Reducing emissions in Scotland

2019 Progress Report to Parliament

Committee on Climate Change
December 2019

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Report to the Scottish Parliament pursuant to Section 9(1) of the Climate Change (Scotland) Act 2009.

Acknowledgements

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A wide range of stakeholders who engaged with us or met with the Committee bilaterally.

Contents

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Lord Deben was the UK's longest-serving Secretary of State for the Environment (1993 to 1997). He has held several other high-level ministerial posts, including Secretary of State for Agriculture, Fisheries and Food (1989 to 1993). He has consistently championed the strong links between environmental concerns and business interests. Lord Deben also runs Sancroft, a corporate responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues. He is Chairman of Valpak Limited and the Personal Investment Management and Financial Advice Association.

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Baroness Brown of Cambridge DBE FREng FRS (Julia King) is an engineer, with a career spanning senior engineering and leadership roles in industry and academia. She currently serves as Chair of the CCC's Adaptation Committee; non-executive director of the Offshore Renewable Energy Catapult; and Chair of the Carbon Trust. She was non-executive director of the Green Investment Bank, she led the King Review on decarbonising transport (2008). She is a Fellow of the Royal Academy of Engineering and of the Royal Society, and was awarded DBE for services to higher education and technology. She is a crossbench Peer and a member of the House of Lords European Union Select Committee.

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Rebecca Heaton is responsible for Drax Group's efforts to mitigate climate change, ensuring that sound science underpins climate change polices and business strategy. She is also responsible for developing sustainability and climate change research programmes. She has a 20 year global career working at the interface between business, science and policy. After an early career in academia, she has held senior roles in a number of large energy companies. A Chartered Forester, her expertise spans energy, climate change and land-use, the interaction between them and the role business has to play in enabling the UK to decarbonise.

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Paul Johnson is Director of the Institute for Fiscal Studies and a visiting professor at University College London (UCL). He is widely published on the economics of public policy and is a columnist for The Times. He was previously director of public spending at HM Treasury and Chief Economist at the Department for Education. He was awarded a CBE for services to economics and social science in 2018.

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Corinne Le Quéré is a Royal Society Research Professor at the University of East Anglia (UEA), specialising in the interactions between climate change and the carbon cycle. She was lead author of several assessment reports for the UN's Intergovernmental Panel on Climate Change (IPCC), Director of the Tyndall Centre for Climate Change Research, and Director of the annual update of the global carbon budget by the Global Carbon Project (GCP). She currently Chairs the French Haut Conseil pour le Climat.

Executive Summary

Our eighth annual report, required by Scottish Ministers under the Climate Change (Scotland) Act 2009, assesses Scotland's progress in achieving its legislated targets to reduce greenhouse gas emissions.

Scotland now has legislated for a net-zero emissions target in 2045. The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 has introduced a world-leading net-zero target for all greenhouse gases - including Scotland's share of international aviation and shipping - and a series of stretching targets on the path to achieving that goal.

In our *Net Zero* report, the Committee made it clear that meeting Scotland's 2045 target is contingent on early and decisive action to strengthen policy. In the Programme for Government, the Scottish Government has sent a strong signal that it is taking the more ambitious targets seriously. New policies implemented as a response to the net-zero target must now begin to deliver meaningful emissions reductions in the real world, and be extended to all areas of the economy.

Next year will see Glasgow host the most important global climate summit (COP26) since Paris in 2015. These crucial talks offer a major opportunity to increase global ambition and effort to cut emissions. The credibility of the UK in the COP26 Presidency - and Scotland, as hosts - now rests on real action at home. By the time of the COP, Scotland must implement new actions to deliver against an updated Climate Change Plan, demonstrating to the rest of the world a clear and credible commitment to achieve net-zero emissions by 2045.

Our key messages for Scotland are:

- **Setting a net-zero greenhouse gas emissions target for 2045 represents a step-change in ambition for Scotland.** This requires urgent action towards meeting it. Every sector of the economy must contribute fully.
- **The Scottish Parliament's 2030 target to reduce emissions by 75% will be extremely challenging to meet. It must be backed up by steps to drive meaningful emissions reductions, immediately.** The recent sharp reductions in Scotland's emissions caused by the virtual elimination of fossil-fired electricity generation in Scotland must now be maintained through action in other sectors. Recent performance in other sectors shows only incremental improvement at best. Scotland's new 2030 target is highly ambitious, and implies that the 2020s must be focused on strong action and delivery. We will assess the feasibility of Scotland's 2030 target as part of our work on the UK Sixth Carbon Budget in 2020.
- **The forthcoming update to Scotland's Climate Change Plan is an opportunity to set a clear and credible path to net-zero emissions in 2045.** The foremost challenge is not to produce a quantified, optimised pathway for emissions reductions in each sector; the greatest need is for improved Scottish Government policies and stronger governance to drive a rapid, sustained transformation to a net-zero Scotland:
  - Net-zero policy must be embedded across all levels and parts of government, with strong leadership and coordination at the centre.
  - The public must be engaged in the challenge and policy should be designed to put people at the heart of it.
  - Policy should provide a clear and stable direction and a simple investable set of rules and incentives that leave room for businesses to innovate and find the most effective means of switching to low-carbon solutions.

- **A Climate Change Plan that puts Scotland on the path to net-zero must focus on taking action in the 2020s and 2030s.** A successful plan would have the following elements:
  - Ensure that by 2032 (or even earlier if feasible) there is no need for anyone in Scotland to buy a petrol or diesel car or van. The necessary electric vehicle charging infrastructure and supporting policies would be in place, as well as infrastructure for public transport and cycling.
  - Ensure that all buildings are as energy efficient as can be practically achieved and that low-regret forms of low-carbon heating (i.e. heat pumps in off-gas areas, hybrid heat pumps, and low-carbon district heating) are being rolled out at scale in the 2020s, as decisions are made about the UK-wide plan for the full decarbonisation of heat.
  - Support the necessary changes in Scottish land use that will underpin net zero. Changing the use of agricultural land is a major goal for Scottish policy, delivering meaningful emissions reductions on farms, and supporting the promised rapid and sustained increase in the rate of tree planting and peatland restoration.
  - Incentivise switches to low-carbon heat and improve energy and resource efficiency in industry.
  - Work with the UK Government to ensure that policy mechanisms and infrastructure (e.g. CO_2 transport and storage, hydrogen clusters, renewable electricity support) are developed in a way that allows Scotland to decarbonise industry, roll-out greenhouse gas removals, and transform low-carbon electricity generation and distribution to enable electrification of other sectors.
  - Tackle skills gaps that would otherwise hinder progress (e.g. for low-carbon heating, energy efficiency, ventilation and thermal comfort) and deliver the commitment to 'green' jobs that has been promised.
  - Engage with the public on emissions reduction opportunities to make lifestyle changes, such as more walking and cycling, having healthier diets, and adopting new low-carbon technologies including electric vehicles and low-carbon heating.
- **The Programme for Government 2019-20, alongside other recent policies, has sent a clear signal that the Scottish Government is taking the more ambitious targets seriously.** Promising new policies for green finance, buildings and transport have been put in place – now they must start delivering emissions reductions in the real world:
  - Scotland has launched calls to bid for a £3 billion green investment portfolio, the new Scottish National Investment Bank has the primary mission of securing the transition to net-zero, and Scotland's 'Growth Accelerator' programme has been extended to a 'Green Growth Accelerator' that allows local authorities to invest in low-carbon infrastructure.
  - Scotland will consult on zero- or ultra-low-emission city centres by 2030, and aims to end the need for new petrol or diesel cars in the public sector fleet by 2025. New funding has been announced for Scotland's public electric vehicle charging network and for loans to purchase ultra-low emission vehicles. A new £500 million fund to improve bus services across Scotland could have a major impact by reducing emissions from petrol and diesel cars, and Scotland has also pledged to decarbonise passenger rail services by 2035, and all flights between Scottish airports by 2040.

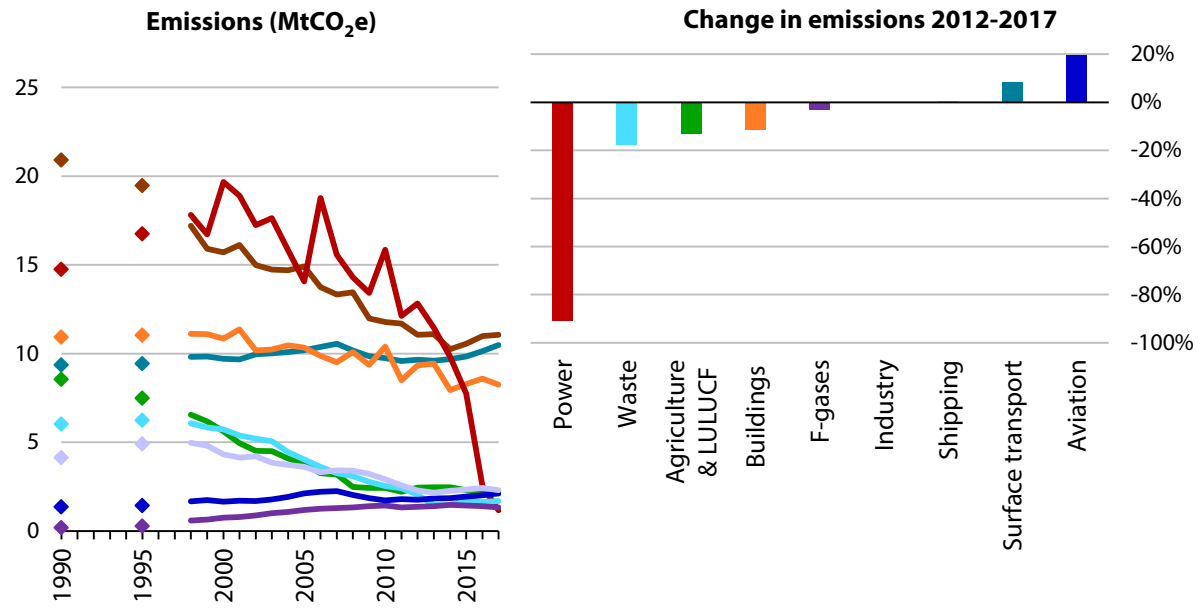
- All new homes will be required to use renewable and low-carbon heat from 2024 - a year earlier than the rest of Great Britain - with low-carbon heat phased in to new non-domestic buildings from this date. Scotland has committed to introducing tighter energy standards for all new buildings, including non-domestic and public sector buildings, by 2021.

- **There is much more work still to be done for the Scottish Government, especially in agriculture and the challenge of changing land use to mitigate climate change:**
  - Agriculture and land use is a critical part of Scotland's ability to achieve net-zero, yet emissions from agriculture have fallen by just 2% since 2008. The Scottish Government's plans for a long-term policy framework to replace the EU Common Agricultural Policy (CAP) are lagging behind both England and Wales. There is now an urgent need to define a post-CAP framework for the 2020s that can significantly reduce emissions from agriculture and deliver transformational land-use change across Scotland.
  - Scotland met its tree-planting targets for the first time in 2018/19 (planting over 11,000 hectares of new trees) but this must continue to rise to a minimum of 15,000 hectares by the mid-2020s and stay there if Scotland is to achieve net-zero. This will require a stable and long-term support mechanism for afforestation.
  - The Energy Efficient Scotland programme for buildings must be extended to non-domestic properties following consultation in the next two years, and Scotland should consider whether the existing targets for domestic buildings can be tightened. The domestic buildings programme has focused so far on social housing and the private rented sector. Further clarity on the package of support and regulation for owner occupied homes will also be required. The Heat Networks Bill in 2020 should provide more clarity on how low-carbon district heating will be incentivised and regulated in Scotland.

- **Scotland achieving its net-zero target is contingent on the rest of the UK, and vice versa.** The UK Government must step up and match Scottish policy ambition in areas where key powers are reserved. Our 2019 UK Progress Report concluded that actions taken by the UK Government to date have fallen well short of those required for the net-zero target. This includes industry, carbon capture and storage, electricity generation, the future of the gas grid, vehicle standards, road freight, and a common aviation framework. Both governments must work more closely and in a more strategic way to make the best use of devolved and reserved policy levers, especially in areas where responsibilities are split including the future of heat, support for electric vehicles, and the delivery of low-carbon infrastructure.
- **Greenhouse gas emissions in Scotland fell by 3% in 2017 to 40.5 $MtCO_2e$.** Greenhouse gas emissions in Scotland have fallen by 47% since 1990, and the economy has grown by 55% in the same period. This progress was primarily driven by the power sector (Figure 1), and 2017 marked the first full year of coal-free electricity generation in Scotland. Non-electrical emissions from buildings also fell, by 4%, though this is likely to have been partly caused by a milder winter than average. Surface transport emissions rose for the fourth consecutive year to 10.5 $MtCO_2e$ (+3%), and have increased by 9% since 2012. When including aviation and shipping, transport is the highest emitting sector in Scotland, at 37% of total emissions.

- **Scotland missed its former annual target for 'net' emissions reductions in 2017. These targets have been replaced with an improved set of annual targets in the 2019 Act.** On the 'net' basis, adjusted for EU Emissions Trading System (EU ETS), Scotland's emissions were 46.4 $MtCO_2e$ in 2017, and the target was 43.9 $MtCO_2e$. Despite actual emissions in Scotland falling, the 'net' measure of emissions increased by 4% as Scotland's allowances under the EU Emissions Trading System increased. Revisions to the UK emissions inventory, particularly in forestry, also made that target harder to achieve. Targets on the 'net' basis have now been superseded by the 2019 Act and we will not report on them in future reports; Scotland's new targets are set on the basis of actual territorial emissions and have more flexibility to cope with year-to-year inventory changes.

Figure 1. Scotland must act now to reduce emissions outside of the power sector



Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Does not reflect forthcoming revisions to peatland emissions or global warming potentials (see Box 1.1).

This report is set out in nine chapters:

- Chapter 1 provides an overview on the latest Scottish emission trends in relation to the emission reduction targets.
- In Chapter 2, we assess the challenge of reaching net-zero greenhouse gas emissions by 2045 in Scotland and what the implications are for near- and medium-term policies that must be reflected in the Scottish Government's next Climate Change Plan.
- The subsequent chapters are focussed on the different sectors of the Scottish economy. In these chapters we present a list of key policy milestones for decarbonising each sector and identify whether the key powers lie with the Scottish or UK Government, followed by a summary of emission trends and the underlying factors.

Chapter 1: Economy-wide progress

This is our eighth report on Scotland's progress towards meeting emission reduction targets, as requested by Scottish Ministers under the Climate Change (Scotland) Act 2009.

Chapter 1 provides an overview on the latest Scottish emission trends in relation to the emission reduction targets. We review performance in reducing emissions across the economy as a whole, and set out the latest trends in emissions in the following five sections:

1. Introduction to reporting progress towards emissions reduction targets.
2. Emissions trends for Scotland in 2017.
3. Summary of progress towards targets against the base inventory.
4. Effects of past and future methodology changes to the Scottish greenhouse gas inventory.
5. Outlook for Scottish emissions data for 2018.

In Chapter 2, we assess the challenge of reaching net-zero greenhouse gas (GHG) emissions by 2045 in Scotland and what the implications are for near- and medium-term policies that must be reflected in the Scottish Government's next Climate Change Plan.

The subsequent chapters focus on the different sectors of the Scottish economy. In these chapters we present a list of key policy milestones for decarbonising each sector and identify whether the key powers lie with the Scottish or UK Government, followed by summary of emission trends and the underlying factors.

1. Introduction to reporting progress towards emissions reduction targets

We welcome the decision by the Scottish Government and Parliament to adopt the Committee's recommendation to target net-zero emissions of GHGs in Scotland by 2045. The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 amended the 2009 Act to set a net-zero target for 2045.

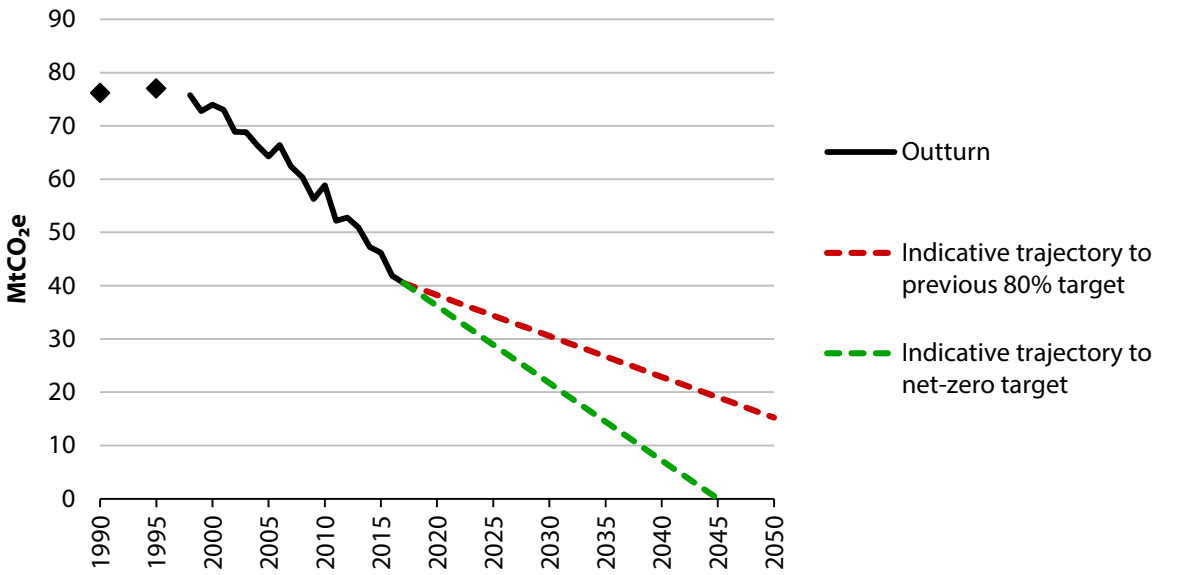
The 2019 Act introduced new emissions reductions targets for 2020, 2030 and 2040 of 56%, 75% and 90% respectively against 1990 levels. The targets for 2020 and 2040 were set in line with the Committee's recommendations, but the Scottish Parliament has set a more stretching 75% reduction target for 2030 than our recommended 70%. The 2019 Act also changes the scope of the emissions targets to cover 'actual' emissions rather than the previous 'net' targets which accounted for EU Emissions Trading Scheme allocations (EU ETS).[1]

The path to achieving net-zero by 2045 will necessitate a steeper reduction in emissions over the next three decades compared to Scotland's previous 2050 target. When all emissions from Scottish peatland are accounted for, emissions will need to fall by an average of 1.8 $MtCO_2e$ each year between now and 2050, equivalent to 3.6% of emissions in 2017 (Figure 1.1).[2]

As part of our *Net Zero* advice, we recommended interim emissions targets for 2030 and 2040 on the basis of a straight-line trajectory of the average emissions reduction required between 2020 and 2045. The Committee will return to the appropriate path for Scottish emissions over the period to 2045 once we have developed a stronger evidence base on the pathway for UK emissions, as part of our advice next year on the UK sixth carbon budget.

[1] 'Actual' emissions are the total emissions from Scotland, including emissions from Scotland's share of international aviation and shipping, without any adjustment for trading of EU allowances.
[2] This rate of reduction assumes 9.6 $MtCO_2e$ of peatland emissions are added to a future inventory for 2017.

Figure 1.1 Indicative rates of decarbonisation required to achieve an 80% reduction by 2050 and net-zero emissions by 2045 in Scotland



Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017*; CCC analysis.
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Does not reflect forthcoming revisions to peatland emissions or global warming potentials (Box 1.1).

2. Emissions trends for Scotland in 2017

On the basis of the latest published GHG emissions inventory, total Scottish emissions fell by 3% in 2017 to 40.5 $MtCO_2e$.[3] Greenhouse gas emissions in Scotland have fallen by 47% since 1990, while the economy has grown by 55% in the same period (Figure 1.2). This compares favourably to reductions in emissions of 2% in 2017 and 39% since 1990 for the whole of the UK.

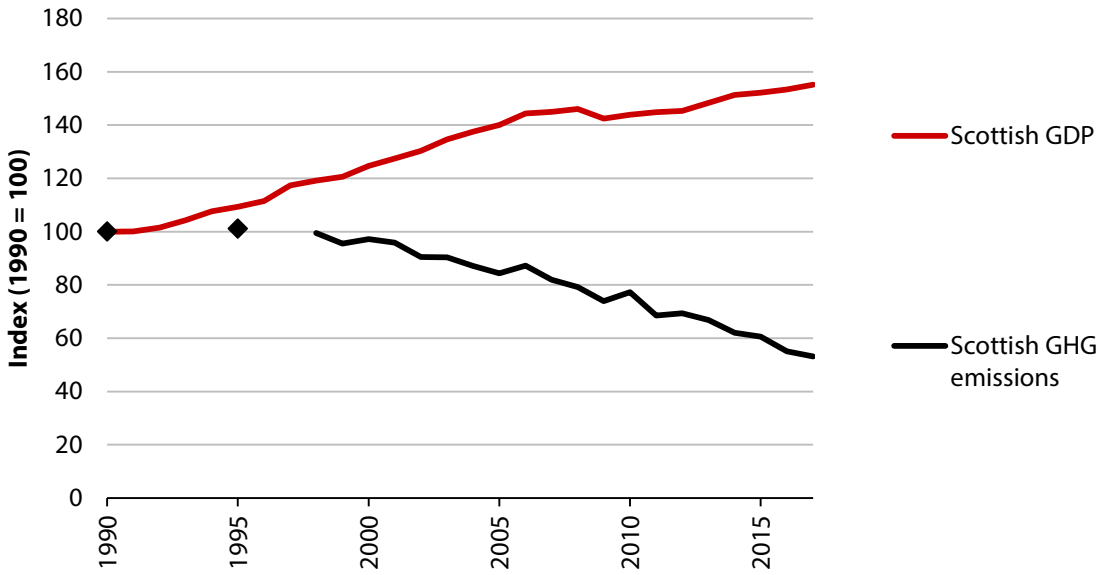
The fall in total emissions in the past five years has not been evenly distributed across all sectors. Strong progress in the power sector has dominated, with smaller reductions in some sectors and increases in others. This trend continued in 2017 (Table 1.1):

- Emissions fell by 1.3 $MtCO_2e$ (-54%) in the power sector in 2017. Emissions have fallen by 91% since 2012 and now account for less than 3% of Scottish emissions. Following the closure of Longannet power station in early 2016, there was zero coal-fired generation in Scotland in 2017. This is an important step for Scotland, but actions are now required in other sectors to ensure that overall progress is maintained.
- Surface transport emissions rose for the fourth consecutive year to 10.5 $MtCO_2e$ (+3%), and have increased by 9% since 2012. When including aviation and shipping, transport is the highest emitting sector in Scotland, at 37% of total emissions.
- Emissions from buildings[4] fell by 0.3 $MtCO_2e$ (-4%). There were smaller changes in other sectors, with emissions falling by 0.1 $MtCO_2e$ across agriculture and land use (-3%), shipping

[3] Including Scotland's share of international aviation and shipping emissions. The latest published inventory does not reflect forthcoming revisions to peatland emissions or global warming potentials (Box 1.1).
[4] Emissions from non-electrical sources of energy, primarily associated with heating.

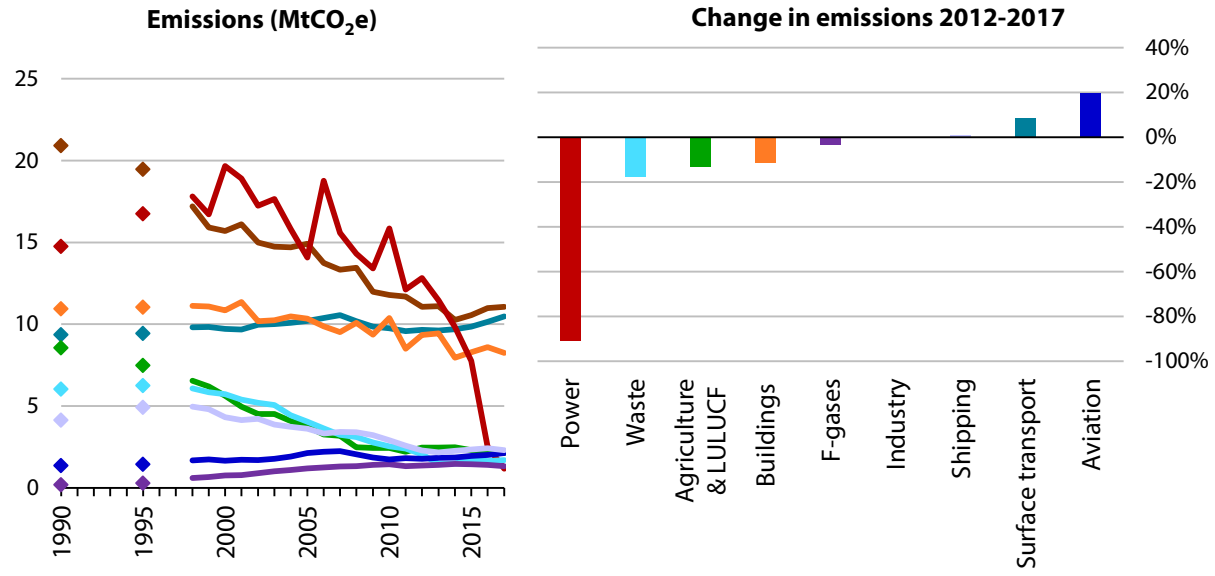
(-5%), and F-gases (-5%), while emissions from industry (+1%) and domestic and international aviation (+6%) both increased by 0.1 $MtCO_2e$ (Figure 1.3).

Figure 1.2 Greenhouse gas emissions have fallen in Scotland as the economy has grown



Source: Scottish Government (2019) *GDP Quarterly National Accounts, 2019 Quarter 2; NAEI (2019)*; CCC analysis.
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. GDP in real terms, chained volume measure.

Figure 1.3 Greenhouse gas emissions by sector in Scotland (1990-2017)



Source: NAEI (2019).
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Does not reflect forthcoming revisions to peatland emissions or global warming potentials (see Box 1.1).

Table 1.1. Greenhouse gas emissions by sector in Scotland

Sector	Emissions in 1990 ($MtCO_2e$)	Emissions in 2017 ($MtCO_2e$)	Change in emissions from 2016 to 2017 ($MtCO_2e$)
Transport, of which:	14.8	14.9	+0.3
Surface transport	*9.4*	*10.5*	+0.3
Aviation	*1.4*	*2.1*	+0.1
Shipping	*4.1*	*2.3*	-0.1
Industry	20.9	11.1	+0.1
Buildings, of which	10.9	8.3	-0.3
Residential buildings	*8.0*	*5.9*	-0.3
Non-residential buildings	*2.9*	*2.3*	-0.1
Agriculture and land use, land-use change and forestry (LULUCF), of which:	8.5	2.1	-0.1
Agriculture	*8.9*	*7.6*	0.0
LULUCF	*-0.3*	*-5.4*	0.0
Waste	6.0	1.7	0.0
F-gases	0.3	1.3	-0.1
Power	14.8	1.2	-1.3
Total	**76.3**	**40.5**	**-1.4**

Source: NAEI (2019).
Notes: F-gas emissions in the 1990 column are shown for 1995, which is the base year against which F-gas emissions reductions are measured in the Climate Change (Scotland) Act 2009. Changes from 2016 to 2017 that are less than 0.05 $MtCO_2e$ are shown as zero change. Values may not sum due to rounding.

3. Summary of progress towards targets against the base inventory

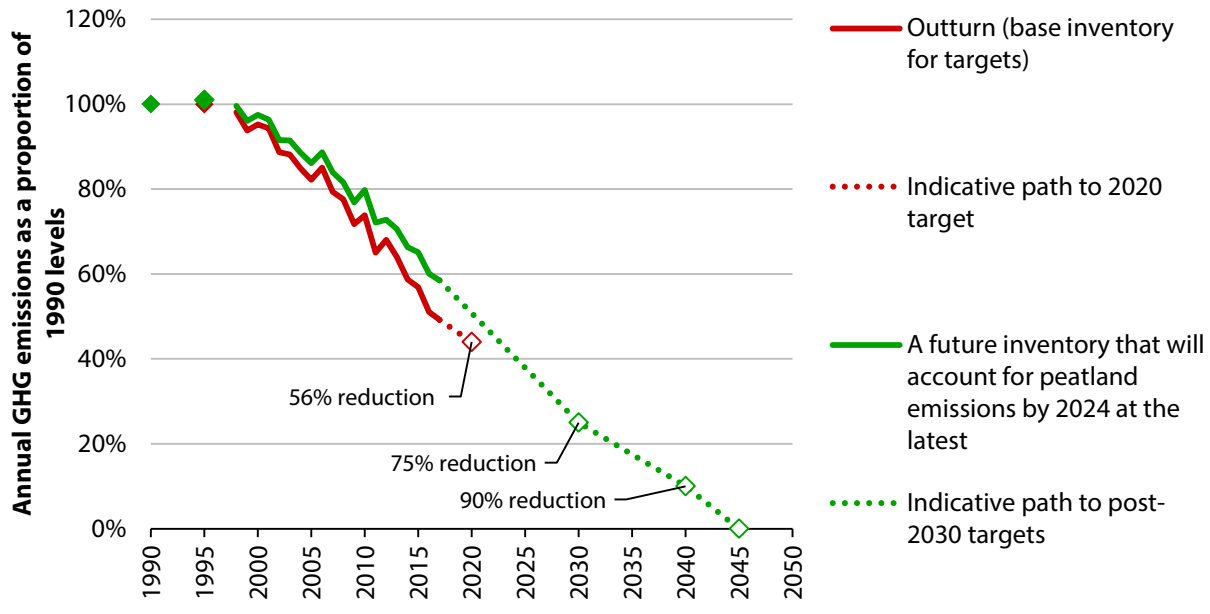
The emissions targets under Scotland's new climate legislation are measured against a 'base inventory' as recommended by the Committee in December 2017.[5] Comparing targets to a base inventory allows the calculation of a reference 'GHG account' that is used to assess target compliance. This measures progress against targets comparable to the inventory on which the targets were set. The use of the base inventory makes Scotland's targets less sensitive to year-to-year changes to the inventory methodology, and must be updated at least every five years.

The 2019 Act defined the reference 'base inventory' as the most recent UK GHG inventory published by 30 June 2018. This defines the base inventory as the one published on 12 June 2018 covering emissions in Scotland from 1990 to 2016. On this basis:

- The 1990 baseline against which emissions reductions are measured was 75.7 $MtCO_2e$.
- For 2017, the inventory-adjusted GHG account was 37.2 $MtCO_2e$.
- Against the 'base inventory', emissions have fallen by 51% from 1990 to 2017.

Unless emissions are reduced in sectors other than electricity generation, Scotland is at risk of missing its interim target of a 56% reduction in emissions by 2020, as set out in the 2019 Act (Figure 1.4, Table 1.2).

Figure 1.4. Indicative pathways to Scotland's newly-legislated emissions targets



Source: NAEI (2019); Chris Evans et al. (2019) *Implementation of an Emissions Inventory for UK Peatlands*; CCC analysis.
Notes: The base inventory is the inventory against which Scotland's emissions reduction targets are currently measured. This is currently the inventory published on 30 June 2018 (Figure 1.5) but this base inventory will be updated well in advance of the 2030 target. The base inventory does not reflect forthcoming revisions to peatland emissions (Box 1.1).

[5] CCC (2017) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework.*

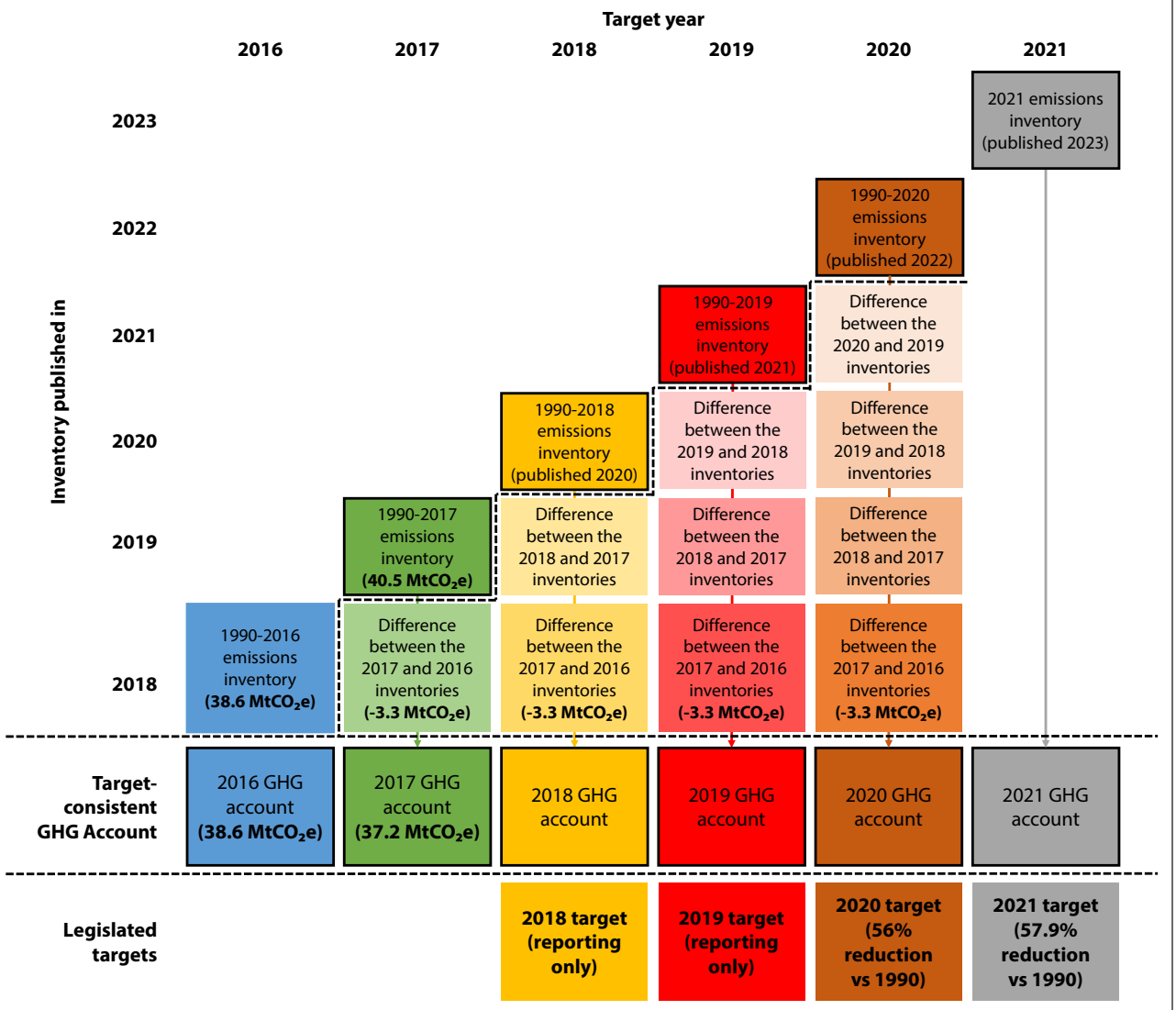
Table 1.2. Scotland's targets and progress to date

Target	Progress to date
2045 net-zero target The 2019 Act set a target to reduce emissions of greenhouse gases to net-zero by 2045. This target accounts for all emissions including Scotland's share of emissions from international aviation and shipping (IAS).	Actual emissions in 2017 were **40.5 $MtCO_2e$, a 47% reduction on 1990 levels.** Scotland must reduce its emissions by an average of 1.8 $MtCO_2e$ per year between now and 2045. In 2017, emissions fell by 1.4 $MtCO_2e$.
2020 interim target and annual targets The 2019 Act established an interim target of a 56% reduction in emissions by 2020, based on the reference 'base inventory' published on 30 June 2018 (Figure 1.5). The 2019 Act set emissions reduction targets for 2018 (54%) and 2019 (55%) for reporting purposes only. The 2019 Act established 75% and 90% reduction targets for 2030 and 2040. These will be assessed against a future inventory which contains emissions from peatland (Figure 1.4). The 2019 Act requires the Committee to define the fair and safe Scottish emissions budget from 2010 to 2050.[6] At the time of analysis for our *Net Zero* report, our assessment of the fair and safe budget was 1,135 $MtCO_2e$.[7] We will review this figure in 2020 as part of our upcoming work on the UK sixth carbon budget.	After adjusting Scottish emissions to the 'base inventory' against which targets are measured **Scotland's emissions were 37.2 $MtCO_2e$ in 2017, 51% below 1990 levels**. The 2020 target (56%) is therefore in reach but also requires reductions in sectors beyond power generation. On the basis of the latest published inventory, cumulative emissions from 2010 to 2017 were 390.6 $MtCO_2e$. This value does not reflect forthcoming revisions to peatland emissions or global warming potentials (see Box 1.1). Accounting for all emissions from peatland over this period could add up to approximately 70 $MtCO_2e$ to this figure.
Previous annual target Prior to the 2019 Act, the Scottish Government had an annual target of 43.9 $MtCO_2e$ 'net' emissions (taking EU ETS allowances into account) in 2017. These targets were superseded by the 2019 Act, but we include here for completeness. Previous annual targets on the 'net' basis now have no legal basis and we will not report on these targets in future reports.	On the 'net' basis, emissions in Scotland in 2017 were 46.4 $MtCO_2e$. Scotland missed its 'net' annual target for 2017. (A) Non-traded emissions = 29.4 $MtCO_2e$ (B) Actual emissions in traded sector = 11.1 $MtCO_2e$ (C) Share of EU ETS cap = 17.0 $MtCO_2e$ **(A) + (C) = 46.4 $MtCO_2e$ 'net' emissions.** (A) + (B) = 40.5 $MtCO_2e$ 'actual' emissions.

[6] The fair and safe Scottish emissions budget is 'the aggregate amount of net Scottish emissions of greenhouse gases for the period 2010 to 2050 as recommended by the relevant body as being consistent with Scotland, in line with the principles set out in article 3 of the United Nations Framework Convention on Climate Change, contributing appropriately to the holding of the increase in global average temperature to well below 2°C above pre-industrial levels, and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.'

[7] This figure includes an estimate of past and future emissions from peatland and is also adjusted for the higher range of AR5 GWP values. Calculated using historical data from 2010 to 2016 and based on the trajectory published in CCC (2019) *Net Zero - The UK's contribution to stopping global warming,* Figure 8.2. We will review this in 2020 as part of our upcoming work on the UK sixth carbon budget.

Figure 1.5. Estimates of LULUCF and non-LULUCF emissions in inventories published 2017-2019



Source: NAEI (2019); NAEI (2018) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2016*; CCC analysis.

Notes: This illustrates the process of adjusting the GHG inventory to create the GHG Account, focusing on the years 2018-2023. The inventory published in June 2018 is the base inventory. Emission estimates in subsequent years are adjusted to meet the scientific methodology used in 2018, using a set of adjustments derived from the differences in emissions estimates for a given year in consecutive inventories. After a maximum of five years from the 2019 Climate Change (Emissions Reduction Targets) Act - in this example by 2023 - the base inventory is updated to re-align with the latest available scientific methodology (potentially together with changes to the legislated targets). In this case, the estimate for 2021 emissions made in 2023 would not be adjusted, and the inventory published in 2022 would become the new base inventory.

4. Effects of past and future methodology changes to the Scottish greenhouse gas inventory

Methodology changes to the emissions inventory are designed to increase the transparency, accuracy, consistency, comparability, and completeness of emissions estimates. There are three primary sources of uncertainty in the inventory:

- **Uncertainty in the current GHG inventory.** This comprises the statistical uncertainty in emission factors and activity data used in estimating emissions. It is internal to the inventory, is well quantified and it is possible to formally assess the probability of errors through methods set out in IPCC guidelines. For the 2014 inventory, the uncertainty was estimated as ±3% with 95% confidence for the UK as a whole, but up to ±10% for Scotland. This measure was higher in Scotland because the uncertainty is concentrated in sectors involving complex biological processes or diffuse sources such as waste, agriculture and land use, land-use change and forestry (LULUCF), which have a greater share of emissions in Scotland.[8]
- **Uncertainty in Global Warming Potentials (GWPs) assigned to GHGs.** GWPs are used to convert emissions from different gases into a single comparable metric (tonnes of CO_2-equivalent, or tCO_2e). As agreed internationally, the inventory uses the GWP evaluated over a 100-year time frame (GWP100). There have been multiple changes to the GWP estimates used for CH_4, N_2O and F-gases since the inception of the inventory. Future changes to GWPs will significantly affect emissions as measured in $MtCO_2e$.
- **Scope of the inventory.** Some sources of emissions and activities (e.g. peatlands) are not currently included in the inventory but will be included in the future, thus adding to overall GHG estimates.

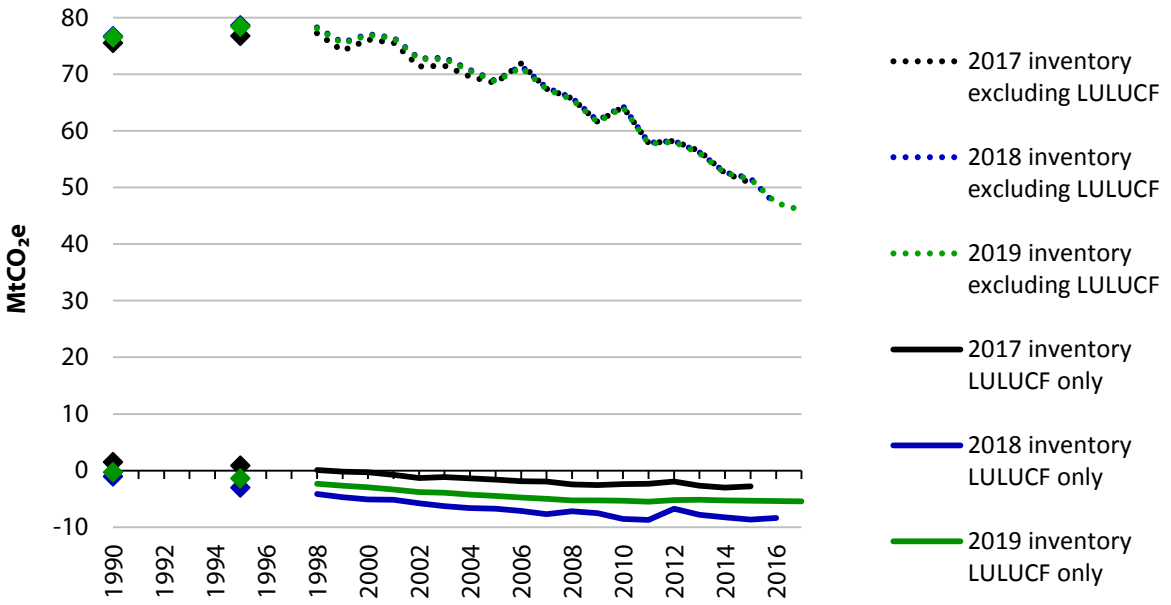
Changes between inventories published in 2018 and 2019 increased the estimate of emissions in 2016 - the most recent comparable year - by 3.3 $MtCO_2e$ (or around 4% of 1990 emissions), and increased the estimate of emissions in 1990 by 0.6 $MtCO_2e$. The previous inventory estimated that emissions in 2016 were 49% below 1990 levels; this has now changed to a 45% reduction on the latest inventory.

In 2017, there were small revisions across several sectors, but the most significant change was in the estimate of emissions from land use, land-use change and forestry (LULUCF) in Scotland, in particular due to the correction of an error in the emissions inventory to address the double-counting of deadwood harvesting that had previously overstated the size of the sink. Methodological changes to how LULUCF emissions are calculated have dominated the differences between the last three published inventories (Figure 1.6). Changes to the inventory have decreased the estimated size of the LULUCF sink in Scotland by 3.0 $MtCO_2e$ in 2016.

There are two known changes to future emissions inventories that could add over 40 $MtCO_2e$ per year to the UK inventory before 2025 (Box 1.1). Our recommended net-zero greenhouse gas target in 2045, as well as the interim targets in 2030 and 2040, takes these two methodological changes into account, while Scotland's new 'base inventory' method for assessing targets is designed to be robust to methodological changes in the near-term.[9]

[8] CCC (2017) *Quantifying Greenhouse Gas Emissions.*
[9] CCC (2017) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework.*

Figure 1.6. Estimates of LULUCF and non-LULUCF emissions in inventories published 2017-2019



Source: NAEI (2019); NAEI (2018) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2016*; NAEI (2017) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2015*; CCC analysis.
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Does not reflect forthcoming revisions to peatland emissions or global warming potentials (see Box 1.1).

Box 1.1 Effect of past and future methodology changes to the Scottish inventory

UK and Scottish emissions targets are based on estimates of greenhouse gas (GHG) emissions produced by the National Atmospheric Emissions Inventory (NAEI). Changes between inventories published in 2018 and 2019 increased the estimate of emissions in Scotland in 2016 (the most recent comparable year) by around 3.3 $MtCO_2e$.

There are two further changes that will be made to the emissions inventory in the near future: the addition of emissions from peatland and revision of the Global Warming Potentials (GWPs) used to calculate aggregate greenhouse gas emissions.

These inventory changes will increase the headline estimate of Scottish emissions, both for the present day and back to 1990:

- **Peatland.** The current inventory captures less than 0.1 $MtCO_2e$ of emissions associated with wetlands in Scotland, but all sources of peatland emissions will be included in the inventory by 2024 at the latest. Work by the Centre for Ecology & Hydrology (CEH) for the BEIS Wetland Supplement project, which will be used as the basis for the emissions inventory, estimates net annual emissions from all peatland sources of 6.1-9.6 $MtCO_2e$ for Scotland in 2013 and a similar amount in 1990.[10]
- **Global Warming Potentials (GWPs).** These are used to aggregate different greenhouse gases together into a common metric, showing their equivalence to carbon dioxide. At COP24 in December 2018 the international community decided to standardise reporting under the Paris

[10] Chris Evans et al. (2019) *Implementation of an Emissions Inventory for UK Peatlands.*

Box 1.1 Effect of past and future methodology changes to the Scottish inventory

Agreement transparency framework using the GWP100 metric (the GWP evaluated over a 100-year time frame). The values to be used are those from the IPCC 5th Assessment Report (AR5). There are two methodologies presented in AR5, with different GWPs, and it is not yet clear which will be used. Both are different from the AR4 values used in the current emissions inventory. The decision requires national inventories to use updated GWP values by the end of 2024. The impact of this change will be to increase the headline figure for UK emissions (excluding peatland) by around 10-50 $MtCO_2e$ in 1990 and 5-20 $MtCO_2e$ for 2017, largely from sectors which have significant methane emissions (i.e. agriculture and waste).

- For the longer term, the IPCC has recently published the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* providing updated guidance and methodologies for compiling GHG inventories. If these are adopted by a future meeting of Parties to the Paris Agreement they will in due course have to be reflected in Scotland's emissions inventory. The effect of these refinements on the emissions inventory is not yet known but will likely bring marginal improvements in the accuracy of the inventory in a number of sectors.

5. Outlook for Scottish emissions data for 2018

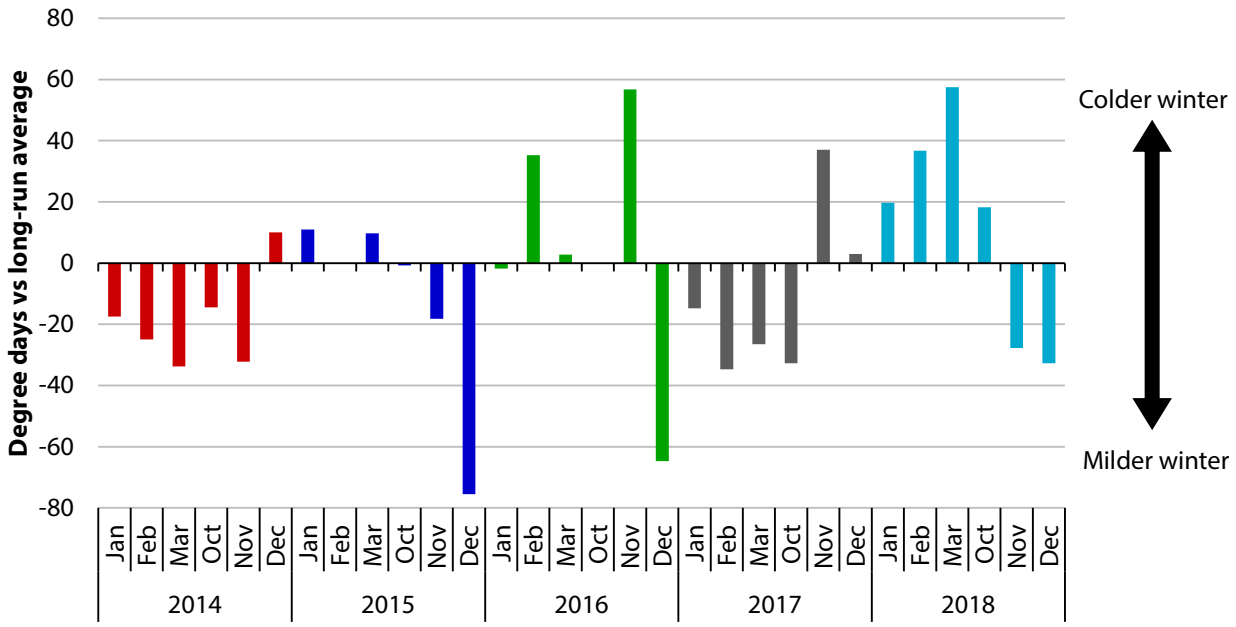
Data on Scottish emissions in 2018 will be published in June 2020. To the extent possible, we will report on 2018 Scottish emissions in our UK progress report at the end of June 2020. In this section, we draw on other data that can provide an indication of what is likely to have happened to emissions data in Scotland in 2018:

- **Diminishing potential to reduce direct emissions from the power sector.** Emissions from the power sector were just 1.2 $MtCO_2e$ in 2017 and grid intensity in Scotland was 24 gCO_2/kWh. The continued deployment of low-carbon generation will be crucial to enable other sectors of the economy in Scotland to decarbonise, but there is now very little scope to reduce direct emissions from electricity generation.
- **Emissions covered by the EU Emissions Trading System (EU ETS).** Verified emissions data from the EU ETS suggest that total emissions covered by the ETS in Scotland increased by around 0.7 $MtCO_2e$ in 2018 compared to 2017.[11] This was largely due to a 2.0 $MtCO_2e$ increase in verified emissions from Peterhead Power Station, offset by decreases at other sites.
- **Temperature in 2018.** There were more heating degree days[12] in the winter (January to March and October to December) months of 2018 in Scotland than the long-run average and when compared to the same period in 2017 (Figure 1.7). In particular, the first three months of 2018 were much colder than usual due to the cold weather events Storm Emma and Anticyclone Hartmut (the 'Beast from the East'). Higher heating demands in 2018 are therefore expected, potentially leading to higher emissions from buildings in 2018 compared to 2017.

[11] European Commission (2019) *Emissions Trading System - Verified Emissions for 2018*. Based on all installations with code UK-S. Around 9% of total EU ETS verified emissions (mainly under Activity Code 20 – Combustion of Fuels) were not classified in this estimate.

[12] Heating degree days (HDDs) are calculated relative to a baseline temperature, typically 15.5 degrees Celsius, which is the outside temperature above which a building needs no heating. One HDD is the number of degrees centigrade deviation from the base temperature of the actual temperature on a given day.

Figure 1.7. Heating degree days variation from the long-run average in Scotland (2014-2018)



Source: Energy Management Register (2019) *Degree day data.* http://www.enmanreg.org/freedd/
Notes: Heating degree days (HDDs) are calculated relative to a baseline temperature, typically 15.5 degrees Celsius, which is the outside temperature above which a building needs no heating. One HDD is the number of degrees centigrade deviation from the base temperature of the actual temperature on a given day. This figure compares HDD in winters from 2014 to 2018, with the twenty-year average. Points above the horizontal axis reflect colder than average temperatures and points below indicate higher than average temperatures.

Chapter 2: The 2045 challenge

Future emissions reductions depend on policies and actions taken now. The adoption of a net-zero target for greenhouse gas emissions in 2045 means that emissions will need to reduce further and faster than under the previous Climate Change Plan. In this section, we set out:

1. Implications of the 2045 net-zero target for the revised Climate Change Plan.
2. Scottish and UK policies to deliver net-zero in Scotland.
3. Recent developments in Scottish climate policy.

1. Implications of the 2045 net-zero target for the revised Climate Change Plan

In February 2018 the Scottish Government published the Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3). Now it has adopted a net-zero target, the Scottish Government has committed to publishing an update to this plan by May 2020.

In last year's Progress Report to the Scottish Parliament, we concluded that RPP3 was a stretching, credible, and well-balanced pathway to meeting Scotland's emissions targets to 2032 in line with a long-term target of 90% reduction by 2050. However, RPP3 was less ambitious than our recommended pathway for agriculture, and the Plan did not implement our advice to go beyond a voluntary approach to meet more ambitious emissions reduction targets on farms.

Despite our generally positive assessment last year, RPP3 is now an insufficient plan. A target for net-zero greenhouse gas emissions by 2045 represents a step change in ambition for Scotland, and means that all sectors will need to contribute fully to reduce emissions. The new Plan must represent a credible path to reducing emissions across all sectors of the economy, as well as increase the rate at which Scotland uses its ability to remove carbon from the atmosphere.

Reaching net-zero emissions will require extensive changes across the Scottish economy, with complete switchovers of several parts of the capital stock to low-carbon technologies and development of new industries for carbon capture and storage (CCS) and low-carbon hydrogen production. Major infrastructure decisions need to be made in the near future and implemented quickly.

The adoption of such a stringent economy-wide target makes it imperative that the highest possible ambition is adopted in all sectors. Challenges that have not yet been confronted must now be addressed. Where there are remaining emissions these will need to be fully offset by removing CO_2 from the atmosphere and permanently sequestering it, for example through afforestation and using sustainable bioenergy in combination with CCS.

The foremost challenge is not to produce a quantified, optimised pathway for emissions reductions in each sector; the greatest need is for improved Scottish Government policies and stronger governance to drive a rapid, sustained transformation to a net-zero Scotland:

- Net-zero policy must be embedded across all levels and parts of government, with strong leadership and coordination at the centre.
- The public must be engaged in the challenge and policy should be designed to put people at the heart of it.
- Policy should provide a clear and stable direction and a simple investable set of rules and incentives that leave room for businesses to innovate and find the most effective means of switching to low-carbon solutions.

As part of legislating the net-zero target for 2045, the Scottish Parliament also set interim targets for reductions of 75% on 1990 emissions by 2030 and 90% by 2040 (Figure 1.4). The Committee will consider in detail feasible pathways for emissions on the way to net-zero over the coming months as part of our work on setting the UK sixth carbon budget.

It is clear that the 2030 target is likely to be very challenging to meet - it will require Scottish emissions to fall at a similar rate to that over the last decade, but without any contributions from reductions in fossil-fuelled electricity generation that have dominated the falls in Scottish emissions over that time. It also rests - to a substantial degree - on the pace of UK-wide decarbonisation. Decisions about UK-wide policy, for example on the future of the UK's natural gas network, are likely to be germane to achieving the 2030 target, but are not directly within the control of Scottish Government policy. Nevertheless, the next decade will require major efforts in terms of the actions and policies across the other sectors in order to achieve the 2030 target on the way to net-zero emissions by 2045.

2. Scottish and UK policies to deliver net-zero in Scotland

Delivering net-zero emissions by 2045 in Scotland will require a strong policy framework. The rapid transition necessary is made more complicated by the fact that some of the relevant policy levers are devolved to the Scottish Government, while others are held by the UK Government (i.e. they are reserved) (Table 2.1).

The net-zero target is likely only to be feasible with action in parallel to devolved policy from the UK Government, particularly in reserved areas such as fiscal policy, vehicle standards, energy production and heavy industry. The Scottish Government, together with local authorities, can make particular use of devolved policy levers on the demand side even where supply-side policies are reserved to the UK Government (e.g. introducing low emission zones and policies to encourage walking and cycling), provide 'soft' support (e.g. advice on low-carbon heat) to support UK-wide policies, and use planning and procurement powers to drive decarbonisation.

Similarly, the UK target will only be achieved if all of the devolved administrations contribute to reducing emissions. Scotland's contribution is particularly important due to its enhanced ability to use land to sequester carbon. The UK cannot achieve net-zero in 2050 without strong policy from the Scottish Government in across key devolved areas including planning, agriculture, land use, housing and local government.

Based on the Further Ambition scenario presented in our *Net Zero* advice, there is a set of required near- and medium-term actions that are on the 'critical path' towards achieving net-zero emissions by 2045. These are presented at the start of each sectoral chapter.

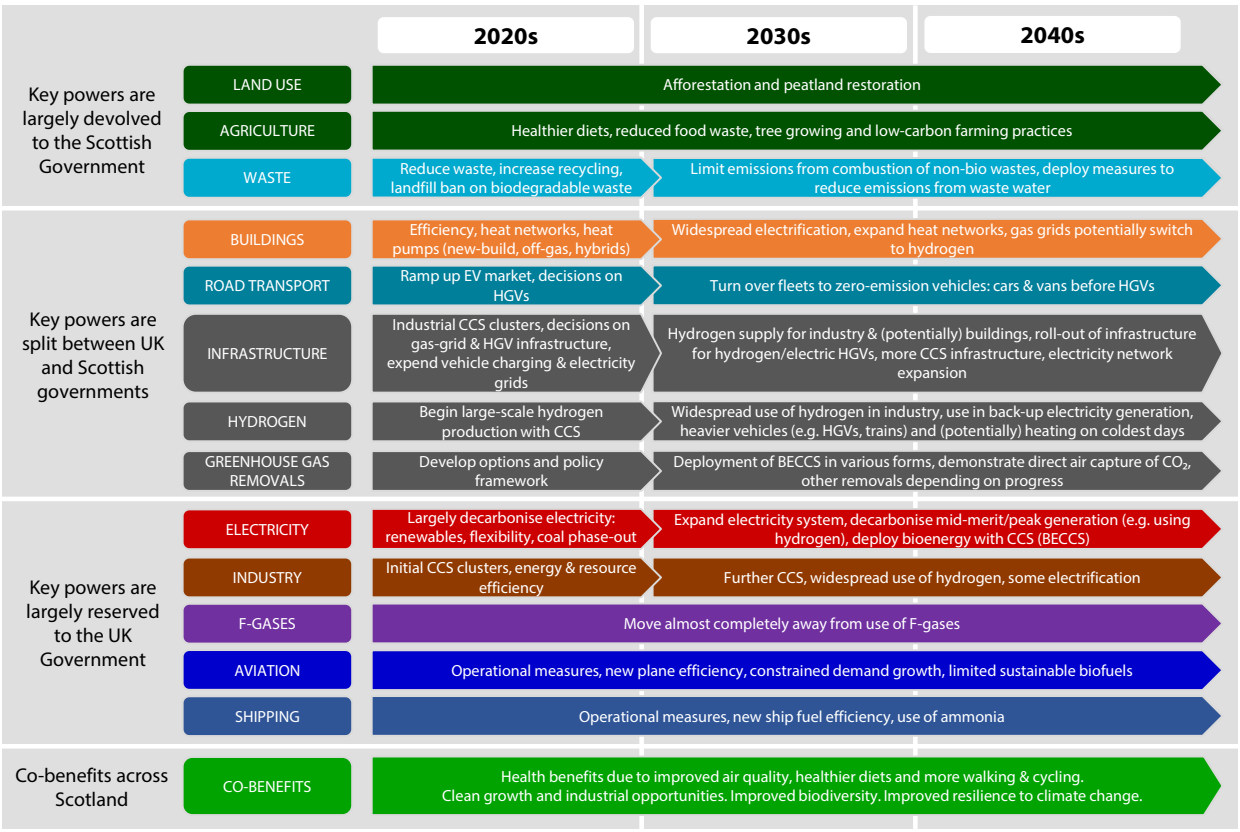
While all sectors will require a significant degree of interdependent policy from both the UK and Scottish governments, the nature of the devolution agreement means that the balance of policy action between Scottish and UK governments varies across different areas of the economy. This balance can be broadly classified in three ways (Table 2.1, Figure 2.1):

- Areas where powers are largely devolved and the Scottish Government can make progress, supported by UK Government;
- Areas where some key powers are reserved, but the Scottish Government can still make significant progress using devolved policy levers; and
- Areas where decarbonisation is most contingent on UK Government policy, but Scottish Government policy is needed.

Table 2.1. Balance of devolved and reserved powers in Scotland

Areas where policy levers are largely devolved	**Areas where certain key powers are reserved**	**Areas where progress is most dependent on UK Government and/or international policy**
The Scottish Government can demonstrate leadership, contingent on appropriate support and funding: • Agriculture • Land use, land-use change and forestry (LULUCF) • Waste • Public engagement	The Scottish Government can still make substantial progress using devolved policy levers: • Buildings • Surface transport • Infrastructure (including EV charging infrastructure, CCS, hydrogen and engineered removals)	Scottish Government policy will still be required to supplement and facilitate decarbonisation in these sectors: • Power • Industry • F-gases • Aviation

Figure 2.1. The transition required for net-zero over the period to 2045



Source: Adapted from CCC (2019) *Net Zero - The UK's contribution to stopping global warming.*

Areas where powers are largely devolved

Agriculture and land use, land-use change and forestry (LULUCF)

As Scotland prepares to leave the European Union, there is now an urgent need to define a post-CAP (Common Agricultural Policy) framework for the 2020s that incentivises the take-up of low-carbon farming practices and technologies, as well as supporting a transition to alternative uses of land that reduce emissions and remove carbon from the atmosphere.

The Scottish Government's published plans for a long-term post-CAP policy framework are lagging behind both England and Wales, where publications outlining possible replacements for the CAP - each with a new focus on providing public money for public goods - are far more detailed and developed.

A fully developed post-CAP framework has the potential to reduce emissions from agriculture significantly and to deliver transformational land-use change in Scotland. These actions will also deliver a wide range of co-benefits important for building climate resilience and wider environmental goals:

- **Agriculture.** There is a strong need to implement a framework with new policies that cover the range of measures across soils and livestock required to reduce emissions on farms. Farmers must be incentivised to diversify the activities carried out on farms, particularly to create more hedgerows and plant trees on farms (i.e. agroforestry).
- **Afforestation.** Reaching the necessary level of CO_2 removal through afforestation by 2045 requires an early and sustained increase in tree-planting rates to 15,000 hectares per year in Scotland as an absolute minimum, or up to 24,000 hectares if feasible. The recent sharp rise in tree-planting rates in Scotland to over 11,000 hectares in 2018/19 is very welcome, but must be sustained and increased over time. Given the time required for trees to grow, slow progress now cannot simply be made up in later years. Measures to improve forest productivity, including sustainable forest management,[13] best practices in silviculture and the use of breeding and genetics to improve the nursery stock, should be further explored and incentivised where they are consistent with long-term decarbonisation.
- **Planting energy crops.** In addition to the wood generated from harvesting forest products, Scotland can also develop a supply chain for bioenergy with carbon capture and storage (BECCS) through short-rotation forestry and planting bioenergy crops, with the further benefit of increased soil carbon sequestration.
- **Peatland.** Scotland must increase the rate of restoration of degraded peatland, and develop sustainable management practices for those lowland peat areas that remain in agricultural production. Scotland must ensure that there is a policy framework in place that is capable of restoring at least 18,200 hectares of degraded peatland per year from the mid-2020s to 2045. In addition to carbon benefits, this will deliver significant co-benefits from improved water filtration and enhanced biodiversity.
- **Behaviour change.** Deeper emissions reductions from agriculture will rely on societal changes in diets and reducing food waste that are discussed later in this section. These

[13] Sustainable forest management was defined in the IPCC (2019) *special report on Climate Change and Land* as 'the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and their potential to fulfil now and in the future, relevant ecological, economic and social functions at local, national and global levels and that does not cause damage to other ecosystems.'

behavioural shifts will free up agricultural land for other activities that remove carbon from the atmosphere.

We set out a list of short- and medium-term policy actions for the Scottish and UK governments to address emissions from agriculture and LULUCF in Chapter 6 (Table 6.1). The Committee will produce further advice on the policies required to reduce emissions from agriculture and land in the first half of 2020.

Waste

Scotland's waste policy is an area of strength compared to other areas of the UK. Scotland has successfully halved its landfill methane emissions from waste in the past decade, and has set a stretching set of policies and targets for waste that, if delivered effectively in the real world, will be consistent with achieving net-zero:

- **Re-use and recycling.** Scotland must continue to deliver policies that divert waste from landfill by encouraging re-use and recycling. The current target of a minimum 70% recycling rate by 2025, as laid out in the 2018 Climate Change Plan, is consistent with net-zero.
- **Biodegradable waste collection.** The Scottish Government must ensure that all people and businesses are prepared for the ban on biodegradable waste (due to come into force by 2021), have access to separate biodegradable waste collection, and clear information about the types of waste that will be affected by the landfill ban.
- **Biodegradable waste treatment.** Scotland's commitment to ban biodegradable waste from landfill by 2021 in Scotland is commendable. However, concerns have been raised by the waste management industry[14] that Scotland is not adequately prepared to deal with the volume of biodegradable waste diverted from landfill, and does not have sufficient non-landfill treatment capacity to meet the current 2021 ban without waste 'simply moving across the border' to landfill sites in England. The Office for Budget Responsibility has suggested that a reduction in Scottish landfill tax receipts as a result of the ban may be 'mostly to the benefit of UK landfill tax receipts by diverting waste to England.'[15] Infrastructure to deal with the biodegradable waste that has been diverted from landfill must be put in place in Scotland.
- **Reducing food waste.** Reducing food waste not only reduces the emissions associated with disposal, but improved efficiency in the food supply chain can also indirectly reduce emissions from agriculture and free up land for activities that remove carbon from the atmosphere. The Scottish Government has set a suitable goal to reduce food waste by 33% before 2025. Delivering a lasting reduction in food waste of this scale would be consistent with our analysis in the *Net Zero* report.

Public engagement

People in Scotland are more concerned by climate change than ever before.[16] To ensure that society is prepared for the transition to a net-zero society, the Scottish Government must continue to engage with people to ensure the costs of decarbonisation are fairly distributed and to educate people on the actions they can take to reduce their carbon footprints. Scotland's

[14] ESA (2019) *Press Statement: SESA: Scottish Landfill Ban is a £100m Landfill Tax Gift to England.*
[15] OBR (2019) *Economic and fiscal outlook - March 2019.*
[16] Scottish Government (2019) *Scottish Household Survey 2018.*

National Forum on Climate Change, announced in the 2019 Programme for Government,[17] is an excellent opportunity to engage people across Scotland:

- **Healthy lifestyle choices.** People can take action immediately to improve their diet and increase the amount of walking and cycling they do. These changes can cut emissions and improve health. The Scottish Government must continue to engage with people over why and how they can make these improvements, and take supporting actions (e.g. ensuring that road infrastructure encourages people to view cycling as a safe option).
- **Future of heating.** Currently the general public has a low awareness of the need to move away from natural gas heating and what the alternatives might be. There is a limited window to engage with people over future heating choices, to understand their preferences and to factor these into strategic decisions on energy infrastructure. This is especially important if solutions to heat decarbonisation in some areas of Scotland, particularly those without access to the gas grid, could differ in different parts of the UK.
- **Skills.** Skills gaps that would otherwise hinder progress must be tackled. For example, new skills support for designers, builders and installers is urgently needed for low-carbon heating (especially heat pumps), energy and water efficiency, ventilation and thermal comfort, and property-level flood resilience.

Sectors where some key powers are reserved, but the Scottish Government can still make significant progress using devolved policy levers.

Surface transport

Transport is now the highest-emitting sector in Scotland, and surface transport contributes the majority of emissions in this sector. Road vehicles in particular must be a major part of the reductions in greenhouse gas emissions needed over the period to 2030. Delays in making policy progress are likely to lead to higher costs and worse air quality, as well as higher greenhouse gas emissions.

Scotland's target of 2032 for an end to the sale of petrol and diesel cars and vans is appropriately ambitious, although an earlier date would be desirable if that turns out to be feasible. The focus must now be on delivery:

- Although the current UK target of 2040 is substantially later than 2032, the lack of Scottish control over vehicle and fuel taxation (and other fiscal levers such as vehicle excise duty and company car tax) ought not to be a barrier as the economics of EVs should be attractive by 2030 compared with petrol and diesel vehicles.
- From a Scottish Government perspective, this means ensuring that the necessary charging infrastructure for electric vehicles (EVs) develops. In October 2019, Scotland had over 3,600 public charging points, around 50 of which were ultra rapid chargers.[18] By 2030, 4240 fast chargers (22 kW), 2800 rapid chargers (43 kW), 900 ultra rapid chargers at 150 kW and 55 ultra rapid chargers at 350 kW will be required for public charging across Scotland.[19]

[17] Scottish Government (2019) *The Government's Programme for Scotland 2019-20*.
[18] Defined as above 150 kW and above.
[19] These figures are based on preliminary analysis of the electric vehicle charging infrastructure required in 2030 as part of the 2019 *Net Zero* advice, and may be refined subsequently following further analysis.

- A substantial roll-out of charging infrastructure will also be required at homes and workplaces. The typical cost for a home charge point and installation is approximately £1000,[20] but this is expected to fall by 2030. The Scottish Government is already supporting the roll-out of private charging points through the Energy Saving Trust, which provides grants of up to £300 through its EV Homecharge scheme on top of funding from the UK Office for Low Emission Vehicles (OLEV), and almost 90% of EV owners in Scotland also have home charging points. A home-charging solution for people living in flats and tenements must also be explored.
- New chargers installed in Scotland should be ready for 'smart' charging that shifts the majority of the charging demand to non-peak periods. This will likely require legislation at UK level. The UK Government has consulted on proposals to require electric vehicle chargepoints sold or installed in the UK have smart charging functionality included.[21]
- It will be important that upgrades to electricity grids in areas where they are required to support charging infrastructure happen in a timely and future-proofed way - the Scottish Government must continue to engage with Ofgem to ensure that this is not a barrier to the rapid adoption of EVs.
- The Scottish Government can also provide support to people considering making their next car an electric vehicle, both through financial support (e.g. through the interest-free loans of up to £35,000 currently offered by Transport Scotland and the Energy Savings Trust, on top of grants from OLEV) and non-financial incentives (e.g. parking access, allowing electric vehicles access to parts of cities where petrol and diesel vehicles are not allowed). Transport Scotland also currently provides funding for housing associations to provide electric vehicles as part of a car club, widening access to the benefits of driving electric vehicles.

The Highlands and Islands region presents a unique challenge for decarbonising transport. A lower population density, with more dispersed smaller communities, means that providing public transport services is more difficult, and people are more reliant on private vehicles, air services and ferries:

- Any strategy for transport in Scotland must take into account the unique characteristics of the Highlands and Islands and rural communities to ensure a just transition takes place. The Committee welcomes recent announcements that are tailored to this region, including the Highland and Islands Transport Partnership (HITRANS) electric vehicle strategy,[22] and the Scottish Government's target for net-zero aviation in the Highlands and Islands region.[23]
- The different challenges do not mean that electrification of transport is incompatible with the highlands and islands; Orkney has one of the highest levels of EV ownership per head of population in the UK, with more than 2% of the total cars and vans on the road being electric.[24]

[20] Energy Saving Trust (2019) *Domestic charge point funding*.
[21] BEIS (2019) *Electric vehicle smart charging*.
[22] HITRANS (2019) *HITRANS Electric Vehicle Strategy*.
[23] Scottish Government (2019) *The Government's Programme for Scotland 2019-20*.
[24] https://www.bbc.co.uk/news/uk-scotland-49319120

Although electric vehicles will have lower emissions and will likely to be cheaper to own and run than petrol and diesel vehicles by 2030, there is still an important role for reducing personal vehicle use, both in terms of greenhouse gas emissions and co-benefits:

- Even though the per-kilometre emissions of vehicles in Scotland has fallen in recent years as new vehicles have become more efficient (though not rapidly enough to be on track to meet EU-wide carbon intensity targets), an increase in the total distance driven means that total emissions have increased in each of the last four years (Figure 3.3). As long as the stock of vehicles in Scotland contains a significant proportion of petrol and diesel vehicles - likely to be until at least 2040 even under a 2030 phase-out of sales - actions that reduce vehicle use will save greenhouse gas emissions and lead to better air quality.
- Replacing shorter car journeys with walking and cycling not only contributes to lower greenhouse gas emissions and better air quality, these active forms of travel can also have significant benefits for health. Action is required to improve cycling infrastructure to ensure that people have the confidence that choosing to cycle will not be at the expense of their safety.
- For longer journeys, there are important roles for public transport and electric bikes. For public transport to contribute fully, its coverage and performance will need to improve and the vehicles (e.g. buses) used will need to switch to zero-emissions technologies rapidly.

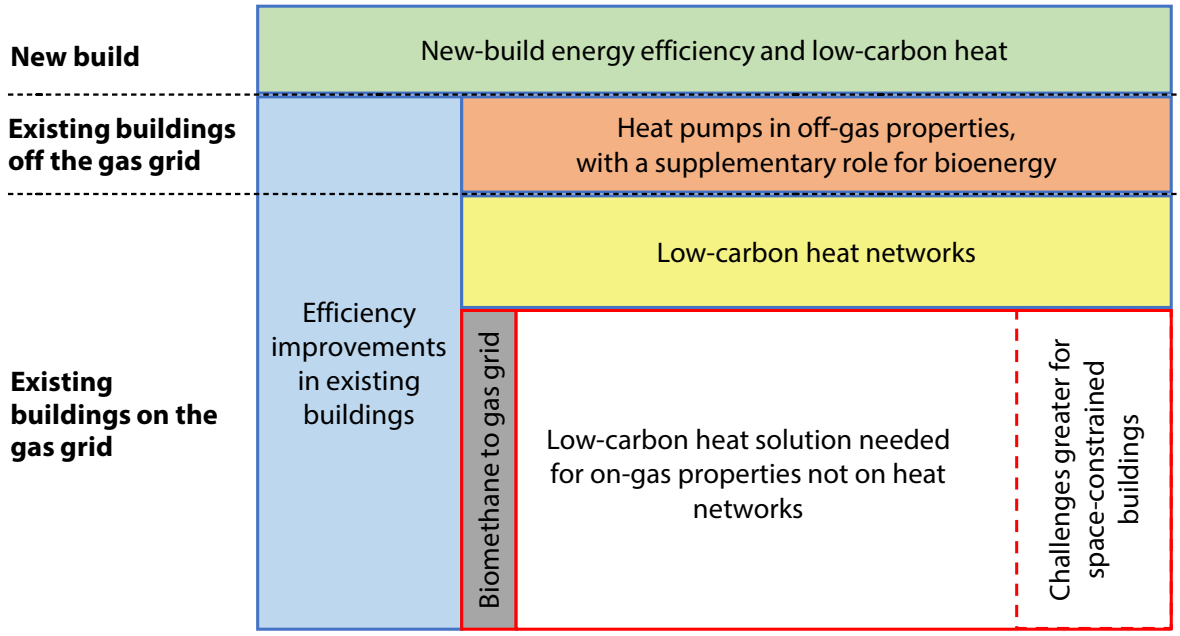
Decisions will be required on the future pathways for decarbonisation of heavy goods vehicles during the 2020s, with important implications for infrastructure roll-out. Scotland can facilitate the roll-out by supporting trials of zero-emission heavy goods vehicles where possible (e.g. by providing financial incentives, supporting pilot projects, or deploying them in municipal fleets). The Aberdeen Hydrogen Fuel Cell Bus Project is an excellent example of how the Scottish Government can support trials that demonstrate and test zero-emission technologies in the real world. However, given the cross-border nature of the freight industry, it is not sensible for Scotland or even the UK as a whole to make such decisions in isolation.

Buildings

Decarbonisation of buildings is one of the most challenging parts of achieving net-zero emissions. While there has been good progress on the policy framework in Scotland on energy improvements and low-carbon new-build, as yet there is still no serious plan for decarbonising heating systems.

Concerted action is required in the 2020s to get on track to net-zero emissions. Some decisions will be required on the precise balance of low-carbon heating solutions, including relating to infrastructure. However, there are several low-regret routes for buildings decarbonisation that can and should be pursued immediately (Figure 2.2).

Figure 2.2. Low-regret actions for buildings decarbonisation



Source: Adapted from CCC (2019) *Net Zero Technical report*.
Notes: Areas where powers are primarily devolved are outlined in blue, areas where powers are largely reserved are outlined in red. The block sizes broadly reflect the scale of emissions reduction, but do not do so precisely. Some potential for heat networks will also be in new-build and off the gas grid. Biomass for heat may also play a role in hard-to-insulate rural properties. Heritage buildings have not been illustrated but will be present on and off the gas grid, as well as in areas suitable for low-carbon heat networks.

While heat decarbonisation is complicated by the split of devolved powers - Scotland only has devolved responsibility for heat policy to the extent that it does not involve the gas network (which is reserved) - these low-regret areas map well to areas of Scotland's devolved competence:

- **Energy efficiency.** There is now a good policy foundation for improving the efficiency of the existing housing stock in Scotland through the Energy Efficient Scotland programme. The domestic buildings programme has focused so far on social housing and the private rented sector. Further clarity on the package of support and regulation for owner occupied homes will also be required. Where possible, energy efficiency policy should support a 'whole-house approach' including low-carbon heating, particularly in homes off the gas grid. Now that a

consultation and benchmarking exercise for non-domestic buildings has taken place, Scotland must now set similarly ambitious energy efficiency standards for non-residential buildings and ensure that standards for all buildings are adhered to.

- **Standards for new buildings.** New homes must be designed for a changing climate, be properly ventilated, moisture-safe, future-proofed for low-carbon heating and deliver ultra-high levels of energy efficiency. We advised on new-build standards in our 2019 report *UK housing: Fit for the future?* The proposed regulation requiring new homes consented from 2024 in Scotland to use renewable or low-carbon heat is consistent with this advice. Following consultation, Scotland should implement rigorous energy efficiency standards that come into force in 2021. Importantly, the Scottish Government has also committed to introduce standards for new non-residential buildings, and net-zero standards for public sector buildings.
- **Low-carbon heat networks.** District heating schemes require a certain density of heat demand in order to be economic, which means that they are potentially well suited to urban areas, new-build developments and some rural areas. A strategic approach - that considers the whole system as well as local variations in housing - is needed to identify the areas where low-carbon district heating can be a cost-effective alternative to other low-carbon heating solutions, taking into account the capital and fuel costs as well as wider considerations like householder engagement. Low-carbon heat sources can include waste heat, large-scale (e.g. water-source) heat pumps, geothermal heat, and potentially hydrogen.
- **Heat pumps in buildings not on the gas grid.** Heat pumps are the leading low-carbon option for buildings not connected to the gas grid. Together with new-build properties, installation of heat pump in buildings off the gas grid can help create the scale needed for supply chains to develop.
- **Building-scale low-carbon heating:**
  - While decisions on the future of gas distribution networks and implications for home heating are reserved, emissions can be reduced sharply in the 2020s through retrofit of hybrid heat pumps. As these can be retrofitted to existing heating systems, without changes to radiators and with the existing boiler used as back-up, there is the potential for rapid deployment in the near term (Box 2.3).
  - Scotland should limit its support for bioenergy use in buildings to biomethane produced from anaerobic digestion and other very niche uses. The widespread use of solid biomass boilers, which currently make up the majority of Scotland's renewable heat capacity, is not consistent with long-term decarbonisation as this biomass resource would deliver greater savings elsewhere in the energy system in Scotland, particularly where combined with carbon capture and storage.[25]

A rapid uptake of building-scale electric solutions in buildings on the gas grid would reduce emissions from fossil fuel use sharply. However, it is likely that some use of natural gas will remain (e.g. on the coldest days as the gas boilers in hybrid heating systems kick in), due to the considerable challenges in fully electrifying heat supply and supplying this electricity in a fully decarbonised manner. Strategic decisions on repurposing parts or all of the gas network to use hydrogen to remove these residual emissions will require close co-operation between HM Treasury, BEIS and the Scottish Government.

[25] CCC (2018) *Biomass in a low-carbon economy*.

Key questions also remain around the current balance of tax and regulatory costs across fuels. Costs are currently significantly larger for electricity than gas or oil heating, and the full carbon costs are not reflected in the pricing of heating fuels. These factors currently weaken the private economic case for electrification in Scotland, and will be heavily influenced by reserved fiscal levers.

Currently the general public has a low awareness of the need to move away from natural gas heating, and what the alternatives might be. There is a limited window (e.g. at most five years) to engage with people over future heating choices, understand their preferences and factor these into strategic decisions on energy infrastructure.

It will also be important to tackle performance and compliance issues to ensure that new buildings and measures retrofitted in existing buildings perform as they should. This includes ensuring strengthened compliance and enforcement extends beyond fire safety to regulations more widely; funding building control adequately; and developing appropriate training and implementing accreditation schemes to tackle the skills gap (Box 2.2).

There is a need to improve how the energy performance of buildings is measured, as there are concerns over the suitability, accuracy and reliability of Energy Performance Certificates (EPCs). Grounding estimates in real-world data, such as from smart meters, should be the basis for reform of monitoring metrics and certification:

- EPCs are based on the SAP 2012 methodology which quantifies a dwelling's performance in terms of energy use per unit floor area (kWh/m^2), a fuel cost-based energy efficiency rating (the EPC rating, in £/kWh/m^2) and emissions of CO_2 (the Environmental Impact (EI) rating, in CO_2/m^2).
- Since the EPC rating is cost-based, it is more suited to issues around fuel poverty rather than energy efficiency improvements or emission savings. It is subject to fuel price variations over time and can lead to perverse incentives where emission-saving measures involve a switch in fuels. For example, the nature of the metric means that a switch to heat pumps is currently disincentivised.[26]
- The SAP method is a normative calculation (e.g. assuming a standard occupancy) using expert knowledge on the main factors in determining home energy efficiency. Estimates are likely to be inaccurate where there are issues with assumptions (as has been the case with solid wall thermal transmittance assumptions), or where what is constructed does not match what has assumed to have been constructed. There can be major discrepancies in the rating for an individual property when assessments are conducted by different assessors.

[26] CCC (2019) *UK housing: Fit for the future?* Box 4.2.

Box 2.2. Key messages from 2019 *UK Housing* report: Areas for progress in delivering better homes

Addressing the multiple gaps and barriers to delivering high-quality, sustainable housing can be achieved through strategic forward planning, robust policies and effective implementation of those policies. Effective implementation will require a fundamental step-change in our approach to building homes:

- **Performance and compliance.** The vital first step is addressing building regulation compliance, and the performance gap between how homes are designed and how they perform when occupied. Tightening standards will have little effect otherwise. It is critical that stronger compliance and enforcement procedures, with greater levels of inspection and appropriate penalties, are in place, ensuring that new and existing buildings are safe, and deliver the energy and ventilation standards expected of them. 'As-built' performance should be formally integrated into the standards and enforcement framework. Closing the energy performance gap could deliver £70-£260 in annual bill savings per household, and around 2 $MtCO_2e$ in annual carbon savings (for the whole of the UK) by 2030.[27]
- **Skills gap.** The chopping and changing of Government policy has inhibited skills development in critical areas. Government must use the initiatives announced under the Construction Sector Deal to tackle the low-carbon skills gap, and develop a world-class construction sector which can realise the domestic and international industrial opportunities related to low-carbon building.
- **Building regulations.** The technology exists to deliver homes that are low-carbon, energy efficient and climate-resilient, with safe air quality and moisture levels. The costs are not prohibitive, and getting design right from the outset is vastly cheaper and more feasible than having to retrofit later. From 2025 at the latest, no new homes should be connected to the gas grid. They should instead be heated through low-carbon sources, have ultra-high levels of energy efficiency and, where possible, be timber-framed. A statutory requirement for reducing overheating risks in new-builds is urgently needed, alongside greater focus on ambitious water efficiency standards and property-level flood protection in areas at current or future high risk of flooding.
- **Retrofitting existing homes.** The 29 million existing homes across the UK must become low-carbon and resilient to a changing climate. This is a UK infrastructure priority and should be supported as such by HM Treasury. Homes must be made ready for low-carbon heating (heat pumps and heat networks). The uptake of energy efficiency measures such as loft and wall insulation must be increased. Upgrades or repairs to homes should include increasing the uptake of passive cooling measures (i.e. shading and ventilation), reducing indoor moisture, improving air quality and water efficiency, and, in homes at risk of flooding, installing property-level flood protection.
- **Finance and funding.** There are urgent funding needs which must be addressed now with the support of HM Treasury: low-carbon heating (currently only funded up to 2021), resources for local authorities and in particular building control. The Scottish and UK governments must implement the Green Finance Taskforce recommendations around green mortgages, green loans and fiscal incentives to help finance upfront costs, as well as improving consumer access to data and advice. It should widen the scope of these measures to include resilience, for example by introducing house resilience surveys which assess water efficiency, flood risk and overheating.
- **Local authority action.** Local authorities can contribute through the services they deliver, their role as social landlords, and through their regulatory and strategy functions. However, climate change has been de-prioritised in the land-use planning system and funding for such measures

[27] Regulations and monitoring metrics are focussed substantially on the modelled performance of dwellings as designed, rather than their actual performance 'as-built'. There is a large body of evidence which points to a substantial gap between the two. This is the 'performance gap'.

Box 2.2. Key messages from 2019 *UK Housing* report: Areas for progress in delivering better homes

remains extremely limited. The regulatory and policy framework must incentivise and enable local and regional authorities to take action and be ambitious, through Government clarifying rights and obligations, and adequately funding local authorities. Clarity is needed on how far local and regional authorities are permitted to go in setting tighter new-build standards. Planning frameworks and guidance should advise local authorities to take a strategic approach to planning for the creation and protection of green spaces and Sustainable Drainage Systems. Local authorities should consider how to shape demand for travel throughout the planning process, with the ultimate goal of reducing the need to travel, alongside making walking, cycling and the use of public transport straightforward and pleasurable.

Source: CCC (2019) *UK housing: Fit for the future?* Chapter 4.

Box 2.3. Hybrid heat pumps

Heat pumps are highly efficient electric heating systems that can produce around three units of heat energy for every unit of electrical energy used, with very low overall carbon emissions.

A 'hybrid' heat pump system is capable of switching from electricity to an alternative fuel source (e.g. as a gas boiler) depending on the fuel cost and heating requirement at any given time. Hybrid heat pumps would use a heat pump to meet the bulk of heat demand, while retaining boilers to provide additional heat on colder winter days. A large deployment of hybrid heat pumps, in combination with much improved energy efficiency across the building stock, by the mid-2030s would reduce emissions very substantially from properties on the gas grid.

A key advantage of hybrid heat pumps is that they can be retrofitted around existing heating systems, retaining the existing radiators and also the existing boiler (although its utilisation would be much decreased). This means that the retrofit could sensibly be done together with improvements to the energy efficiency of the building. In combination, these changes could reduce a household's gas consumption by over 80% and reduce energy bills. However, the capital cost of this heating equipment is currently much higher than a conventional gas boiler, and there are currently few heating contractors with experience in specifying or installing such systems.

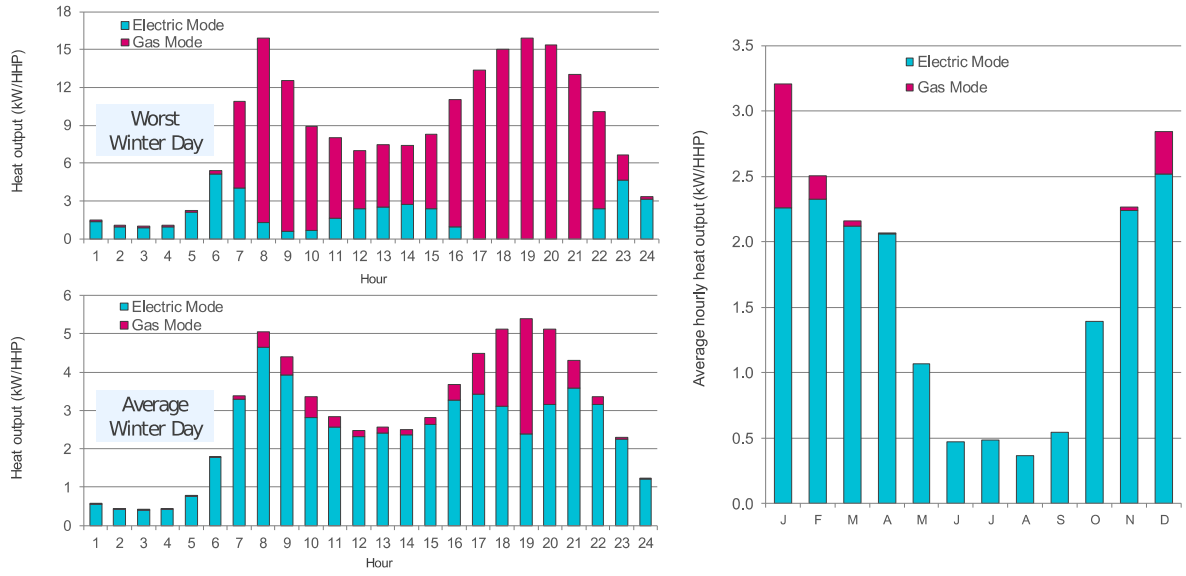
Deployment of hybrid heat pumps at scale in the near term would enable significant near-term emissions reductions to be made without significant initial changes to existing infrastructure, would help increase public familiarity with heat pumps without concern over compromising their comfort, and would provide a flexible market for additional low-cost renewable electricity. This progress can be made without locking out important contributions from hydrogen and all-electric heat pump systems by 2045. This is because the hybrid heat pumps could be run with a hydrogen boiler if the gas grid is converted, or switched over to full electric systems if the gas grid is decommissioned.

Heating costs are currently significantly larger for electricity than for gas or oil heating, and the full carbon costs are not reflected in the pricing of heating fuels. A rebalancing of tax and regulatory costs will be required so that hybrid heat pump systems are more cost-effective to run in their highly-efficient electricity mode for the majority of the time, with boilers only used for additional heat on the coldest days or when electricity demand is high.

Provided they are used efficiently, hybrid heat pumps could deliver carbon savings almost as large as electric heat pumps, but with significantly lower impact on the cost of electricity (Figure B2.3.a, Figure B2.3.b).

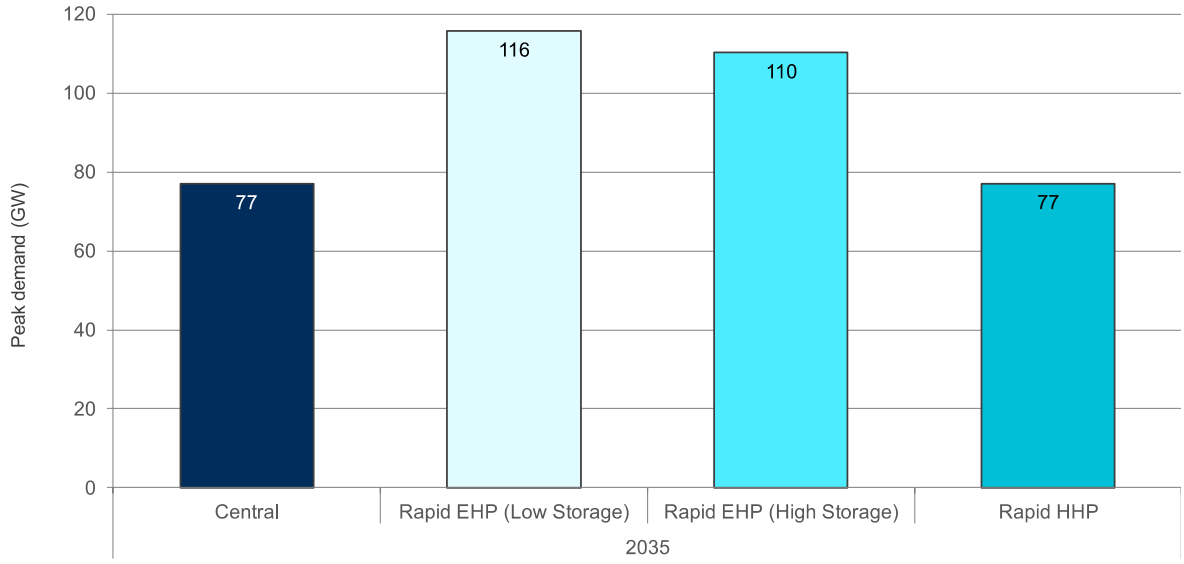
Box 2.3. Hybrid heat pumps

Figure B2.3.a. If used efficiently, hybrid heat pumps could meet over 90% of heat demand in electric mode



Source: Vivid Economics and Imperial College (2019) *Accelerated electrification and the GB electricity system.*

Figure B2.3.b. Unlike conventional heat pumps, hybrid heat pumps may have little impact on peak electricity demand



Source: Vivid Economics and Imperial College (2019) *Accelerated electrification and the GB electricity system.*
Notes: Deployment of heat pumps in 2035 in the fully electric (Rapid EHP) scenario is the same as in the hybrid (Rapid HHP) scenario. The Rapid EHP scenario comprises a Low Storage (15% of heat pumps are fitted with storage by 2035) and High Storage (40% by 2035) variant.

Infrastructure

Reaching net-zero emissions will require development or enhancement of shared infrastructure such as electricity networks, hydrogen production and distribution and CO_2 transport and storage.

Scotland has a newly-developed framework for identifying the necessary infrastructure and developing a strategy to deliver it through the time-limited Infrastructure Commission for Scotland. The Scottish Government, Infrastructure Commission for Scotland, UK Government, National Infrastructure Commission and HM Treasury should give urgent consideration to how such infrastructure might best be identified, financed and delivered.

We have identified five priority areas for low-carbon infrastructure in Scotland, which should be considered as it develops the fourth National Planning Framework in 2020:

- **CO_2 transport and storage infrastructure.** Plans for early deployment of CO_2 transport and storage infrastructure linked to industrial clusters must be delivered with urgency. CCS is a necessity for reaching net-zero GHG emissions. Scotland has competitive advantages in CCS: Scotland's industrial clusters and largest sources of CO_2 in North East and Central Scotland are linked by a network of pipelines to depleted and well-mapped oil and gas fields in the North Sea. These depleted gas fields and aquifers offer vast CO_2 storage potential.
- **Hydrogen infrastructure.** Hydrogen has the potential to replace fossil fuels in areas where electrification may reach limits of feasibility and cost-effectiveness: industrial heat, heat for buildings on colder winter days (e.g. as part of a hybrid heating system), flexible and schedulable power generation and heavy-duty vehicles. In order to develop the hydrogen options that are central to our net-zero scenarios for Scotland, significant volumes of low-carbon hydrogen must be produced by 2030, for use in industry and in applications that would not initially require major infrastructure changes (e.g. power generation, injection into the gas network and depot-based transport).

  In the longer-term, CCS will also provide the opportunity to generate low-carbon hydrogen for use in industry, which we expect to be most cost-effectively[28] produced from natural gas reformation with CCS. Scotland could capitalise on this as a potential leader in CCS.
- **Engineered removals.** Deployment of engineered removals will be crucial to achieving net-zero in Scotland. Scotland is ideally placed to deliver both direct air CO_2 capture and storage (DACCS) and bioenergy with CCS (BECCS) due its proximity to CO_2 storage in the North Sea, and ability to use its land for tree planting and energy crops. BECCS will need to start being deployed sufficiently early in Scotland (e.g. by 2030) to build up to a potentially large contribution in the longer term. This will require CO_2 storage infrastructure, as well as using more of Scotland's land area for short-rotation forestry and energy crops.
- **Expansion of electric vehicle charging networks and electricity grid capacity** to accommodate further increases in renewable generation capacity and meet increased demand for electric vehicle charging and use of heat pumps.
- **Decisions on the future pathways for heating buildings and decarbonisation of heavy goods vehicles** will be required on during the 2020s, with important implications for infrastructure roll-out in Scotland. If these solutions are based on the use of hydrogen, this would require an increasing of hydrogen production and extending access to hydrogen beyond the industrial clusters mentioned above. The split of devolved and reserved powers

[28] Compared to electrolysis using excess low-carbon electricity. CCC (2018) *Hydrogen in a low-carbon economy*.

means these decisions will likely be made by at UK level. The Scottish Government must be involved this decision-making process, and prepared to act to deliver infrastructure once decisions are made.

Although the gas and electricity networks are reserved to the UK Government, Scotland's Vision to 2030[29] is a useful contribution to the policy debate around these networks.

Table 2.1. Near- and medium-term milestones for infrastructure in Scotland

Action	Timing	Primary responsibility
Set out preferred mechanism for CO_2 transport and storage infrastructure.	2019	UK Government
Set out plan to enable multiple UK CCS facilities to be operational by the mid-2020s.	2019	UK Government
Low-carbon hydrogen production at scale, initially centred around industrial clusters, for use initially in applications that would not require major infrastructure changes (e.g. applications in industry, power generation, injection into the gas network and depot-based transport).	2020s	UK Government
Trials and pilot projects to establish the practicality of switching to hydrogen across a range of sectors and applications. It is also necessary to demonstrate that hydrogen production from CCS can be sufficiently low-carbon to play a significant role.	2020s	Joint
Initial deployment of engineered greenhouse gas removals, driven by incentives and enabled by CO_2 infrastructure development.	Second half of the 2020s	Joint
Decisions about how to switch to zero-emissions (e.g. hydrogen or electric) HGVs will be required in the second half of the 2020s. This will necessitate small-scale trial deployments of hydrogen HGVs in a variety of fleets prior to this, in the UK or elsewhere.	Second half of the 2020s	UK Government and international partners
Strategic decisions on the future of the natural gas grid and the future balance between hydrogen and electrification for heating, taking into account the views of the public. Transition to sustainable heat networks market.	Mid-2020s	UK Government
Development of charging infrastructure and policy to enable sales phase-out of petrol and diesel cars, vans and motorbikes by 2032, or earlier if feasible.	2020s	Scottish Government

[29] Scottish Government (2019) *Scotland's electricity and gas networks: vision to 2030*

Sectors where decarbonisation is most contingent on UK Government policy, but Scottish Government policy is needed

Power sector

More rapid electrification in Scotland must be supported by further development of low-carbon generation capacity, accompanied by measures to enhance the flexibility of the electricity system to accommodate high proportions of variable generation (e.g. wind). Most of the key levers for the power sector in Scotland are reserved to the UK Government, although the Scottish Government can influence the deployment of low-carbon electricity through its planning regime and leasing of Scottish waters through Crown Estate Scotland.

Given the important roles for electrification in both transport and heat, electricity demand is expected to rise across Scotland. The UK should aim to support a quadrupling of low-carbon power generation on the GB network by 2050, a significant portion of which will be located in Scotland due to its potential for onshore, offshore and remote island wind generation and BECCS. If low-carbon production in Scotland continues to grow, Scotland is likely to continue to be a net exporter of electricity to the rest of GB.

This means deployment of more low-carbon capacity in the 2020s, potentially consistent with a carbon-intensity of 50 gCO_2/kWh for the whole GB grid by 2030 (Box 3.5). While key options like wind look increasingly as though they can be deployed without subsidy, this does not mean they will reach the necessary scale without continued intervention at the UK level (e.g. through continued auctioning of long-term contracts with subsidy-free reserve prices).

Solutions that enhance system flexibility (e.g. smart charging of vehicles and hybrid heat pumps), will be important in ensuring that demand peaks are manageable. Sufficiency of network capacity and mechanisms to maintain system stability will be key in enabling maximum use of renewable generation. Networks will need to be upgraded in a timely manner and future-proofed to limit costs and enable rapid uptake of electric vehicles and heat pumps. Furthermore, a challenge across the UK is that, as dependency on electricity grows and the electricity system becomes further decarbonised making increasing use of non-synchronous generation technologies, the stability of the system needs to be maintained and overall resilience ensured.

Box 2.4. Increasing power sector ambition across Great Britain in the 2020s

In the past, the Committee assessed progress towards reaching an emissions intensity of under 100 gCO_2/kWh by 2030 in the GB power system, and presented scenarios for achieving an emissions intensity of 50-100 g/kWh by 2030.[30] This target was a suitable objective to meet the previous 2050 UK target for a reduction of 80% of emissions, at least cost. Achieving net-zero emissions by 2050 could require earlier electrification and/or earlier power sector decarbonisation of the GB grid, increasing the level of low-carbon generation that would need to come online in the 2020s.

- The CCC's scenarios for 100 gCO_2/kWh in 2030 require around 270 TWh of low-carbon generation to be online by 2030, comprising around 75% of generation. Of this, 165 TWh has already been contracted, and a further 75 TWh could be achieved by delivering the ambition in the offshore wind sector deal. This would leave a gap of 25 TWh of low-carbon generation.
- In our recent *Net Zero* report we recommended an end to sales of petrol and diesel cans and vans by 2035 at the latest and that no new home should be connected to the gas grid past 2025,

[30] CCC (2018) *Progress Report to Parliament*.

Box 2.4. Increasing power sector ambition across Great Britain in the 2020s

increasing deployment of electric vehicles and potentially heat pumps. A heat decarbonisation strategy could imply further electrification beyond this.

- Without an increase in low-carbon generation, meeting new electricity demands would likely increase UK gas-fired power generation, increasing power sector emissions.

The Committee now recommends the Government pursue pathways consistent with the level of low-carbon generation in a 50 gCO_2/kWh scenario for 2030,[31] ensuring that new electricity demands can be met without increasing emissions. This would add 50 TWh to the policy gap in 2030, leaving a total of 75 TWh additional uncontracted low-carbon required during the 2020s.

This new ambition can be delivered under the current electricity market arrangements, by making use of competitive auctions and applying a technology-neutral approach wherever possible.

- The current system is working well. The package of instruments – notably the carbon price support, Contract-for-Difference mechanism and capacity market[32] – introduced under the Electricity Market Reform have delivered low-cost emissions reductions while maintaining security of supply. Government still has an important role to play in offering long-term contracts to mitigate risks and reduce project costs. Contracts could be offered to a pipeline of mature renewables such as onshore wind, solar PV and offshore wind, which can meet new electricity demands at low cost.[33]
- We do not expect renewables without a Government-backed contract (so-called 'merchant' renewables) to be deployed at sufficient scale to meet the generation gap in 2030. Analysis by Aurora projects that merchant renewables could contribute 13 TWh of generation in 2030. Moreover, additional low-carbon generation from long-term contracts will affect the marginal value of new generation and the volatility of revenue (i.e. 'price cannibalisation'), which could further diminish the role of merchant renewables in the decade to come.
- Alongside new renewables, technologies which can offer firm and flexible power, such as nuclear and CCS, will be required for a power system in 2050 contributing fully to achieving overall net-zero emissions. The scale of deployment required by 2050 will necessitate continued investment in these options between now and 2050.

Increased deployment of variable renewables and increasing electricity demand will require continued improvements in system flexibility, and widespread upgrades to the UK's distribution networks.

- Analysis by Vivid Economics for the Committee suggests that as upgrading distribution network capacity is relatively insensitive to the size of the capacity increase, future-proofing networks as and when they are upgraded can enable greater electrification at lowest cost.
- It is essential, therefore, that when network capacity is increased, this is to a sufficient level to avoid having to upgrade the capacity again prior to 2050.

Moreover, an increasing amount of low-carbon generation will require significant improvements in system flexibility in order to function effectively. Progress is being made and will need to continue at pace in the 2020s.

Source: Adapted from CCC (2019) *Progress Report to Parliament,* Box 3.5.

[31] Our emissions intensity indicator is based on UK generation, excluding imports. If an estimated 32 TWh of imports in 2030 (BEIS (2018) *Energy and Emissions Projections)* were met by UK based gas-fired generation, emissions intensity would reach 130 gCO_2/kWh instead of the 81 gCO_2/kWh in the Government's projections.
[32] As a response to consultations, BEIS published *Technical Amendments to the Capacity Market* in February 2019 where Government confirmed that the Capacity Market remained the right mechanism to ensure security of supply.
[33] Vivid Economics & Imperial College (2019) *Accelerated Electrification and the GB Electricity System.*

Industry

The split of devolved and reserved powers means a long-term policy framework that can deliver widespread decarbonisation of manufacturing and fossil fuel supply - while maintaining competitiveness - is likely to be determined at UK level. The two priorities for the UK Government are to establish an incentive mechanism for decarbonising industry, and to promote innovation that can deliver new technologies for industrial decarbonisation:

- **Incentive mechanism.** The UK Government must urgently establish a mechanism to incentivise widespread uptake of near-zero emissions technologies in industry, including the use of hydrogen, electrification, CCS and BECCS, as well as support for energy and resource efficiency. The design of this mechanism must ensure it does not drive industry overseas, which would not help to reduce global emissions, and be damaging to the UK economy.
- **Innovation in industrial decarbonisation technologies.** Innovation will be essential across technologies to decarbonise industrial combustion. Industrial hydrogen-using technologies, across heat and off-road mobile machinery, are not yet commercially available, and should be developed, as they will likely play an important role in decarbonising industry. BECCS (bioenergy with carbon capture and storage) and electrification are also likely to play a role in some industrial sectors and applications. Innovation across these technologies is urgent given the need to prepare for abatement in line with refurbishment and replacement cycles. These constraints also mean that the development of hydrogen-ready technologies is an urgent priority.

Although some of the powers to incentivise industrial decarbonisation are reserved, though there is an essential role for Scottish Government intervention to incentivise energy and resource efficiency and to decarbonise space and process heating in industry.[34] The UK Government's Industrial Heat Recovery Support Programme (IHRSP) has £18 million assigned for match funding feasibility studies or capital projects. As heating and cooling is a devolved issue, it does not cover sites in Scotland.

Research and innovation can be supported directly by the Scottish Government (for example through Scottish Enterprise grants). However, the scale of the innovation challenge in industry is such that is likely to require a UK-wide, and indeed international, level of support. Innovation that is delivered through UK-funded programmes (for example Innovate UK and Research Council activities overseen by UK Research & Innovation) will deliver benefits to industry across the UK, including Scotland.

Two significant decarbonisation funds for capital expenditure were announced in the past year: the £315m Industrial Energy Transformation Fund (IEFT) and the £170 million Industrial Decarbonisation programme delivered through the Industrial Strategy Challenge Fund (ISCF). The Scottish Government has a key role to play in ensuring that Scottish business and industry are well positioned to access these funds. The Scottish Government can work with UK Government to ensure that the schemes are designed to meet the needs of Scottish industry, as well as provide support and advice to Scottish organisations that are applying for these funds.

[34] For example, through the existing Low Carbon Infrastructure Transition Programme (LCITP), Resource Efficient Scotland (RES) and Energy Efficient Scotland Programmes.

3. Recent developments in Scottish climate policy.

Since announcing that it would adopt the net-zero target, the Scottish Government has taken commendable steps to reinforce this ambition with meaningful policy in advance of the next Climate Change Plan.

There is more to be done, but the Programme for Government published in September 2019 - supported by other policy announcements - has put Scotland in a strong position to deliver emissions reductions outside the power sector in the near future.

Our 2018 Progress Report to Scottish Parliament identified transport and buildings as two areas where urgent decarbonisation is needed in Scotland. The Scottish Government has responded with new policies in these areas that have the potential to deliver meaningful emissions reductions. There have also been significant advances in green finance and investment:

- **Green finance and investment.** Scotland has launched a public call for projects to attract a £3 billion green investment portfolio backed by public and private finance,[35] in addition to a commitment to leverage public procurement by consulting on legislation to require public bodies to set out how they will meet Scotland's climate change and circular economy obligations. The Scottish National Investment Bank, with a budget of £130 million in its first year, will have the primary mission of secure the transition to net-zero in Scotland.

  Scotland has expanded its existing **'**Growth Accelerator**'** programme to become the 'Green Growth Accelerator'. The delivery model of this programme is yet to be confirmed, but any additional support for local authorities to invest in emissions-reducing infrastructure for their area is welcomed.

- **Transport.** The largest investment in transport is £500 million to improve bus services across Scotland, which could have a major and immediate impact on carbon emissions by reducing emissions from petrol and diesel cars. Scotland has committed to consulting on the introduction of zero- or ultra-low-emission city centres by 2030, and zero-emission buses (i.e. electric or hydrogen) will be an important alternative to conventional vehicles.

  Scotland is aiming to demonstrate leadership within the public sector by phasing out petrol and diesel cars, as well as phasing out 'the need for any new petrol and diesel light commercial vehicles' by 2025.

  The Scottish Government has made a further £17 million available for zero interest loans to support the purchase of ultra-low emission vehicles, and has separately announced a total of £7.5 million of private and public funding for expanding public charging infrastructure and electricity networks.[36]

  The Scottish Government has also pledged to decarbonise all passenger rail services by 2035, ahead of the UK's target of 2040, and to decarbonise flights within Scotland (i.e. between two Scottish airports) by 2040.

- **Buildings.** The Committee welcomes the announcement that all new homes will be required to use renewable and low-carbon heat from 2024 - a year earlier than the rest of Great Britain - with low-carbon heat phased in to new non-domestic buildings from this date.

[35] Scottish Government (2019) *Scotland's Green Investment Portfolio: call for projects.*
[36] Scottish Government (2019) *Press release: More electric vehicle charging points.*

Scotland has also committed to introducing tighter energy standards for all new buildings, including non-domestic and public sector buildings, by 2021. The Scottish Government should ensure that these new-build standards are fully compliant with our recommendations from the 2019 *UK Housing* report, delivering homes that are designed for a changing climate, properly ventilated, moisture-safe, future-proofed for low-carbon heating and have ultra-high levels of energy efficiency.

The Low Carbon Heat Funding scheme will provide a minimum £30 million of support for renewable heat projects, with a focus on renewable heat in off-gas homes, urban areas, and industrial heat. A Heat Networks Bill in 2020 should provide more clarity on how low-carbon district heating will be incentivised and regulated in Scotland.

There are some sectors where less policy detail was provided. The Scottish Government are expected to provide more clarity in upcoming publications:

- **Agriculture** emissions have fallen by less than 2% since the 2009 Climate Change Act, and we have consistently highlighted the ineffectiveness of the voluntary approach taken in recent years.

  The Scottish Government has introduced a Rural Support Bill that would allow Scottish Ministers to amend or replace the EU Common Agricultural Policy elements of retained EU law and provide new powers for the collection of agricultural data. This Bill is designed to maintain and simplify the existing CAP scheme in the three to five years after leaving the EU. It does not set out the future direction of Scottish rural support policy, nor does it make provisions for Ministers to create new policy or reform existing policy. The Scottish Government has expressed a desire to do so in a future Agriculture Bill rather than accept the inclusion of a Scottish schedule in the UK Agricultural Bill. To-date, no long-term plans have been published.

  The Scottish Government's must deliver a credible post-CAP framework that links financial support to agricultural emissions reduction and increased carbon sequestration. The Committee will advise further on the design of effective agriculture and land use policy in early 2020.

  The commitment to develop a national nitrogen balance sheet is welcomed. This will be an important tool for Scotland to monitor sources of N_2O emissions and identify areas where emissions can be reduced.

- **Power sector** emissions have fallen to near-zero in Scotland, but there is less of a clear strategy on how Scotland - and the UK as a whole - will achieve the necessary scale and nature of expansion of low-carbon generation, networks, flexible demand and storage to achieve net-zero emissions across all sectors of the economy and ensure adequate electricity supply resilience. Scotland's Energy Statement - expected in 2020 - should provide more clarity on the generation capacity that Scotland is aiming to achieve between now and 2045, while the Sectoral Marine Plan for Offshore Wind should expand on how much offshore wind capacity Crown Estate Scotland could make available in its future leasing rounds.

  To a large extent, delivering further expansion of renewable electricity and improving the electricity network in Scotland is contingent on policies from the UK Government. However, the strategic direction for low-carbon energy as a whole set by the Scottish Government, including for heat and transport, and an appropriate planning framework can play important roles in encouraging investment in the required new facilities.

- **Industry.** There have been several developments in UK policy that will have an impact on Scottish industry, including the IETF, ISCF, and consultation on industrial carbon capture business models.

  The Scottish Government has signalled its intention to engage more closely with businesses though a Mission Zero Business Summit hosted in October 2019, a new online 'single entry point' for businesses, and a new business support partnership between Scottish Enterprise, Highlands and Islands Enterprise, the Scottish Environment Protection Agency and Scottish Natural Heritage. If delivered effectively, this support and information will enable Scottish industry to access UK-wide schemes including the ISCF and IETF.

  Scotland's £30 million Low Carbon Heat Funding scheme has identified 'Heat and Industry' as one of three themes for projects, with a on process efficiency, waste heat recovery, and projects that encourage re-use of heat to adjacent commercial and/or domestic premises.

  The Scottish Government has also committed to ensuring that Scottish Water - the publicly-owned water company and the biggest electricity purchaser in Scotland - becomes a zero-carbon electricity user by 2040 through a combination of renewable energy and biogas generation, tree planting and peatland protection, waste reduction, and reducing emissions from processes, vehicles and buildings.

Chapter 3: Surface transport, aviation and shipping

Table 3.1. Short- and medium-term actions for decarbonising transport in Scotland

Action	Timing	Primary responsibility
Consider bringing forward the target to eliminate the need to buy a petrol and diesel car or van in Scotland from 2032 to 2030, if feasible and backed up a strengthening of the UK Government's target date. Encourage the UK Government to bring forward its target in line with Scotland's targets.	2020	Scottish Government
Bring forward the ban on new conventional vehicle sales in the UK to 2035 (or ideally earlier) and clarify that only battery electric (or other zero-carbon) vehicles will be permitted to be sold after this point.[37]	2020	UK Government
Clarify the UK regulatory approach to the EU 2020/21 new car and van CO_2 targets and set stretching CO_2 targets for new cars and vans beyond 2020, requiring a high electric vehicle market share. A real-world testing regime for vehicle emissions must be used alongside standardised tests.	2019	UK Government
Implement policies, including fiscal instruments, to strengthen incentives to purchase cleaner vehicles. If current purchasing trends are not reversed, new car and van emissions targets will be missed.	2019	UK Government
Set stretching targets for CO_2 emissions reductions from new HGVs to address the rise in emissions and exploit opportunities to improve logistics and increase uptake of eco-driving.	2019	Joint
Set out policies to address the decline in bus usage and develop new schemes to increase levels of walking and cycling.	2019	Scottish Government
Develop policy and infrastructure to enable sales phase-out of petrol and diesel cars, vans and motorbikes.	2020s	Scottish Government
Make a decision on how to switch to zero-emissions (e.g. hydrogen or electric) HGVs. This will necessitate small-scale trial deployments of zero-emission HGVs in a variety of fleets prior to this, in the UK or elsewhere.	Second half of the 2020s	UK Government

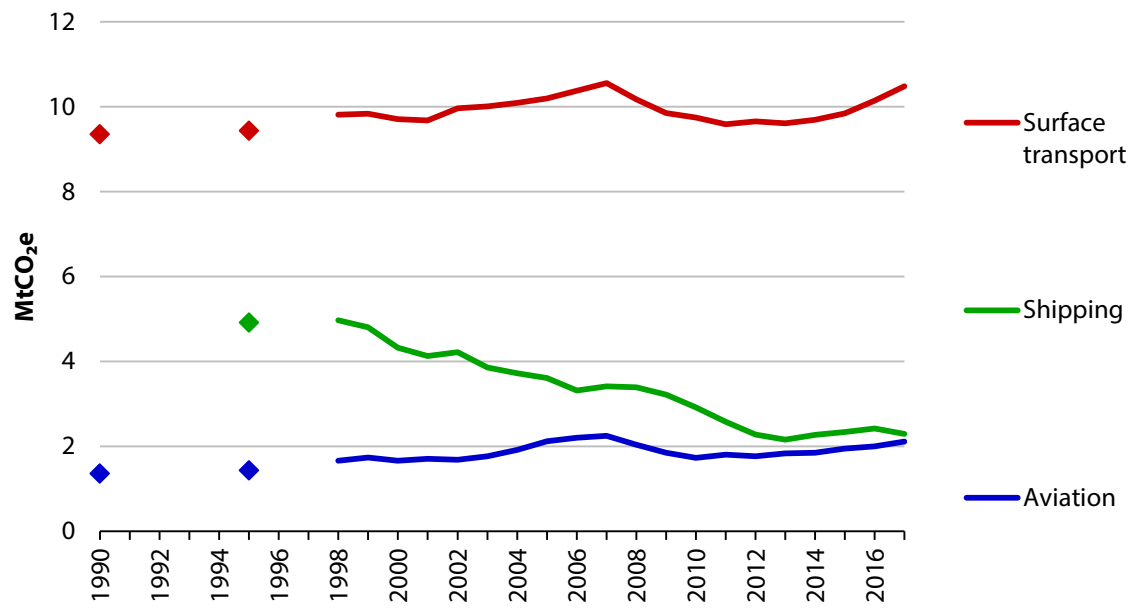
Source: Adapted from CCC (2019) *Progress Report to Parliament.*
Notes: Our UK Progress Report identified several actions due for completion in 2019.

[37] Scotland does not have the power to set legal bans on the sales of certain vehicles.

1. Latest emission trends

Scottish climate targets cover emissions from all transport in Scotland, including Scotland's share of international aviation & shipping (IAS) emissions. Transport emissions increased by 3% in 2017 (Figure 3.1) and accounted for 37% of all Scottish emissions. This is the third consecutive annual increase, and emissions from transport are now at the highest level since 2009.

Figure 3.1. Emissions from transport in Scotland (1990-2017)



Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Includes Scotland's share of emissions from international aviation and shipping.

2. Surface transport

Latest emissions trends

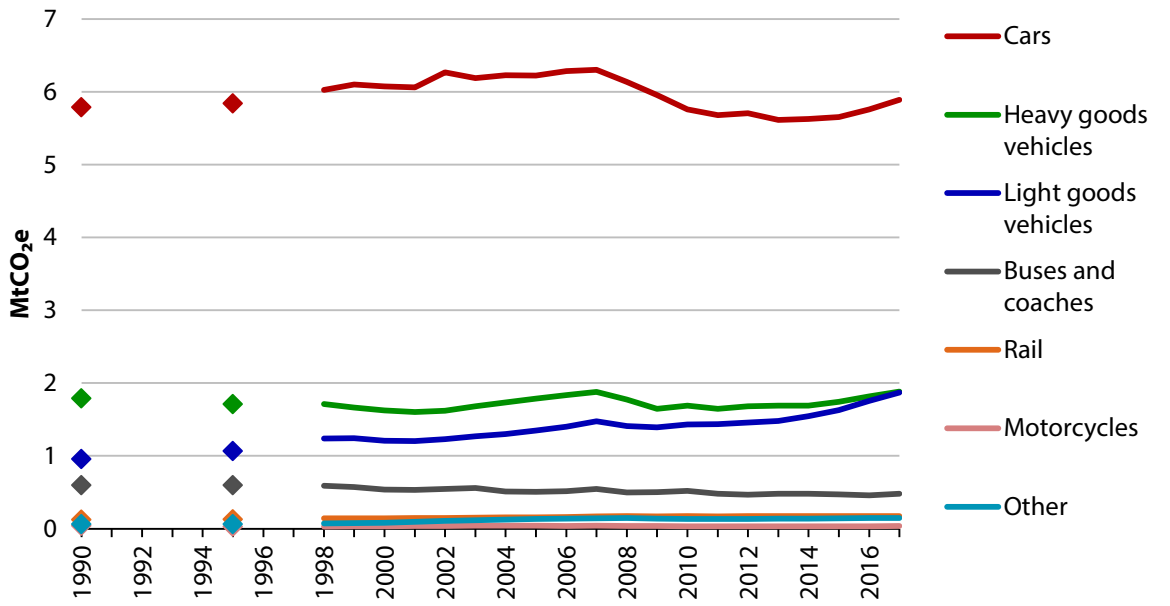
Surface transport emissions increased by 3% in 2017, the fourth consecutive annual increase, to 10.5 $MtCO_2e$. Emissions from surface transport in Scotland were 12% higher in 2017 than in 1990, and were just 1% lower than the peak in 2007.

Cars, vans and heavy goods vehicles (HGVs) account for 65% of total transport emissions in Scotland and are therefore a critical area for achieving progress towards Scotland's emissions reduction targets. Emissions from each of these modes of transport increased in 2017 (Figure 3.2):

- Emissions from cars increased by 2% in 2017 to 5.9 $MtCO_2e$.
- Emissions from vans have increased in each year since 2010, and rose again in 2017 to 1.9 $MtCO_2e$ (+7%). Emissions from vans are now almost double (+96%) the 1990 level.
- Emissions from heavy goods vehicles (HGVs) increased in 2017 by 4% to 1.9 $MtCO_2e$.

The increase in emissions from domestic transport primarily reflects steady increases in distances driven by both cars and vans (Figure 3.3).

Figure 3.2. Emissions from surface transport in Scotland (1990-2017)



Source: NAEI (2019).

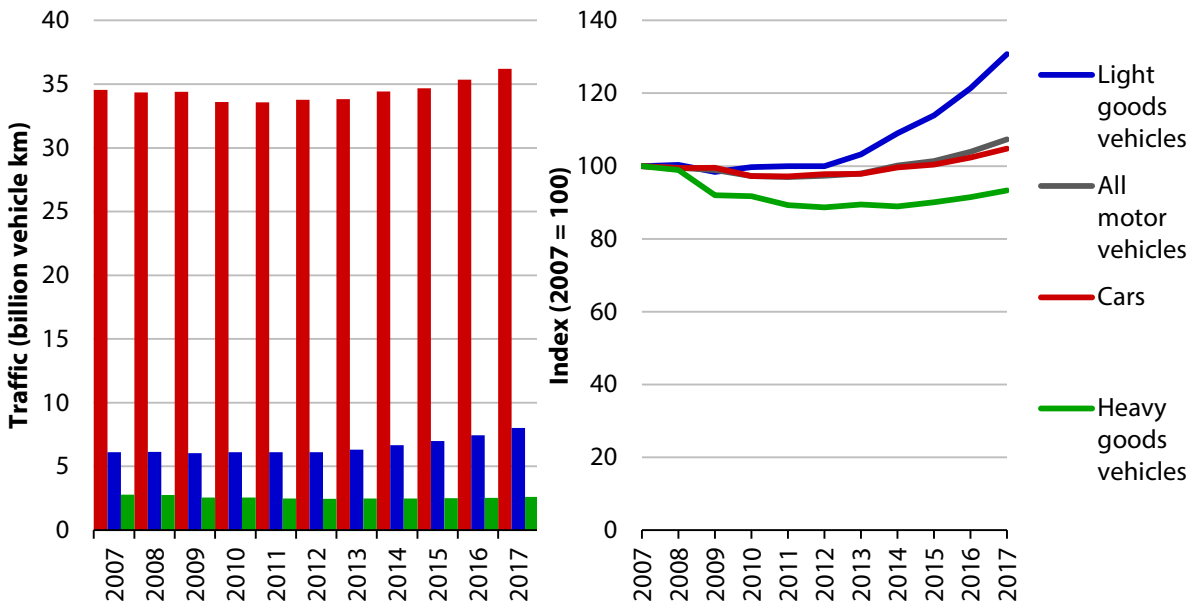
Road traffic

The total distance travelled by road vehicles in Scotland has increased steadily since 2011 at an average rate of 1.7% per year (Figure 3.3). This means that, in spite of some improvements in vehicle efficiency, emissions from road vehicles have continued to rise (Figure 3.2):

- Car traffic has increased by 5% since 2007. This is broadly in line with the increase seen in car travel for the UK as a whole.
- The Highlands and Islands are more reliant on road transport than the Scottish average. Vehicle ownership in the Highlands and Islands Transport Partnership region is 18% higher, and average distances travelled by road are estimated to be around 20% higher than the Scottish average.[38]
- The distance travelled by vans has increased by over 30% in the last ten years. The Committee has previously analysed the underlying causes of the increase in UK-wide van traffic, including GDP growth in sectors associated with high van use (such as construction, transport, utilities, ICT, wholesale, retail and food) and the rise of online shopping.[39]
- The distance travelled by HGVs fell from 2007 to a low in 2012, though it has since risen at an average of around 1% per year for the past five years.

[38] HITRANS (2019) *HITRANS Electric Vehicle Strategy*.
[39] CCC (2018) *Progress Report to Parliament*, Annex – Growth in Van Demand.

Figure 3.3. Distance travelled by vehicles in Scotland (2007-2017)



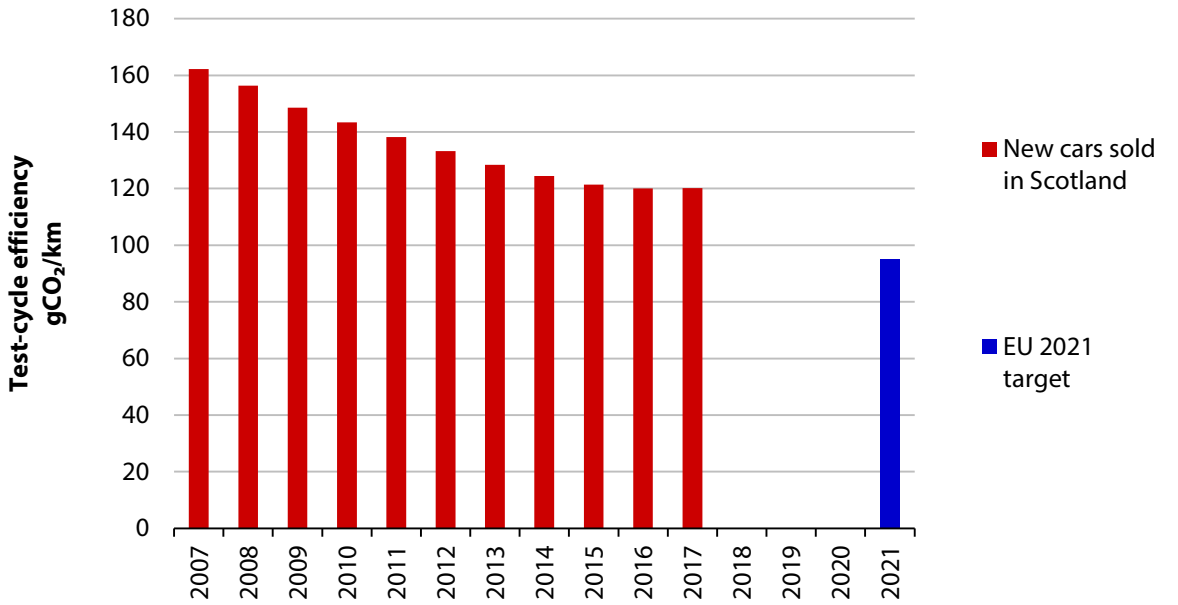
Source: Scottish Government (2019) *Scottish Transport Statistics No 37: 2018 Edition*.
Notes: The graph on the left does not show data for buses or motorcycles.

CO_2 intensity of cars

There has been some progress in improving new-car efficiency - both test-cycle efficiency and real-world CO_2 intensity - mainly through the EU new-car CO_2 regulation targeting 95 gCO_2/km by 2020/21. However, the rate of improvement has slowed down in the last five years and cars sold in Scotland in 2017 were less efficient than those in 2016 (Figure 3.4):

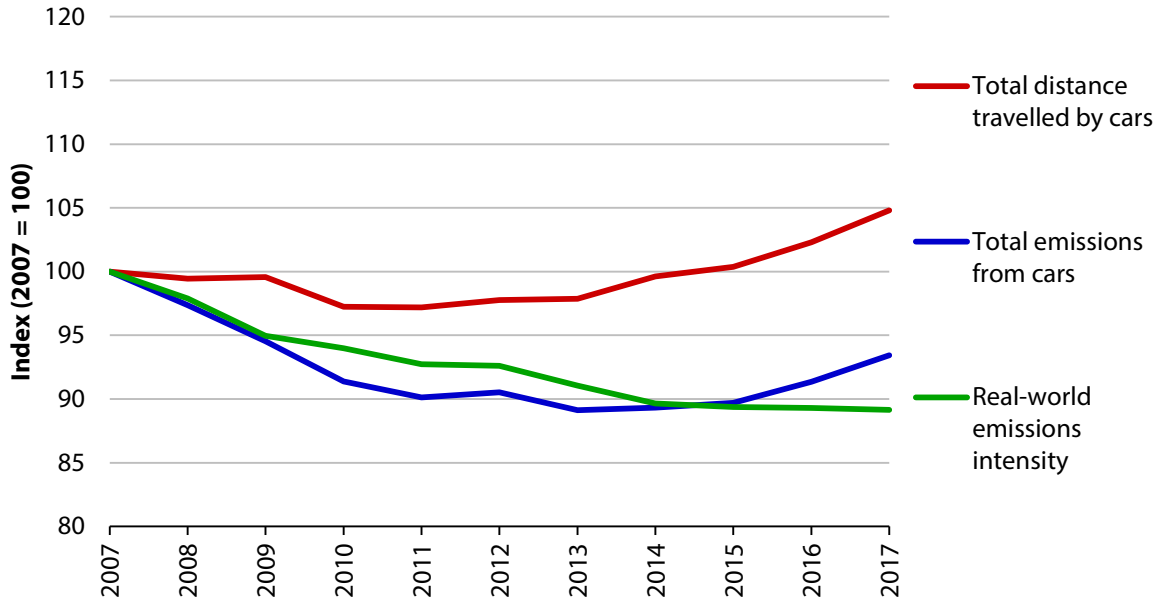
- The CO_2 test cycle efficiency of new cars in Scotland deteriorated slightly by 0.1% to 120.2 gCO_2/km in 2017. This was marginally better than the UK average of 121.0 gCO_2/km, but well short of meeting the 2021 EU target.
- The overall real-world emissions intensity (average GHG emissions per km travelled) of all cars in Scotland was 163 gCO_2e/km in 2016. Since 2007, emissions from cars have fallen by 7% despite a 5% increase in distance travelled (Figure 3.5).

Figure 3.4. Test-cycle emissions intensity of new cars in Scotland (2007-2017)



Source: Scottish Government (2019) *Scottish Transport Statistics No 37: 2018 Edition*.

Figure 3.5. Real-world emissions intensity of all cars in Scotland (2007-2017)



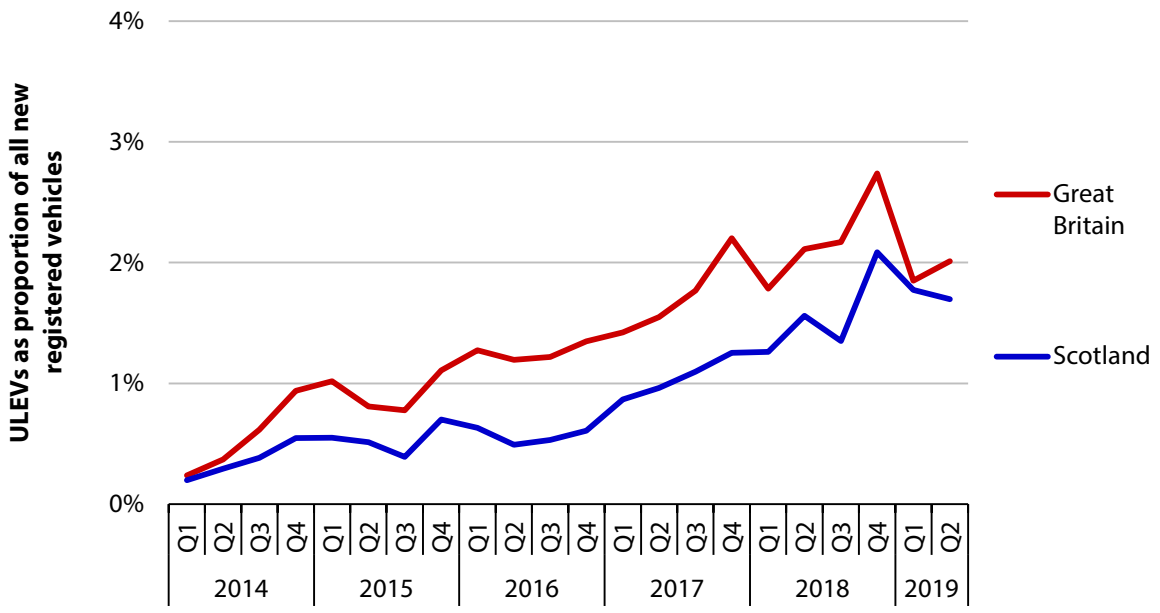
Source: NAEI (2019); Scottish Government (2019) *Scottish Transport Statistics No 37: 2018 Edition*; CCC analysis.

Electric vehicle sales and charging infrastructure

There has been an increase in electric vehicle (EV) sales at the UK level since 2010, although this is from a low base and has been largely driven by sales in England. However, this rate of increase is accelerating and the rate of ultra-low emission vehicle (ULEV) uptake in Scotland is now comparable to the rest of Great Britain:

- Scotland accounted for 6% of all new ULEV registrations in the UK in 2018, lower than Scotland's share of total UK new vehicle registrations (8%).
- New electric vehicle sales as a percentage of total sales were lower in Scotland (1.5%) in 2018 than for Great Britain as a whole (2.2%), although the gap narrowed significantly in 2018 and the first half of 2019 (Figure 3.6).
- Now that Scotland has set a net-zero target, it should aim for all cars, motorcycles and vans to be zero-emission vehicles (i.e. battery electric vehicles) rather than just ultra-low emission (such as plug-in hybrid vehicles).

Figure 3.6. ULEVs as proportion of all new registered vehicles, Scotland and GB (2014-2019)



Source: DfT (2019) *Licensed ultra low emission vehicles by local authority: United Kingdom*.

Electric vehicle owners and potential buyers frequently demand more public charging infrastructure, based on the perceived need to drive longer distances than currently offered by battery electric vehicles.[40] A sufficient public network of rapid chargers must be installed in Scotland to address consumer concerns about range:

- In October 2019, Scotland had over 3,600 public charging points. Almost fifty of these were ultra rapid chargers.[41]
- Scotland has more charging points per vehicle (790 cars, motorcycles and vans per public charging point) than the UK as a whole (1390 cars, motorcycles and vans per charging point).

In total, across Scotland, 4240 fast chargers (22 kW), 2800 rapid chargers (43 kW), 900 ultra rapid chargers at 150 kW and 55 ultra rapid chargers at 350 kW are required for public charging by 2030.[42] This would require an overall investment of £280 million between now and 2030. Charging infrastructure will also be required at homes and workplaces.

Active travel and public transport

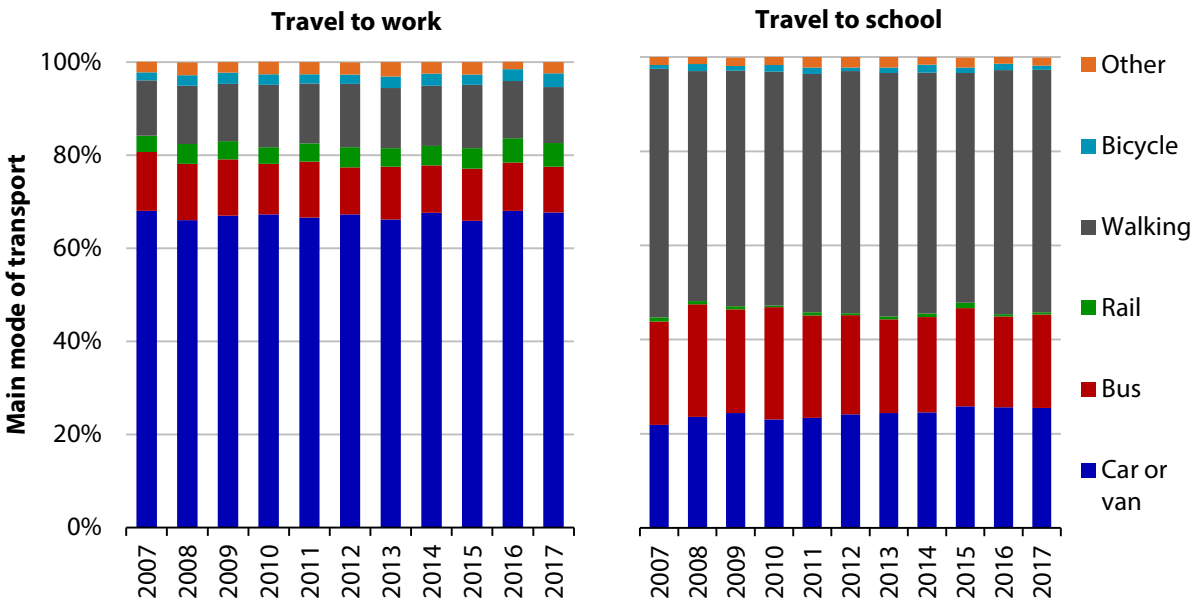
Despite policies such as Smarter Choices Smarter Places and the Cycling Action Plan, there has been no significant behavioural shift away from cars towards public transport, walking and cycling in Scotland in the last decade (Figure 3.7):

- In 2017, 68% of Scottish commuters' usual method of travelling to work was by car or van, unchanged from 2007. The number of pupils whose main method of travel to school is by car or van has increased from 22% in 2007 to 26% in 2017.
- The proportion of people who usually walk to work was unchanged at 12% in 2017 compared to 2007, though the rate of cycling has almost doubled from 1.7% to 3.0%. The proportion of schoolchildren walking to school fell by 1 percentage point to 52% in the same period and the rate of cycling was unchanged.
- The proportion of people using the bus for their main method of transport has fallen for travellers to work (-2.9 percentage points) and to school (-2.1 percentage points), while rail use has increased amongst commuters (+1.6 percentage points) and fallen amongst school pupils (-0.4 percentage points).

While the use of cars and vans to commute to work is lower in large urban areas (50%) than the Scottish average, the ambition in the Programme for Government to aim for zero- or ultra-low-emission city centres by 2030 will require the provision of ultra-low-carbon public transport options, cycling routes, and extensive deployment of electric vehicle recharging infrastructure to support a shift away from the use of conventional vehicles.

[40] This perception has persisted, despite a sustained increase in EV ranges. While the majority of daily driving can be completed by electric vehicles with only 50 miles of range, electric vehicle buyers also consider whether their vehicle will be able to drive longer distances, even if only occasionally required. Evidence suggests that a range of around 370 km (230 miles) is enough to completely address range anxiety.
[41] Defined as 150 kW and above. Data from Zap-Map (2019) https://www.zap-map.com/statistics/
[42] These figures are based on preliminary analysis of the electric vehicle charging infrastructure required in 2030 as part of the 2019 *Net Zero* advice, and may be refined subsequently following further analysis.

Figure 3.7. Main modes of transport to work and school in Scotland (2007-2017)



Source: Scottish Government (2019) *Scottish Transport Statistics No 37: 2018 Edition.*

Passenger rail electrification

The Scottish Government has a rolling programme of electrification which forms part of a wider £5 billion investment package for Scotland's railway infrastructure. Of the 2,776 km of rail track in Scotland, approximately one quarter is electrified. The Scottish Government has pledged to fully decarbonise all passenger rail by 2035:

- To date, the programme has delivered the Airdrie to Bathgate Railway, the Cumbernauld electrification project, the Edinburgh to Glasgow via Falkirk line and the £12 million Paisley Canal electrification project.
- The electrification of the Stirling/Alloa/Dunblane lines was completed in December 2018 and will improve journey times for passengers traveling to Edinburgh or Glasgow.
- The Shotts line between Holytown Junction and Midcalder Junction was completed on time and in budget in March 2019, providing an additional 74km of electrified railway.

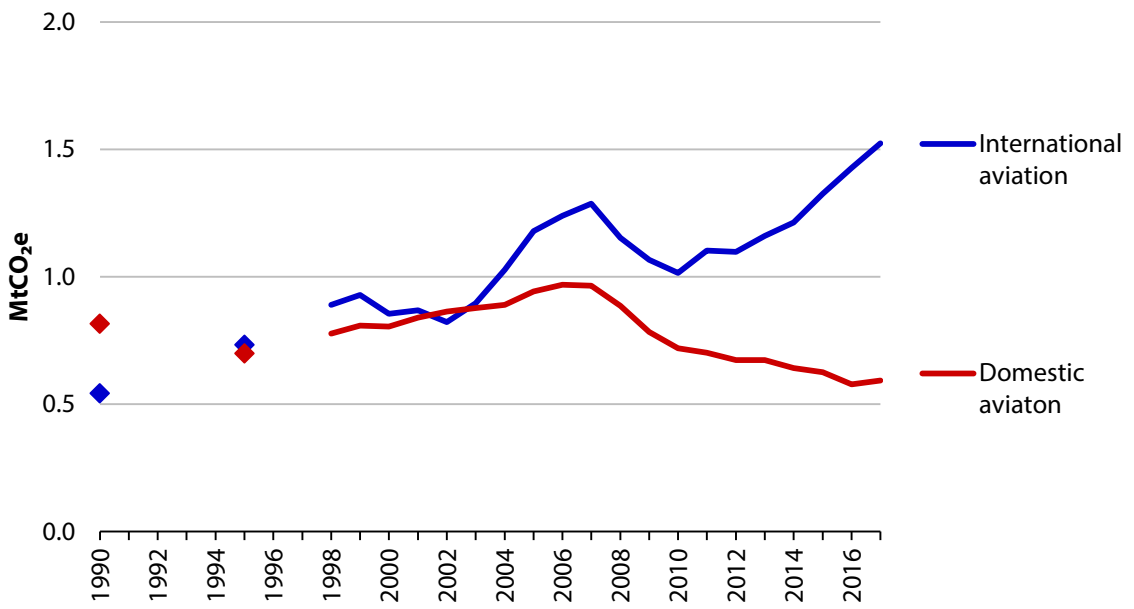
3. Domestic and international aviation

Latest emissions trends

Aviation emissions grew 6% in 2017 to 2.1 $MtCO_2e$ and are now 56% higher than 1990 levels (Figure 3.8). This has largely been due to an increase in emissions from international flights:

- Emissions from domestic flights increased by 2% to 0.6 $MtCO_2e$, and were 27% below 1990 levels.
- In contrast, emissions from international flights are now 81% greater than in 1990, and increased by 7% in 2017 to 1.5 $MtCO_2e$.

Figure 3.8. Emissions from domestic and international aviation in Scotland (1990-2017)

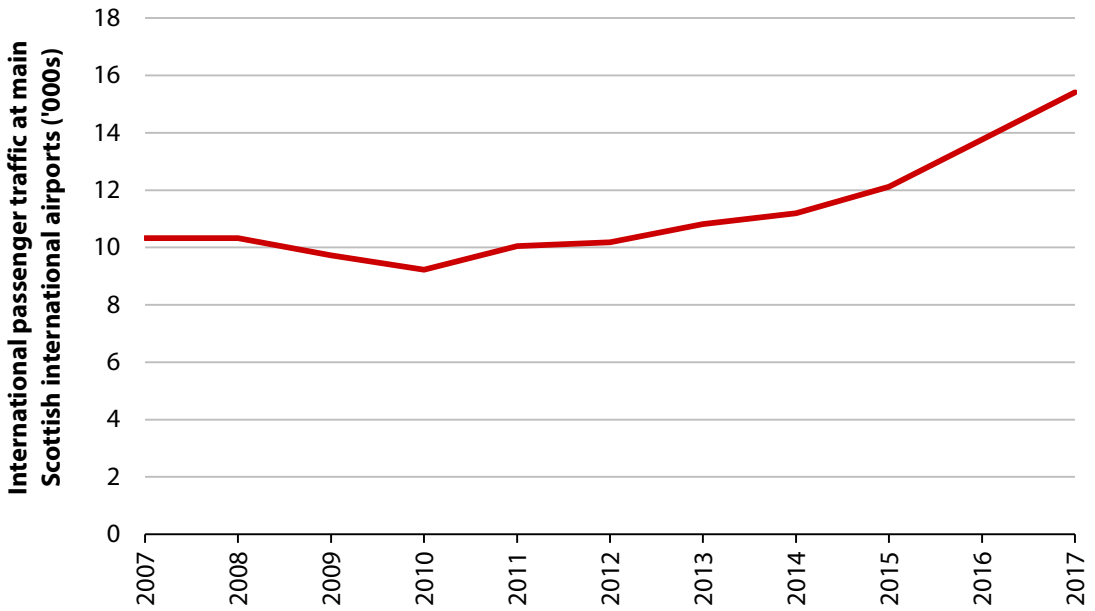


Source: NAEI (2019).
Notes: Scotland's share of international aviation emissions as defined in the NAEI inventory. Domestic emissions include Scottish flights to the rest of the UK. Flights between Scottish airports account for around 5% of total passenger traffic in Scotland.

Airport traffic in Scotland

Of the 30 million airport passengers in Scotland in 2017, around 75% travelled from Edinburgh and Glasgow. Around 5% of all terminal passenger traffic was within Scotland, 39% was to/from other parts of the UK, and 43% was between Scotland and mainland Europe. The number of passengers on international flights from main Scottish airports has increased by 49% since 2007 (Figure 3.9).[43]

Figure 3.9. International traffic to and from main Scottish international airports (2007-2017)



Source: Scottish Government (2019) *Scottish Transport Statistics No 37: 2018 Edition.*
Notes: Scotland's main international airports, as defined by the Civil Aviation Authority, are Aberdeen, Edinburgh, Glasgow and Glasgow Prestwick.

[43] Scotland's main international airports, as defined by the Civil Aviation Authority, are Aberdeen, Edinburgh, Glasgow and Glasgow Prestwick.

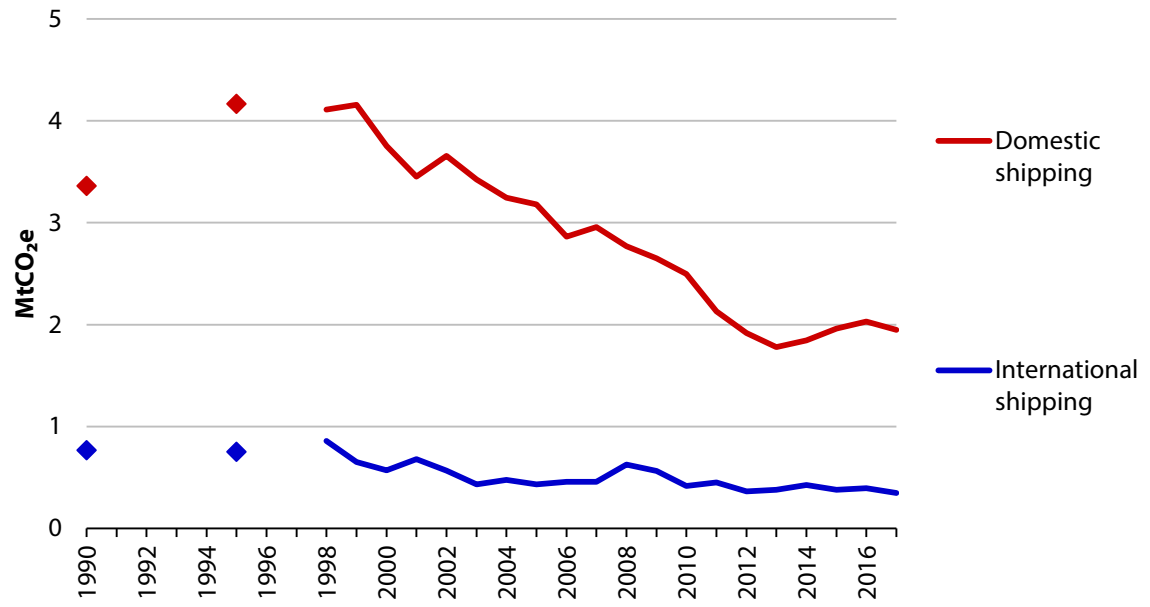
4. Domestic and international shipping

Latest emissions trends

Shipping emissions fell by 5% in 2017 to 2.3 $MtCO_2e$, following three successive annual increases from 2013 to 2016, and are now 44% below 1990 levels. Domestic shipping was the major source of shipping emissions in Scotland, responsible for more than five times the greenhouse gas emissions than from international shipping (Figure 3.10):

- Domestic shipping emissions fell by 4% in 2016 to 1.9 $MtCO_2e$, and were 42% below 1990 levels. Emissions have fallen by 53% since the peak in 1999. The largest sources of UK domestic shipping emissions were coastal shipping (1.5 $MtCO_2e$) and fishing vessels (0.4 $MtCO_2e$).
- International shipping emissions also fell (by 11%) to 0.4 $MtCO_2e$, and are now 54% below 1990 levels.

Figure 3.10. Emissions from domestic and international shipping in Scotland (1990-2017)



Source: NAEI (2019).
Notes: Scotland's share of international shipping emissions as defined in the NAEI inventory.

Chapter 4: Industry

Table 4.1. Short- and medium-term actions for decarbonising industry in Scotland

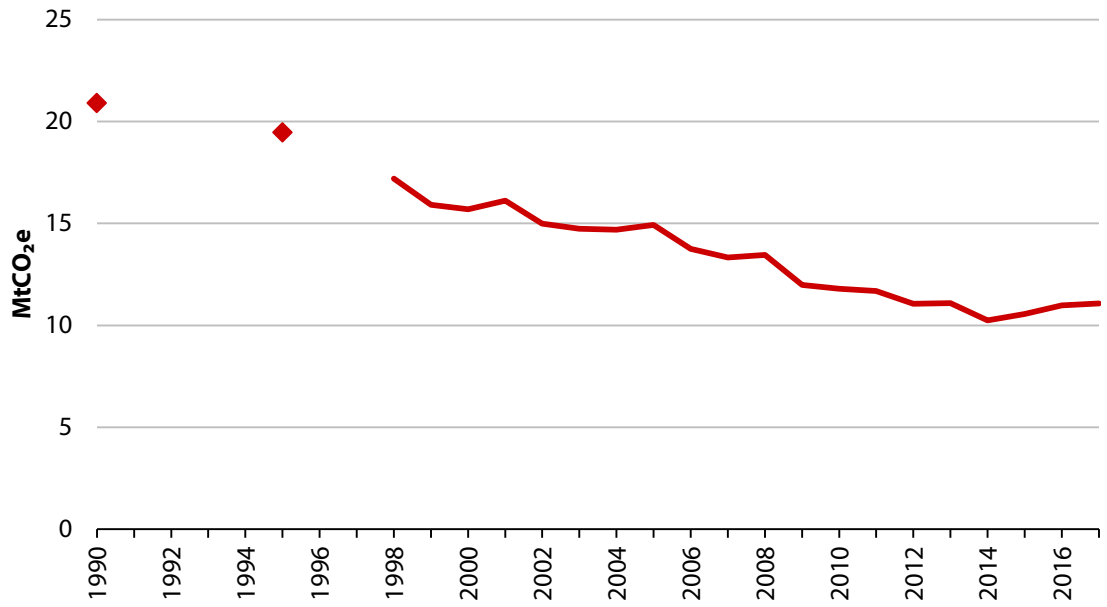
Action	Timing	Primary responsibility
Following the BEIS consultation on CCS business models in July 2019, consult on mechanisms to incentivise widespread industrial fuel switching. Identify when those industrial sites that will require CCS and/or fuel switching would need to install them in order to fit with their refurbishment cycles.	2019	UK Government
Secure (e.g. taxpayer or consumer) funding for mechanism to incentivise widespread industrial fuel switching and CCS.	2020	UK Government
Deliver near-term capital support for industrial decarbonisation, through the Industrial Energy Transformation Fund (IETF) and Industrial Strategy Challenge Fund (ISCF). Where necessary this should be accompanied by bespoke support for operational expenditure for these projects.	2019	UK Government
Publish the results of the evaluation of Climate Change Agreements to inform any successor scheme for 2023.	2019	UK Government
Strengthen policies to reduce methane leakage and venting to near-zero.	2020	UK Government
Establish policies to develop near-zero GHG emission technologies for off-road mobile machinery.	2020	UK Government
Ensure CO_2 transport and storage infrastructure is operational, and hydrogen available, at multiple industrial clusters in the UK.	Mid-2020s	UK Government
Deliver a Circular Economy Bill that helps to drive efficient use of resources in both production and consumption of resources, leading to overall improvements in industrial resource efficiency.	Early 2020s	Scottish Government
Demonstrate a range of industrial fuel-switching technologies including electrification, hydrogen and BECCS.	Early 2020s	UK Government
Award first support for industrial fuel switching and CCS through an incentive mechanism designed to enable widespread industrial fuel switching and CCS.	End 2021	UK Government
Enable delivery of substantial improvements in industrial energy efficiency in line with the upper end of ambition in the *Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050*.	2020s	UK Government

Source: Adapted from CCC (2019) *Progress Report to Parliament.*
Notes: Our UK Progress Report identified several actions due for completion in 2019.

1. Latest emissions trends

Direct[44] emissions from industry[45] were broadly flat in Scotland, increasing by less than 1% to 11.1 $MtCO_2e$ in 2017, in contrast to an overall 1% fall UK-wide. Emissions from the sector accounted for 27% of total Scottish emissions and have decreased by 47% since 1990 (Figure 4.1).

Figure 4.1. Emissions from industry in Scotland (1990-2017)



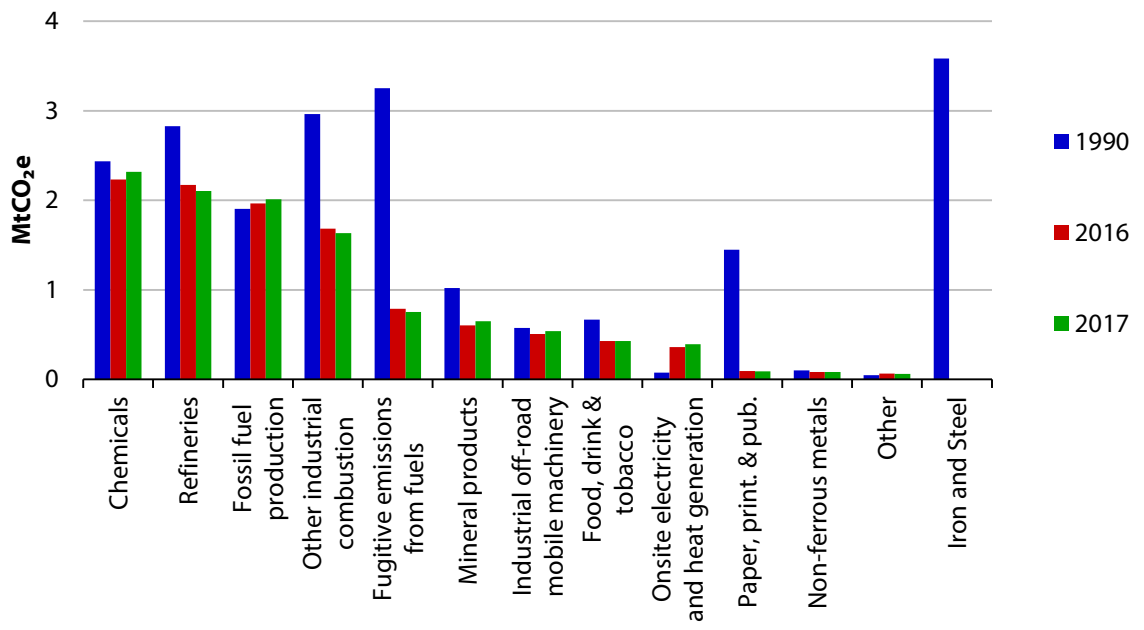
Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Industrial activity includes manufacturing, construction, water and waste management, refining of petroleum products and a range of activities linked to energy supply (extraction and production of oil, gas and solid fuels).

Chemicals manufacture, refineries, oil and gas extraction and production, and other industrial combustion are the main sources of emissions in the industry sector in Scotland, and make up almost 60% of total emissions in this sector:

- From 1990, emissions from the manufacture of chemicals increased significantly but peaked in 2000 and have since decreased. Emissions increased by 4% in 2017 to 2.3 $MtCO_2e$ and were 5% lower than 1990.
- Emissions from refineries decreased by 3% in 2017 to 2.1 $MtCO_2e$, and were 26% lower than 1990 levels.
- Emissions from fossil fuel production increased by 2% to 2.0 $MtCO_2e$. Emissions in 2017 were 6% higher than 1990 levels.

[44] Direct emissions include autogeneration but exclude emissions from generation of electricity supplied through the grid, which are covered in Chapter 9.
[45] Industrial activity includes manufacturing, construction, water and waste management, refining of petroleum products and a range of activities linked to energy supply (extraction and production of oil, gas and solid fuels).

Figure 4.2. Sources of industry emissions in Scotland (1990, 2016, 2017)



Source: NAEI (2019); CCC analysis.

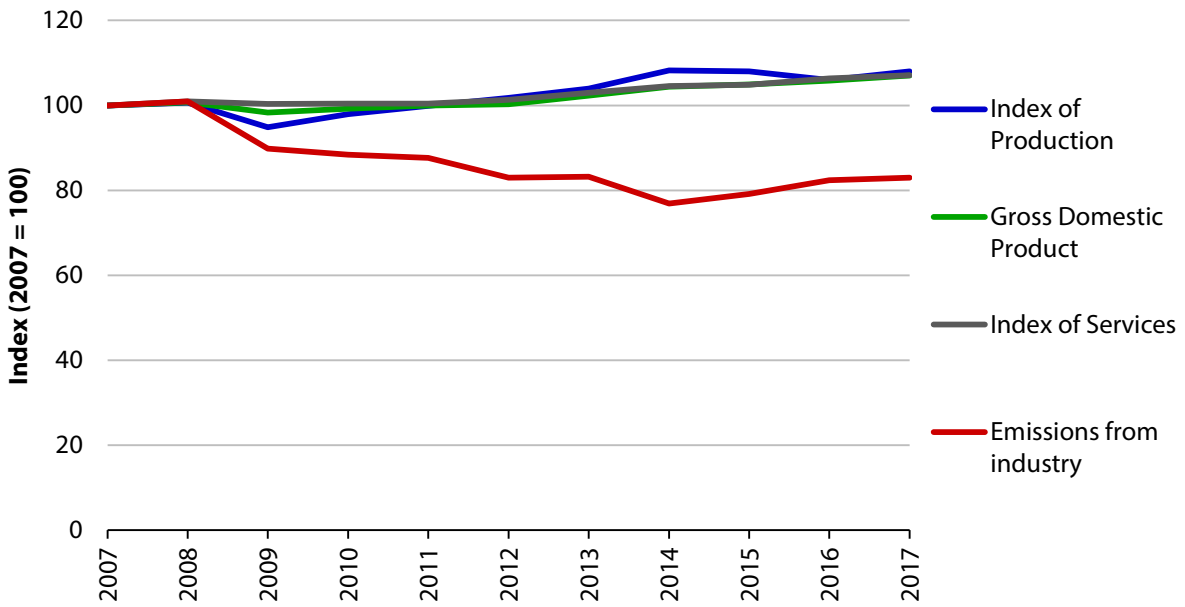
The largest reduction in emissions since 1990 has occurred in the iron and steel sector. Previously the largest source of industry emissions, emissions in this sector have decreased by over 99% from 3.6 $MtCO_2e$ in 1990 to less than 0.1 $MtCO_2e$ in 2017 (Figure 4.2). Around two-thirds of this reduction came before 1995, with the closure of Ravenscraig steelworks in 1992.

The largest point source of emissions in Scotland is now the cluster of industry at Grangemouth, which accounted for over 30% of industry emissions in Scotland (3.6 $MtCO_2$) in 2017.[46]

In the last decade emissions from industry have fallen by almost 20%, while the economic output from production[47] has increased at the same rate as the service sector in Scotland (Figure 4.3).

[46] SEPA (2019) *Scottish pollutant release inventory*. Emissions total given is for Grangemouth Refiner, Grangemouth CHP, Ineos Chemicals Grangemouth, Ineos Infrastructure (Grangemouth), and Ineos FPS Grangemouth.
[47] The Index of Production measure covers production in the mining, quarrying, manufacturing, energy supply, water supply, and waste management sectors.

Figure 4.3. Industry emissions, Scottish GDP and Index of Production and Services (2005-2017)



Source: NAEI (2019); *Scottish Government (2019) GDP Quarterly National Accounts, 2019 Quarter 2.*
Notes: The Index of Production measure covers production in the mining, quarrying, manufacturing, energy supply, water supply, and waste management sectors. The Index of Services covers distribution, hotels, catering, transport, storage, communication, business services, finance, government, and other services.

Chapter 5: Buildings

Table 5.1. Short- and medium-term actions for decarbonising buildings in Scotland

Action	Timing	Primary responsibility
Develop a fully-fledged strategy for decarbonised heat. This must be designed to fully decarbonise buildings across the Scotland in line with the net-zero goal. HM Treasury must commit to working with BEIS and the Scottish Government, undertake a review of where the costs of the transition should fall, and allocate sufficient funding to deliver over the full period from now to 2050.	2020	Joint
Publish detailed plans to phase out the installation of fossil fuel heating in off-gas properties in the 2020s, ensuring there is no policy hiatus in 2021 following the closure of the RHI.	2019	Joint
Legislate new-build standards to ensure that all new homes built from 2025 at the latest are designed for a changing climate, are ultra energy efficient and use low-carbon heat. Ambitious standards for non-residential buildings must also be decided and set.	Regulations set by 2021	Scottish Government
Tackle performance and compliance issues to ensure that new buildings and measures retrofitted in existing buildings perform as they should. This includes consulting on strengthened compliance and enforcement measures which extend beyond fire safety to regulations more widely and funding building control adequately.	2019	Scottish Government
Make strategic decisions on the future of the natural gas grid and the future balance between hydrogen and electrification for heating, taking into account the views of the public. Transition to a sustainable heat networks market.	Mid-2020s	UK Government
Implement Scotland's clear trajectory of standards covering owner-occupied, social- and private-rented homes and non-residential buildings. Alongside trajectories for energy efficiency, all new heating systems to be low-carbon from 2030 in off-gas properties and 2035 across the building stock.	2020-2040	Scottish Government
Review professional standards and skills across the building, heat and ventilation supply trades with a nationwide training programme to upskill the existing workforce.	2019-2022	Scottish Government
Reform monitoring metrics and certification to reflect real world performance, rather than modelled data (e.g. SAP). Accurate performance testing and reporting must be made widespread, committing developers to the standards they advertise.	2020-2022	Scottish Government

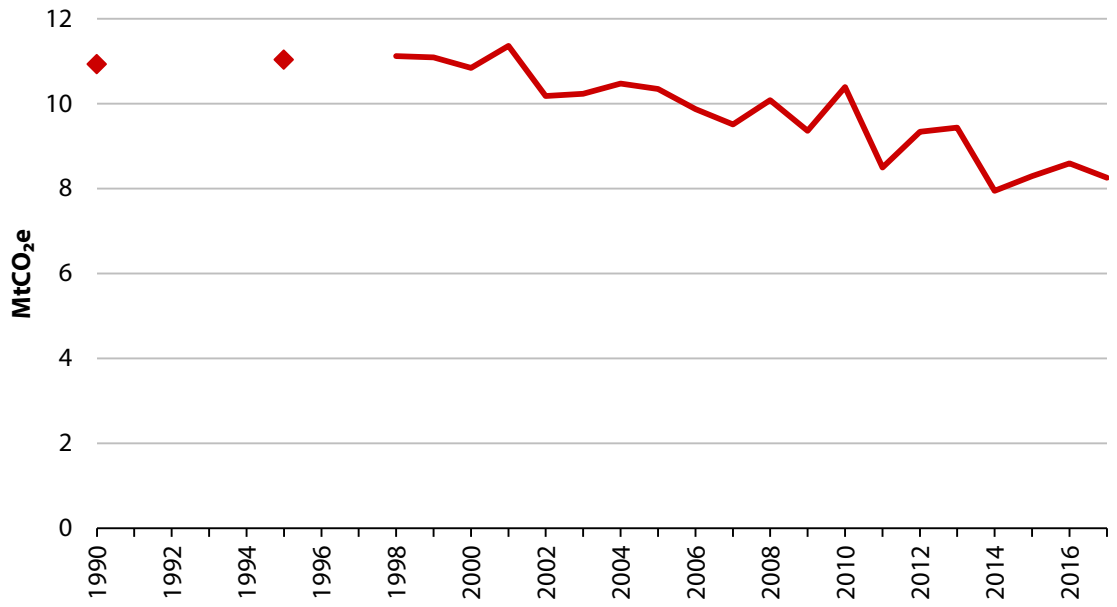
Source: Adapted from CCC (2019) *Progress Report to Parliament.*
Notes: Our UK Progress Report identified several actions due for completion in 2019.

1. Latest emissions trends

Direct emissions from buildings decreased by 4% in 2017 to 8.3 $MtCO_2e$.[48] Emissions from buildings accounted for 20% of total emissions and were 24% lower than 1990 levels (Figure 5.1). Emissions decreased in both residential and non-residential buildings in 2017 (Figure 5.2):

- Emissions from residential buildings decreased by 4% to 5.9 $MtCO_2e$ and accounted for 15% of total emissions in 2017. Emissions from homes were 26% lower than 1990.
- Non-residential buildings emissions decreased by 3% to 2.3 $MtCO_2$ in 2017. They were 20% lower than in 1990. This annual fall was marginally greater in commercial buildings (-4%) than public sector buildings (-3%).
- Milder weather from January-March and October-December meant there were fewer heating degree days in the winter months of 2017 compared to the 20-year average and to 2016 and 2018 (Figure 1.7). The 4% fall in emissions seen in 2017 could reverse in 2018 as a result of colder weather in 2018, particularly the extreme cold weather in March 2018.

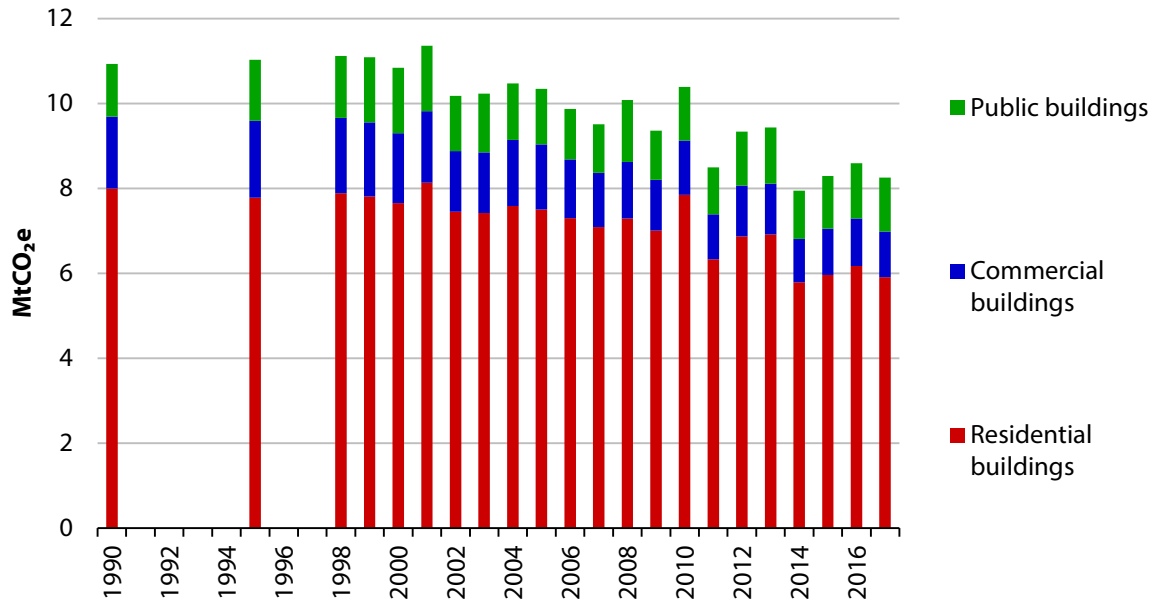
Figure 5.1. Emission from buildings in Scotland (1990-2017)



Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997.
Direct emissions from buildings exclude power sector emissions resulting from buildings electricity consumption.
Emissions are not adjusted for temperature.

[48] Direct buildings emissions exclude power sector emissions resulting from electricity consumption. Not adjusted for temperature.

Figure 5.2. Emissions from residential, public and commercial buildings in Scotland (1990-2017)



Source: NAEI (2019).

2. Low-carbon heat

The Scottish Government has a target to source 11% of non-electrical heat demand from renewable sources by 2020.[49] The provisional estimated share of non-electrical heat demand met by renewable sources in 2017 was 6.3%, up 0.8 percentage points from 2016 (Figure 5.3):

- There was 2.0 GW of installed renewable heat capacity in Scotland in 2018, up 4% from 2017 and quadruple the level in 2011. This capacity delivered a total of 5,230 GWh of renewable heat, up 14% from 2017.
- The increase in output seen in 2018 was largely due to newly operational biomass and energy from waste sites, as well as an increased heat output from existing biomass sites.

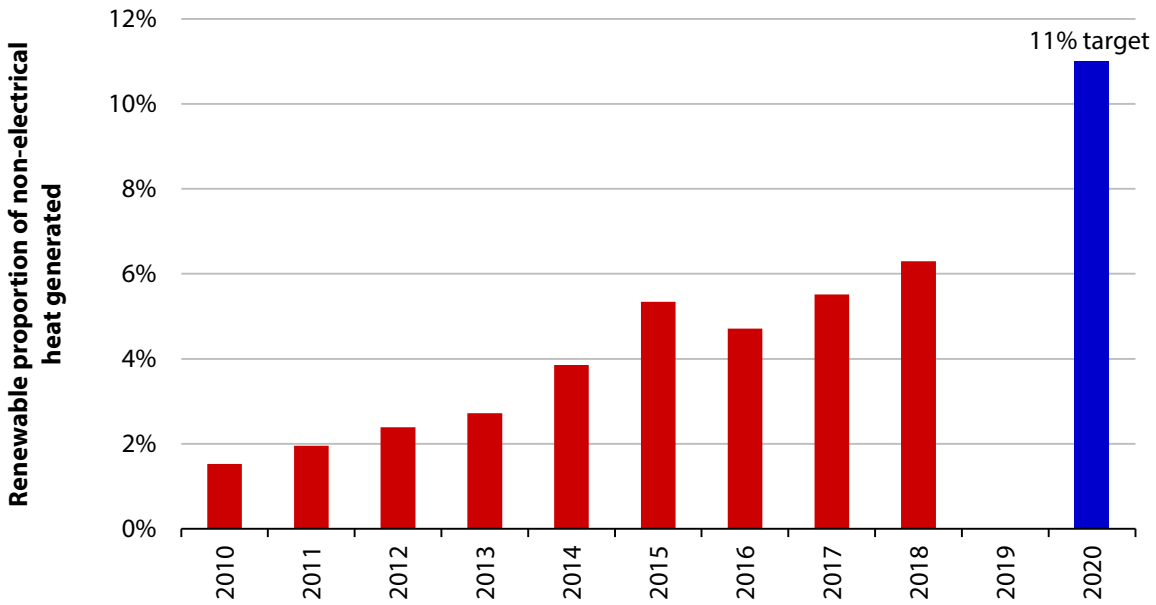
Without a rapid increase in renewable heat capacity, Scotland is likely to miss its 11% target for 2020. While the non-electrical heat demand target can be a useful instrument for monitoring and encouraging the uptake of renewable heat, a fundamental issue with the target is that it puts biomass on a level footing with heat pumps:

- The majority of all renewable heat output (3,850 GWh, 73%) and capacity (1.7 GW, 83%) in 2018 came from biomass (wood) combustion and biomass (wood) combined heat and power (Figure 5.4).
- In contrast, heat pumps provided only 340 GWh (6%) of output and 0.2 GW (9%) of capacity in 2018.

[49] The definition of renewable heat includes biomass (wood) combustion, biomass (wood) combined heat and power, solar thermal panels, heat pumps (water, air and ground source), and energy from waste (EfW) including anaerobic digestion, landfill gas capture, non-wood biomass combustion, advanced thermal treatment, and biomethane gas to grid injection.

The Committee has recommended that the UK should limit support for bioenergy use in buildings to biomethane produced from anaerobic digestion and other niche uses. The current rate of uptake of biomass combustion for heating in Scotland is therefore not building towards long-term decarbonisation of heat, as this bioenergy will need to be prioritised for use with carbon capture and storage (CCS) in order to achieve the deep reductions in economy-wide emissions by 2050.[50]

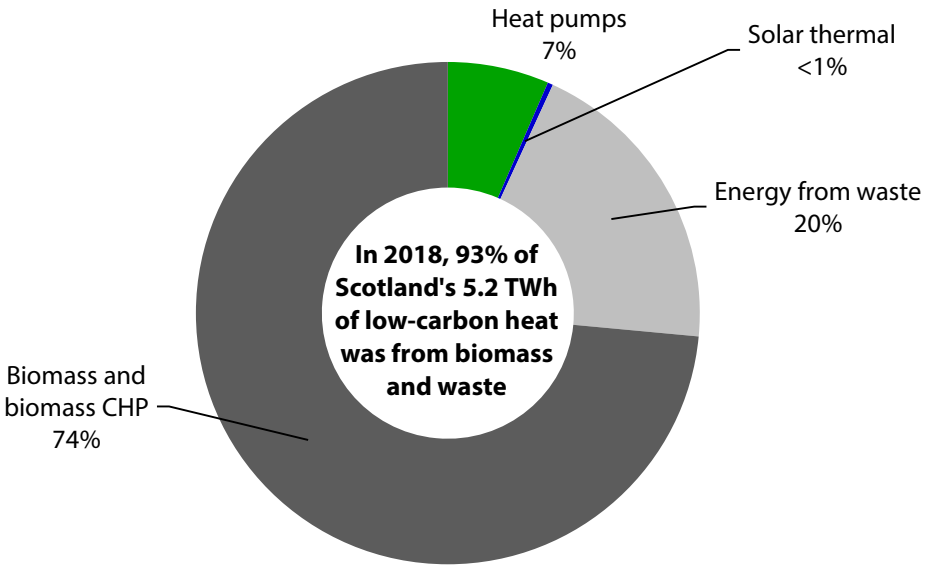
Figure 5.3. Share of renewable heat in non-electrical heat demand (2010-2017, 2020 target)



Source: Energy Saving Trust (2019) *Renewable Heat in Scotland, 2018*.
Notes: Share in 2018 is provisional estimate due to uncertainty in total heat demand in 2018. The non-electrical heat demand for 2018 has been estimated by holding the 2017 value constant. The update to the Renewable Heat in Scotland, 2018 report to be published in early 2020 will contain a revised estimate.

[50] CCC (2018) *Biomass in a low-carbon economy*.

Figure 5.4. Renewable heat generated in Scotland in 2018 by technology



Source: Energy Saving Trust (2019) Renewable Heat in Scotland, 2018.

3. Energy efficiency

Energy efficiency measures in homes

The Scottish Government tracks the level of insulation measures in homes through the Scottish House Condition Survey (SHCS):

- The latest survey found no significant change in the aggregate number of insulation measures from 2016 to 2017 across loft insulation, cavity wall insulation or solid wall insulation.
- In 2017, 57% of gas and oil boilers meet the minimum efficiencies specified by current Building Standards, an increase of 5 percentage points from 2016.
- In 2017, 42% of Scottish homes had Energy Performance Certificates (EPC) rated band C or better,[51] up from 39% in 2016 and from 35% in 2014 - the first year in which data based on the latest Standard Assessment Procedure (SAP 2012) is available (Figure 5.5).

The Scottish Government set out a framework of standards with clear trajectories for improving energy efficiency across the housing stock in their March 2019 consultation on the Energy Efficient Scotland programme, with a target of all homes achieving minimum EPC band C by 2040, where technically feasible.[52]

The Committee has previously highlighted the general approach of the Energy Efficient Scotland programme (including the use of backstop mandatory requirements) as an effective and

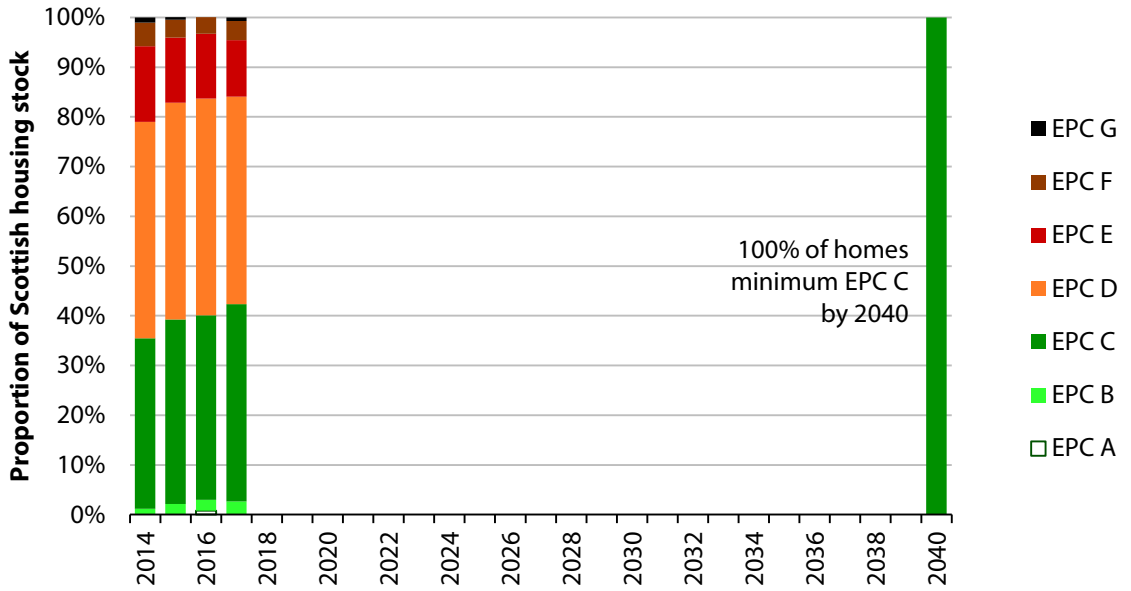
[51] Under the SAP 2012 methodology.
[52] The Scottish Parliament also considered the timescales for Energy Efficient Scotland, with a majority supporting an amendment in May 2018 calling on the Scottish Government to bring forward the date for all homes to achieve EPC Band C to 2030.

comprehensive approach to energy efficiency, although there are now questions around whether the targets can be tightened in light of Scotland's new 2030 emissions target. The Scottish Government has recently consulted on accelerating the Energy Efficient Scotland targets.

The domestic buildings programme has focused so far on social housing and the private rented sector. Further clarity on the package of support and regulation for owner occupied homes will also be required. As an area of substantial public interest and scrutiny, this is likely to be a priority in the next Scottish Parliament from 2021.

There is also a need to improve how the energy performance of buildings is measured, as there are concerns over the suitability, accuracy and reliability of EPCs. Grounding estimates in real-world data, such as from smart meters, should be the basis for reform of monitoring metrics and certification (Chapter 2).

Figure 5.5. Energy Performance Certificate ratings of Scottish housing (2014-2017)



Source: Scottish Government (2019) *Scottish House Condition Survey*.
Notes: 2040 target is taken from the Energy Efficient Scotland route map, and may be brought forward.

Energy efficiency in non-residential buildings

The Scottish Government has carried out new analysis to establish a baseline for non-domestic buildings' energy efficiency. This is a crucial step to setting targets for non-domestic buildings in the Energy Efficient Scotland programme.

EPC data for around 30,000 non-domestic buildings in Scotland was used to extrapolate across the whole building stock, classified by building type. This has allowed a benchmarking exercise

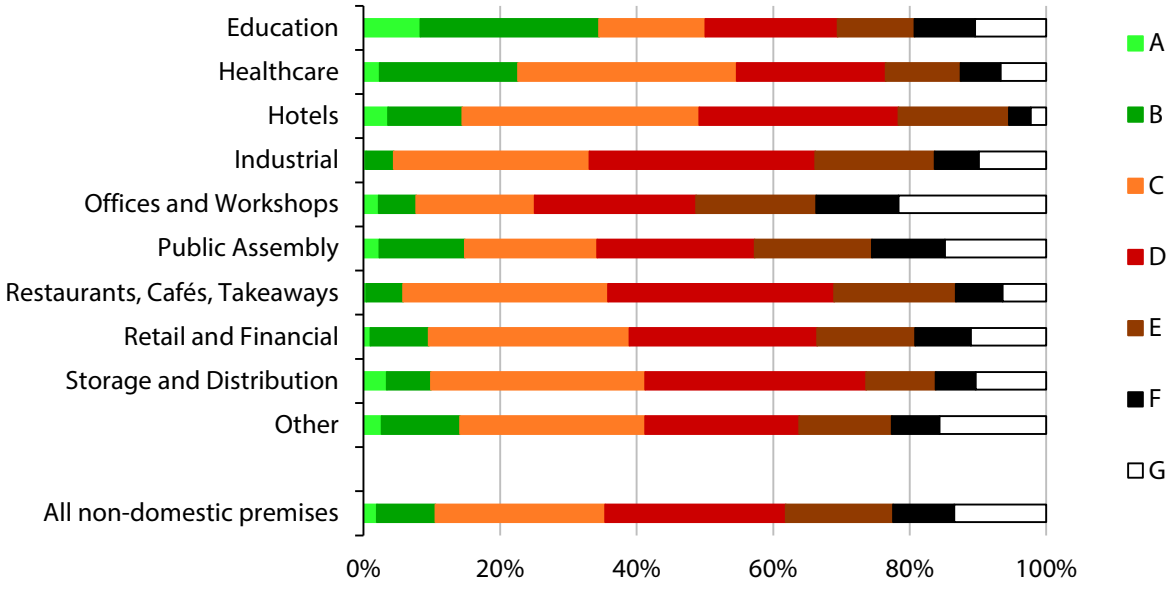
to classify the current building stock both by EPC band and by 'comparative ratings' relative to a 'reference building' for each building type.[53]

Based on this comparative rating assessment, only 11% of all non-domestic buildings in Scotland are predicted to have lower emissions than their corresponding reference building - i.e. Band A or B (Figure 5.6). The Scottish Government has committed to perform further analysis of what a 'good' reference building looks like for each non-domestic building type in Scotland.

The analysis has also highlighted the different challenges for decarbonising heat in Scotland's non-residential buildings in Scotland compared to homes:

- EPC data indicates that 50% of non-domestic premises in Scotland use electricity as their main heating fuel, with only 42% using natural gas.
- In contrast, electricity is the primary heating fuel of only 12% of Scottish households, with 79% of homes using natural gas as their primary source of heat.

Figure 5.6. Non-domestic building types by comparative rating band



Source: Scottish Government (2018) *Scotland's non-domestic energy efficiency baseline.*
Notes: Buildings within comparative rating bands A and B have lower emissions than the reference building for buildings of their type, while those banded C or worse have higher emissions.

[53] The 'reference building' has the same dimensions, location and orientation as the actual building and houses the same activities. However, the performance of the fabric, lighting, heating and hot water service of the reference building are standardised to reflect a high level of efficiency. Natural gas is assumed to fuel heating and hot water regardless of the fuel type used in the actual building. This approach allows for a rating independent of building use assumptions. Buildings within comparative rating bands A and B have lower emissions than the reference building for buildings of their type, while those banded C or worse have higher emissions.

4. Fuel poverty

In July 2019, the Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019 became law. This Act set a legal target to eliminate fuel poverty as far as possible, with no more than 5% of households to be in in fuel poverty and no more than 1% in extreme fuel poverty by 2040.

The Act has also redefined fuel poverty in Scotland. A household is now considered fuel poor if, once it has paid for its housing costs, it needs more than 10% of its remaining income to pay for its energy needs, and if this expenditure then leaves the household in poverty.

Under the new definition, 23.7% (583,000) of households were living in fuel poverty in 2017, which showed no statistically significant change to the rate in 2016 (25.7%). The rate of extreme fuel poverty under the new definition was 11.9%, which was similar to the 2016 figure (12.6%).[54]

[54] The rates of fuel poverty and extreme fuel poverty in 2017 showed no statistically significant difference to 2016, based on the sample size used in the SHCS.

Chapter 6: Agriculture and land use, land-use change and forestry

Table 6.1. Short- and medium-term actions for decarbonising agriculture and land use in Scotland

Action	Timing	Primary responsibility
Set out firm policies and an implementation plan to reduce GHG emissions in agriculture in Scotland.	By mid-2020	Scottish Government
Ensure the ongoing design of the post-CAP framework in Scotland, including the testing and trialling of options, will incentivise the take-up of low-carbon farming measures and changes in land use to increase carbon removals.	2020	Scottish Government
Ensure a long-term policy framework and funding is in place to support a minimum of 18,200 hectares of peatland restoration per year between now and 2045.	2020	Scottish Government
Follow through on commitments in Scotland's 2019-2029 Forestry Strategy to increase overall annual afforestation rates to at least 15,000 hectares in the early 2020s.	Early 2020s	Scottish Government
Increase the take-up of low-carbon farming practices and develop a strong regulatory baseline that includes low-regret options, with incentives and a wider policy framework for further measures.	Early 2020s	Scottish Government
The Industrial Strategy's Transforming Food Production Challenge Fund: ensure future calls are allocated to projects that deliver supporting emissions reduction and clean growth in the food and agriculture sectors.	2020	UK Government
Target investment in R&D and innovation. Test and pilot options to deliver sustainable agricultural productivity improvements in crops and livestock; productivity improvements in trees and energy crops; low-carbon technologies and options for low-carbon agricultural machinery e.g. tractors and robotics.	2020s	Joint
Ensure the post-CAP framework promotes transformational land use change and measures for deep emissions reductions including afforestation and peat restoration.	2020s	Scottish Government

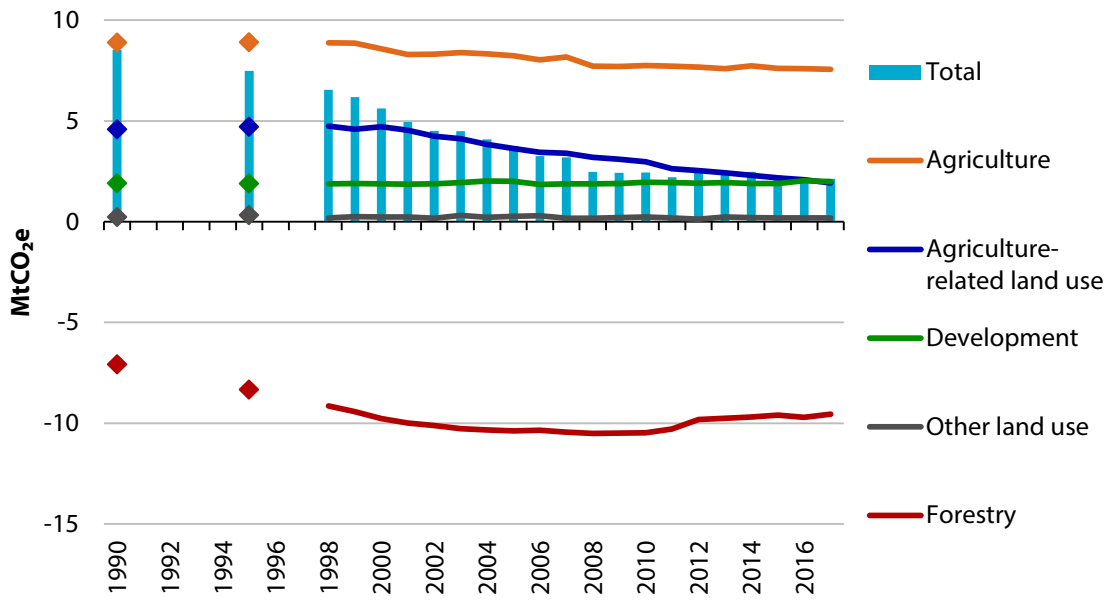
Source: Adapted from CCC (2019) *Progress Report to Parliament.*
Notes: Our UK Progress Report identified several actions due for completion in 2019.

1. Latest emissions trends

Total emissions from agriculture and the land use, land-use change and forestry (LUCLUF) sector have fallen by over 75% since 1990. This progress has primarily been due to an increase in the size of the forestry sink and a fall in emissions from agriculture-related land use,[55] whereas direct emissions from agriculture have held been largely constant:

- Two-fifths (38%) of this fall was driven by a 2.5 $MtCO_2e$ increase in the size of the forestry sink between 1990 and 2017.
- A further 2.7 $MtCO_2e$ (42%) of the reduction was from falls in agriculture-related land use, primarily due to decreasing levels of grassland conversion to cropland.
- Direct emissions from agriculture have fallen much more slowly, decreasing by 1.3 $MtCO_2e$ since 1990 (Figure 6.1).

Figure 6.1. Emissions from agriculture & LULUCF in Scotland (1990-2017)



Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997.
Does not reflect forthcoming revisions to global warming potentials (Box 1.1).

Estimates of emissions from agriculture and LULUCF sector are more sensitive to methodological changes to how emissions are calculated:

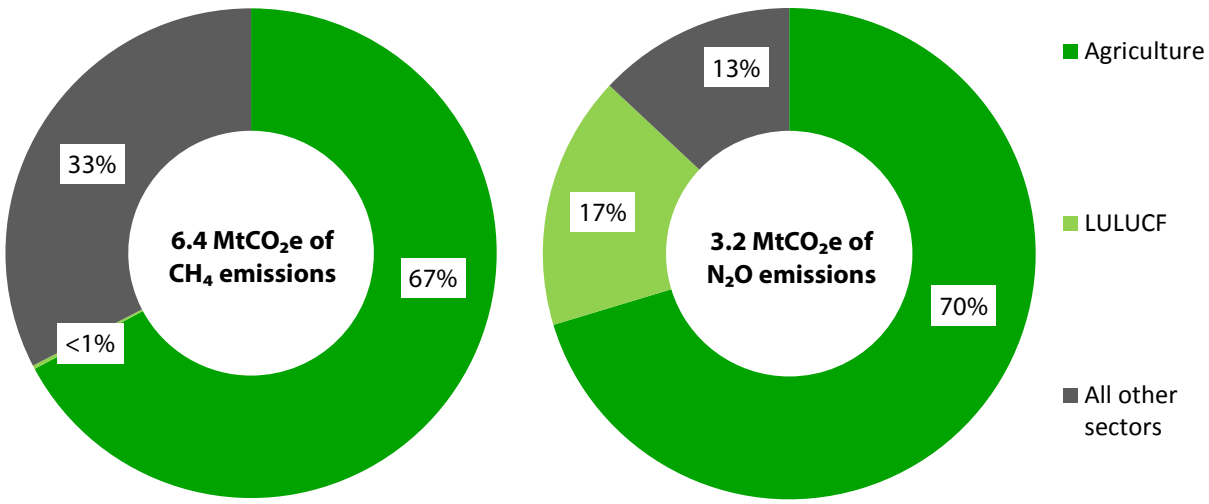
- Methodological changes to how LULUCF emissions are calculated have dominated the differences between the last three published inventories (Figure 1.6). Agriculture and LULUCF emissions tend to be more challenging to estimate due to the complex biological

[55] Agriculture-related land use covers emissions from existing cropland and grassland and land-use changes to cropland and grassland.

processes involved, although the introduction of the 'smart' agriculture inventory in 2018 is a welcome improvement.

- The agriculture and LULUCF sector produces two-thirds (65%) of all non-CO_2 greenhouse gas emissions in Scotland (Figure 6.2). Future changes to the GWPs (Box 1.1) that are used to calculate the global warming impact of CH_4, N_2O and F-gases relative to CO_2 will therefore have a more significant impact in this sector.
- Once a decision is made on how emissions from peatland will be included in the inventory (by 2024 at the latest), the estimate of net annual LULUCF emissions could increase by 6.1-9.6 $MtCO_2e$.

Figure 6.2. Methane (CH_4) and nitrous oxide (N_2O) emissions from Agriculture & LULUCF (2017)



Source: NAEI (2019).
Notes: Does not reflect forthcoming revisions to peatland emissions or global warming potentials (Box 1.1).

2. Agriculture

Emissions from agriculture were largely unchanged in Scotland in the five years from 2012 to 2017, falling by 1% in 2017 to 7.6 $MtCO_2e$ (Figure 6.3):

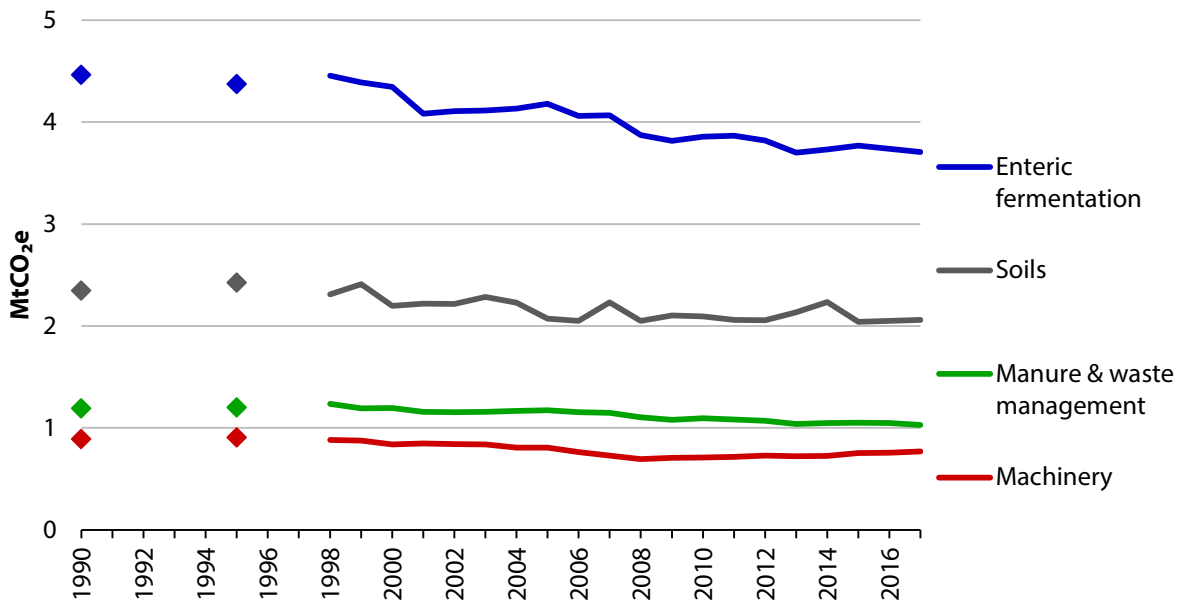
- Emissions from the digestive processes of livestock (enteric fermentation) account for half (49%) of all agricultural emissions, and have fallen by 3% since 2012. A further 14% of emissions are from manure and waste management, which fell by 4% from 2012 to 2017.
- Soil emissions account for a further 27% of emissions from agriculture, and have been unchanged since 2012.
- The remaining emissions (10%) were from machinery, which have increased by 5% since 2012.

The 2016 Scottish Survey of Farm Structure and Method has established a new baseline for two indicators on voluntary soil testing and nutrient management measures. An update to this survey is due 'circa 2019'[56] which should provide evidence of any change in uptake of these voluntary measures on farms:

- 64% of farmers surveyed carried out pH testing on other (arable) land in 2016.
- 30% of farmers surveyed carried out pH testing on grassland in 2016.
- 42% share of farms surveyed completed a nutrient management plan on other (arable) land in 2016.
- 17% of farmers surveyed completed a nutrient management plan on grassland in 2016.

There has been no clear shift in emissions from agriculture in the past five years. The Committee has repeatedly recommended that the Scottish Government should consider moving beyond a voluntary approach with agricultural greenhouse gas reduction policies, and we will be advising further on policy to reduce emissions from agriculture in early 2020.

Figure 6.3. Emissions from agriculture in Scotland (1990-2017)



Source: NAEI (2019).

[56] Scottish Government (2018) *Climate Change Plan Monitoring Report.*

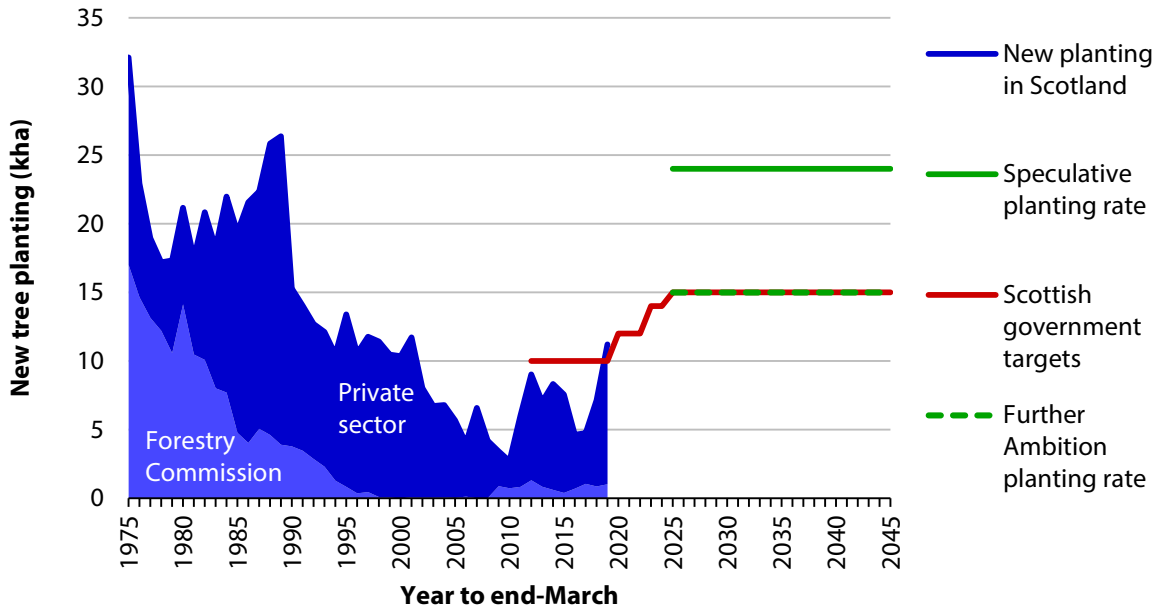
3. Afforestation

Our recommendation that Scotland can achieve net-zero emissions ahead of the rest of the UK takes into account Scotland's ability to use its significant land area to remove CO_2 from the atmosphere. This relies on an immediate and sustained increase in tree planting rates between now and 2045. Our 2019 *Net Zero* report recommended that Scotland plants between 15,000 and 24,000 hectares (ha) of new trees each year from the mid-2020s.

In the year ending March 2019, the Scottish Government, met its own tree-planting targets for the first time by planting 11,200 ha of new trees. Over 90% of this new planting was private,[57] with 1000 ha planted on Scotland's national forest estate (Figure 6.4). Forest Research attributed this increase to greater availability of grant funding in Scotland and increased confidence in forestry arising from strong timber values.[58]

In its Programme for Government, the Scottish Government has committed to increasing its ambition for 2019/20 by 20% - to 12,000 ha - on the way to the existing 15,000 ha target for 2024/25 in the 2018 Climate Change Plan.

Figure 6.4. New tree-planting in Scotland (1975-2019)



Source: Forest Research (2019) *Forestry Statistics 2019*, New planting and restocking: time series; CCC analysis.
Notes: Planting rates in the 'Further Ambition' and 'Speculative' scenarios from 2025 are taken from our 2019 *Net Zero* report. The Forestry Commission in Scotland was split in April 2019 - responsibility for managing Scotland's national forest estate has been transferred to Forestry and Land Scotland.

[57] Trees planted on public land that is not part of Scotland's national forest estate is considered 'private' planting.
[58] Forest Research (2019) *Forestry Statistics 2019*, New planting and restocking: time series.

4. Peatland restoration

In their natural state, peatlands continuously sequester CO_2 from the atmosphere, transferring it into organic matter which can remain stable for thousands of years if the ground remains waterlogged. When peatlands are drained to provide fibre, fuel and land for food production, this stored carbon is released. Scottish peatlands are a vast carbon store containing over 6,500 $MtCO_2e$ of carbon, equivalent to 160 years' worth of Scotland's total greenhouse gas emissions in 2017.[59]

Degraded peatlands risk significant carbon emissions whether or not they are currently accounted for in the current inventory. Peatland emissions will be included in the inventory by 2022 at the latest, and are expected to add 6-10 $MtCO_2e$ of annual emissions to the Scottish inventory depending on the methodology used.[60] Ricardo Energy and Environment has estimated that 0.6-1.4 $MtCO_2e$ of greenhouse gas emissions were released from a six-day wildfire in the Flow Country in 2019; it is not yet clear how this event will impact on future Scottish greenhouse gas inventories.[61]

In 2017-18, 3,600 ha of peatland were restored in Scotland and Peatland Action has carried out further feasibility studies on over 25,000 ha of unrestored peatland. In June 2019, Scottish Government committed £11 million to fund projects to restore degraded peatlands, on top of an initial commitment of £3 million.

Analysis for our *Net Zero* report shows that a minimum of 18,200 ha of peatland re-wetting should be carried out in Scotland annually from the mid-2020s to 2045 to deliver 1.1 $MtCO_2e$ of greenhouse gas abatement, in addition to significant co-benefits from improved water filtration and enhanced biodiversity.[62] From 2017 to 2050, this would require restoring over 450,000 hectares of unimproved grassland[63] on upland peat as well as the re-wetting of 46,000 ha of peatland extraction sites. The level of ambition in Scotland's 2018 Climate Change Plan is consistent with this recommendation, aiming for 20,000 ha of peatland restoration each year.

[59] Scottish Natural Heritage (2019) *Peatland ACTION Carbon Facts and Figures.*
[60] Chris Evans et al. (2019) *Implementation of an Emissions Inventory for UK Peatlands.*
[61] Ricardo Energy and Environment for WWF Scotland (2019) *Carbon loss and economic impacts of a peatland wildfire in north-east Sutherland.*
[62] CCC (2019) *Net Zero Technical report.*
[63] CEH (2018) *Quantifying the impact of future land use scenarios to 2050 and beyond*. Unimproved Grassland is the combined area of the Eroded Modified Bog, Grass Dominated Modified Bog and Extensive Grassland categories and can be drained or undrained.

Chapter 7: Waste

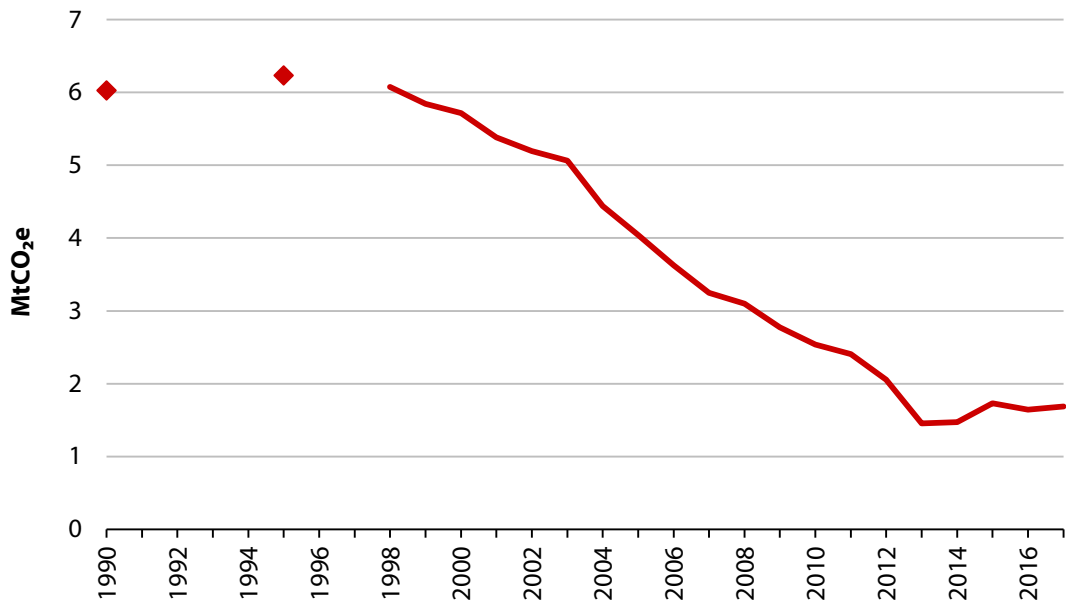
Table 7.1. Short- and medium-term actions for decarbonising waste in Scotland		
Action	**Timing**	**Primary responsibility**
Support local authorities and businesses in Scotland to prepare for the 2021 ban on biodegradable waste to landfill, minimising the amount of biodegradable waste that is diverted to landfill in England.	End of 2020	Scottish Government
Deliver Scotland's net-zero-consistent targets from the 2018 Climate Change Plan to reduce food waste by 33% and recycle 70% of all waste generated by 2025.	2020s	Scottish Government
Source: Adapted from CCC (2019) *Progress Report to Parliament.*		

1. Latest emissions trends

In 2017, emissions from waste in Scotland increased by 3% to 1.7 $MtCO_2e$, 72% below 1990 levels (Figure 7.1). Almost all (1.6 $MtCO_2e$) emissions from waste were methane.

Waste emissions accounted for only 4% of total emissions of Scotland in 2017. This is a sharp reduction since 1990, when waste accounted for 8% of Scottish emissions. The long-term fall in emissions is mainly due to a reduction in total waste generated and an increase in recycling.

Figure 7.1. Emissions from waste in Scotland (1990-2017)



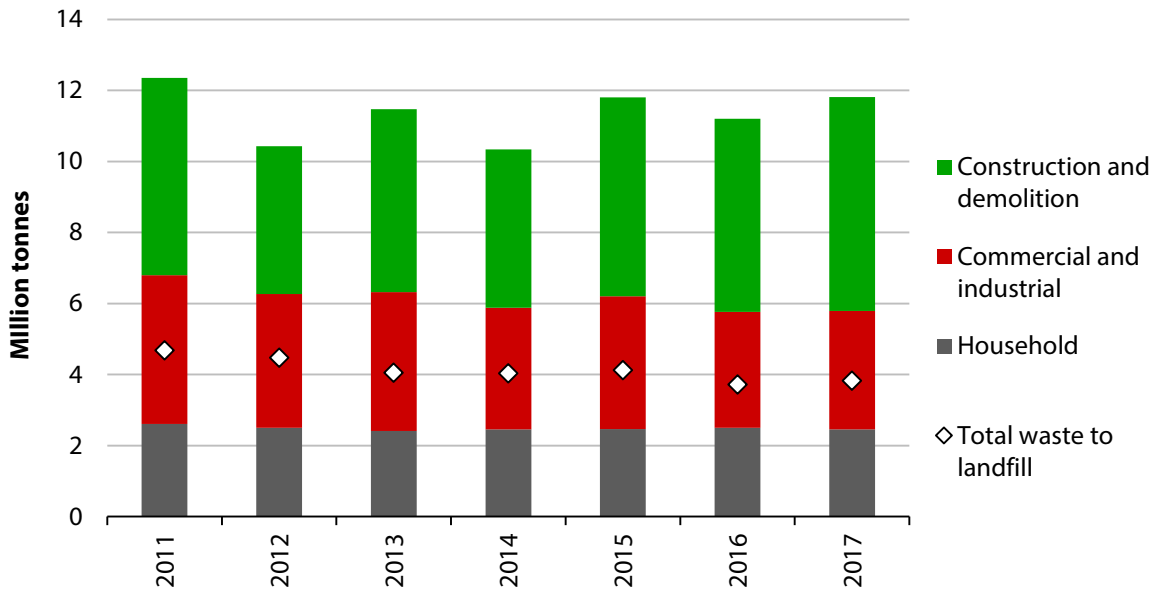
Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997. Does not reflect forthcoming revisions to global warming potentials (Box 1.1).

2. Total waste generated and sent to landfill

In 2017, the total waste generated in Scotland was 11.8 million tonnes, which was 4.3% lower than the 2011 baseline used in Scotland's waste reduction targets (Figure 7.2):

- In 2017, 21% of total waste generated was from households, 28% from commercial and industrial sources, and 51% from construction and demolition.
- The share of total waste from all sources sent to landfill increased by 0.1 percentage points in 2017 to 32.6% of total waste. Scotland's Zero Waste Plan target for 2025 is 5%.
- In 2017, 58.9% of all waste was recycled, composted, or reused, down 0.2 percentage points from 2016. The target for 2025 set out in the Zero Waste Plan is 70%.

Figure 7.2. Waste generated by sector and total waste sent to landfill in Scotland (2011-2017)



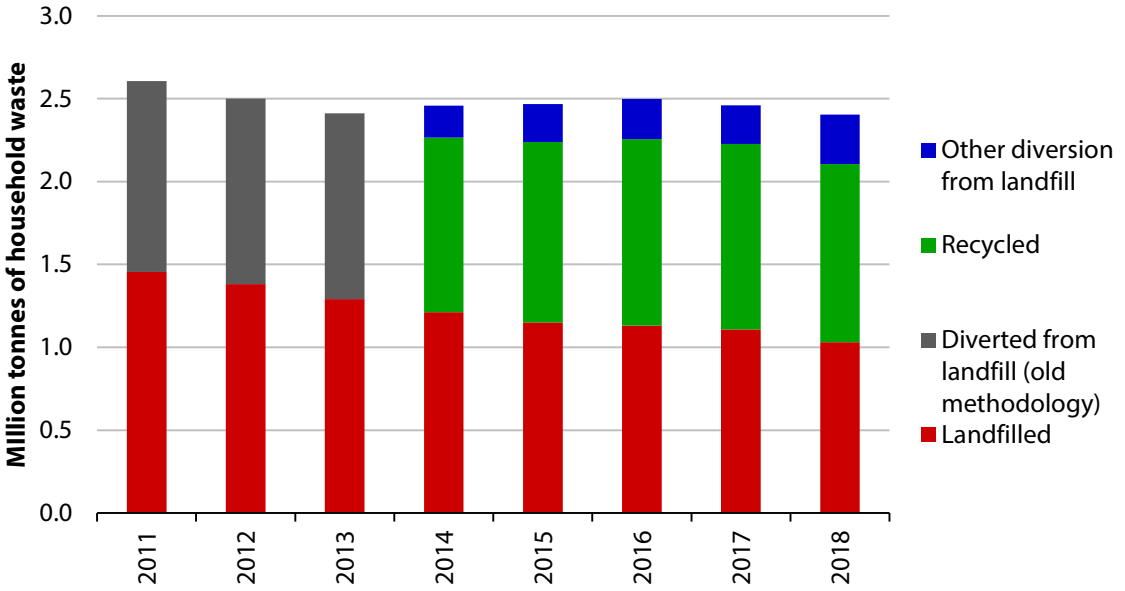
Source: SEPA (2019) *Waste from all sources: waste data tables 2017.*

Scotland had a target to develop at least six landfill sites with methane gas capture in 2018/19, and exceeded this target with eight Scottish Government supported projects underway as of September 2018.

3. Household waste

Household recycling rates decreased slightly in 2018 to 44.7%, but more waste was recycled than sent to landfill for the second consecutive year. This is short of Scotland's indicator to recycle 60% of household waste by 2020 (Figure 7.3).

Figure 7.3. Household waste generated, landfilled and recycled in Scotland (2011-2018)

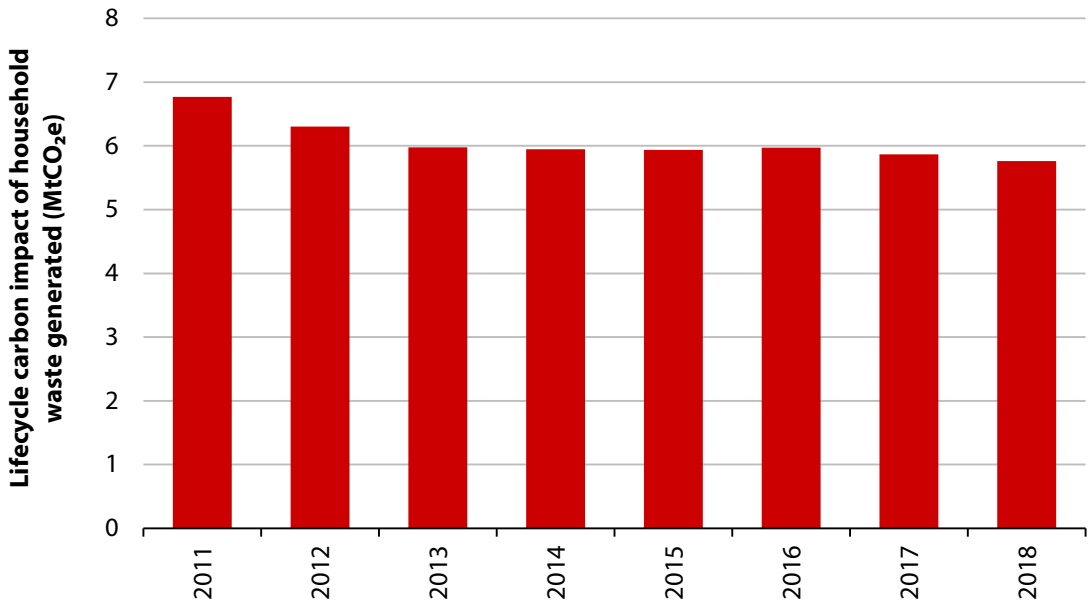


Source: SEPA (2019) *Scottish Household waste - summary data 2018.*
Notes: Scotland revised the methodology of the measurement of the total tonnage of waste that was recycled in 2014. Prior to 2014, household waste composted that did not reach the quality standards set by PAS 100/110 was included in the recycling figures. Therefore, rates pre-2014 should not be compared with post-2014 rates.

In addition to the annual emission from waste in the NAEI greenhouse gas inventory for Scotland, SEPA provides a separate assessment of the lifetime carbon impact of household waste generated in Scotland. This is a measure of the whole-life carbon impacts of waste, from resource extraction and manufacturing emissions, through to waste management emissions:

- The lifecycle carbon impact of Scottish waste generated and managed in 2018 was 5.8 $MtCO_2e$ (Figure 7.4).
- This carbon impact has steadily declined since 2011, with a 15% decrease from 2011 to 2018. This was largely a result of improved recycling rates, particularly for high impact waste materials, as well as reduction in waste generated and reduced landfilling of biodegradable waste.

Figure 7.4. Lifecycle carbon impact of household waste generated in Scotland (2011-2018)



Source: SEPA (2019) *Scottish Household waste - summary data 2018.*

4. Food waste and biodegradable waste

In 2019, Zero Waste Scotland produced an updated estimate of the total volume of food and drink waste in Scotland in 2013. This figure will be used as a benchmark for the Scottish Government's target to reduce all food waste arising in Scotland by 33% by 2025. In 2013, nearly one million tonnes of food and drink was wasted in Scotland:

- Household (solid and liquid waste) – 598,946 tonnes (61%)
- Food and drink manufacturing – 248,230 tonnes (25%)
- Other sectors – 140,714 tonnes (14%)

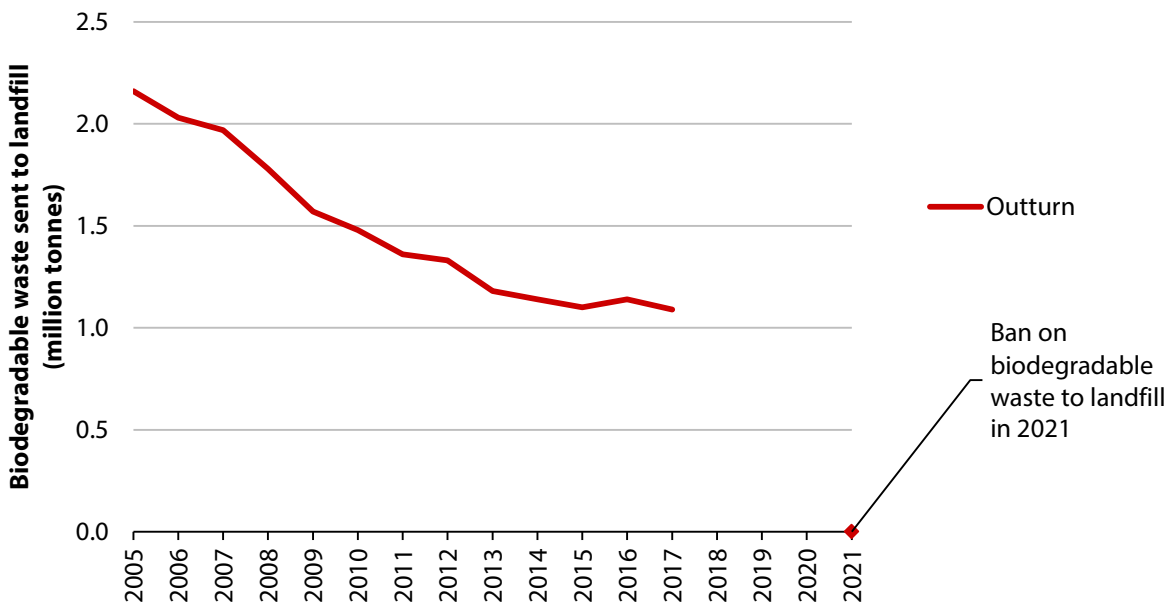
From the start of 2021, the landfilling of all biodegradable municipal waste will be illegal in Scotland:

- In 2017, 1.1 million tonnes of biodegradable waste was sent to landfill in Scotland (Figure 7.5). This was a decrease of 4% since 2016, and ahead of Scotland's interim 2020 milestone of 1.26 million tonnes before an outright ban in 2021.
- Approximately 28% of all Scottish waste sent to landfill in 2017 was biodegradable. There is therefore likely to be a significant drop in the volume of total waste sent to landfill in Scotland once the 2021 ban comes into force.

Processes must be in place to ensure that local authorities and businesses are prepared for the new regulations on biodegradable waste. Concerns have been raised by the waste management industry[64] that Scotland is not adequately prepared to deal with the volume of biodegradable waste diverted from landfill, and does not have sufficient non-landfill treatment capacity to meet the current 2021 ban without waste 'simply moving across the border' to landfill sites in England.

The Office for Budget Responsibility has forecast that the ban could reduce Scottish landfill tax receipts by around £15 million per year from 2021/22, but this may be 'mostly to the benefit of UK landfill tax receipts by diverting waste to England.'[65]

Figure 7.5. Biodegradable municipal waste sent to landfill in Scotland (2005-2017)



Source: SEPA (2019) *Waste from all sources: waste data tables 2017.*

[64] ESA (2019) *Press Statement: SESA: Scottish Landfill Ban is a £100m Landfill Tax Gift to England.*
[65] OBR (2019) *Economic and fiscal outlook - March 2019.*

Chapter 8: F-gases

Table 8.1. Short- and medium-term actions for reducing F-gas emissions in Scotland		
Action	**Timing**	**Primary responsibility**
Develop and enforce legislation for F-gases that is at least as strong as the existing 2014 EU F-gas Regulation and consistent with the Kigali Amendment. This must restrict the use of F-gases to the very limited situations where there are currently no viable alternatives.	2020s	UK Government
Phase in dry powder inhalers and low-GWP alternatives to metered-dose inhalers.	2020s	Scottish Government
Source: Adapted from CCC (2019) *Progress Report to Parliament*.		

1. Latest emissions trends

F-gases are released in small volumes. However, they are very effective at trapping heat and some of them will remain in the air for many centuries after their release. As a result, they have a high climate impact per molecule, which is reflected in the high Global Warming Potentials (GWP) used in international emissions accounting.

The four F-gases included in the UK emissions inventory are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3):

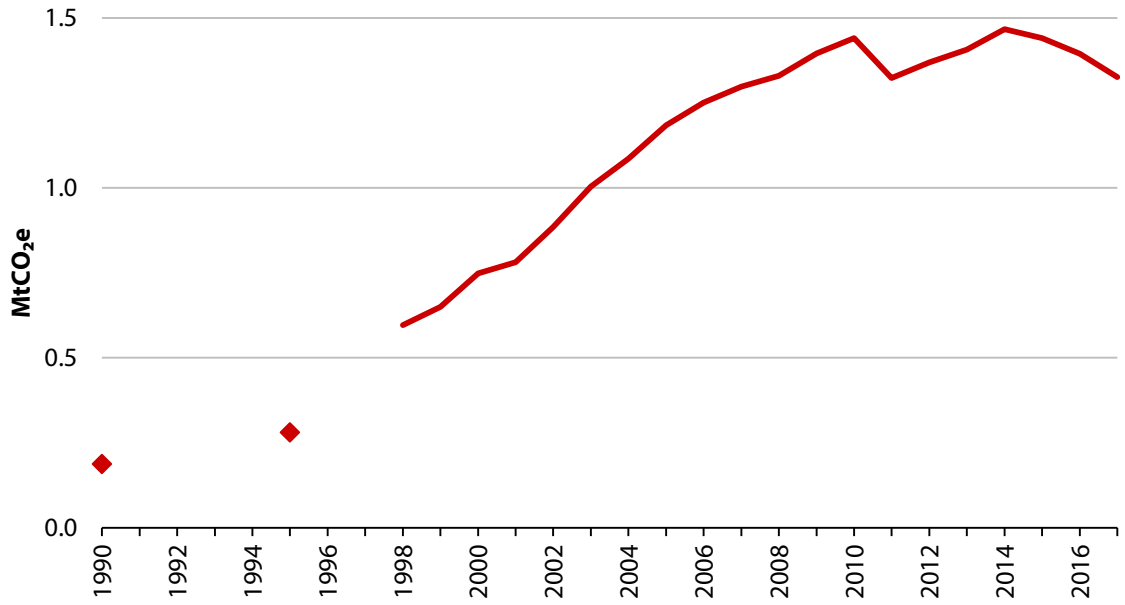
- HFCs (86% of total F-gas emissions in 2017) are used in refrigeration, air-conditioning appliances, aerosols and foams, metered-dose inhalers and fire equipment. They are emitted during the manufacture, lifetime and disposal of these products and can stay in the atmosphere for up to 270 years.
- PFC emissions (11%) result mainly from the manufacture of electronics and sporting goods. They are also a by-product of aluminium production. Their lifetime in the atmosphere ranges from 2,600 to 50,000 years.
- SF_6 (3%) is mainly used in insulation for electricity networks, magnesium casting and military applications. It stays in the atmosphere for around 3,000 years.
- NF_3 emissions are currently very low and result from semi-conductor manufacturing. NF_3 stays in the atmosphere for around 700 years.

F-gas emissions in Scotland are currently mainly accounted for within the Industry sector due to their use in large scale refrigeration, although of these emissions also occur in transport and commercial buildings. F-gas emissions accounted for 3% (1.3 $MtCO_2e$) of total Scottish emissions in 2017, and were seven times higher than in 1990:

- F-gas emissions increased almost continuously since 1990 to a peak of 1.5 $MtCO_2e$ in 2014 (Figure 8.1).
- F-gas emissions have fallen by 10% in Scotland between 2014 and 2017, in large part due to the EU F-gas Regulation coming into force in January 2015.

In contrast to F-gas emissions in the UK as whole, F-gas emissions in Scotland did not peak in 1997. The rapid reduction seen in the UK from 1997 to 2000 was driven by regulations to reduce leakage from halocarbon production, which were not manufactured at scale in Scotland at the time.

Figure 8.1. F-gas emissions in Scotland (1990-2017)



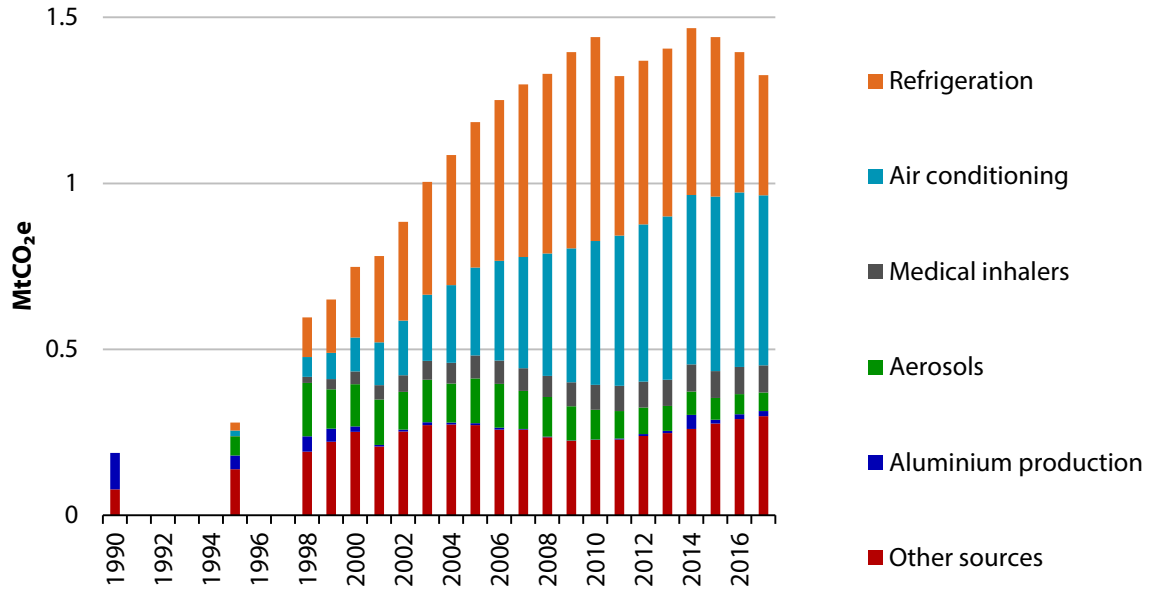
Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997.
Does not reflect forthcoming revisions to global warming potentials (Box 1.1).

Around 27% of F-gas emissions in Scotland stem from refrigeration, 39% from stationary and mobile air conditioning and 6% from medical inhalers (Figure 8.2). A large part of the increase in F-gas emissions is due to a rise in their use in commercial and industrial refrigeration units, together with an increase in air conditioning. F-gas emissions from refrigeration and air conditioning (RAC) have increased from 0.05 $MtCO_2e$ in 1995 to 0.9 $MtCO_2e$ in 2016.

Regulation of F-gases are not a devolved matter, with controls currently determined at the UK and EU level. Without policy intervention it is likely that F-gas emissions would continue to increase due to increasing use of products and appliances using F-gases, such as refrigeration and air conditioning.

The UK Government has committed to developing and enforcing a regulatory regime for F-gases that is at least as strong as the current EU regulations. The Scottish Government should work with the UK Government to ensure that F-gas emissions are reduced to near-zero in Scotland by 2045.

Figure 8.2. F-gas emissions in Scotland by sector (1990-2017)



Source: NAEI (2019).

Chapter 9: Power

Table 9.1. Short- and medium-term actions for decarbonising power in Scotland

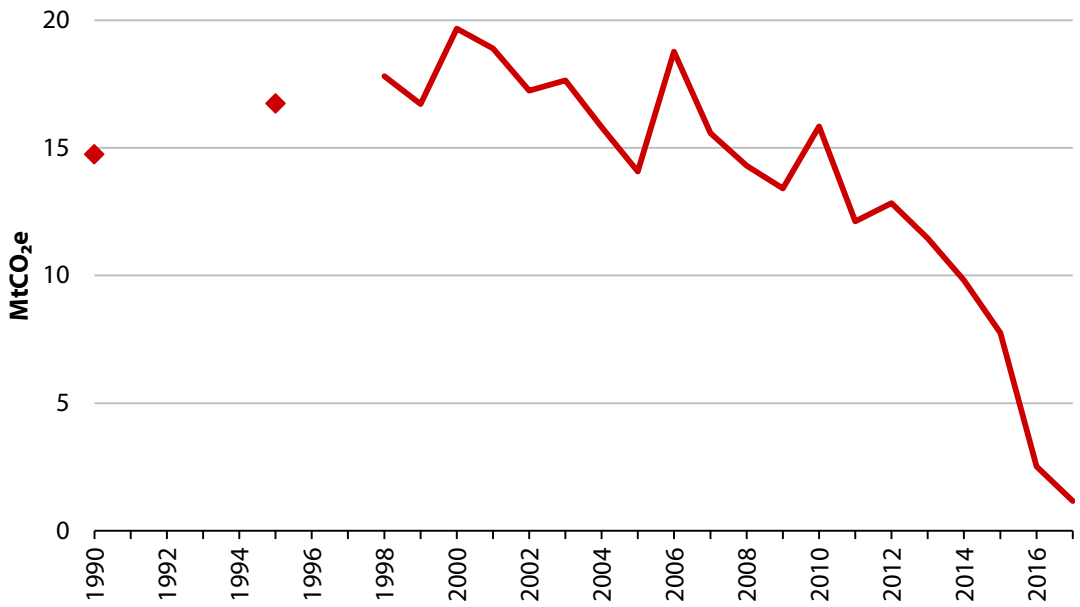
Action	Timing	Primary responsibility
Develop contingency plans that allow for additional low-carbon generation to be brought forward in the event of delay or cancellation of planned projects, or imports of electricity below projected levels.	2019	UK Government
Develop and deliver a plan, in coordination with Ofgem, to upgrade networks in the 2020s to accommodate new electricity demands (e.g. from electric vehicles), and future-proof them in order to limit costs.	2019	UK Government
Outline in the forthcoming Energy White Paper a level of ambition compatible with achieving net-zero emissions. This should include the outline of a subsidy-free route to market for the cheapest low-carbon generation from 2020.	2019	UK Government
Deliver plans to decarbonise the power system consistent with a level of ambition for a GB-wide grid emissions intensity towards 50 gCO_2/kWh in 2030.	2030	UK Government
Develop clear plans to ensure adequate resilience of energy supplies as heat and transport become more electrified.	2020	UK Government
Continue to improve system flexibility through the implementation of all actions in the Smart Systems and Flexibility plan.	2022	UK Government
Use the 2020 Energy Statement to set out an updated assessment of how much renewable and low-carbon energy generation will be required to meet net-zero in Scotland, with a clear trajectory to 2045.	2020	Scottish Government
Crown Estate Scotland to set out its plans for ScotWind Leasing following the publication of the draft Sectoral Marine Plan. This leasing process should provide certainty and clarity to investors seeking to lease seabeds for new offshore wind farms in Scottish waters.	2020	Scottish Government

Source: Adapted from CCC (2019) *Progress Report to Parliament*.
Notes: Our UK Progress Report identified several actions due for completion in 2019.

1. Latest emissions trends

In 2017, direct emissions from electricity generation accounted for just 1.2 $MtCO_2e$ (3%) of Scotland's actual emissions, falling by 1.3 $MtCO_2e$ from 2016. In the past five years, the power sector has transformed from the second largest to the smallest emitting sector of the Scottish economy. Emissions have fallen by an average annual rate of 23% between 2007 and 2017, and are now 92% below 1990 levels (Figure 9.1).

Figure 9.1. Emissions from the power sector in Scotland (1990-2017)



Source: NAEI (2019) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2017.*
Notes: No emissions data are available for devolved administrations for 1991-1994 or 1996-1997.

2. Electricity generation, demand, capacity and transmission

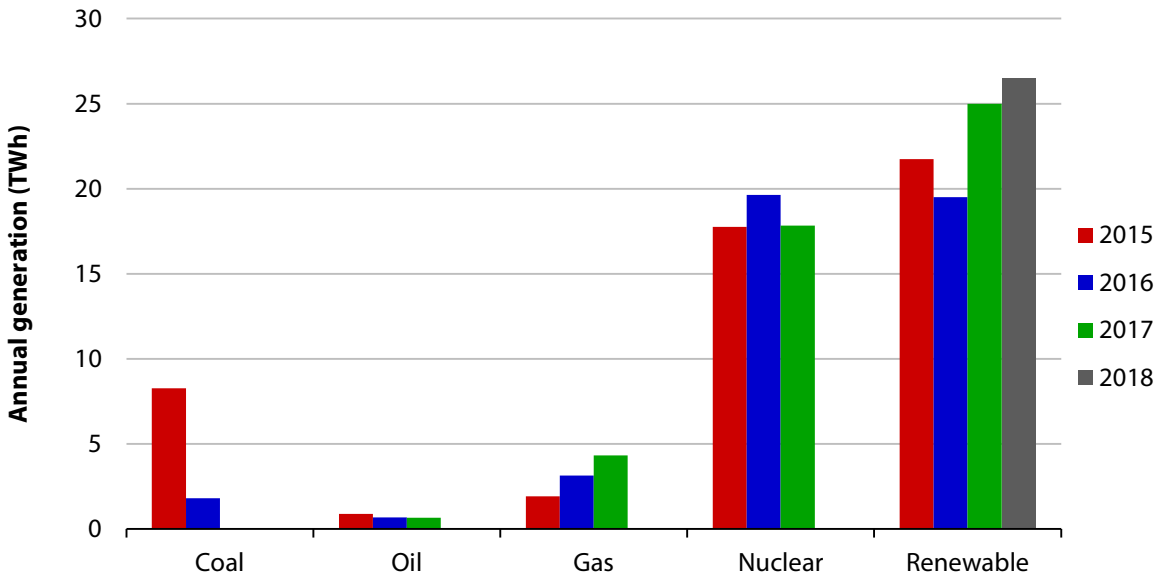
2017 was an historic year for electricity generation in Scotland. For the first time, there was no coal-fired generation in Scotland and renewable sources provided more than half (52%) of total electricity generation, while fossil fuel sources provided a record low 10%.

Emissions fell in 2017 despite an overall increase in electricity generation of 7%. This rise in total generation was due to an increase in output from renewable and gas-fired generation, offset by falls in coal-fired and nuclear generation:

- Renewable generation increased by 5.5 TWh (+28%) compared to 2016. This was due to continued expansion of renewable capacity in 2017 (+13%) and more favourable weather compared to the adverse weather conditions that inhibited generation in 2016 (Figure 9.2).
- Nuclear generation decreased by 1.8 TWh (-9%) in 2017 as a result of maintenance outages.
- There was zero coal-fired generation in Scotland in 2017 following the closure of Longannet in March 2016.

- Gas-fired generation increased by 38% to 4.3 TWh, and accounted for 87% of all fossil-fuelled electricity generation.

Figure 9.2. Scottish power generation mix (2015-2018)



Source: BEIS (2018) *Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2017; BEIS* (2019) *Energy Trends 6.1 Renewable electricity capacity and generation.*
Notes: Renewables figures by type are taken from Energy Trends 6.1,whereas the total is taken from Electricity generation and supply figures. These totals may not match exactly in some years. Coal includes a small quantity of non-renewable wastes and other thermal.

Renewable energy

For renewable electricity generation and capacity, data are available up to 2018. Scotland accounted for 24% of all UK renewable generation in 2018. Renewable electricity generation in Scotland grew by 6% in 2018, while capacity increased by 10%:

- The Scottish Government has a target to meet 100% of gross electricity consumption[66] with renewables by 2020. This measure rose to 70% in 2017, up from 54% in 2016, and provisional estimates suggest this increased further to 76% in 2018.[67]
- As of June 2019, there was 11.6 GW of operational renewable electrical capacity in Scotland, up 1.2 GW (+11%) from June 2018.
- Scotland continues to be a testbed for floating offshore wind. Hywind, the world's largest floating offshore wind farm (30 MW) started generating power to the grid in 2017.
- An additional 13.0 GW of renewable electricity projects are either in planning (4.2 GW), awaiting construction (7.6 GW) or under construction (1.2 GW). The vast majority (92%) of capacity in this pipeline is wind.

[66] Total generation adjusted for net electricity transfers into/out of Scotland.
[67] Scottish Government (2019) *Energy Statistics Database September 2019.*

Scotland's target to meet 100% of gross electricity consumption with renewables by 2020 remains challenging, as it is unlikely that all the projects consented will progress to the commissioning stage. However, renewable generation in the first half of 2019 was 19% higher than the first half of 2018 and if this rate of progress can be maintained then the target is within reach.

In the longer term, the September 2019 Contracts for Difference (CfD) auction awarded contracts to 741 MW of wind projects (275 MW of which was remote island wind) to come online in Scotland between 2023 and 2025. However, the continued absence of access to auctions for CfDs for onshore wind and the lack of industry confidence in the viability of 'merchant' wind projects present challenges to deliver sufficient renewable generation capacity in the mid-2020s across the UK.

Electricity demand

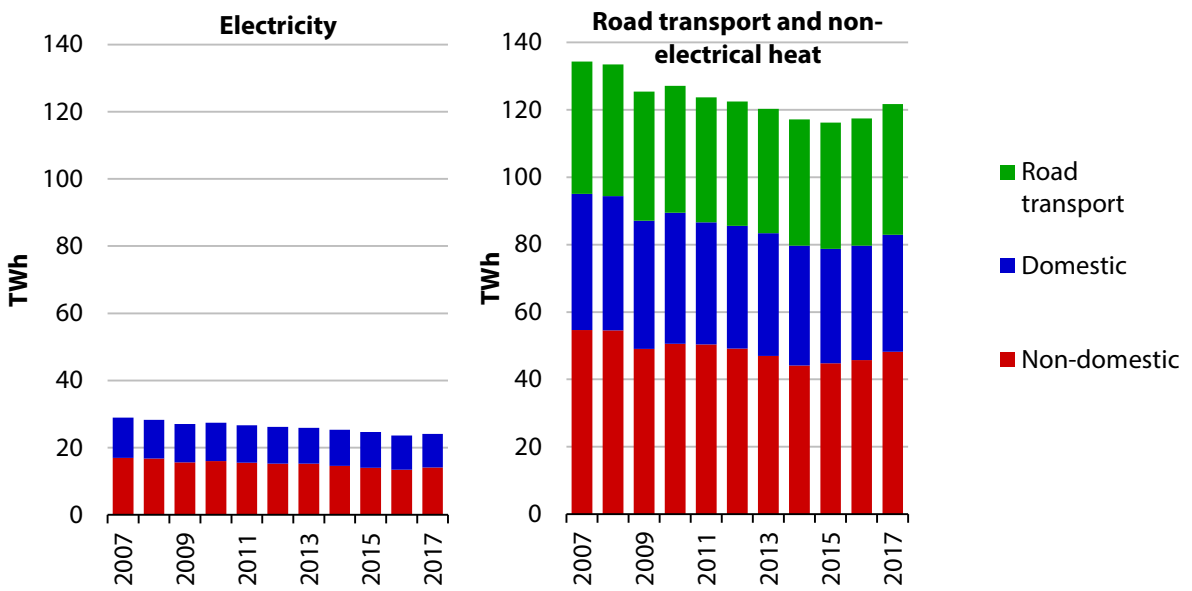
Electricity demand has fallen in Scotland in the last decade, primarily as a result of efficiency improvements (Figure 9.3). The energy demand for non-electrical heat and road transport is much larger than total electricity demand in Scotland:

- Electricity demand decreased by 17% from 2007 to 2017 in both the domestic and non-domestic sectors. Domestic electricity demand fell to 10.0 TWh in 2017 and non-domestic demand was 14.1 TWh.
- In 2017, electricity consumption increased on the previous year for the first time since 2010. This increase was concentrated in the non-domestic sector, where consumption increased by 4.8%, while domestic demand fell by 1%.
- Energy demands for heating also fell, by 13%, from 2007 to 2017, whereas energy demands for road transport has fallen by 1% (and increased by 5% since 2012).

Electricity demand in Scotland is expected to grow due to the electrification of heat and transport. Our *Net Zero* scenario requires a doubling of UK electricity generation from 300 TWh today to around 600 TWh in 2050 (Box 2.4).

Increasing the flexibility of electricity demand and generation will allow the existing distribution network capacity in Scotland to be fully utilised, but the expected levels of growth of electricity demand will require timely investment in network reinforcements. These should take the available least-regret opportunities to minimise future network losses and the need for further future upgrades.

Figure 9.3. Final energy consumption in domestic, non-domestic and transport sectors (2007-2017)



Source: Scottish Government (2019) *Energy Statistics Database September 2019.*
Notes: The electricity consumption figure is adjusted to ensure consistency with the gross electricity consumption used as the denominator for the renewable electricity target. The figure used here is higher than the figure published in the sub-national final energy consumption table due to differences in measurement. The heat figure for 2017 is an estimate based on gas consumption for 2017 and consumption of residual fuels relating to heat for 2016.

Transmission and interconnection

Investment in electricity infrastructure is crucial to realising Scotland's renewable energy potential, allowing power to flow from remote areas of high wind resource, where grid connections are often weak, to major centres of demand. This is particularly the case for the Highlands and Islands, where weak or non-existent connections to the mainland grid network have been a challenge to the deployment of renewable technologies.

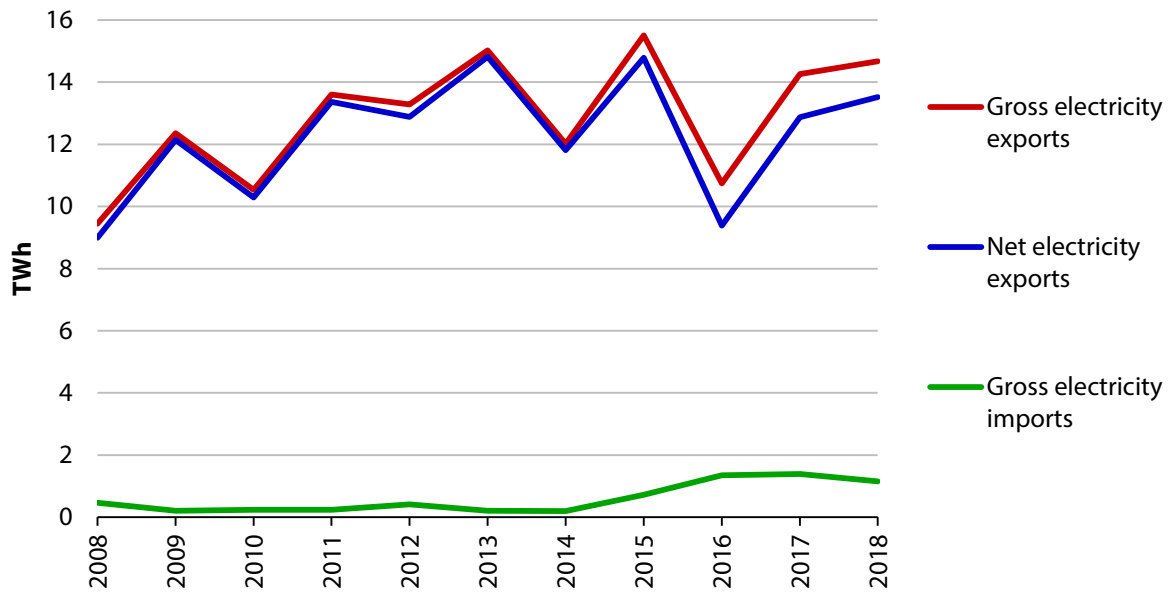
To support the future growth of renewable generation, large-scale investment into Scotland's transmission system is being delivered by a series of network development and reinforcement projects:

- The Western Link High Voltage Direct Current (HVDC) 'bootstrap' project has a capacity of 2.2 GW to support the export of renewable energy from Scotland to England and Wales. Power first flowed through the link in December 2017, but was shut down in May 2018 and April 2019 due to faults during testing. The link was put back into operation in June 2019.
- The Caithness-Moray HVDC transmission link was completed in January 2019, and provides an additional 1.2 GW of transmission capacity in the north of Scotland. The link has enabled the recently-completed Beatrice (588 MW) and Dorenell (177 MW) wind farms to connect to the grid.
- Ofgem has provisionally approved a 600 MW subsea electricity transmission link to connect Shetland to the National Electricity Transmission System for the first time by 2021, a 220 MW link to Orkney, and a 600 MW link to the Western Isles. However, these approvals were both

provisional on sufficient volume of island wind projects being awarded a Contract for Difference (CfD) to ensure the transmission links are utilised. While four projects were awarded contracts in the 2019 CfD auction, Ofgem judged that these were not of sufficient capacity to justify new transmission lines at this time.

In the past decade, Scotland has increased the amount of electricity that it exports and imports to and from the rest of the UK (Figure 9.4). The closure of schedulable fossil-fuelled generation in Scotland has increased the need for the transmission system to be capable of importing power into Scotland at times of high demand and low wind. Plans should be in place to continue to securely meet demand in the absence of power from Hunterston (due to close in 2023) and Torness (due to close in 2030).

Figure 9.4. Total annual electricity imports and exports to and from Scotland (2008-2018)



Source: Scottish Government (2019) *Energy Statistics Database September 2019.*

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