Balance Sheet (SNBS) and the Climate Change (Nitrogen Balance Sheet) (Scotland) Regulations 2022 came into force on 11 March 2022[17]. These require the balance sheet to be regularly updated.

Nitrous oxide, a form of reactive nitrogen, is a GHG. Therefore, the production of the SNBS will contribute to tackling climate change because it will help track the flow of nitrogen in Scotland and identify opportunities to improve efficiency[18].

The first SNBS was published in 2021 and showed that nitrogen flows in Scotland are highly complex. Much of the reactive nitrogen that enters the system (e.g. from fertiliser use) is recycled within it and then forms a useful output (e.g. via food) or is lost to the

[c] Emissions intensity is defined as average emissions per household for Residential and as sectoral emissions divided by gross value added for the industrial and services sectors.

environment (e.g. emissions to air). In addition, of all nitrous oxide emissions, the majority come from agriculture[19].

Other forms of reactive nitrogen can be emitted to the atmosphere in the form of nitrogen dioxide and other oxides, primarily from transport, and in the form of ammonia, primarily from agriculture.[19] These are primarily of air quality concern so covered in the Baseline Evidence Review on Air.

International comparisons

The UK Government has released preliminary statistics for GHG emissions for 2021[20]. This suggest that in 2021, total UK territorial greenhouse gas emissions were 424.5 MtCO2e, 4.7% higher than 2020, yet 5.2% lower than 2019, which the report states reflects the impacts of the imposing and lifting of COVID-19 restrictions on emissions. The emissions were 47.3% lower than the 1990 baseline.

The statistics report states that the increase in emissions between 2020 and 2021 was driven by all sectors, but particularly transport[20]. The 2021 figures for Scotland are yet to be released, however historically there has been a high correlation between the UK and Scotland emissions statistics and so it is likely that the emissions for Scotland will follow a similar pattern[9].

As well as the reports produced for Scotland, the CCC also produce assessments of the UK government's progress in reducing emissions. The CCC's 2022 progress report to parliament[2121] stated that the UK's GHG emissions, including the UK's share of international aviation and shipping emissions, were 447 MtCO2e in 2021[d]. This was a 47% decrease since 1990, a 10% decrease from 2019 but a 4% increase from 2020, likely due to rebounds from the COVID-19 pandemic.

The rebound mostly occurred in surface transport, electricity generation and manufacturing where emissions have increased from 2020. Emissions in 2021 were still

[d] This figure is higher than the 424.5 MtCO2e figure reported by the UK Government above as the CCC figure includes the UK's share of international aviation and shipping emissions. Progress-in-reducing-emissions-2022-Report-to-Parliament.pdf (theccc.org.uk)`

affected by pandemic restrictions, especially in the aviation sector where emissions were down 60% on 2019 levels. The CCC note that the long-term impact of pandemic restrictions on GHG emissions is unclear[21].

Through the Sixth Carbon Budget, UK has set a target to achieve net-zero emissions by 2050, corresponding to a 63% reduction in emissions from 2019 to 2035 (78% relative to 1990)[22]. In its 2022 assessment, the CCC state that while there has been progress in reducing emissions and developing a Net Zero strategy, over a third of Government plans cannot be relied on to deliver the necessary emissions reductions, meaning that the current strategy will not deliver Net Zero by 2050.

For example, the CCC highlights that progress on delivery is lacking, and policy gaps remain in key areas such as energy efficiency (e.g. insulation of homes) and agriculture/land use, and areas with potential to deliver great savings across sectors[21]. This was a similar message to that in the 2021 report[23].

In 2021, the CCC stated that Scotland has decarbonized faster than the UK average, likely due to the speed and scale of power sector decarbonisation[23]. However, it notes that in future, actions will need to move away from the power sector and that there is therefore an opportunity for Scotland to exceed UK Government action in other areas such as agriculture, tree planting, waste management, buildings efficiency and public transport[23].

The Intergovernmental Panel on Climate Change (IPCC) published a summary of the global efforts for mitigation of climate change in 2022[24]. The report states that the total net anthropogenic GHG emissions have continued to rise between 2010 and 2019. Average annual GHG emissions during 2010–2019 were higher than in any previous decade, but the rate of growth was lower than that between 2000 and 2009[24]. Global net anthropogenic GHG emissions were 59 ± 6.6 GtCO2e in 2019. This is about 12% (6.5 GtCO2e) higher than in 2010 and 54% (21 GtCO2e) higher than in 1990.

In terms of the sectors implicated, the IPCC states that net anthropogenic GHG emissions have increased since 2010 across all major sectors globally. Emissions reductions in CO_2 from fossil fuels and industrial processes, due to improvements in energy intensity of GDP and carbon intensity of energy, have been less than emissions

increases from rising global activity levels in industry, energy supply, transport, agriculture and buildings. An increasing share of emissions can be attributed to urban areas.

In 2019, approximately 34% (20 GtCO2e) of total net anthropogenic GHG emissions were from the energy supply sector, 24% (14 GtCO2e) from industry, 22% (13 GtCO2e) from agriculture, forestry and other land use (AFOLU), 15% (8.7 GtCO2e) from transport and 6% (3.3 GtCO2e) from buildings[24].

The IPCC state that GHG emission trends vary widely between global regions. For example, least developed countries and small island developing states have much lower per capita emissions than the global average.

Scotland was mentioned by the IPCC[24] in relation to agricultural sustainability policies and the Climate Change Act.[24]

Summary

Using the CCC's recommended reporting method, Scotland has met the 2020 greenhouse gas emissions reduction target of a 56% reduction from the 1990 baseline. However, this should be interpreted with caution given that Scotland missed the previous three targets for GHG emissions (for 2017, 2018 and 2019).

The COVID-19 pandemic is likely at least partly responsible for the large decrease in emissions seen between 2019 and 2020. It is expected that the lifting of restrictions and the recovery from the pandemic will increase emissions and may make meeting future targets more difficult. Further monitoring of emissions will be needed to determine whether the reductions seen between 2019 and 2020 are sustained during the recovery from the COVID-19 pandemic.

Since 1990, decreases in greenhouse gas emissions have been driven by improvements in the energy supply sector though capacity for further improvement here may be limited. Domestic transport is now the largest source of GHG emissions in Scotland. The transport, buildings and agriculture and land use sectors have been identified as areas where future reduction efforts are likely to be needed.

The Climate Change Plan set targets for the emissions intensity of residential buildings and from the industrial and services sectors to reduce by 30% on their 2015 baselines by 2032. There has been some progress in reducing emissions intensity in the services sector and slower progress in the residential sector. However, emissions intensity in industry has increased since 2015.

Overall, global emissions are increasing and so Scotland may be seen as performing relatively well as emissions are decreasing. Similar trends are also seen at a UK level, but Scotland may be performing better than the rest of the UK due to the decarbonisation of the energy sector.

Energy use

Scotland has a number of targets relating to energy consumption, energy intensity and energy productivity[e] contained in strategies such as the, Energy Strategy[25], Energy Efficient Scotland route map[26], Heat in Buildings Strategy[27] and Fuel Poverty Strategy[28]. These are outlined below along with information on progress towards them.

It is important to note that much of energy policy and legislation is reserved to the UK Government and there are areas of legal complexity. Although energy use itself is not necessarily an environmental condition factor, the ways in which we use energy and the sources it comes from have important environmental implications e.g. in terms of reducing emissions.

Overall energy consumption

The energy consumption target for Scotland was set in 2010 through the Conserve and Save: Energy Efficiency Action Plan[29]. The target was for energy consumption to reduce by 12% of an average baseline consumption level from 2005-2007 by 2020. This corresponds to a target of 139,500 GWh in 2020. Scotland met this target in 2013, seven years early[14].

In 2020, Scotland's energy consumption was reported to be 14.4% below the 2005-2007 baseline[30], at a total of 144,903 GWh consumed[14]. Factors contributing to the decrease in energy consumption include energy efficiency, the impact of the economic cycles, prevalent energy price rises and weather patterns[14].

Consumption by sector

The UK Government's department for Business, Energy & Industrial Strategy (BEIS) produce National Statistics on the total final energy consumption at regional and local

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[e] Energy consumption – is a measure of the total energy used; Household energy intensity - the average energy use per household in Scotland; Emissions intensity is average emissions per household for Residential and sectoral emissions divided by sector gross value added for Industrial and Services sectors; Energy productivity - is GVA (gross value added) from the input of one gigawatt hour consumed. Higher energy productivity means "squeezing" more out of every unit of energy consumed.

authority levels[31]. These can be used to calculate the sectors contributing to Scotland's energy consumption.

There are three main sectors for energy consumption reported by BEIS for 2019[f]:

- Industrial, Commercial and other – responsible for 5,436.7 ktoe of consumption of all fuels
- Domestic – Responsible for 3,798.0 ktoe of consumption of all fuels
- Transport (only including road and rail, not electricity) – Responsible for 3,265.7 ktoe of consumption of all fuels

The Scottish Energy Statistics Hub reports consumption by different sector definitions. It states that in 2019 heat was responsible for 50.9% of energy consumption, transport for 24.6%, electricity for 21.7% and the rest (2.81%) was attributed to other[14].

When split by domestic and non-domestic sectors, these are responsible for 41.2% and 58.8% of energy consumption respectively[14].

For the sources of energy consumed, see the Energy Sources section below.

Energy for heating – net zero progress

The Scottish Government's Heat in Buildings Strategy[27] recognises that, alongside reductions in energy consumption, energy sources used for buildings will need to change to zero emissions, to meet the 2045 net zero target.

Despite this, the 2019 Scottish House Condition Survey[32,g] found that 81% of Scottish households (around 2.0 million) use mains gas for heating, 11% use electricity and 5% use oil, similar to the proportions reported in 2018.

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[f] The estimates are given in in thousands of tonnes of oil equivalent (ktoe) for the years 2005 - 2019. The equivalent figures in GWh are no longer provided in the BEIS publication but can be calculated by multiplying figures by 11.63.

[g] A nationally representative survey of the condition of Scottish homes as well as the experiences of householders. All survey figures are estimates of the true prevalence within the population and will contain some error associated with sampling variability, which is discussed in the statistical report.

Only around 11% of households (approx. 278,000) have a renewable or very low emissions heating system, such as a heat pump, biomass boiler or electric storage heating. Therefore, further work will be needed to reduce reliance on non-renewable heating sources to meet emission reduction targets.

The Climate Change Plan 2022 Monitoring Report[33] indicates that it is too early to say whether the target of increasing to 1.5 million existing domestic properties using low and zero greenhouse gas emissions heating systems by 2030 will be achieved.

Energy intensity of residential buildings

The Climate Change Plan[5] set a target for the energy intensity[h] of residential buildings to fall by 30% from 2015 levels by 2032. From 2005 to 2019, energy intensity of residential buildings has fallen by 24.8% to 17.7 MWh. Between 2015 and 2019 the reduction was 1.3%[14]. The 2022 monitoring report[33] assesses the target as on track according to a minimum viable pathway.

Energy productivity

Scotland's energy strategy set a target for a 30% increase in energy productivity across the Scottish economy by 2030 from a 2015 baseline[25,i].

Provisional figures for 2020 show energy productivity across the whole economy is £0.961m GVA per GWh, 5.9% below the 2015 baseline. Compared to 2019, energy productivity worsened by 9.9 percentage points in 2020, due to a 0.1% decrease in consumption and a 9.7% fall in GVA[14].

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[h] Energy intensity - the average energy use per household in Scotland.

[i] The 2030 energy productivity target is a measure of the combination of energy consumption and the output of the economy. It is measured by the gross value added (GVA) achieved in the economy from the input of one gigawatt hour of energy. Higher energy productivity means you get more economic activity for each unit of energy used, in other words, squeezing more value added out of every unit of energy consumed across the economy. Energy productivity is improved by decreasing consumption and increasing GVA

The Scottish Government reporting suggests that this is due to the impact of COVID on the economy in 2020 since the measure depends on GVA. As a result, the one-year change should be interpreted with caution.

The Climate Change Plan[5] set a target for energy productivity in both the industrial and services sectors to increase by 30% from a 2015 baseline to 2032.

In 2018, industrial energy productivity was 1.7% above the baseline, an increase from 2017 when it was 3.6% below. This was driven by a decrease in consumption.

In 2018, energy productivity in the services sector was 0.1% above the 2015 baseline[14]. The 2022 Monitoring Report assesses the industrial energy productivity target as on track on the basis of unpublished data which suggests that which puts it 7.8% above the 2015 baseline in 2019.

ClimateXChange analysed government policies and programmes to provide insights into how energy productivity can be promoted in the industrial and commercial sectors in 2016[34]. Between 2003 and 2012, energy productivity had increased. However, it is important to note that energy productivity decreased between 2019 and 2020[14] suggesting longer term monitoring needed.

The research found that few governments have developed coherent national energy productivity programmes, which could be a missed opportunity to both promote and increase energy productivity[34]. It also found issues with the current reporting system.

International comparisons

The UK saw a similar change in energy consumption to Scotland whereby consumption was significantly affected by the COVID-19 pandemic. Specifically, total energy consumption in the UK decreased by 17.9 mtoe (12.9%) between 2019 and 2020 to 121.0 mtoe. This was driven by decreases in consumption in industry, services and transport (transport decreased by 16.2 mtoe) but increases in the domestic sector (0.9 mtoe)[35].

There is now data available on energy consumption at a UK level for 2021. It shows that total final energy consumption was 5.4% higher than in 2020, with increases in all

sectors, aligned with the return to pre-pandemic activities. Energy consumption from most sectors was in line with pre-pandemic averages. [36]

In the UK, domestic energy intensity has fallen from 0.8 ktoe in 2000 to 0.6 ktoe in 2020, similar to the trajectory for household energy intensity.

Industrial energy intensity has also decreased, by a third between 2000 and 2020. However, the UK saw an increase in energy intensity in the services sector between 2019 and 2020. Despite this, the long-term trend has been a decrease in energy intensity. Energy intensity in air transport increased by 3.8 per cent in 2019 reflecting a 3.3 per cent drop in passenger kilometres but only a 0.4 per cent drop in consumption[35].

Countries in the EU consumed 37,086 petajoules (PJ) of energy in 2020, 5.6% less than in 2019. In terms of trends over time, energy consumption was slowly increasing from 1994 until it reached its peak of the last three decades in 2006, since then it has decreased from its 2006 peak by 10.5 %[37]. There were three dominant sectors responsible for final end use of energy in the EU in 2020, transport (responsible for 28.4 % of consumption), households (28.0 %), and industry (26.1 %).[37]

The World Bank provides information on countries' energy use worldwide. In terms of energy use (kg of oil equivalent per capita), using data from 2014 and 2015, it shows that the UK is ranked 44th with an energy use of 2,765 kg of oil equivalent per capita[38].

Summary

Although energy use itself is not necessarily an environmental condition factor, the ways in which we use energy and the sources it comes from have important environmental implications e.g. in terms of reducing emissions.

Scotland met its target to reduce energy consumption by 12% by 2020 seven years early. The majority of energy is consumed by the 'industrial, commercial and other' sector, and the majority is used for heat.

There has been progress against the target to reduce the energy intensity of residential buildings by 30% from 2015 levels by 2032. However, there has been limited progress in improving energy productivity in the services sector.

COVID may have impacted on progress towards the target to increase energy productivity across the Scottish economy by 30% by 2030 from a 2015 baseline. In 2020, energy productivity was lower than 2015 levels though this is likely to have been affected by the impact of COVID on the economy.

Further work will be needed to reduce reliance on non-renewable heating sources to meet emission reduction targets.

Energy sources

As highlighted above, it is important to note that much of energy policy and legislation is reserved to the UK Government and there are areas of legal complexity.

Sources of energy consumed

For the total amount of energy consumed in Scotland, see the Energy Use section above.

Fuel types

There are different types of energy and fuel types which make up the total energy consumed in Scotland.

The UK Government's department for Business, Energy & Industrial Strategy (BEIS) produce National Statistics on the total final energy consumption at regional and local authority levels[31]. These can be used to calculate the fuel types contributing to Scotland's energy consumption.

The fuel types responsible for energy consumption in Scotland in 2019 were[31,j]:

- Petroleum – 5,466.2 ktoe
- Electricity – 2,0769.5 ktoe
- Bioenergy and wastes – 677.9 ktoe
- Gas – 608.2 ktoe
- Coal – 110.4 ktoe
- Manufactured fuels – 81.9 ktoe

Renewable energy

Scotland's Energy Strategy, published in 2017, set a target for the equivalent of 50% of the energy for Scotland's heat, transport and electricity use to come from renewable sources by 2030[25]. In 2009, the target was for 30% of Scotland's energy consumption to

[j] The estimates are given in in thousands of tonnes of oil equivalent (ktoe) for the years 2005 - 2019. The equivalent figures in GWh are no longer provided in the BEIS publication but can be calculated by multiplying figures by 11.63.

come from renewable sources by 2020[25]. Progress against this target is also reported as a National Performance Indicator[39].

Provisional figures for 2020 show that the percentage of the energy for Scotland's energy use from renewable sources was 25.4%[40,39, 14], an increase from 24.0% in 2019 and 7.6% in 2009[39]. The increase between 2020 and 2019 is attributed to greater renewable electricity generation, largely due to wind generation[39,k] This misses the 2009 target that 30% of Scotland's energy consumption would come from renewable sources by 2020[25], but does make progress towards the target of 50% in 2030.

Low carbon electricity

The Scottish Energy Statistics Hub reports that in 2021, 84.5% of the electricity that Scotland consumed came from low carbon sources with the rest (14.4%) from fossil fuels. This is down from 86.1% in 2020. Low carbon sources can include renewables, nuclear electricity generation and green hydrogen solutions for heating and transport.

Over half (51.6%) of the electricity Scotland consumed in 2021 is from renewable sources, with over two-fifths (41.3%) from wind[14].

Sources of Energy Generation

In 2019, in Scotland, indigenous production of energy totalled 80,141 ktoe, 80.4% of Scotland's input to the energy system. Of this, the majority is primary oils (53,881 ktoe) and natural gas (19,934 ktoe). The rest is primary electricity production (5,296 ktoe), bioenergy and wastes (762 ktoe) and coal (268 ktoe)[14].

Of Scotland's input to the energy system, 19.6% comes from imports, which again is primarily oils, gas and petrol.[14] The majority of Scotland's energy is exported (77,013 ktoe), mostly made up of oil and natural gas.

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[k] Scotland's renewable energy target is calculated by the sum of renewable electricity and heat generation and estimated biofuel use in transport in Scotland, divided by Scotland's gross electricity consumption, non-electrical heat demand and energy used for transport. Therefore, progress towards the target will come from increasing renewable generation and reducing energy consumption. Scottish Energy Statistics Hub (shinyapps.io)

This suggests that while Scotland is seen to be performing relatively well on the amount of renewable energy consumed, it still contributes a large amount to fossil fuel production.

Fossil fuel generation – oil and gas

It is estimated that in 2019, Scotland (including Scotland adjacent waters) produced 54.0 million tones (equivalent to 628 TWh) of oil equivalent of crude oil and natural gas liquids[41]. This represents a 40% decrease since 1999 but a 2.2% increase since 2019.

Production across the UK Continental Shelf has increased steadily since 2014 due to substantial investment. Further investment is expected and the CCC have noted that the impact of this on GHG emissions is uncertain, but that preventing further development would send a clear message of commitment to combatting climate change[42]. Scotland accounts for 95.2% of all UK crude oil and natural gas liquids production[14]

In 2019, Scotland produced 23.2 mtoe (equivalent to 270 TWh) of natural gas, six times Scotland's gas consumption. This has dropped from 25.6 mtoe in 2016. Scotland accounts for 61.4% of UK gas production[14].

Of all of Scotland's primary energy generated via oil and gas, more than four fifths (81.1%) of Scotland's was exported in 2019, with only 11.5% domestically consumed. This represents a decrease from 13.3% in 2012[14].

There are currently no targets for levels of oil and gas production in Scotland or the UK. There also remain questions on the compatibility of new fields for fossil fuel production in the North Sea with climate change ambitions[9].

The Climate Change Committee recently wrote to the Secretary of State for the Department of Business, Energy and Industrial Strategy in the UK Government. It outlined that while it has not been able to establish the net impact on global emissions of new UK oil and gas extraction, its view is that the best way to tackle climate change and reduce exposure to fluctuating energy prices is to reduce the reliance on fossil fuels and therefore limit their production[42].

Heat generation

The 2009 Renewable Heat Action Plan[43] set a target of delivering 11% of Scotland's non-electrical heat demand from renewable sources by 2020.

This target was missed in 2020[l], only 6.2% of Scotland's non-electrical heat demand was from renewable sources, similar to the 2019 figure. However, Scotland generated 5,008 GWh of renewable heat in 2020, a record year for energy generation from renewable heat, with the increase largely due to an increase in energy generation from heat pumps[14]. The reason that the increase in renewable heat energy generation did not lead to an increase in the share it makes up of heat demand is due to an increase in heat demand and reduction in large biomass output[14].

Electricity generation

Amount of electricity generated

In 2020, Scotland generated 51.9 TWh of electricity. 40.5 TWh of electricity was supplied by major power producers, the highest amount since 2015. Scotland's public supply consumed 23.5 TWh of this in 2020, 45.2% of Scotland's generated electricity. 6.9 TWh of domestic generation is consumed to generate electricity, and 2.2 TWh is lost through transmission and distribution networks. The remainder (19.3 TWh) is exported to the rest of the UK.[14]

Share of electricity generated by source

According to the Scottish Energy Statistics Hub, the majority of the electricity (electricity being only one aspect of energy) that Scotland generates is from low carbon sources[m], 88.1% in 2020, with 10.9% generated from fossil fuels.

This represents a rapid change since 2010 when approximately half of Scotland's generation came from each of low carbon sources and fossil fuels. The statistics hub states that this change has been driven by privatisation and subsidy schemes

[l] This was also reported in the media e.g. Scottish government misses renewable heat target - BBC News

[m] Low carbon solutions include renewables, nuclear electricity generation, and electricity and green hydrogen solutions for heating and transport.

introduced to encourage the development of low carbon and renewable technologies as well as national and international incentives[14].

Renewable electricity generation

The Scottish Government set a target that by 2020 Scotland would generate the equivalent of 100% of its own electricity demand from renewable sources. This target was narrowly missed. In 2020, the equivalent of 98.6% of gross electricity consumption[n] was from renewable sources (equivalent to 32,063 GWh), rising from 89.8% in 2019. The increase stems from the 1.9 TWh increase in renewable electricity generation, of which 0.9 TWh of this increase can be attributed to Hydro sources and 0.7 TWh from onshore wind[14].

In 2021, 27.2 TWh of renewable electricity was generated in Scotland. This is a 15.1% decrease compared to 2020, which is likely due to milder weather throughout the year.[44,40]

Renewable electricity comes from a number of sources[o]:

- Most renewable electricity generated in Scotland is from onshore wind[45] which, in 2020, generated 19,583 GWh, 61.1% of the total renewable electricity generated. This represents a significant increase since 2009. Between 2009 and 2020, generation of electricity from onshore wind has more than quadrupled[14].
- Offshore wind generated 3,492 GWh in 2020, representing 10.9% of renewable electricity generation. This is likely to generate more in the future with 10 offshore wind projects in development[14].
- Hydro sources generated 6,187 GWh in 2020, representing 19.3% of renewable electricity generation. The capacity of hydro generation has increased by 25% between 2000 and 2021.[14]

[n] There is a difference between this measure and the low carbon electricity information presented earlier. Here gross electricity consumption equates to total electricity generation minus net exports.

[o] The data below is taken from Scottish Energy Statistics Hub (shinyapps.io). However, these figures can also be expressed as capacity of the system which can also be viewed on Scottish Energy Statistics Hub (shinyapps.io) or Renewable Energy Facts & Statistics | Scottish Renewables

- Solar photovoltaics (PV) generated 353 GWh (1.1%) of all renewable electricity in Scotland in 2020. Progress was rapid between 2010 (2 MW) and 2016 (326 MW) before slowing in more recent years. The Scottish Energy Statistics Hub suggests that this may be due to the closure of the Renewables Obligation accreditation to all solar in March 2017[14].
- Bioenergy and energy from waste generated 2,437 GWh (7.6%) of all renewable electricity in 2020.
- Wave and tidal did not generate any electricity in Scotland in 2020 in terms of GWh. However, there is capacity in the system (22 MW in September 2021). The capacity is small but Scotland is ahead of the rest of the UK as 17 of the 19 UK sites are in Scotland. Further projects are also being developed[14].

The future of renewable electricity generation

The House of Commons Scottish Affairs Committee published a report on Renewable Energy in Scotland in September 2021. It suggested that there was a huge potential scale of renewable energy in Scotland. However, it notes that further investment in the grid is needed to ensure that renewable energy can move around the UK and ensure that net zero targets are met. It also suggests that more investment is needed in tidal renewable energy. It highlights that further research is needed on Green hydrogen and Carbon Capture Utilisation and Storage (CCUS)[46].

However, it is important to note that the CCC state that the potential for further emissions savings from electricity generation and the power sector has largely run out. It suggests that the focus should shift to other sectors.[9]

International comparisons

In the UK in 2021, total inland consumption of energy[p] was 170.6 mtoe, a 2.2% increase from 2020 but an 8.5% decrease from pre-pandemic levels. Total final energy consumption[q] was 5.4% higher than 2020.

[p] This includes fuel use by consumers, fuel used for electricity generation and other transformation. Energy Trends March 2022 (publishing.service.gov.uk)

[q] Excludes non-energy use consumption Energy Trends March 2022 (publishing.service.gov.uk)

Data is not yet available for the sources of energy consumed in the UK in 2020. However, in 2020 total primary energy consumption in the UK was 163.3 mtoe, 11% lower than in 2019. This was likely at least partly due to the impacts of the pandemic. Energy from renewable sources accounted for 13.6% of total energy consumption in 2020, an increase from 11.7% in 2019, but missing the target of 15% by 2020[47]. In 2020, there were decreases in consumption of every fuel type, except energy from bioenergy and waste[35].

In England and Wales, consumption from electricity from low carbon (49.3%) and renewable (33.6%) sources are substantially lower than in Scotland[14] and a significantly smaller proportion of electricity is produced from low carbon sources (39.2%)[14].

In 2021, the UK generated 106.9 mtoe of energy, a 14% decrease from 2020 and the lowest level in over 50 years[36].

The share of energy production from low carbon sources was 28.2%, an increase from 13.3% in 2020. Production from all fuel types decreased from 2020 to 2021, except for bioenergy and waste. The decrease was due to delayed oil and gas maintenance as a result of the COVID-19 pandemic, outages on the nuclear fleet and less favourable weather conditions for renewables[36].

Renewable energy accounted for 43.1% of electricity generation (a subset of all energy generation) in the UK in 2020, largely due to energy from wind, and the first time it has made up a larger proportion than fossil fuels. This also meant that low-carbon generation of electricity (which includes renewables) was at a record high, at 59.3% of all production. 37.7% of electricity generation was from fossil fuels, a record low[47]. Renewable electricity generation fell by 9.5% between 2020 and 20201 to 121.9 TWh, largely due to less favourable weather conditions[36].

In the EU, of the fuels used for energy consumption in 2020, oil and petroleum products accounted for the biggest share (35.0 %), followed by electricity (23.2 %), and natural gas (21.9 %). There was a decrease in the EU in the amount and share of fossil fuels in energy consumption between 1990 and 2020 (from 9.6 % in 1990 to 3.6 % in 2000, 2.8 % in 2010, and 2.1 % in 2020). Consumption from natural gas sources has remained relatively stable over this period. Consumption of energy from renewable

sources has increased from 4.3 % in 1990 to 5.3 % in 2000 and 8.8 % in 2010, finally reaching 11.8 % in 2020[37].

In 2020, countries in the EU produced 24 027 petajoules (PJ) of energy, 7.1% lower than in 2019. Renewable energies accounted for the highest share in primary energy production in the EU in 2020 (40.8%), followed by nuclear heat (30.5%), solid fossil fuels (14.6%), natural gas (7.2%), oil and petroleum products (3.7%), and non-renewable waste (2.4 %)[37].

The World Bank provides information on countries' energy use worldwide. This shows that in terms of the percentage of total energy consumption from fossil fuels, the UK comes 59th of 141 countries with data available for 2013, 2014 or 2015, at 80.4%[48]. The UK is 39th in its electric power consumption (2014 data) with 5,130 kWh per capita, this is above the 3,128 kWh per capita world average but below the EU average (6,022 kWh per capita)[49].

In terms of electricity production from oil sources, the World Bank data suggests the UK is 96th with a value of 0.6%[50] (data for 2015). Considering the amount of electricity produced from renewable sources, the UK is fifth at 77,262,000,000 kWh[51] (data for 2015).

Summary

In terms of the sources of the energy consumed in Scotland, petroleum was the fuel type responsible for the largest share, followed by electricity. There has been an increase in the percentage of energy that Scotland uses that is from renewable sources but the target for 30% by 2020 was missed.

Further work will be needed to meet the 50% target for 2030. Of the electricity that Scotland consumed in 2021, 84.5% came from low carbon sources with over half from renewable sources.

Scotland only very narrowly missed its 2020 target to generate the equivalent of 100% of Scotland's own electricity demand from renewable sources. This is a largely positive result, however renewable generation decreased slightly in 2021. The target for the percentage of Scotland's heat demand met by renewable sources was also missed.

Nonetheless, there are positive trends, with the capacity of renewable electricity generation experiencing large increases and the share of electricity generation from low carbon sources is increasing.

That said, the majority of energy that Scotland produces is from oil and gas sources, and the amount produced increased between 2019 and 2020. The majority of energy produced in Scotland is exported. This suggests that while Scotland is seen to be performing relatively well on the amount of renewable energy produced and consumed, Scotland still contributes a large amount to fossil fuel production.

Similar trends are seen in other countries. However, it has been reported that Scotland has a higher percentage of consumption of electricity from low carbon and renewable sources than England and Wales.

Energy efficiency

The Scottish Government's Heat in Buildings Strategy[27] brings together its aims for energy efficiency and decarbonisation of heat in support of the statutory target to achieve net zero greenhouse gas emissions by 2045. 'As set out in the Climate Change Plan Update, emissions for homes and non-domestic buildings combined will have to fall by 68% by 2030 compared to 2020'.[5] The strategy is set out in sectors[52] which are covered below.

Domestic buildings

The Scottish Government's policies on energy efficiency and residential building decarbonisation have been recognised as being ambitious, and ahead of other areas of the UK[9].

All housing

The Heat in Buildings Strategy indicates that the Scottish Government will introduce regulations requiring that all residential properties in Scotland achieve an Energy Performance Certificate (EPC)[r] of at least equivalent to an EPC band C by 2033, where technically and legally feasible and cost-effective. Where this is not possible, properties should achieve the highest standard possible. This will be introduced once the methodology of calculating EPCs has been reformed.[27]

The strategy also proposes to regulate such that all homes use zero emissions heating (and cooling) by 2045 and to regulate such that all new homes and buildings applying for a building warrant from 2024 only use zero direct emissions[s] heating.

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[r] A measure of how energy efficient a property is Guide to Energy Performance Certificates - Energy Saving Trust

[s] Defined by the Scottish Government as those which *"produce no direct greenhouse gas emissions at the point of use"* and which do not allow for offsetting as described in Chapter 2: The Standard - New Build Heat Standard: scoping consultation - gov.scot (www.gov.scot). This could be individual electric heat pumps, heat network connections of electric storage heaters.

EPC ratings are derived using a UK Government calculation methodology called the Standard Assessment Procedure[53]. Since its first publication in 1993, SAP has been regularly updated with the latest version being SAP 2012 and SAP 10 being due to be introduced in Scotland later in 2022.

Based on the most up to date SAP methodology (SAP 2012 based on RdSAP[t] (v9.93)) shows that an estimated 45% of Scottish housing stock was rated at EPC C or above in 2019 (the most recent data available[u]). However, to facilitate comparisons with previous years, an older methodology (SAP 2012 based on RdSAP (v9.92)) can be used. This shows that an estimated 47% of Scottish housing stock was rated at EPC C or above in 2019, an increase from 44% in 2018 and 35% in 2014[14].

To provide comparisons back to 2010, the SAP 2009 methodology can be used and shows substantial increases in the proportion of houses rated EPC C or above. An estimated 51% of Scottish housing stock was at EPC C or above in 2019, 27 percentage points higher than in 2010. The proportion of properties in the lowest EPC bands also halved[32].

The Climate Change Plan Monitoring Report for 2022 states that it is too early to say whether the 2033 target it on track since more recent data than 2019 is not available[33].

Social landlords

The Energy Efficiency Standard for Social Housing (EESSH)[54] was introduced in March 2014 and set a minimum level of energy efficiency for landlords to achieve by 31 December 2020 that varies dependent upon the dwelling type and the fuel used to heat it. The minimum level was mostly between EPC C and EPC D[54]. A second EESSH milestone has been set such that 'all social housing meets, or can be treated as meeting, EPC Band B, or is as energy efficient as practically possible, by the end of December 2032 and within the limits of cost, technology and necessary consent'.[54]

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[t] RdSAP is a simplified version of SAP which applies to existing dwellings while SAP itself must be applied to new dwellings. Like the main methodology, it has also been subject to regular updates.

[u] At June 2022, the most recent Scottish House Condition Survey was published for 2019 Scottish House Condition Survey - gov.scot (www.gov.scot)

The EESSH is monitored by the Scottish Housing Regulator and its latest Annual Report indicates that 89% of homes in scope met the standard in 2020/21[55], representing a two percentage point increase from 2019/20[56], but missing the 2020 target. For Local Authorities, this value was 86.4%, for Registered Social Landlords, this value was 92%. The Scottish Housing Regulator note that there was a 52% decrease in the amount of money invested by landlords to meet EESSH in 2020/21, likely due to the impact of the pandemic[55].

Houses in fuel poverty

Alongside the overall target to achieve EPC C in all Scottish homes by 2033, in its Fuel Poverty strategy, the Scottish Government has stated its ambition to maximize the number of fuel poor households attaining the equivalent of EPC B by 2040[28]. This is important because the lowest rates of fuel poverty were associated with higher energy efficiency standards in 2019[32]. The Heat in Buildings Strategy also reflects this ambition, noting that *"we are taking action through our delivery programmes to maximise the number of homes with households in fuel poverty achieving a level of energy efficiency equivalent to EPC C by 2030 and EPC B by 2040"*.

Further analysis is required to examine progress against this target.

Owner occupied homes

In the Heat and Buildings Strategy, the Scottish Government set out proposals to introduce regulations from 2023 to 2025 requiring all owner occupier homes to meet EPC band C where technically feasible and cost effective by 2033. Detailed proposals will be subject to consultation.[27]

In 2019, the Scottish House Condition Survey[32,g] estimated that 41% of owner occupied homes reached EPC C[32,v]. 10% were in the lowest energy bands (F and G), the highest proportion of all tenure types (owned, private rented, local authority and housing association).

[v] Under the SAP 2012 (RdSAP v9.93) assessment method.

Private rented homes

The Scottish Government had previously committed to the introduction of regulations to ensure properties in the private rented sector reach an EPC D by 2025. However, due to the impacts of the pandemic, this will not be taken forward. Instead, it has said it will work with the sector to introduce regulations in 2025 requiring all private rented sector properties to reach a minimum standard equivalent to EPC C by 2025 where technically feasible and cost-effective, at change of tenancy, with a backstop of 2028 for all remaining existing properties[52].

In 2019, an estimated 40% of private rented homes reached EPC C[32].

Non-domestic buildings

The Scottish Government are investigating a new regulatory framework for non-domestic buildings to ensure they are net zero by 2045. This will include trigger points, backstop dates, compliance and enforcement approaches. Consultation is expected in 2022 with regulations introduced by 2025[57]. These will require owners to reduce demand for heat through energy efficiency improvements where feasible, and install a zero emissions heating supply[58].

The Scottish Government also aim for all non-domestic buildings to meet zero emission heating requirements by 2045 and publicly-owned buildings to meet zero emission heating requirements by 2038[58]. All non-domestic buildings are currently required to produce an EPC on sale or rental to a new tenant. Since 2016 regulations have required non-domestic buildings over 1000 square meters to produce an Energy Action Plan at the point of sale or rental.[58]

The methodology underpinning non-domestic EPC assessment is different and not comparable to that for domestic buildings. It is more useful as an indicator of overall emissions than of energy efficiency performance comparison between buildings[14].

The Scottish Government published an analysis of non-domestic EPCs in the Scottish Government's Non-Domestic Energy Efficiency Baseline in December 2018[59]. It found that 13.5% of non-domestic buildings have an EPC rating of C or above. The rating varies between the types of non-domestic properties in Scotland. For example, storage

and distribution and education buildings tend to have lower emissions (39.1% and 37.0% respectively at EPC band C or above), whereas hotels (1.5%) and restaurants, cafes and takeaways (0.5%) tend towards higher emissions, and therefore poorer EPC ratings[14].

Public sector non-domestic buildings/The civil estate

In 2018, the Scottish Government assessed that there was no statistically significant difference in the distribution of EPC bands for private and public sector occupied buildings[59].

Section 76 of the Climate Change (Scotland) Act 2009 requires Scottish Ministers to report annually to Parliament on progress towards improving the efficiency and sustainability of buildings that form part of the civil estate in Scotland (including the estate of core Scottish Government and its Executive Agencies).[60]

The most recent report under this act was produced for the year 2017-18[61]. The report states that since the inception of the series of reports in 2010/11 improvements in energy efficiency have been delivered across the civil estate with a range of measures implemented such as low-energy lighting and installation of photovoltaic solar panels. As a result, there has been improvements in energy consumption per person and per square meter. This trajectory suggests that efficiency and sustainability are improving across the civil estate.[61]

Actions contributing to energy efficiency and consumption reduction

Many features of properties can affect their energy efficiency rating. For example, levels of insulation and boiler efficiency as well as building fabric. The Heat in Buildings Strategy[27] outlines a Scottish Government commitment to invest £1.8 billion over the next five years for energy efficiency and zero carbon heating in Scotland's buildings.

The Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3)[62] set a target for 60% of walls to be insulated by 2020 where technically feasible. In 2019, an estimated 59% of dwellings had some form of wall insulation (cavity or other), an increase from 42% in 2007. Levels were higher in the social sector (70%) than the private sector (55%). However, cavity walls were more likely to be insulated (73%) than

solid walls (18%). There is evidence that wall insulation can save around 10% of energy consumption[45].

Levels of loft insulation have also increased. In 2019, an estimated 94% of Scottish homes were insulated to 100mm or more, up from 73% in 2007[45,32]. RPP3 also set a target for 70% of lofts in the residential sector to have at least 200 mm of insulation by 2020 where technically feasible. In 2019, an estimated 64% of dwellings had loft insulation of 200mm or more, a substantial rise from 18% in 2007, but slightly below the target[45,32]. No 2020 data is available since the Scottish House Condition Survey was paused in that year due to COVID[63]. Installing loft insulation has been shown to reduce energy consumption by 1.7%[45].

The energy efficiency of boilers in Scottish homes has also increased. In 2019, an estimated 64% of gas and oil boilers met Building Standards' minimum efficiencies, a substantial increase from 30% in 2012. In addition, there has been a 54 percentage point increase from 2010 to 2019 (22% of dwellings to 76% of dwellings) in the percentage of dwellings with a condensing boiler. On average, installation of condensing boilers saves 7.4% of energy consumption[45].

While improving energy efficiency is inherently good for meeting targets related to energy and climate change, a 2017 review published by the Scottish Government also found strong evidence that improved energy efficiency can lead to warmer homes and thus physical health benefits such as reductions in disease and mortality, particularly for the elderly and young children. It also identified mental health benefits due to decreased stress[64].

However, it is important to note that these energy consumption savings do not take into consideration the 'rebound effect' i.e. where savings are reduced as a result of changes in behavior. For example, as a consequence of installing insulation, people may use their heating for longer if it costs less to heat the home as a result of the insulation[64].

International comparisons

According to the English housing survey for 2020-21[65], the energy efficiency of the English housing stock has continued to improve. In terms similar to the EPC rating

reported in Scotland, the proportion of dwellings in the highest SAP energy efficiency rating (EER) bands A to C increased between 2010 and 2020, from 14% to 46%. Over the same period, the proportion of dwellings in the lowest three bands (E, F and G bands) has fallen from 39% to 10%. In 2020, the majority of dwellings (87%) were in EER bands C or D, compared with 61% in 2010. These figures are similar to those in Scotland.

The increase in energy efficiency was seen in houses of all tenure types except from private rented dwellings where there was no significant increase. Furthermore, the social sector remained more energy efficient than the private sector. In the social rented sector, the majority of dwellings (66%) were in EER bands A to C, compared to private rented and owner occupied dwellings (both 42%)[w]. The increases in energy efficiency were thought to be due to increases in cavity wall insulation, boiler upgrades and double glazing.

The EU has reported that 75% of their buildings are not energy efficient[66]. However, the exact definition of energy efficient in this context was not clear and it is not possible to determine whether this is comparable with Scottish sources. The EU plans to improve energy efficiency through the Energy Performance of Buildings Directive. This requires that the worst-performing 15% of the EU building stock be upgraded from EPC G to at least EPC F by 2030, with public and non-residential buildings by 2027 and that residential buildings be renovated from G to at least F by 2030, and to at least E by 2033.

Summary

There have been improvements in the energy efficiency ratings of domestic buildings. However, more work will be needed to meet the target of all housing being rated as equivalent to EPC C or better by 2033 where technically and legally feasible and cost effective. The Scottish Government's Climate Change Plan Monitoring currently assesses this target as 'too early to say'.

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[w] This is supported by data from the Office for National Statistics Energy efficiency of housing in England and Wales - Office for National Statistics (ons.gov.uk)

Of the homes owned by social landlords, 89% met the Energy Efficiency Standard for Social Housing in 2020/21 missing the target of 100%. Nonetheless, this is much better than owner occupied homes where only 41% reached EPC C and private rented homes where 40% reached EPC C. In the non-domestic sector, only 13.5% of buildings have an EPC rating of C or above.

There have been increases over time in the measures implemented to improve energy efficiency such as installing insulation and boilers. Similar trends have been seen in England, including the trend of better energy efficiency for social housing compared to private housing.

Therefore, while Scotland's energy efficiency and decarbonisation policies are regarded as ambitious, it is likely that more work is needed to reach the goals.

Climate change planning – mitigation

Mitigation refers to reducing the greenhouse gas emissions in the atmosphere in order to slow or stop global climate change.[67] For information on levels of greenhouse gas emissions, see the Greenhouse gas emissions section of this review.

Current plans

The Scottish Government published an update to its 2018 Climate Change Plan in 2020[5] to illustrate the path to meeting the ambitious emissions reduction targets sets out in the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, which include the Net Zero by 2045 target[4].

The plan emphasises that actions will recognise the importance of a just transition (to eliminate inequalities), involve strong public engagement and will ensure that there is a green recovery from the COVID-19 pandemic. It also acknowledges the interrelated crisis of biodiversity loss.

The plan sets out over 200 policies and actions that will be taken until 2032 in different sectors including electricity, buildings, transport, industry, waste, agriculture, negative emissions technology, land use, land use change and forestry. Many of these policies have been developed further[33] such as through the Heat in Buildings Strategy[27] and the route map to achieve a 20% reduction in car kilometers by 2030[68].

Scottish Government introduced required sustainability reporting in 2015, by an Order under the Climate Change (Scotland) Act 2009. This aligns with section 44 of the Climate Change Act, which places duties on all public bodies to carry out their activities and operations in ways that help contribute to achieving our emissions targets, and to act sustainably.[60]

A repository of the reports produced under this requirement are collected by the Sustainable Scotland Network[x]. The repots cover climate change governance, corporate emissions and adaptation measures for each organisation.

[x] A repository of reports can be found here Reports (sustainablescotlandnetwork.org)

Assessment of progress against plans

Assessment of progress towards climate change mitigation plans can be made by analysing greenhouse gas emissions statistics, which show that GHG emissions are decreasing, but more work is needed to reach Net Zero. More detail can be found above.

Alongside the climate change plan, the Scottish Government also produced a monitoring framework. The most recent monitoring report was published in May 2022. The report states that overall, progress towards policy outcome indicators (i.e. measures of whether the outcome of a policy has been reached) is on track for 27 policies, off track for seven and too early to say for 10[33].

The CCC has also provided an independent assessment[9]. It concluded that the updated climate change plan[5] sets high ambitions for emissions reduction which have been supported by funding announcements. However, it highlights the following potential issues[9]:

- A comprehensive and detailed policy framework is needed to shift the focus to implementation as they have not been able to establish whether the current policies and proposals add up to the required emissions reductions.
- There is a need for the new Agriculture Bill in 2023 to be ambitious enough to meet targets.
- The ambition for 2030 relies on engineered greenhouse gas removals, however there is uncertainty around whether these will be delivered on time and so contingency plans are needed.
- Some commitments extend beyond devolved areas and go ahead of the UK Net-Zero strategy.

Sustainable Scotland Network provide an assessment of public bodies' climate change adaptation plans. The assessment for 2020/21 concluded that the majority of bodies had made some assessment of climate risks and had risk management processes in place, with the majority around flood risks[16]. However, it is important to note that the approach to assessment is subject to change.

Future opportunities

The CCC notes that the potential for further emissions savings from electricity generation and the power sector has largely run out. It suggests that the focus should shift to other sectors.[9] In addition, it states that annual targets during the 2020s will be very difficult to meet, even with the strongest climate policies[9].

Nature-based solutions

One aspect of the Climate Change Plan is 'nature-based solutions' to climate change[5], for both mitigation and adaptation. These make use of nature and natural environments and provide opportunities to mitigate climate change, and also provide benefits to people and nature[69].

Nature-based solutions can help with climate change mitigation by using ecosystem services to sequester and reduce greenhouse gas emissions and expand carbon sinks. They can also help with climate change adaptation (discussed further below) by preserving ecosystem services that are necessary for human life in the face of climate change and to reduce the impact of the effects of climate change. NatureScot state that, compared to technology-based solutions to climate challenges, nature-based solutions are often more cost-effective, longer lasting, and have multiple synergistic benefits such as improvements to biodiversity[69].

The Climate Change Plan states that 'The Scottish Government is committed to deploying nature-based solutions at scale and in a sustainable and managed way' and cite work on peatland restoration and woodland creation as examples[69].

ClimateXChange recently published an assessment of the evidence for the GHG mitigation potential of four nature-based solutions in Scotland (agroforestry, hedgerows, un-cultivated riparian buffer zones and the restoration of species-rich grasslands)[70]. The report concluded that there is some evidence that above-ground carbon sequestration is increased by expanding tree and woody vegetation cover in agroforestry, hedgerows and riparian buffer zones. However, it found very limited evidence for an increase in above ground carbon sequestration as a result of species-rich grassland restoration and for the effects of all four nature-based solutions on soil carbon sequestration. The net

GHG mitigation potential of the four nature-based solutions was also found to be a function of local climate, soil type, soil wetness and previous land use.

Overall, the report found that there is a large amount of uncertainty in the GHG mitigation potential of the four nature-based solutions considered. It also cautioned against offshoring GHG emissions as a result of implementing these solutions. However, it did find that the nature-based solutions examined had other benefits such as agroforestry and other types of woodland planting, including hedgerows, helping to reduce soil erosion, decrease freshwater sedimentation and increase biodiversity and increasing the area of species-rich grassland increasing terrestrial biodiversity[70].

One example of a nature-based solution is blue carbon, which is carbon contained in coastal and marine ecosystems. The CCC produced a briefing on the potential for blue carbon to contribute to climate mitigation. This states that, while there is some uncertainty, restoration and creation of saltmarsh and seagrass ecosystems is likely to yield an additional GHG abatement of well below 1 MtCO2e/yr, which is a relatively small amount, but may provide important local benefits. It recommends that blue carbon be included in the GHG inventory, considered in policy decisions and be monitored, protected and restored[71].

International comparisons

The Climate Change Committee have provided an independent assessment of the UK's Net Zero Strategy. This concludes that it is an ambitious, comprehensive and globally leading strategy due to its cross cutting policies and sector policies. However, it highlights that some key issues need to be resolved for effective implementation such as the development of delivery mechanisms for policies in the agriculture sector and the development of a Net Zero Test to ensure policies are consistent with the strategy[72].

In its 2022 progress report, the CCC stated that while there has been progress in reducing emissions and developing a Net Zero strategy, over a third of Government plans cannot be relied on to deliver the necessary emissions reductions, meaning that the current strategy will not deliver Net Zero by 2050. For example, it highlights that progress on delivery is lacking, and policy gaps remain in key areas, such as energy efficiency (such as insulation of homes) and agriculture/land use, and areas with

potential to deliver great savings across sectors[21]. This was a similar message to that in the 2021 report[9].

The Intergovernmental Panel on Climate Change (IPCC) published a report assessing global climate change mitigation progress. According to the IPCC, the expansion of policies and laws addressing climate change mitigation have led to reductions in emissions and increased investment in low GHG technology and infrastructure. However, policy coverage is uneven across sectors.

The IPCC also note that there has been an increase in the diversity of actors undertaking mitigation measures, and the approaches that they take, for example, there have been increasing roles for non-state actors including businesses and citizens[24]. The report also notes that there are close links between climate change mitigation and adaptation. For example, mitigation strategies which are sustainably developed are more likely to be acceptable and effective[24].

The Climate Change Performance Index evaluates and compares the climate protection performance of 60 countries and the European Union (EU) based on 14 indicators from four categories: GHG emissions, renewable energy, energy use and climate policy[73]. Interestingly, it concludes that no country performs well enough in all index categories to achieve an overall very high rating. The first three overall positions therefore remain empty.

The index does not separate Scotland from the UK. The UK is ranked seventh[74]. The CCPI experts still regard the UK as a leading country on climate policy, however they state that progress is still needed to meet renewable energy and GHG emission targets.[75]

Summary

Scotland's climate change mitigation plans, including the Net Zero by 2045 target, are regarded as ambitious, and there has been some progress in implementing policies to expand mitigation efforts. However, further work is required to ensure policies are implemented effectively to deliver emission reduction ambitions. In addition, while reductions in GHG emissions in Scotland have historically been from the energy supply

sector, Scotland will likely now have to find opportunities in other sectors. Some potential areas for further exploration are nature-based solutions.

Similar conclusions can be made about the UK, with it being ranked seventh of all countries on climate change performance but the CCC's recent assessment stating that current plans will not deliver Net Zero by 2050 without further development.

Climate change planning - adaptation

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation to climate change as: "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".[76]

Adaptation planning

Both Scotland and the UK have climate change legislation which gives the public sector a responsibility to consider climate change adaptation in their functions.[77] There are two key pieces of legislation: the UK Climate Change Act 2008[78] and the Climate Change (Scotland) Act 2009[3].

The UK Climate Change Act requires that the UK government produce Climate Change Risk Assessment (CCRA), and a National Adaptation Programme to address the identified risks every five years.[79] The development of the CCRA, is informed by an independent climate risk assessment produced by the CCC[80]. The most recent national adaptation programme was published in 2018 after the publication of the 2017 CCRA[81]. There has since been a 2022 CCRA, but the subsequent adaptation plan is still to be developed[82]. Climate change adaptation planning is largely a devolved matter[81]. However, as the impacts of climate change cut across many policy areas some adaptation planning is reserved[83].

The Climate Change (Scotland) Act 2009 requires a Scottish Climate Change Adaptation Programme (SCCAP) to be created to address the risks identified for Scotland in the UK CCRA[79]. In addition, it established the Public Bodies Climate Change Duties which came into force on 1 January 2011. As part of this, public bodies must ensure that they carry out their functions in the best way possible to deliver any Scottish statutory adaptation programme, and report how they do this.[79]

Details of the climate change risk assessments produced by the UK Government and the CCC can be found below in the sections on the impact of climate change on people and the environment within this review.

In 2019, the Scottish Government published a five year climate change adaptation programme[84] called the Climate Ready Scotland: climate change adaptation programme 2019-2024 (SCCAP2). This is a requirement of the Climate Change (Scotland) Act 2009 and addresses the risks set out in the UK Climate Change Risk Assessment (UK CCRA) 2017, which was published under section 56 of the UK Climate Change Act 2008[84].

The SCCAP2 sets out seven outcomes, which each have sub-outcomes[84]:

1. Our communities are inclusive, empowered, resilient and safe in response to the changing climate
2. The people in Scotland who are most vulnerable to climate change are able to adapt and climate justice is embedded in climate change adaptation policy
3. Our inclusive and sustainable economy is flexible, adaptable and responsive to the changing climate.
4. Our society's supporting systems are resilient to climate change
5. Our natural environment is valued, enjoyed, protected and enhanced and has increased resilience to climate change
6. Our coastal and marine environment is valued, enjoyed, protected and enhanced and has increased resilience to climate change
7. Our international networks are adaptable to climate change

Assessment of Scotland's adaptation progress

A recent report from the CCC assessing progress against SCCAP2 published in March 2022[83], states that progress in delivering adaptation has stalled, and that it has stalled in most sectors. However, it does note that there are a limited number of areas where good progress is being made. Specifically, the vision and outcomes are welcomed but it is suggested that more is needed to drive effective action, for example through clear time-bound quantitative targets with ownership from Government.

Furthermore, CCC suggest that the level of Scotland's adaptation response can be raised. For example, local adaptation responses could be used as templates for wider action, such as Glasgow's Climate Adaptation Strategy and Action Plan which includes targets of £184 million per year for 2025 to close its adaptation finance gap. In addition,

the need for monitoring and evaluation of adaptation progress is highlighted to better understand changes in climate risks.

The CCC also provided more detailed assessment of adaptation progress, and recommendations for how to improve this, for key sectors.

Prior to the March 2022 report discussed above, the Climate Change Committee has undertaken two independent reviews of the Scottish Climate Change Adaptation Programme (SCCAP[85]. Key findings from the 2019 report include that there has been progress in peatland restoration, increasing marine resilience and understanding of flood risk. The areas of greatest risk were identified as pests and diseases in forests, declines in seabird populations and soil health. The report also highlighted that data and evidence gaps mean it is difficult to assess progress for certain adaptation priorities.

In 2021, the Scottish Government published its second annual report on SCCAP2.[86] Overall, Scottish Ministers suggested that good progress continues to be made in implementing SCCAP2, considering the impact of the COVID-19 pandemic. However, it is important to note that this makes a more positive assessment of progress towards adaptation than the CCC's report and should be considered in that context.

The Scottish Government's report highlights announcements over the past year of enhanced funding commitments for flood risk management and coastal change adaptation which it indicates will support the accelerated delivery of several of the key SCCAP2 outcomes as part of a green recovery from COVID-19. It also highlights that Adaptation Scotland[79] has been set up to support capacity building and action on adaptation by the public sector, businesses and communities across Scotland.

International comparisons

The UK Government published its national adaptation plan in 2018[87]. This states that it is primarily for England but also covers reserved powers. The CCC published its assessment of this plan in 2019[88].

The assessment paints a stark picture of the state of adaptation progress in England. Specifically, it states that England is not prepared for even a 2°C rise in global temperatures and only a handful of sectors have plans which consider this. This is

supported by the CCC's reporting that while the quality of adaptation planning from infrastructure providers has increased, coverage of more sectors and improvement in the planning is needed[89]. In addition, in its assessment of the national adaptation plan, the CCC conclude that many national plans and policies lack a basic acknowledgement of long term climate change, including agriculture, health and other infrastructure. It suggests that priority given to adaptation has been eroded over the past ten years.

The CCC report therefore argues that the UK Government must raise the profile of adaptation and strengthen the governance used to prepare for the impact of climate change. These findings are mirrored in the 2021 progress update[90].

The European Commission adopted a new strategy for adaptation to climate change in 2021[91]. The Strategy has four objectives: to make adaptation smarter (i.e. informed by data and risk assessments, some of which can be found on the European Commission/European Environment Agency's Climate-ADAPT website[92]), swifter and more systemic, and to step up international action on adaptation to climate change (e.g. by increasing international finance support).

The European Commission evaluated the effectiveness of the previous adaptation strategy[93], published in 2013[94]. Its 2018 evaluation[95] of this found that the strategy delivered on its objectives to promote action by Member States and that there has been some progress against the eight actions set out in the strategy. However, the evaluation suggests that Europe is still vulnerable to the impacts associated with climate change within and outside its borders and suggests that more work is needed in some areas to prepare vulnerable regions and sectors[95].

The Paris Agreement requires each party to prepare, communicate and maintain nationally determined contributions (NDCs) which outline how they will reduce emissions and adapt to the impact of climate change[96]. NDCs are submitted to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat every five years. The next set of NDCs are to be submitted by 2025.

The UNFCCC published a synthesis report in 2021 to summarise the NDCs submitted by that point[96]. The report found that most parties had included sufficient information in their NDC plans and many were increasing their focus on adaptation measures.

However, it suggested that there needed to be an increase in the ambition in NDCs to reduce GHG emissions enough to retain the emission levels needed to keep global warming below two degrees[96].

Summary

Despite some positive findings that Scotland's adaptation to climate change programme is making progress, the most recent assessment by the Climate Change Committee states that progress has stalled.

A similar picture is seen elsewhere. For example, in the EU, where there has been progress in implementing actions in some areas, but more is needed. According to the CCC, England still has a particularly long way to go in implementing climate change adaptation processes.

Adaptation is likely to be critically important going forward given the significant impacts of climate change on people and the environment, explored further below.[83]

Impact of climate change on natural environment/people and the built environment

Current impacts

The impacts of climate change are already being witnessed in Scotland[97]:

- Scotland's 10 warmest years on record have all occurred since 1997. The average temperature for 2010-2019 was around 0.7°C warmer than the 1961-1990 average.
- There has been an increase in rainfall over Scotland in the past few decades, with an increasing proportion coming from heavy rainfall events. The average year between 2010 and 2019 was 9 % wetter than the 1961-1990 average.
- Average sea level around the UK has risen by approximately 1.4 mm/year since the start of the 20th century.

SEPA has produced a resource where trends over time in key climate variables can be explored[98]. These trends have implications for the natural and built environments, biodiversity and people.

The impact of climate change is also discussed in other evidence reviews such as those on water, land and soils, and population, human health and cultural heritage.

Future risks

It is important to note that the trends listed above are predicted to intensify, and other impacts may emerge. The level of change will depend on global progress in reducing greenhouse gas emissions[99]. However, it is clear that climate change will impact people and the environment to some extent and so adaptation efforts will be needed.

Under the Climate Change Act 2008, the UK Government produce a climate change risk assessment (CCRA) every five years. The most recent CCRA was made in 2022[82].

The Scottish Government also use the UK CCRA to produce its adaptation plan[y]. The report highlights 61 risks across multiple sectors. For example, those relating to soil health, agricultural productivity, water availability and energy supplies.

The assessment cites evidence which suggests that the cost of climate change to the UK could be at least 1% of GDP by 2045[82]. However, the report does suggest that, for many of the risks, there are actions that can be taken now to improve resilience.

The CCC also produce an independent assessment of UK climate risk, which supports the UK Government's assessment[100]. The report states that in Scotland annual temperatures could rise by up to two degrees, summer rainfall decrease by up to 16%, winter rainfall increase by up to 13% and sea levels rise by up to 54cm by 2080, continuing trends already seen, but the extent of change will depend on the level of global emissions[97].

The BBC has produced a visualisation tool to show the projected impacts of climate change in postcode areas in the UK, such as temperature highs and rainfall levels, if warming reaches 2 degrees or 4 degrees, and how this compares to current conditions[101]. For example, at the ESS office, if global temperatures rise by four degrees, there could be a 14% increase in the volume of rain falling. The BBC has also produced a visualisation tool to show postcode areas currently vulnerable to extreme heat, which will likely become more relevant for people as temperatures increase[102].

As part of the CCC's assessment of climate risk, there is also a summary of the risks for Scotland[103]. The CCC state that of the 61 risks assessed, 32 require more action in Scotland and the urgency score for 25 risks have increased since the previous CCRA. There has been a decrease in urgency score for only one risk. Flooding is among the greatest risk to people, communities and buildings in Scotland. Other risks assessed as having a high future magnitude score include:

[y] Adaptation to climate change - Climate change - gov.scot (www.gov.scot). The most recent Scottish adaptation plan was published in 2018 following the 2017 climate change risk assessment from the UK Government.

- Impacts on the natural environment (terrestrial, freshwater, coastal and marine species, forests and agriculture)
- Increase in the range, quantities and consequences of pests, pathogens and invasive species (which also negatively affect the natural environment)
- Impacts (such as from flooding and coastal erosion) which damage infrastructure (energy, transport, water and technology)
- The impact of extreme temperatures, high winds and lightning on the transport network.
- The impact of increasing high temperatures on people's health and wellbeing
- Changes in household energy demand due to seasonal temperature changes.
- Increased severity and frequency of flooding of homes, communities and businesses.
- Damage to cultural heritage assets as a result of temperature, precipitation, groundwater and landscape changes.
- Impacts internationally that may affect the UK, such as risks to food availability, safety and security, risks to international law and governance from climate change that will affect the UK, international trade routes, public health and the multiplication of risks across systems and geographies

The report also recognises that there are interactions between risks.

A variety of organisations have highlighted examples of how the natural environment and people are likely to be affected by climate change. Some are listed below[104,105].

- Natural environment
    - Loss of, or significant changes to habitats
    - Increased flooding of rivers
    - River channel readjustments
    - Eutrophication
    - Drying out of peat soils
    - Decline of species not adapted to warmer climate
    - New species may move to or out of Scotland
    - Rising sea levels and changes in erosion and deposition

    - Increasing ocean temperatures and acidity
    - Changes to productivity of agriculture and forestry due to warmer conditions, but increased threats from, e.g. climate, pollution, pests and diseases
    - Changes to forestry industry such as drought, disease and wind damage[z]
- Built environment
    - Increased flooding
    - Increased extreme weather which may disrupt transport, energy and communication networks
    - Reduced energy supply security and efficiency – for example due to changes in ability to generate renewable energy
    - Erosion of historic built environment and chemical damage from pollution[aa]
- People
    - Increased spread of pests and diseases
    - Strain on global food security
    - Increased competition for water between households, agriculture and industry
    - Increased flood risk

[z] In 2008, Scottish Forestry conducted spatial modelling research to better understand the impact of climate change on forestry in Scotland. The research found that climate change will create many challenges and opportunities for Scotland's forest industry. Productivity will increase in some areas and a wider selection of species will become suitable. However, there are also potential threats, including drought, increased insect and disease damage, and wind damage, hence new techniques to combat these will be necessary. There are many uncertainties associated with climate change, and its likely impact on trees, management systems and forest operations. Impacts of Climate Change on Forestry in Scotland: A Synopsis of Spatial Modelling Research

[aa] Historic Environment Scotland have produced a report highlighting the specific impacts of climate change on the historic environment, to be used as a tool for assessing the hazards and level of risk A Guide To Climate Change Impacts | Historic Environment Scotland

- Amplifying many causes of poor health such as temperature related mortality and morbidity, issues associated with flooding, reduced food security and increased volatility of international markets[106]
- Mental health impacts - According to the Scottish Household Survey, in 2019, 68% of respondents thought that climate change was an immediate and urgent problem[107]. If action is not taken to tackle the climate emergency, this could lead to high levels of climate anxiety, particularly among young people who may feel it is their responsibility to tackle the issue, without having any power to do so.[106]

It is also important that policies and actions are in place to adapt to the effects of climate change. More information can be found above, however, it is likely that more is needed to plan to adapt to climate change to protect the natural environment[83].

Unequal impacts on people

It is important to note that the impacts of climate change will not affect everyone equally.

The Scottish Parliament's Information Centre (SPICe) published briefing on the impact of climate change on health in Scotland in 2012 and stated that climate change is likely to have a significant impact on people's lives. However, SPICe also found that it is likely that the effects of climate change will be most severe for those already facing disadvantage[106].

This is supported by the CCC[108]. In its report analysing how climate change adaptation can work with the Scottish Government's Just Transition programme, it states that for most of the impacts associated with climate change, those who are most vulnerable will be most heavily impacts and least able to adapt. The CCC give examples of characteristics that may contribute to vulnerability to climate change, such as having low income, ill-health, being elderly or living rurally. It therefore suggests that fairness, inequalities and potential unintended consequences for vulnerable groups should be considered throughout adaptation policy design[108].

This is also discussed in the population, human health and cultural heritage review.

International comparisons

It is widely recognised that climate change impacts and will continue to impact the natural and built environments and people across the world.[24]

Similar to Scotland, worldwide there have been increased temperatures and more extreme weather events which impact the natural environment and people. In addition, those who are most vulnerable are disproportionately affected[24,109].

As well as assessments for Scotland, the CCC also produce assessments of climate risk in the rest of the UK. For England, it states that of the 61 issues assessed, 34 require more action and 23 have increased in urgency score since the previous CCRA. There has been a decrease in urgency score for only one risk[103].

In Wales, 32 require more action and 26 have increased in urgency score, with one decreasing[103]. In Northern Ireland, 31 risks require more action, 19 require further information. However the report also notes that there is a lower quality of evidence for Northern Ireland and relatively limited climate policy in place[103].

These values are very similar for Scotland, where 32 require more action and 25 have increased in urgency score[97].

Summary

Climate change is already impacting people and the environment both in Scotland and worldwide. In Scotland, for example, temperature rises and changes in rainfall patterns will affect most aspects of the environment and people's lives such as through increased flooding and changes in species distribution.

These impacts are very likely to increase and intensify over time, however the extent of the impact will be dictated by global progress in reducing greenhouse gas emissions. Nonetheless, regardless of the extent of GHG emissions reductions, climate change will impact people and the environment and so adaptation efforts will be necessary.

It is important to note that the impact of climate change on people will be unequal, with vulnerable people most likely to be affected and least able to adapt.

Scotland appears to be performing comparatively with the other countries in the UK in terms of the number of climate risks that require action. However, in all countries the CCC assesses that around half of the issues identified will require more action, which suggests a large amount of action will be required.

Limiting greenhouse gas emissions and global warming will partly mitigate the impacts of climate change, but adaptation efforts are also needed.

4. Summary of next steps

This baseline review identified a wide range of possible issues for further analysis, including missed targets for emissions, progress towards energy efficiency targets, further analysis of energy sources and stalling of progress on adaptation.

However, for the purposes of our initial analytical priorities, ESS will focus on:

- Progress against greenhouse gas emission targets.
- Progress on climate change adaptation, including planning for extreme weather events.

ESS' proposed Strategic Plan describes how issues will be prioritised for further analysis according to a range of criteria, including:

- Importance – the size and risk of the potential effect on the environment and/or public health; the urgency with which improvement is required;
- Nature and Scope – recent trends in environmental performance; whether the issue of concern appears to be systematic and/or longstanding;
- Neglect – whether there has been action taken on the issue of concern, or further action is planned in the near future; and
- Added-value – the contribution we could make, considering whether other monitoring, oversight or scrutiny bodies are planning to take, or could take, action to address the issue of concern.

These priorities in the area of climate change account of that scheme. They recognise the importance of reducing emissions and adapting to climate change for their cross-cutting influence in many environmental and social areas such as for agriculture, biodiversity and human health. They also consider the missed targets on emissions and stalled progress on adaptation. In keeping with the prioritisation process, the contributions of other actors and the added value that ESS can bring to an area will also be considered, in deciding where to focus future work.

Although ESS intends to focus on two issues in the first instance, other issues will be retained on a list for potential future analysis and horizon scanning in line with the stages of monitoring and analysis work set out in the strategic plan.

5. Summary of key sources

The end notes to this review provide details of the references and sources used throughout the document. This section is intended to provide a shorter note of those reports (in future iterations) and data sources which have been identified as likely to be important for an ongoing understanding of biodiversity in Scotland.

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