Document 11

December 2022

Scottish Emissions Targets - first five-yearly review

Climate Change Committee

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December 2022

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The Committee

The Rt. Hon John Gummer, Lord Deben,
Chairman

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). Lord Deben also runs Sancroft, a corporate responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues.

Professor Keith Bell
Scotland Champion

Keith Bell is a co-Director of the UK Energy Research Centre (UKERC), a Chartered Engineer and a Fellow of the Royal Society of Edinburgh. He has been at the University of Strathclyde since 2005, was appointed to the Scottish Power Chair in Smart Grids in 2013 and has been involved in energy system research in collaboration with many academic and industrial partners.

Professor Michael Davies

Michael Davies is Professor of Building Physics and Environment at the UCL Institute for Environmental Design and Engineering (IEDE). At UCL his research interests relate to the complex relationship between the built environment and human wellbeing. He is also Director of the Complex Built Environment Systems Group at UCL and a member of the Scientific Advisory Committee of 'Healthy Polis'.

Professor Piers Forster

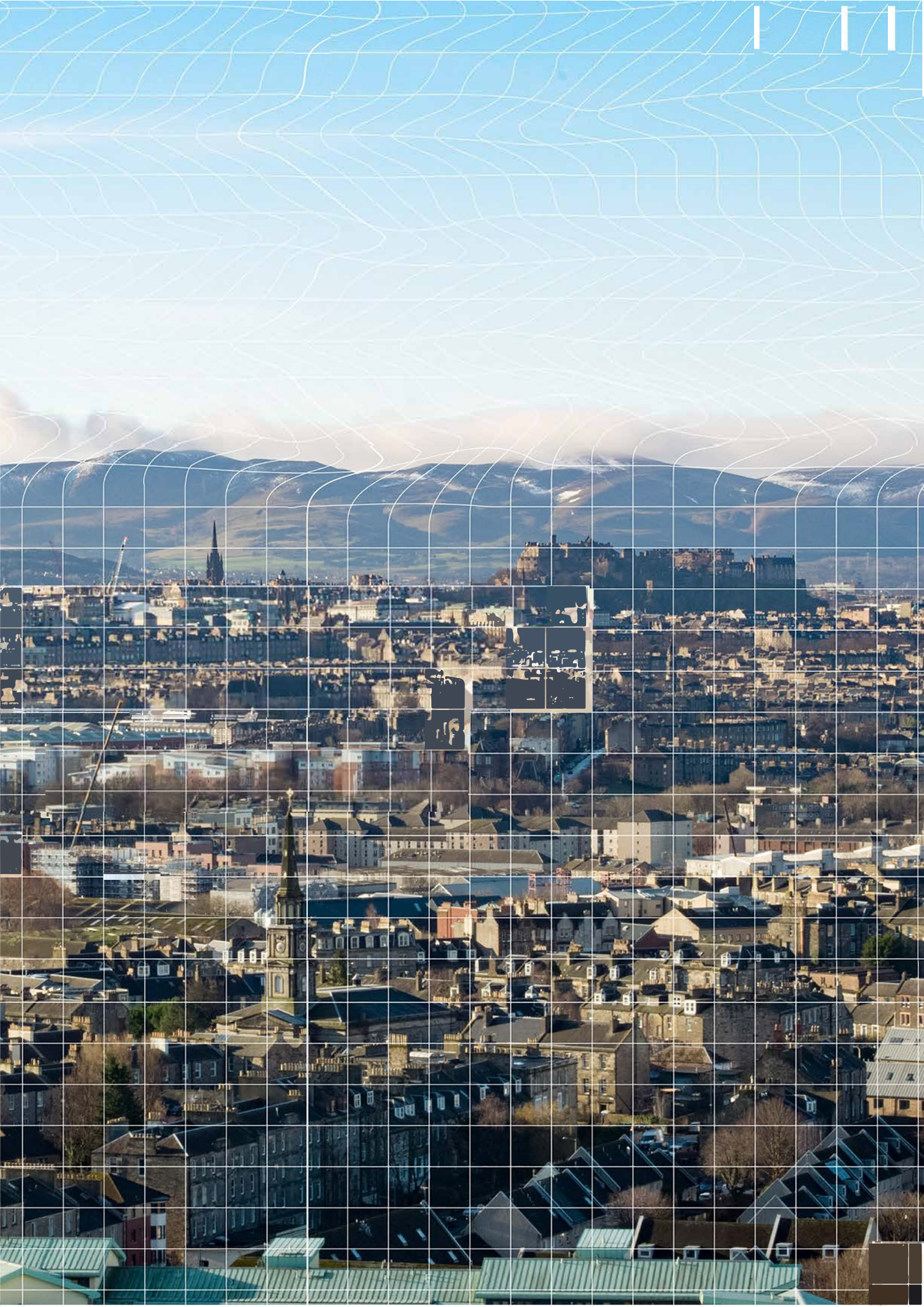
Piers Forster is Director of the Priestley International Centre for Climate and Professor of Physical Climate Change at the University of Leeds. He has played a significant role authoring Intergovernmental Panel on Climate Change (IPCC) reports, and is a coordinating lead author role for the IPCC's sixth assessment report.

Paul Johnson CBE

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 he co-wrote the 'Mirrlees review' of tax system design. He was previously Chief Economist at the Department for Education (2000 to 2004).

Professor Corinne Le Quéré FRS

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) and she currently Chairs the French Haut Conseil pour le Climat.



Executive summary

Scotland's emissions reduction targets are amongst the most stretching in the world and the Scottish Government has placed a welcome focus on a fair and just transition. Key milestones are ambitious, but a clear delivery plan on how they will be achieved is still missing and there is no quantification of how policies combine to give the emissions reduction required to meet Scotland's targets.

In these two reports we first review Scotland's targets in light of changes to the methodology for estimating emissions since our previous target advice. We then assess Scotland's progress in emissions reduction, policy plans, and delivery of those plans in the last year. Our focus is shifting to monitoring a set of quantified indicators of decarbonisation progress.

Our key messages in these reports are:

- **Changes in emissions accounting methodology do not imply the need to change the Net Zero and 2030 and 2040 interim targets, as legislated by the Scottish Parliament.** Changes in emissions accounting methodology since the assumptions in our 2019 Net Zero advice to Scotland have not significantly changed the feasibility of the targets. We continue to advise that these targets should be achieved through domestic action, without the use of emissions credits.

  - **The 2030 interim target.** In 2019, the Scottish Parliament legislated an interim target of a 75% reduction on 1990 levels by 2030, going beyond CCC advice. Our updated pathway to Net Zero confirms that this remains extremely challenging and suggests a 65-67% reduction in Scotland's emissions by 2030 is both feasible and consistent with Scotland's Net Zero commitment. The legislated 2030 target means that policies must go further than the CCC pathway. Despite the scale of the challenge in the 2020s, Scotland is still not delivering on key milestones such as energy efficiency in homes and peatland restoration.

  - **Net Zero and the 2040 interim target.** The Net Zero date of 2045 and 2040 interim target of a 90% reduction remain appropriate. Under the Climate Change (Scotland) Act (the Act), underperformance against targets (e.g. in the 2020s and early 2030s) requires equivalent outperformance of later targets (e.g. in the early 2040s) to compensate. Our updated pathway indicates that reductions beyond the legislated targets may be feasible from the mid-2030s onwards. However, until the extent of the required overperformance is clearer, we do not recommend that the targets be changed.

- **Scotland's annual targets in the 2020s should be adjusted.** The annual targets from 2021 to 2029 are set by a straight line between the 2020 and 2030 interim targets. However, the level of the 2020 interim target was based on our 2017 advice using an older accounting methodology, before significant changes to the treatment of peatland emissions in the inventory were introduced. We therefore recommend that the annual targets be adjusted to align with a translation of the legislated 2020 target to the new inventory basis. Without this adjustment, these already challenging annual targets will be made much more difficult to achieve, simply as an artefact of emissions accounting.

- **The 2020 interim target was achieved.** On the basis of the latest greenhouse gas (GHG) inventory, emissions in 2020 fell by 12% from 2019 to 40.6 $MtCO_2e$ and by 51% since 1990. On the 'GHG Account' basis, on which performance against the legislated targets is assessed, emissions were 59% lower than in 1990 and the 2020 interim target of 56% was achieved. The fall in emissions in 2020 was largely due to travel restrictions during the COVID-19 pandemic, without which it is unlikely the target would have been met. The annual targets in the 2020s will be much harder to achieve as emissions rebound.

- **A quantified plan is urgently needed**. The Scottish Government urgently needs to provide a quantified plan for how its polices will combine to achieve the emissions reduction required to meet the challenging 2030 target. The plan must detail how each of Scotland's ambitious milestones will be achieved.

- **Working with the UK Government**. Many aspects of policy, especially in the industry, engineered removals and electricity supply sectors, are reserved to the UK Government. Nevertheless, industry is Scotland's second-highest-emitting sector and the Scottish Government has chosen to place a heavy reliance on engineered removals. Finding a way to cooperate with the UK Government effectively is key for realising both Scotland's ambitions and the full potential of Scotland's contribution to the UK's own decarbonisation plans.

- **Transport.** Plans to decarbonise transport in Scotland are falling behind. While sales of electric vehicles are increasing fast in Scotland, they are behind those of the UK as a whole and the CCC's updated pathway. Scotland has a laudable aim to reduce car-kilometres by 20% on 2019 levels by 2030 which, if delivered, would bring benefits to the wellbeing of Scottish citizens. This is a challenging goal and current plans lack a full strategy with sufficient levers to deter car use. Scotland has also committed to growth in aviation following the pandemic, which will make emissions targets increasingly difficult to meet.

- **Buildings.** Scotland has ambitions to decarbonise buildings much faster than the UK as a whole. However, despite substantial funding commitments and good progress on enabling measures such as local energy and heat network planning, there are not yet adequate policies in place to deliver low-carbon heat and energy efficiency improvements at the required rate.

- **Agriculture and land use.** Detail on low-carbon agriculture policy following exit from the EU Common Agricultural Policy is needed urgently. Scotland currently has no aim to shift to lower-carbon diets, increasing the challenge in this sector. Progress in the land use sector is mixed:

  - While Scotland's tree-planting rates are higher than those in the rest of the UK combined, rates have recently plateaued and are off track to meet Scotland's 2024/25 target of 18,000 hectares per year. Significant barriers such as land availability and skills shortage remain.

  - With 80% of Scotland's peatlands being degraded, peatland emissions are significant. Despite this, restoration rates are less than half of Scotland's own target of 20,000 hectares per year, which is in turn much less ambitious than our recommendation of 45,000 hectares per year by 2022. Barriers such as skills shortages and contractor availability need to be addressed to ensure the required rapid scale-up.

The rest of this executive summary is set out in three sections:

1. Target advice
2. Emissions in 2020
3. Policy progress

We provide a full set of recommendations to the Scottish Government in Annex 2 at the end of this report and on our website.

Changes to methods for estimating emissions affect Scotland disproportionately, due to the frequent and often significant changes to estimated emissions in the land use sector and the relatively high importance of that sector to total emissions. To avoid changes to estimation methodologies affecting the achievability of the targets, a 'Greenhouse Gas Account' methodology is used, so that targets are judged against a frozen 'base inventory' which is reset to align with the latest methodology every five years.

The base inventory will be reset in 2023 to align with the 1990-2020 inventory (published in June 2022). Here we review Scotland's current targets. Once Parliament has expressed its ambition by legislating targets, we apply the principle that methodological updates should only lead to a reduction in ambition in those targets where they have a material impact on their achievability. A recommendation for increasing ambition would only be given if there is a clear case that this is achievable.

Current targets
Scotland's 2030 and 2040 interim targets and the Net Zero date were legislated in 2019 following our 2019 Net Zero advice. While the Net Zero date of 2045 and the 2040 interim target for a 90% emissions reduction are both in line with our advice, the 2030 interim target for a 75% reduction goes significantly beyond our advice. The 2020 interim target for a 56% reduction was in line with our 2017 Advice on the Scottish Climate Change Bill. Annual targets are set by taking a straight line between the interim targets.

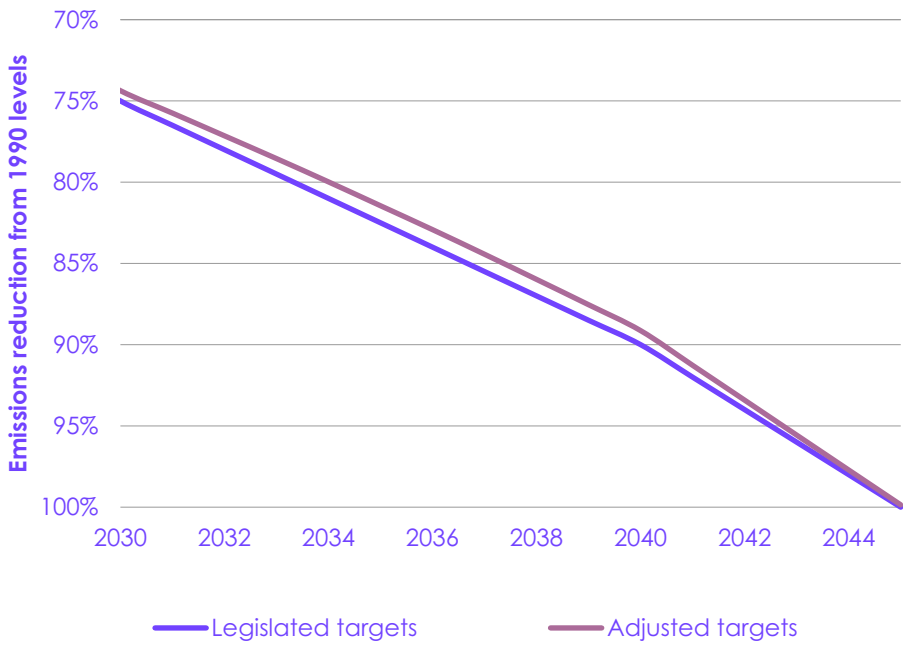
(a) Target recommendations based on methodology changes

- **Changes in emissions accounting methodology do not imply the need to change the Net Zero and 2030 and 2040 interim targets, as legislated by the Scottish Parliament.**

  – Our advice in 2019 included a forward-looking estimate of anticipated changes to the reporting of emissions from peatlands. The other methodological changes are relatively minor and do not lead to significant changes in the achievability of the targets. Therefore, changes in accounting methodology do not justify changing the percentage reduction targets now (Figure 1).

  – We continue to advise that crediting of carbon units should not be used to meet Scotland's targets. Our general principle is that targets should be achieved with domestic action. Instead, we recommend that Scotland rapidly ramps up delivery. Any shortfall to the 2030 target and the annual targets would need to be compensated by extra emissions reduction, beyond the legislated targets, by 2045.

Figure 1 Targets before and after methodological changes



Source: Scottish Government (2019) Climate Change (Emissions Reduction Targets) (Scotland) Act 2019; CCC analysis.

- **Annual targets in the 2020s should be adjusted.**
  - The annual targets for 2021 to 2029 are set by a straight line between the 2020 and 2030 interim targets. However, the level of the 2020 interim target was based on an older accounting methodology, before the updated treatment of peatland emissions in the inventory. The 2020 target for a 56% reduction equates to a reduction of 48.5% on the new basis.
  - Setting the challenging annual targets for 2021 onwards on the basis of a straight line from the 2020 target of 56% immediately makes them much harder to achieve. This is not about ambition, but rather an unfortunate and unforeseen consequence of the interplay between the procedure for setting the annual targets in the Act and timing of this advice, which is one year too late to allow for a change to the 2020 interim target.
  - Technical changes leading to the targets becoming unachievable is not the intention behind the Act. Indeed, the reason for its mechanisms around emissions accounting and the five-yearly reviews is to ensure that inventory changes on their own do not make the targets unachievable. Should the annual targets in the 2020s not be corrected, there is a real risk that the targets being missed every year would undermine the credibility and strength of the Scottish framework for emissions reduction.

- We therefore recommend that the path for annual targets through the 2020s is drawn not based on the 56% target (which was on the old methodology) but on a translation of that 2020 target to the new inventory basis (i.e. 48.5%). This is appropriate, as these targets will be assessed against the new inventory methodology. The new recommended annual targets are given in Table 1. These should be updated even if it requires an adjustment to the Act to allow it. We also recommend that future advice on the level of the targets is requested in time to avoid a similar situation occurring again.

- **Scotland's fair and safe emissions budget should be aligned with the interim targets.** The Act currently sets a limit of total emissions in the period 2010 to 2050 to 1,240 $MtCO_2e$. This is the level we advised in our 2020 letter to be consistent with our Balanced Pathway, but this is inconsistent with Scotland's legislated 2030 target. We recommend it is changed to 1,028 $MtCO_2e$, making it consistent with the legislated interim targets and our recommended annual targets in the 2020s (Table 1).

Table 1
Recommended annual targets in the 2020s

Year	Current target	Recommended target
2021	57.9%	51.1%
2022	59.8%	53.8%
2023	61.7%	56.4%
2024	63.6%	59.1%
2025	65.5%	61.7%
2026	67.4%	64.4%
2027	69.3%	67.0%
2028	71.2%	69.7%
2029	73.1%	72.3%

Source: CCC analysis; Scottish Government.

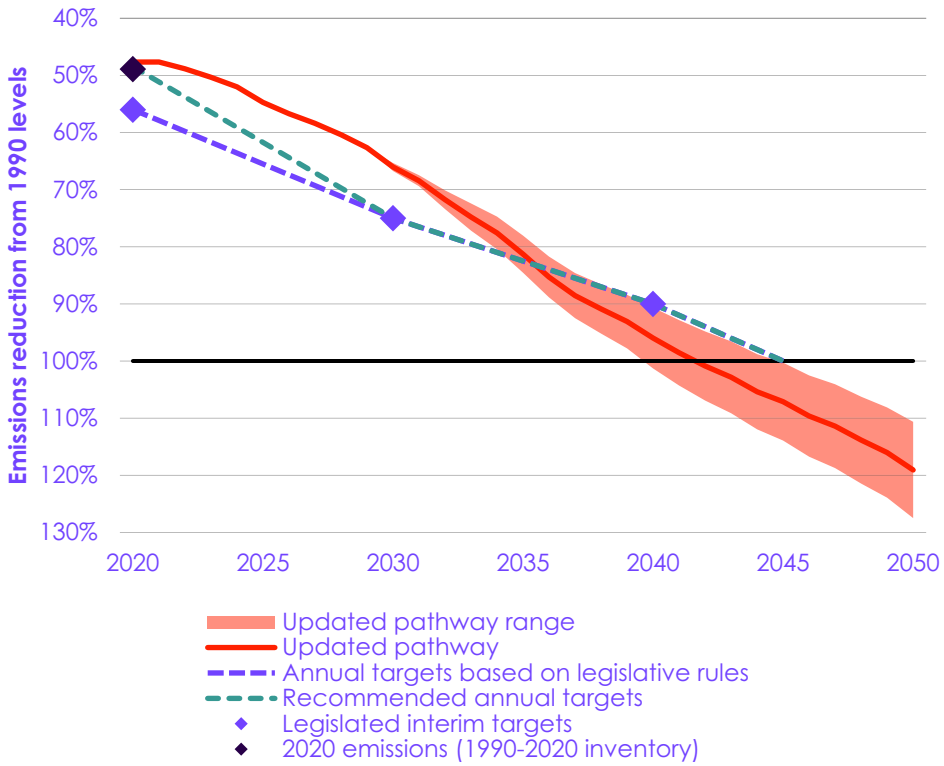
(b) The CCC's updated pathway

In order to assess how feasible Scotland's targets are, and whether any increase in ambition might be appropriate, we have provided an updated pathway for Scotland. Starting from the Balanced Pathway for Scotland, developed as part of our UK Sixth Carbon Budget analysis, we have updated to reflect the latest emissions estimation methodology, allocated engineered removals to Scotland and increased ambition in some sectors to align with our highly ambitious Tailwinds scenario (Figure 2).

- Our updated pathway achieves a reduction of 65-67% from 1990 levels by 2030, and continues to show that the 2030 target of a 75% reduction is extremely challenging.

- The 2040 and 2045 targets remain appropriate, with our updated pathway indicating that it may be possible to outperform these, although this is uncertain.

Figure 2 Our updated pathway for Scotland compared to 2020 emissions and the targets



Source: Scottish Government (2019) *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019;* CCC analysis.
Notes: The range in the updated pathway comes from a range in our pathway for engineered removals. All values based on 1990-2020 inventory methodology.

(c) Aviation multiplier

We recommend that Scotland sets a minimum goal of no further warming after 2050 from non-CO_2 effects in aviation. However, we recommend that the aviation CO_2 emissions multiplier remains at one (equal to no multiplier). This is because of the short lifetime of non-CO_2 effects and their uncertainties, which mean that policies designed around a multiplier risk encouraging strategies that may create perverse incentives to increase CO_2 emissions.

2. Emissions in 2020

On the basis of the latest (1990-2020) GHG emissions inventory, Scottish territorial emissions fell by 12% between 2019 and 2020 to 40.6 $MtCO_2e$ and by 51% on 1990 levels. On the 'GHG Account' basis, on which performance against the legislated Scottish targets is assessed, emissions were 59% below 1990 levels and so the 2020 interim target for a 56% reduction was achieved (Figure 3).

The fall in emissions in 2020 was largely due to the travel restrictions during the COVID-19 pandemic and it is unlikely the target would have been achieved without the impacts of the pandemic.

There is now a significant risk of Scotland failing to meet its annual targets in the 2020s and the interim 2030 target. This is due to three factors (Figure 3):

1. The expected rebound in emissions following the pandemic. The UK as a whole saw a 4% increase in overall emissions in 2021 due to increased activity, especially in the transport sector, and a similar rise is expected in Scotland.

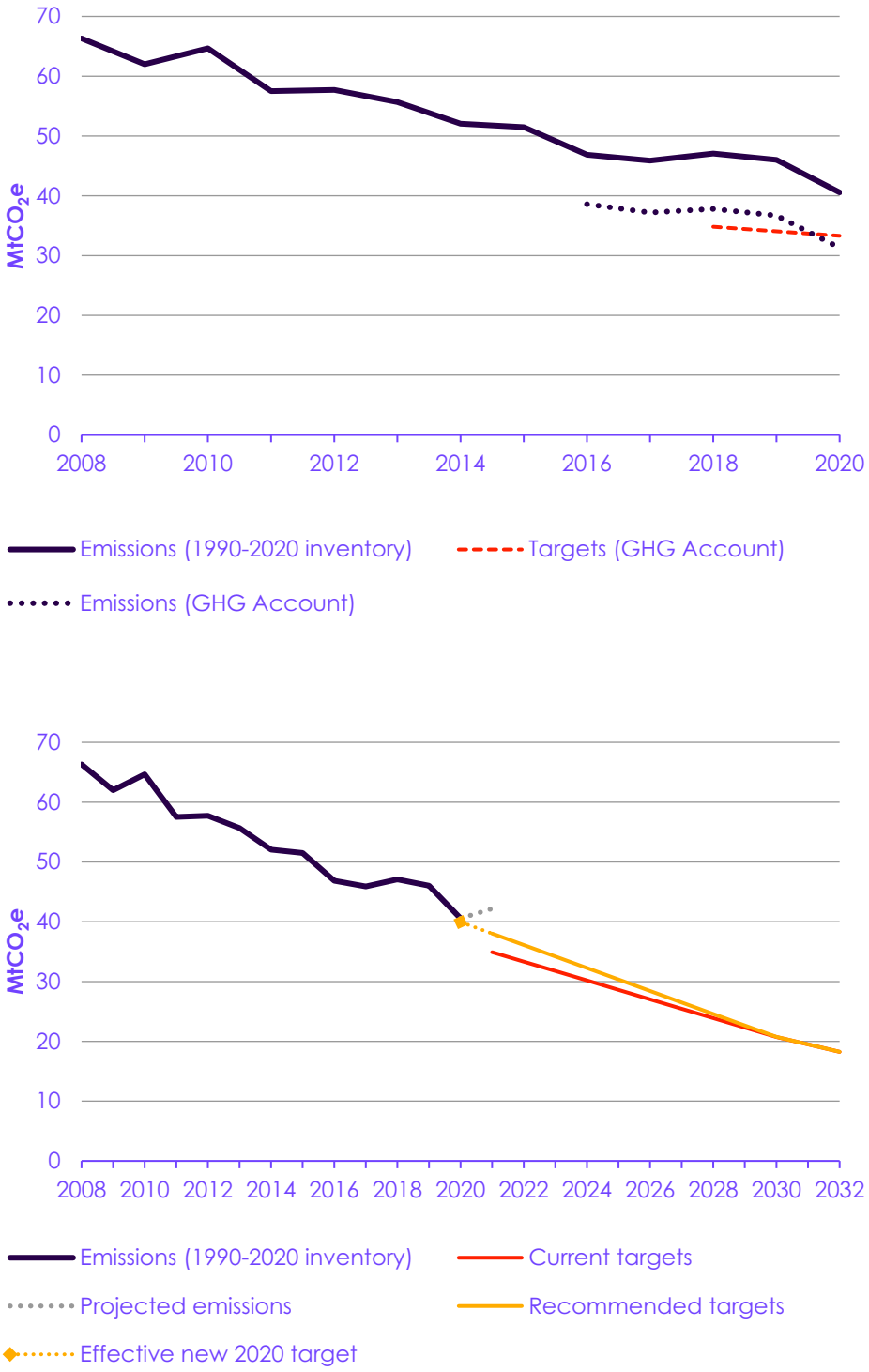
2. When the GHG Account base inventory is reset next year, the targets will be much harder to achieve, largely due to the updated treatment of peatland emissions in the inventory. This effect will be mitigated if our recommendation to adjust the annual targets to align with the latest inventory is accepted.

3. A very rapid reduction in emissions is required anyway in order to meet the challenging 2030 interim target.

Scotland has failed to achieve seven out of eleven of its targets to date. The trend of failure will continue without urgent and strong action to deliver emissions reductions, starting now. Figures 4 and 5 show the scale of the challenge, with the Scottish Government's 2020 update to its Climate Change Plan (CCPu) projecting fast decarbonisation in the 2020s, especially in the transport and buildings sectors.

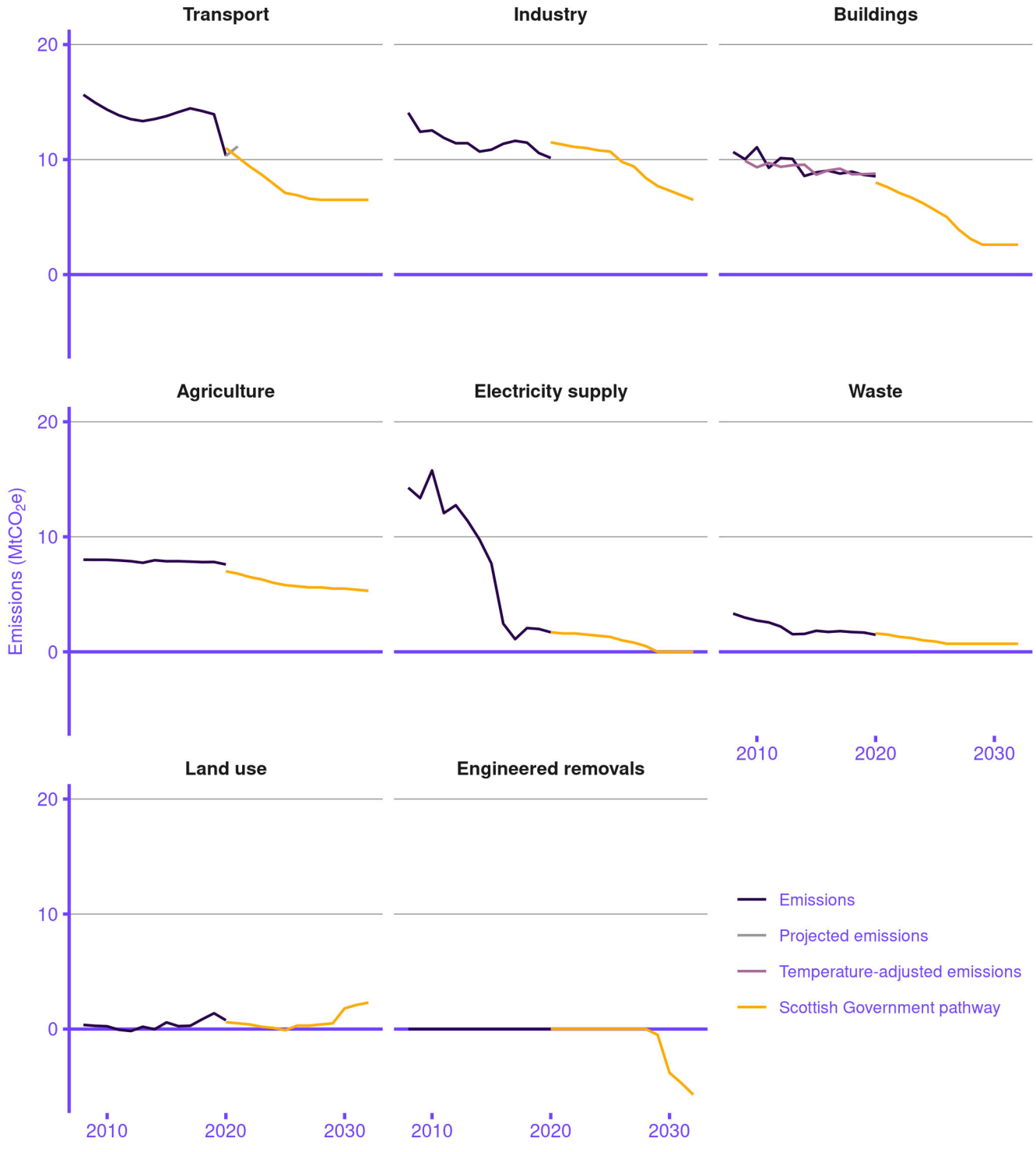
In 2018 Scotland's consumption emissions grew 3% to 70 $MtCO_2e$, which is 50% higher than territorial emissions. This corresponds to an average of 13 tCO_2e per person, 22% higher than the UK average per person.

Figure 3 Scotland's emissions and targets



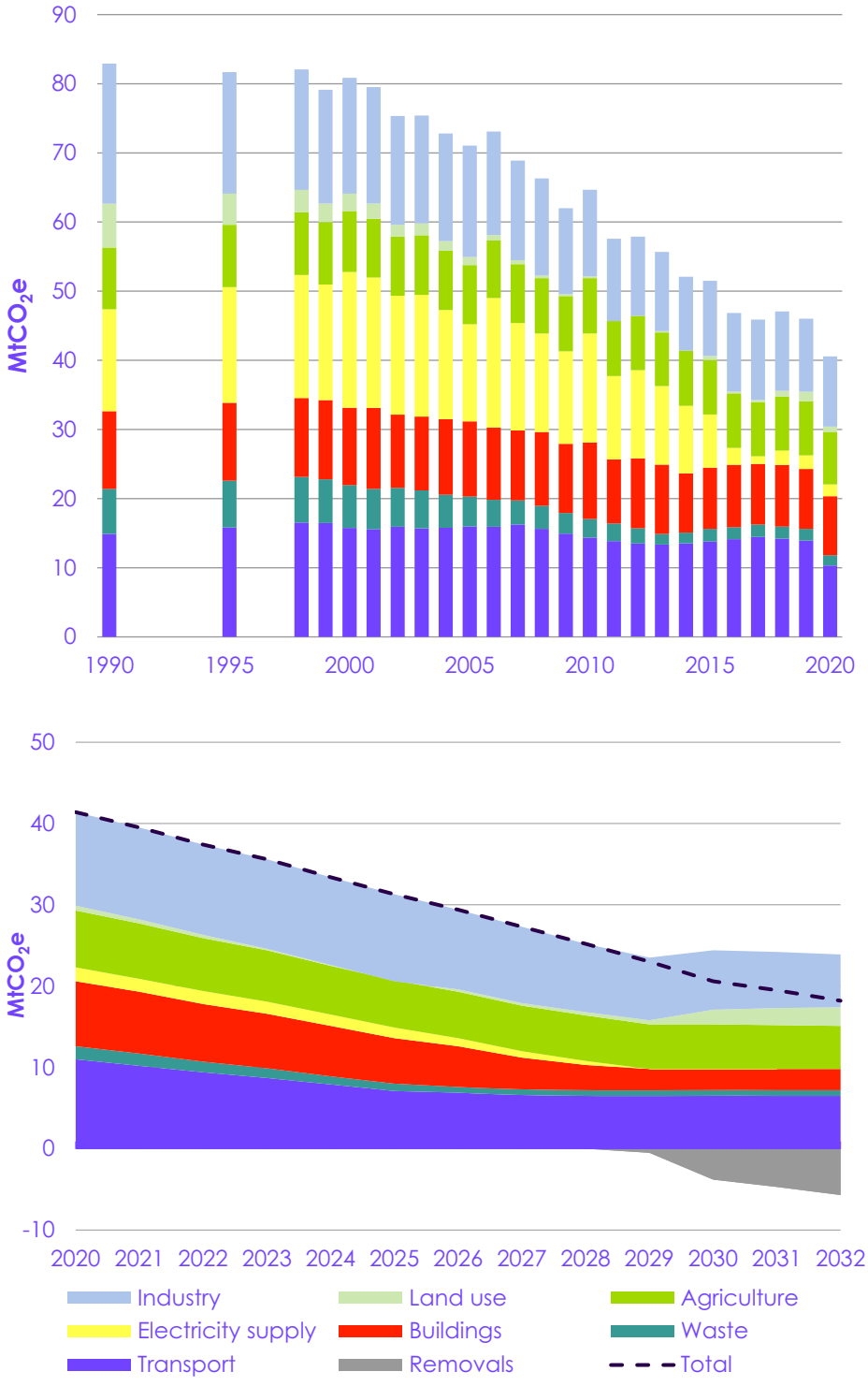
Source: NAEI (2022) Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland, CCC analysis, Scottish Government; Scottish Government (2019) *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019;* Scottish Government (2020) *Scottish Greenhouse Gas Statistics*; CCC analysis.
Notes: Projected in emissions in 2021 assume the same 4% increase seen in the UK.

Figure 4 Scotland's historical emissions (2008-2020) compared to the Scottish Government's pathway (2020-2032) by sector



Source: NAEI (2022) *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990-2020*; Scottish Government (2020) *Securing a green recovery on a path to Net Zero: Climate Change Plan 2018-2032 – update*; CCC analysis.
Notes: The transport emissions in 2021 are a projection assuming Scottish emissions in surface transport, aviation and shipping rose by the same proportion as those in the UK.

Figure 5 Scotland's historical emissions (1990-2020) and the Scottish Government's pathway (2020-2032) by sector



Source: NAEI (2022) *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990-2020*; Scottish Government (2020) *Securing a green recovery on a path to Net Zero: Climate Change Plan 2018-2032 – update.*
Notes: Historical emissions are not available for the years 1991-1994, and 1996-1997.

3. Policy progress

The Scottish Government has committed to extraordinary ambition to decarbonise the economy over the next decade, with a welcome focus on a fair and just transition. Key milestones are ambitious, but there is no clear delivery plan on how they will be achieved and no quantification of how policies combine to give the emissions reduction required to meet Scotland's 2030 target.

Many aspects of policy to decarbonise the industry, engineered removals and electricity supply sectors are reserved to the UK Government. Nevertheless, industry is the second-highest-emitting sector in Scotland and the Scottish Government has chosen to place a heavy reliance on engineered removals in its decarbonisation plans. Finding a way to cooperate effectively with the UK Government in these areas is key for realising both Scotland's ambitions and the full potential of Scotland's contribution to the UK's own decarbonisation plans.

For key sectors in which policy is significantly devolved, our indicators show that progress towards meeting these milestones is not happening fast enough, and policies and plans are not yet sufficient to speed things up to the required rate (Table 2).

Table 2
Progress against Scotland's milestones

Sector	Milestone	Ambition	On track?
Transport	No new fossil-fuel car sales by 2030	High	Slightly off track
	20% reduction on 2019 car-kms by 2030	High	Significantly off track
	Aviation demand	None	N/A
Buildings	Low-carbon heat	High	Too early to say
	Energy efficiency	High	Significantly off track
Agriculture and land use	Afforestation	High	Slightly off track
	Peatland restoration	Low	Significantly off track
Waste	Recycling rates	High	Significantly off track

(a) Transport

10.3 $MtCO_2e$ in 2020, down 26% since 2019 and down 3% from 2010 to 2019
While transport emissions fell sharply in 2020 due to the pandemic, there had been no real reduction in emissions prior to that. The Scottish Government now plans for emissions in the transport sector to be roughly half those in 2019 by 2030. This requires a transition to electric vehicles at a faster rate than our updated pathway and the UK as a whole, together with major progress on the demand side. These plans are now falling behind.

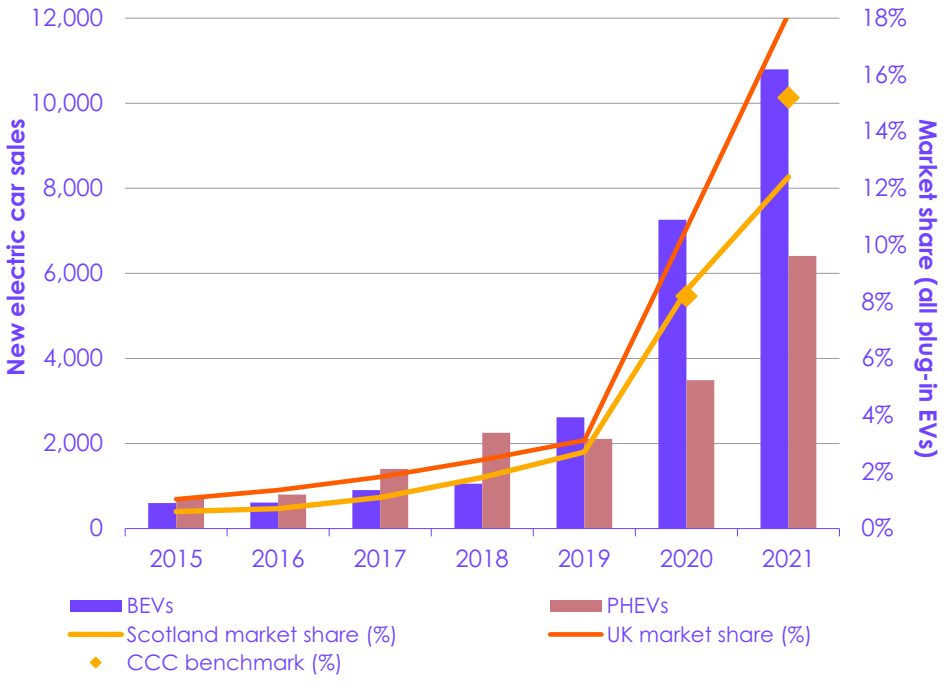
- **Zero-emission vehicle sales**. Scotland plans to transition to 100% battery electric vehicle car and van sales by 2030, going beyond the UK plans which allow a continued role for plug-in hybrids. To support this, interest-free loans for purchasing both new and second-hand electric vehicles are available. However, sales are lower than the UK as a whole and are off-track compared to our pathway (Figure 6).

- **Charging infrastructure**. Scotland has more public charge-points per vehicle than any other UK nation and offers grants for installing home chargers. However, concerns over user experience, price disparities and suitability for van use need to be addressed to ensure the transition is on course to reach all of the consumer base.

- **Car demand**. Scotland has a laudable aim to reduce car-kilometres by 20% compared to 2019 levels by 2030. If achieved this would provide significant co-benefits to Scottish citizens through reduced congestion and air pollution, and increased cycling and walking. However, car use was steadily increasing prior to the pandemic (Figure 7). In order to meet this milestone Scotland needs a full strategy with plans to deter car use, to accompany current plans to encourage active travel and the use of public transport.

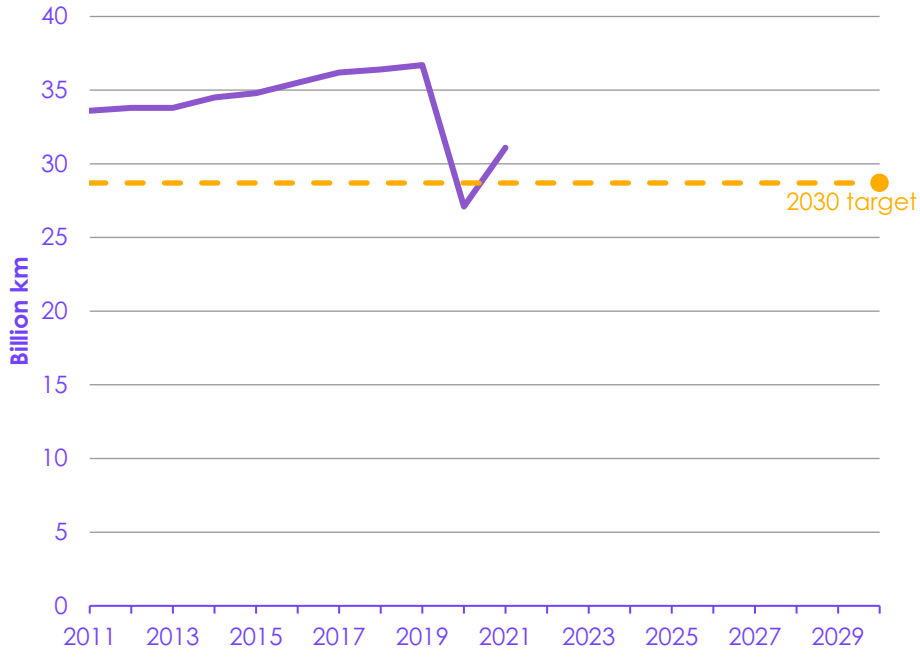
- **Aviation demand**. The Scottish Government has committed to growth in aviation demand following the pandemic, which runs counter to the very challenging emissions reduction targets. It has made no commitments to use its devolved powers, such as airport expansion control and Air Departure Tax, to curb aviation growth.

Figure 6 Number of new electric car and market share of total car sales in Scotland



Source: DfT (2022); CCC analysis.

Figure 7 Car use over time, versus 20% reduction target



Source: DfT (2022); CCC analysis.

(b) Industry

10.1 $MtCO_2e$ in 2020, down 4% since 2019 and 19% since 2010
Industry is the second-highest-emitting sector in Scotland. The Scottish Government plans to reduce the sector's emissions by around a third by 2030, but many policy levers are reserved to the UK Government. While good progress has been made in supporting innovation and skills in this sector, policies are needed to improve resource efficiency. Improvements to the collection and reporting of industrial decarbonisation data is essential to enable effective monitoring of progress.

(c) Buildings

8.5 $MtCO_2e$ in 2020, down 1% since 2019 and 6% (on a temperature adjusted basis) since 2010
The Scottish Government has set out an ambition to reduce emissions from buildings by around 70% in the next decade but policies are not yet sufficient to deliver this.

- **Low-carbon heat in homes**. Scotland aims to reach 1.2 million homes with low-carbon heating by 2030, considerably faster than our updated pathway and the ambition of the UK as a whole. Good progress in heat network planning has been made but, overall, policies are not yet in place to support the transition beyond the risky UK-wide market-based approach.

- **Energy efficiency in homes.** Funding is in place to improve efficiency in social housing and fuel-poor homes, and the Scottish Government has consulted on proposals to reform Energy Performance Certificates (EPCs). However, there is a lack of regulations and incentives in place to drive improvements to energy efficiency. Policies for minimum efficiency standards for private-rented and owner-occupied homes are not in place.

- **Monitoring and evaluation.** It is currently very difficult to monitor progress against the necessary measures for decarbonising the buildings sector due to a lack of adequate and up-to-date data. This must be addressed in the Scottish Government's proposed framework for monitoring and evaluating policy progress, which is now overdue.

(d) Agriculture

7.6 $MtCO_2e$ in 2020, down 3% since 2019 and 5% since 2010
There has been minimal progress in reducing agricultural emissions in the past decade, yet the Scottish Government plans to reduce emissions by nearly 30% in the next decade.

- **Low-carbon farming.** Detail on low-carbon agriculture policy following exit from the EU Common Agricultural Policy is needed urgently. Although a consultation on the forthcoming 2023 Agriculture Bill opened in 2022, timescales and incentives remain short-term. This severely constrains the time available to meet the required emissions reduction.

- **Demand and consumption.** Scotland has no commitment to introduce policy to reduce meat and dairy consumption. While there is an ambition to reduce 2013 food waste levels by one third by 2025, policy is needed to support a shift to healthier, lower-carbon diets.

(e) Electricity supply

1.7 $MtCO_2e$ in 2020, down 14% since 2019 and 89% since 2010
Emissions from electricity supply have fallen significantly. Policy is primarily reserved, with a UK target to fully decarbonise the sector by 2035, but more clarity from the Scottish Government is needed on how a fully decarbonised and resilient Scottish electricity system will operate, and in particular how adequate network capacity will be delivered to utilise expected increases in renewable electricity generation.

In the past year there has been a number of developments which will help contribute to reducing electricity emissions in both Scotland and the wider UK:

- **ScotWind.** In the 2022 ScotWind leasing round, seabed rights for 28 GW of offshore wind capacity were procured. If delivered this would be significantly in excess of the Scottish Government's ambition for 8-11 GW by 2030.

- **Transmission network developments.** Ofgem has approved two new subsea link projects between Scotland and England. These are expected to be operational in the second half of the 2020s and will help connect future Scottish renewable generation to demand centres in England.

(f) Waste

1.5 $MtCO_2e$ in 2020, down 12% since 2019 and 45% since 2010
Scotland plans to reduce waste emissions by more than half by 2030. Some progress in waste-reduction policies has been made, for example consulting on a Circular Economy Routemap and introducing a moratorium for incineration and energy from waste facilities. However, we have not yet seen the necessary progress in our indicators, and Scotland is significantly off-track on recycling rates.

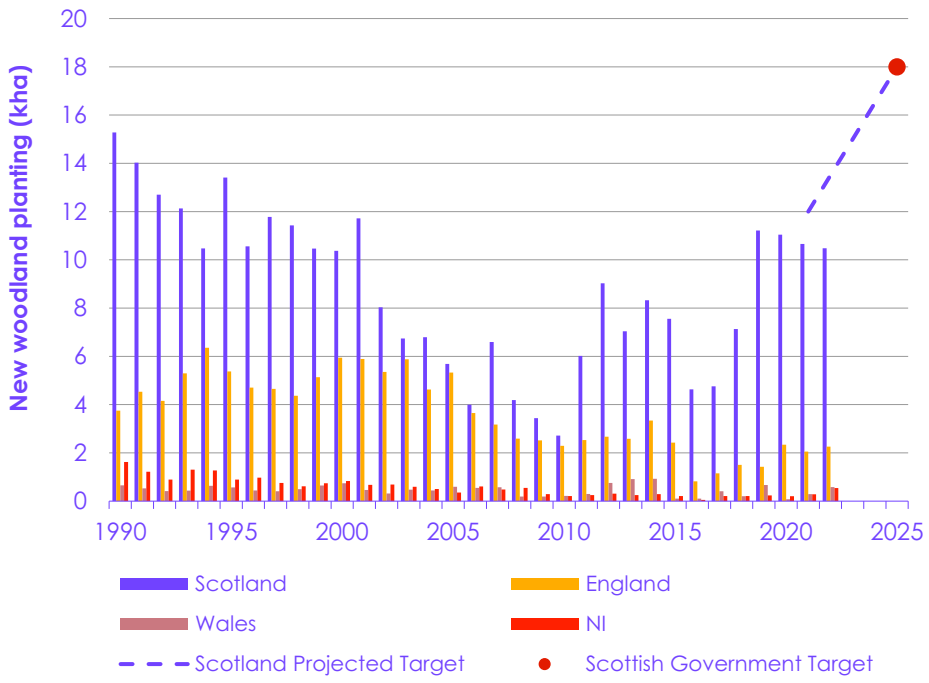
(g) Land use

0.8 $MtCO_2e$ in 2020, down 0.6 MtCO2e since 2019 and up 0.5 $MtCO_2e$ since 2010
Scotland has small net emissions from land use, as land use sources (11.9 $MtCO_2e$ in 2020) are similar in extent to land use sinks (-11.2 $MtCO_2e$ in 2020). Action is needed now to ensure the necessary reductions to net emissions in this sector.

- **Trees and woodland.** Scotland has consistently planted trees at a faster rate than the rest of the UK combined. However, rates have plateaued recently and are off track to meet the Scottish Government's target of 18,000 hectares per year by 2024/25 (Figure 8). Significant barriers from insufficient skilled workforce capacity, availability of land and contract restrictions on tenant farmers need to be overcome to deliver the required scale-up.

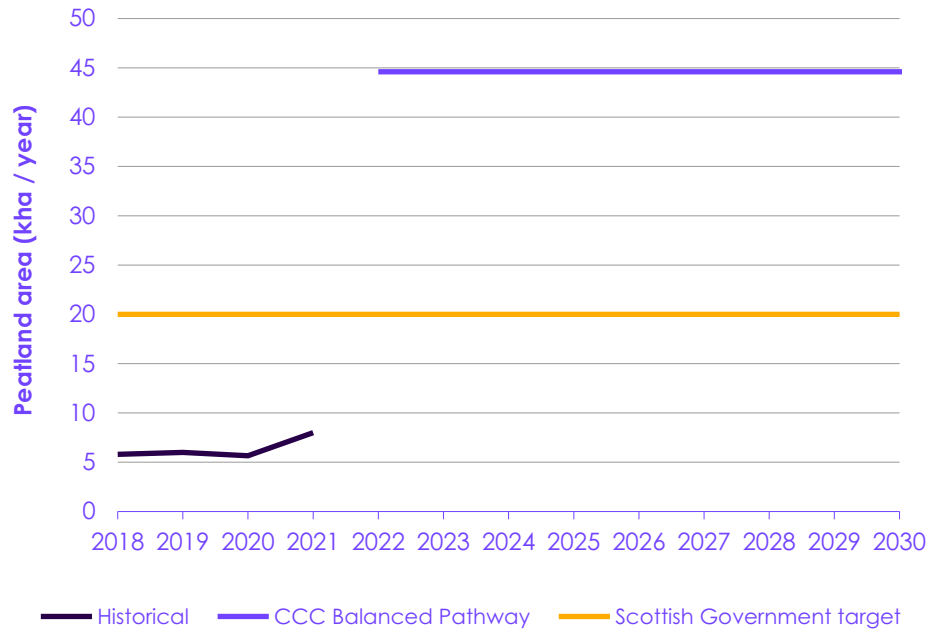
- **Peatlands.** Around 80% of Scotland's peatlands are degraded and contribute significantly to land use emissions. Scotland's targets for peatland restoration are not ambitious enough and are not being met (Figure 9). If ambition is not increased and delivery barriers, such as skills shortages and contractor availability, are not overcome, emissions in the land use sector will be well above the necessary contribution to Scotland's 2030 target.

Figure 8 UK afforestation rates and Scottish Targets



Source: Scottish Government (2020) *Securing a green recovery on a path to Net Zero: Climate Change Plan 2018-2032 – update;* Forest Research (2022).

Figure 9 Peatland area under restoration management – historical delivery and targets



Source: Scottish Government (2022) *Climate Change Plan: monitoring reports.*
Notes: Restoration management has occurred in Scotland pre-2018. The values reported here reflect reporting in the Climate Change Plan Monitoring reports.

(h) Engineered removals

The Scottish Government has chosen to rely heavily on engineered removals to meet its 2030 target, with plans assuming approximately two-thirds of the UK's stated ambition will be delivered in Scotland. With the Scottish Cluster on the reserve list for Track 1 of the UK's Carbon Capture, Utilisation and Storage (CCUS) cluster sequencing programme, the developers must now focus on securing a successful Track 2 Cluster sequencing bid once that process is launched, ensuring that engineered removals projects make up part of their proposal.

Chapter 1:

Our approach to reviewing the current targets

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Introduction

Scotland is committed to reaching Net Zero greenhouse gas (GHG) emissions by 2045 and has interim targets in 2030 and 2040 defined under the Climate Change (Scotland) Act (2019).[1]

Changes to methods for estimating emissions affect Scotland disproportionately, due to the frequent and often significant changes to estimated emissions in the land use sector and the relatively high importance of that sector to total emissions. To avoid changes to estimation methodologies affecting the achievability of the targets, a 'Greenhouse Gas Account' methodology is used, so that targets are judged against a frozen 'base inventory', which is reset to align with the latest methodology every five years.

The greenhouse gas base inventory will be reset next year to align with the 1990-2020 inventory (published in June 2022). In this report, we review Scotland's current targets to check if methodological changes have significantly affected their achievability. Once Parliament has expressed its ambition by legislating targets, we apply the principle that methodological updates should only lead to a reduction in ambition in those targets where they have a material impact on their achievability. A recommendation for increasing ambition would only be given if there is a clear case that this is achievable.

In this chapter we give a summary of current climate science, before demonstrating that Scotland's legislated targets are consistent with the temperature goal of the Paris Agreement. We then describe our approach to assessing if the targets should be changed.

In Chapter 2 we discuss the updates to our land use sector emissions pathway. In Chapter 3 we describe our engineered removals pathway for Scotland. Finally, we summarise the changes to the targets based on methodological changes as well as presenting our most up to date pathway for Scotland and give our recommendations in Chapter 4.

Human activity is warming the climate by around 0.25°C per decade and deep decarbonisation is required across all sectors to mitigate further warming.

Human activity is warming the climate by around 0.25°C per decade and is identified as the main driver of unprecedented changes across our climate system, some of which are irreversible. The Intergovernmental Panel on Climate Change (IPCC) has summarised the latest evidence on physical climate change, the impacts of climate change and the effectiveness of global efforts to reduce emissions in their Sixth Assessment Cycle (AR6) reports for Working Groups I, II and III (Box 1.1).

Pathways presented in the IPCC Working Group III report that limit global temperature increases to 1.5°C with little-to-no overshoot involve limiting cumulative CO_2 emissions and reaching global Net Zero CO_2 emissions by mid-century, reducing the possibility of severe risks to the earth's human and natural systems.[2] Achieving these outcomes at a global level will require deep decarbonisation across all sectors in this and the coming decades.

Box 1.1
IPCC Sixth Assessment Cycle reports for Working Groups I, II and III

Working Group I: The Physical Science Basis
There is unequivocal evidence that human influence has warmed the atmosphere. Rapid and extreme changes across the entire climate system are evident today and will continue to increase in severity until global CO_2 emissions, followed by global GHG emissions, reach Net Zero.

The range of estimated sensitivity of atmospheric concentrations of CO_2 has narrowed, making climate scientists' projections of future warming more robust and reducing the likelihood of both the most optimistic and the most pessimistic projections of climate futures being realised.

Working Group II: Impacts, adaptation and vulnerability
Human-induced climate change has caused widespread impacts, losses and damage to people and ecosystems around the world. Climate hazards are occurring simultaneously and interacting. Exceeding 1.5°C global warming will result in severe additional impacts, some of which will be irreversible.

Adaptation to climate change can reduce climate risk and vulnerability, but progress has been uneven. The effects of climate change are not felt equally, and the poorest populations are often the least able to adapt. There is an urgent need for worldwide climate-resilient development.

Working Group III: Mitigation of climate change
Stabilising temperatures at 1.5°C above pre-industrial levels by the end of the century will require deep decarbonisation in this decade and the subsequent decades, reaching global Net Zero CO_2 emissions around the middle of the century, and Net Zero emissions for all greenhouse gases in the second half of the century.

Pathways implied by aggregated Nationally Determined Contributions (NDCs) submitted to COP26 (as set out before mid-October 2021) would make it likely that warming exceeds 1.5°C this decade and that unprecedented rates of decarbonisation would be needed over the period 2030-2050 to keep end-of-century warming under 2°C.

Well-targeted climate policy, falling costs of emissions reduction technologies, increased volume and quality of financial flows towards low-carbon investment and international cooperation are key enablers of a strengthened mitigation response. Accelerated action on mitigation, in conjunction with adaptation, is required for sustainable development, which can increase the range of global options available for further decarbonisation.

Source: IPCC (2021) *Working Group I Summary for Policymakers;* and *Working Group I Technical Summary*, IPCC (2022) *Working Group II Summary for Policymakers*; IPCC (2022) *Working Group III Summary for Policymakers.*

2. Scotland's current targets

Scotland's 2040 and 2045 interim targets are consistent with our advice, but their 2030 interim target is significantly more challenging.

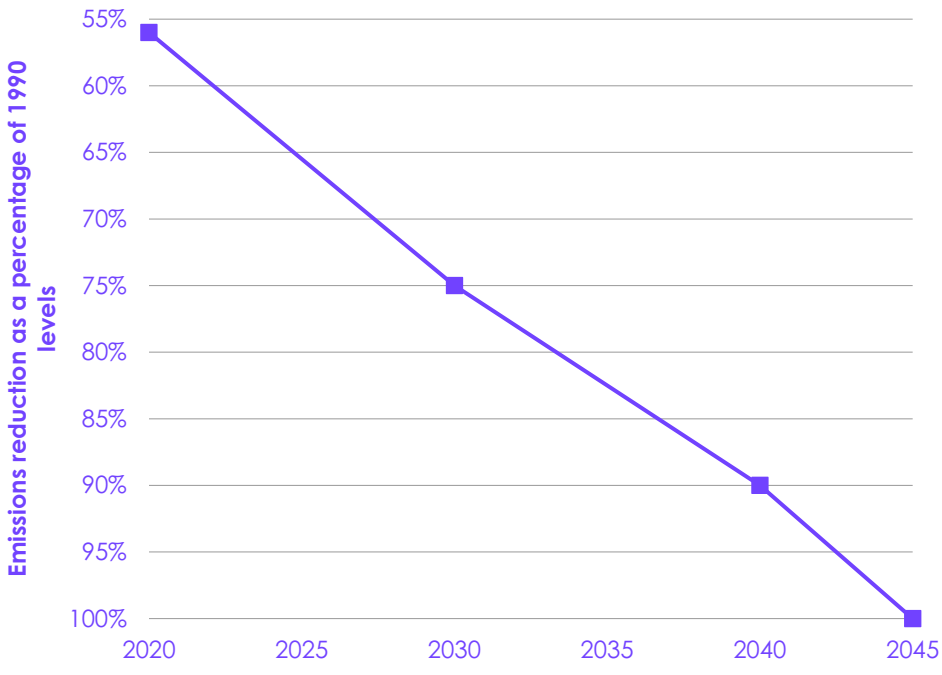
Scotland currently has a Net Zero target date of 2045 as well as interim targets for 2020, 2030 and 2040. Annual targets also apply in all years up to 2045, on a straight-line basis between these key targets (Figure 1.1). These targets are set as a percentage reduction on 1990 emissions. A 'fair and safe' emissions budget of 1,240 $MtCO_2e$ for total emissions in the years 2010-2050 has also been set.

The Net Zero target and the 2040 interim target for a 90% reduction on 1990 levels are both consistent with our advice from 2019,[3] which was based on a linear reduction in emissions to Net Zero in 2045. The 2030 interim target for a 75% reduction is more ambitious than our recommendation, which was for a 70% reduction. The 2020 target, which has been achieved, was in line with our 2017 advice on the Scottish Climate Bill.[4]

In 2020 we produced a detailed pathway for Scotland as part of our analysis for the UK Sixth Carbon Budget.[5] This pathway gave emissions reductions of 64% by 2030, 86% by 2040 and 93% by 2045 before allowing for any engineered removals in Scotland. Our advice at the time was that the 2045 Net Zero date was still appropriate as some engineered removals in Scotland are expected, but that the 2030 target was extremely difficult to meet as none of our pathways achieved a 75% reduction.

Scotland currently has ambitious interim targets leading to Net Zero in 2045.

Figure 1.1 Currently legislated emissions targets



Source: Scottish Government (2019) *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019.*

3. Scotland's targets in an international context

Scotland's targets are consistent with global efforts to limit global temperature increases to 1.5ºC above pre-industrial levels.

The stated objective of the Climate Change (Scotland) Act (2019) is to ensure that Scotland contributes appropriately to the global efforts to deliver on the aims of the Paris Agreement. This is reflected in the target review and monitoring provisions in the Act, which require the CCC to assess the contribution of Scottish targets to global efforts to limit global average temperature increases to 1.5ºC above pre-industrial levels on a five-yearly cycle.

Scotland's targets can be said to be consistent with global efforts to limit global temperature increases to 1.5ºC above pre-industrial levels. The compatibility of the targets with the 1.5ºC temperature goal has been assessed by examining the rate at which Scotland is planning to reduce emissions in more detail and comparing these rates to those of 1.5ºC-compatible pathways* from the IPCC AR6 scenario database and global and UK-specific emissions reduction pathways (Figure 1.2).

Scotland's targets sit at the upper end of the range of reductions implied by the IPCC's 1.5ºC-compatible pathways.

Figure 1.2 shows that the reductions on 2010 levels implied by Scotland's 2045 Net Zero target and interim targets sit at the upper end of the range of reductions in the same time frame implied by the 1.5ºC-compatible pathways from the IPCC AR6 scenario database. The IPCC WGIII Summary for Policy Makers states that globally modelled pathways that limit warming to 1.5ºC (>50%) reduce emissions by 37% (28% - 57%) from 2010 to 2030.† Scotland's targets aim to reduce GHG emissions by 68% from 2010 to 2030.

We are not able to assess the impact on global temperatures of Scotland's targets in this report. However, we can conclude that Scotland's targets involve emissions reductions in line with global 1.5ºC-compatible pathways.

In assessing the adequacy of Scotland's contribution to the aim of limiting temperatures to 1.5ºC, we can also look at equity considerations which would require Scotland, as a developed country, to decarbonise faster than some other countries. By aiming to reach Net Zero by 2045, Scotland is pursuing a faster transition than many other countries. If these targets are met, Scotland will contribute to global efforts to limit warming to 1.5ºC both through its emissions reduction and through the strong example it sets for other developed countries to take ambitious action without delay.

To ensure that Scotland's ambition is realised, Scotland must now focus on delivery of its stretching targets.

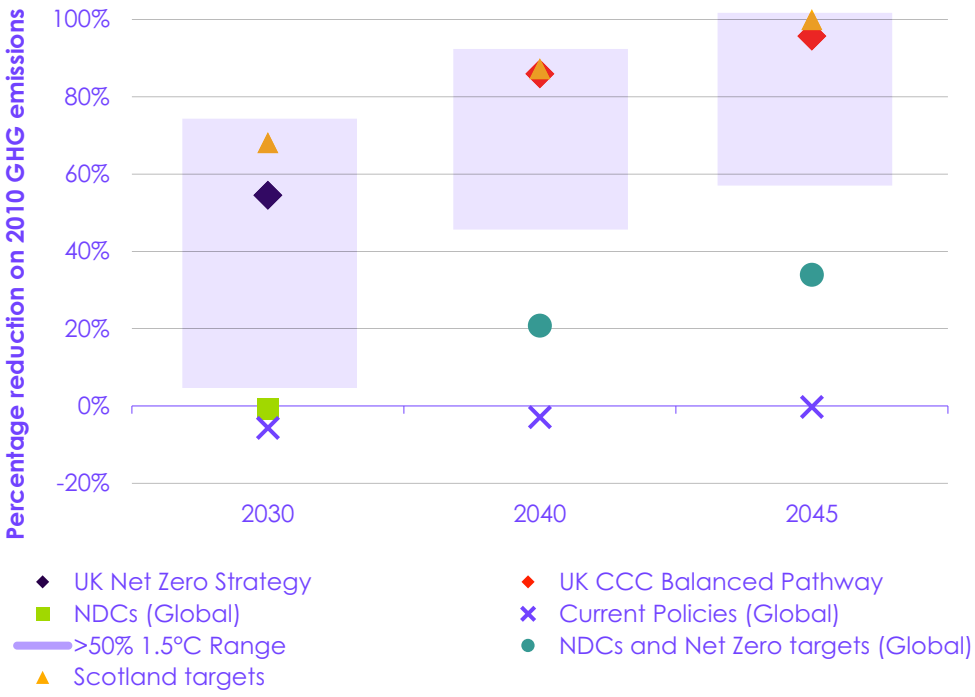
To ensure that this ambition is realised, Scotland must now focus on delivery of its stretching targets. Looking toward the future, the CCC has recommended an earlier Net Zero date for Scotland than the UK as a whole, primarily due to its greater potential to sequester carbon in both land and geological storage than other parts of the UK. This strong potential means that options for Scotland reaching net negative emissions after 2045 should be explored so that it can contribute even further to global decarbonisation efforts.

* With limited or no overshoot.

† This figure has been updated since the Special Report on Global Warming of 1.5C, which stated that pathways consistent with limiting temperature increases to 1.5C above pre-industrial levels reduced GHG emissions by 45% on 2010 levels by 2030.

The rate of emissions reduction implied by the Scottish targets is similar to the rates of reduction in 1.5°C-compliant scenarios reviewed by the IPCC.

Figure 1.2 Scotland's targets in a global context



Source: Climate Action Tracker; IPCC Sixth Assessment Report Scenario Database; CCC analysis.
Notes: Aggregation of greenhouse gas emissions is done using IPCC AR5 GWP values with a 100-year time horizon and without feedbacks, with a methane correction factor applied to Climate Action Tracker global values which have been calculated using AR4 GWP values. The shaded ranges are calculated using the pathways from the 1.5C (with no or limited overshoot) category from the global GHG emissions scenario database used for the IPCC Sixth Assessment Report cycle. The global emissions data points are taken from Climate Action Tracker projections and cover all GHGs. The UK data points cover all GHGs and use the Net Zero Strategy (NZS) for 2030 and the CCC Sixth Carbon Budget Balanced Pathway for 2040 and 2045 as the NZS pathway does not cover these years. The reductions implied by the UK NZS and CCC Balanced Pathway targets include international aviation and shipping in the UK emissions considered, meaning that the 2030 reduction is not equal to the reduction implied by the UK NDC.

4. Our approach to reviewing the targets

Scotland's emissions are particularly susceptible to methodological changes in emissions accounting and so a 'GHG Account' methodology is used for assessing targets.

Due to a significant contribution from the land use sector, emissions in Scotland are particularly susceptible to methodological changes in emissions accounting. Because of this, and in accordance with CCC recommendations in 2017,[6] Scotland uses targets set on a percentage reduction basis against 1990 levels of emissions. As estimates of 1990 emissions are also affected by methodological changes to estimation methods, this approach is more robust to changes than emissions targets set on an absolute ($MtCO_2e$) basis.

The methodology for assessing performance against the legislated emissions targets is reset every five years and the targets are revisited at that time.

However, even with percentage targets, changes in estimation methodology could make near-term targets that were previously stretching but achievable become either significantly more difficult or easier to meet. To avoid this, Scotland uses a 'GHG Account' methodology when assessing whether targets have been met (Box 1.2) to ensure that performance is effectively measured on the methodology in place when the targets were set.

To prevent the inventory and the GHG Account from diverging too significantly over time, the methodology for assessing performance against the legislated emissions targets is reset to the latest inventory method every five years. The targets are revisited at this time to ensure they are still both feasible and stretching, despite the methodology changes, and are in line with the latest climate science. We approach the question on whether the targets are appropriate in two ways:

1. **Adjustments to legislated targets due to methodological changes only (Chapter 4, section 1).** In this approach we start from the legislated targets and consider how changes in emissions accounting methodology would change the feasibility of the targets. This is the only basis under which we would recommend a reduction to the ambition expressed by Parliament via its legislated targets.

2. **An updated pathway for Scotland (Chapter 4, section 2).** In this approach we consider the most appropriate targets based on our most up-to-date analysis for Scotland. We start from our Scottish analysis developed as part of the advice on the UK's Sixth Carbon Budget and then adjust to use the latest emissions accounting methodology, use a more up-to-date land use pathway (Chapter 2), add in a pathway for engineered GHG removals for Scotland (Chapter 3) and consider further steps that could be taken. A recommendation for increasing ambition would only be given if there is a clear case that this is achievable.

Box 1.2
Scotland's GHG Account and annual adjustment mechanism

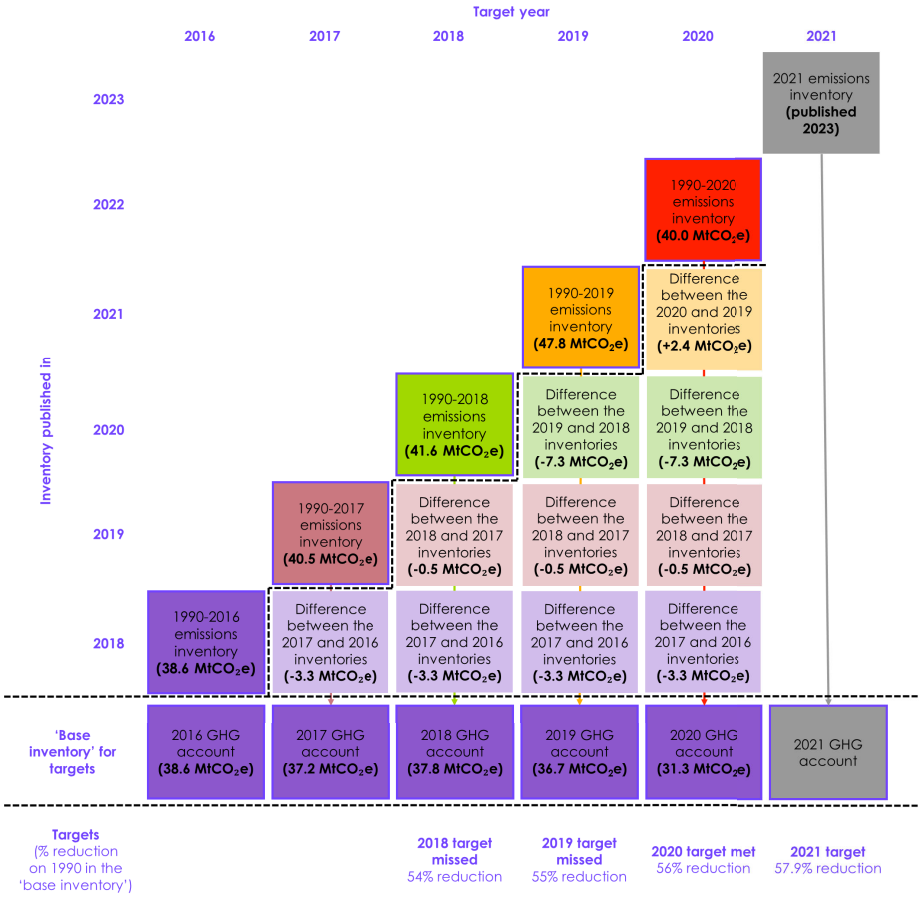
Scotland's emissions targets are assessed against the Scottish Greenhouse Gas (GHG) Account, a methodological approach used to adjust annual emissions to the methodology of the 'base inventory', which is currently the 1990-2016 inventory. This way, the impact of changes in methodology in determining whether Scotland has met each annual target is minimised. Methodology changes to the emissions inventory are designed to increase the transparency, accuracy, consistency, comparability and completeness of emissions estimates. These can come from updates to use more accurate emissions factors and/or activity data and from changes in the scope of the inventory, such as the recent update to the treatment of emissions from peatlands.

Changes to emissions estimates also arise from changes to the internationally agreed global warming potentials of greenhouse gases. Scotland is particularly susceptible to changes due to the large contribution from the land use sector, which has large uncertainties and tends to change more significantly than other sectors.

The GHG Account allows for annual emissions data to be assessed against targets while accounting for inventory changes, but not changing the target. In any given year the GHG account is estimated by the following steps (illustrated in Figure B1.2):

- Take the new emissions inventory, which includes estimates of emissions in the most recent year and revised estimates of emissions in previous years (which have also been estimated in previous inventories).
- Calculate the difference in emissions between the last two inventories in the year before the most recent one (this is the latest year which is covered by both inventories).
- Use this difference to estimate what the latest year's emissions would be if calculated with the older inventory methodology.
- Repeat these steps until the reference inventory is reached. This is the GHG Account.
- Compare the GHG Account to 1990 levels in the reference inventory, comparing this to the annual percentage target to assess whether it was met.
- Every five years reset the latest inventory to be the new reference inventory. At this point the targets are also reviewed.

Figure B1.2 Scottish GHG Account



Source: Climate Change Committee (2018) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework.*

Source: Climate Change Committee (2018) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework.*

Endnotes

[1] Scottish Government (2019) *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019*, https://www.legislation.gov.uk/asp/2019/15/enacted

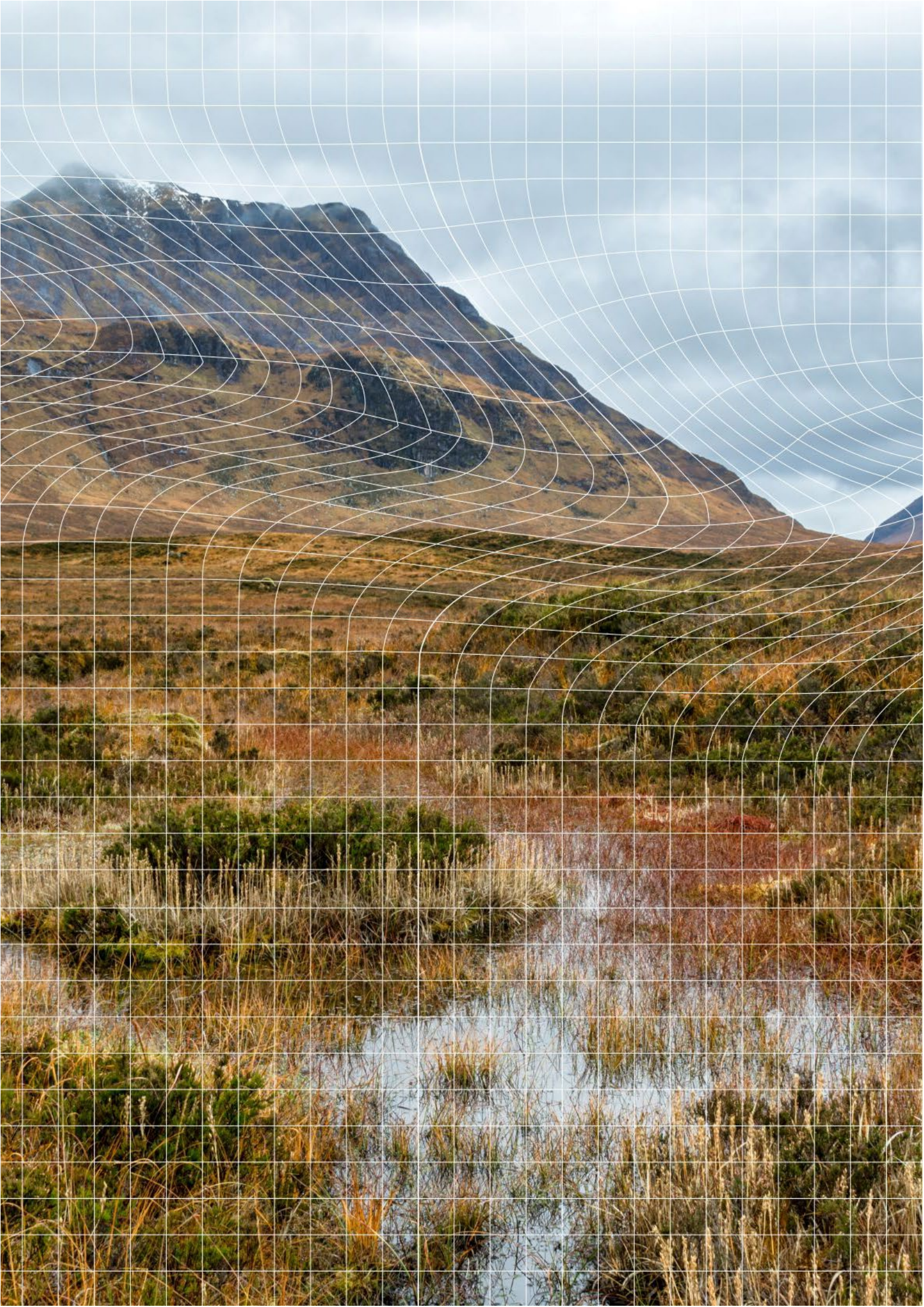
[2] Intergovernmental Panel on Climate Change (2022) *Climate Change 2022: Mitigation of Climate Change*, https://www.ipcc.ch/working-group/wg3/

[3] Climate Change Committee (2019) *Final assessment of Scotland's first Climate Change Adaptation Programme,* https://www.theccc.org.uk/publication/final-assessment-of-scotlands-first-climate-change-adaptation-programme/

[4] Climate Change Committee (2017) *Advice on the new Scottish Climate Change Bill*, https://www.theccc.org.uk/publication/advice-on-the-new-scottish-climate-change-bill/

[5] Climate Change Committee (2020) *Sixth Carbon Budget*, https://www.theccc.org.uk/publication/sixth-carbon-budget/

[6] Climate Change Committee (2018) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework*, https://www.theccc.org.uk/publication/letter-lord-deben-roseanna-cunningham-msp-advising-scottish-climate-target-framework/



Chapter 2

Changes in the land use sector

1. Emission pathway for Scotland's land use sector 42

Introduction and key messages

In this chapter we set out the analytical approach to updating the CCC pathways for the land use sector. Due to the extent of peatlands and forestry in Scotland, changes to emissions accounting for these subsectors can have a significant impact on estimates of Scotland's overall emissions. Here we set out the relevant technical and methodological changes in the sector, embedding recent changes to the UK GHG inventory and underlying datasets into the CCC land use pathways.

Our key messages are:

- **Sixth Carbon Budget measures are unchanged.** This new analysis focuses on methodological and inventory changes. The underpinning assumptions regarding woodland creation, peatland restoration and their sustainable management remain unchanged from that set out in our 2020 advice on the UK Sixth Carbon Budget.[1]

- **Forestry.** The approach for the forestry pathway has focused on a methodology update, moving towards the CARBINE forestry model to become aligned with how forestry is represented in the UK GHG inventory.

  - The methodology change captures the impact of new planting on GHG emissions and woodland creation before 2019. This results in a reduced estimate of the forestry sink up until the mid-2030s compared to the CCC's Sixth Carbon Budget advice.

  - This lag is due to the balance of new woodland planting taking years to reach peak sequestration and a weakening of the sink strength from established forests.

- **Peatlands.** The CCC peatland pathway has been adjusted to the relevant emission factors for organic soils to align with the treatment of peatlands in the 1990-2019 GHG inventory.

  - Our analysis of paths to Net Zero in 2020, as part of advice on the UK's Sixth Carbon Budget, took a cautious approach on the assumed treatment of peatland emissions in advance of the update in the emissions inventory, assuming potential changes would be at the higher end of estimated ranges. The UK GHG inventory went on to use a lower emission factor for forestry peats and AR5 without feedbacks values.

  - These updates to align with the inventory methodology have led to an overall reduction in the estimated net emissions associated with the peatland subsector for Scotland compared to our previous assumptions. Peatland emissions are 3.5 $MtCO_2e$ lower in 2030 compared to the estimate assumed in the Sixth Carbon Budget analysis.

  - Due to the large areas of forestry on organic and peat soils in Scotland, there is an overlap in this subsector with the described methodology changes for forestry.

- **Impact of land use model updates.** The trajectory of the land pathway is now one of increasing emissions over the next decade, with the sector not becoming a net sink until 2040, three years later than the CCC's original analysis. Due to the lag effect from land use change measures, targets for woodland creation and peatland restoration must be met to avoid further delays of emission reduction in this sector.

1. Emission pathway for Scotland's land use sector

(a) Scotland's land use emissions

Emissions reported under the land use sector are the balance of emission sources and removals from the atmosphere. Net emissions associated with land use in Scotland have risen overall since 2012.

Net greenhouse gas emissions from Scotland's land use sector in 2020 were 0.8 $MtCO_2e$*, a substantial reduction of 5.6 $MtCO_2e$ since 1990. Emissions reported under this sector are the balance of emission sources and removals from the atmosphere (i.e. 'sinks').

- Sources of emissions in the land use sector (e.g. drained peatlands and land allocated to crops) are now 12.0 $MtCO_2e$, 21% below those in 1990.
- Emissions sinks in the land use sector (e.g. forest and grasslands) now remove 11.2 $MtCO_2e$ from the atmosphere, almost balancing the sources. This represents a 27% increase in overall sinks since 1990.
- Despite the overall long-term decrease, net emissions from the land use sector have risen overall since 2012. This is due to a legacy of low tree-planting rates in the 1990s reducing the strength of the land sink and continued emissions from degraded peat soils.

(b) Land use in the CCC Sixth Carbon Budget – original pathways

The Sixth Carbon Budget analysis took a bottom-up approach, producing a series of abatement pathways that set out the contribution of land to Net Zero by 2050.

The CCC's UK Sixth Carbon Budget analysis in 2020, which produced Scotland-specific outputs, took a bottom-up approach, producing a series of abatement pathways that set out the contribution of land to Net Zero by 2050. In these pathways, key priorities for land – producing food for a growing population and for settlement growth to support housing and other economic activity – are met before allocating additional land for climate mitigation.

The Balanced Net Zero Pathway represents our central scenario, with the 2020 model resulting in estimated net emissions from the land sector in Scotland of 2.5 $MtCO_2e$ in 2030 and -4.3 $MtCO_2e$ in 2045 (Figure 2.1). In this analysis, the sector becomes an estimated net sink in 2037.

- The Scottish Government announced a programme of peatland restoration in 2018. We include this in the CCC baseline emissions projection. This equates to 20 kha of peatland restoration achieved annually.
- Due to the Sixth Carbon Budget scenarios being developed prior to a decision on how to include peatlands in the inventory, we took a cautious approach on how it might be included. We assumed the impact of the potential changes would be at the higher end of estimated ranges, so as not to recommend targets which might be rendered unachievable by a subsequent choice of emissions accounting methodology. The UK GHG inventory went on to use a lower emission factor for forestry peats than we assumed and it was agreed at COP26 to use AR5-low GWPs (in the Sixth Carbon Budget analysis we assumed AR5-high).

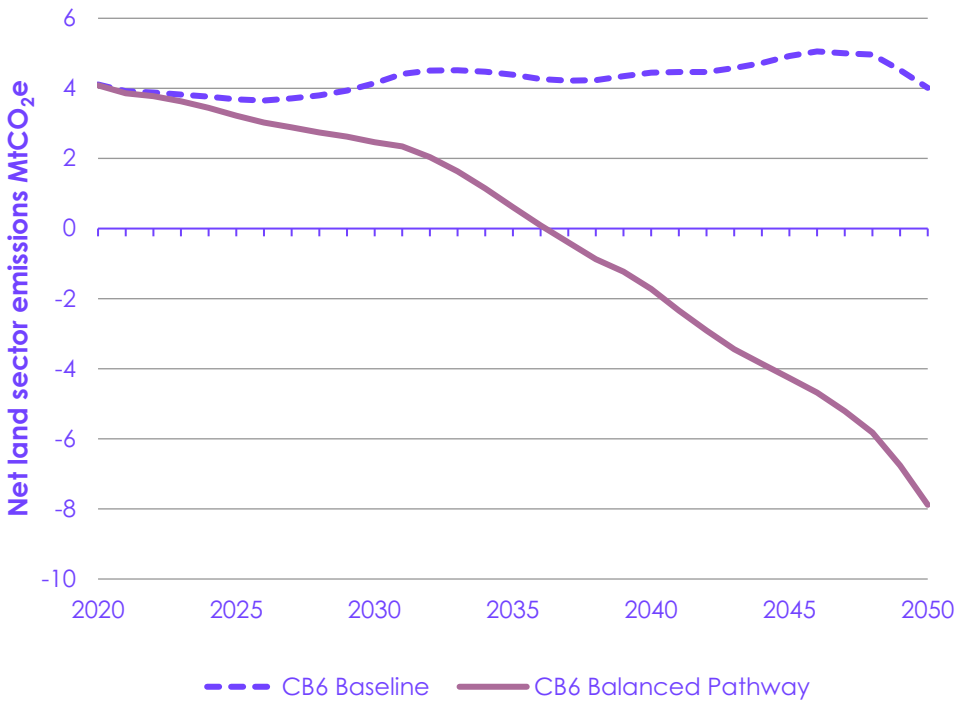
* Using global warming potentials (GWPs) from IPCC's 5th Assessment Report (AR5), without climate-carbon feedbacks, also referred as AR5-low.

- The representation of forestry pathways was underpinned by the C-Flow model. This represents new woodland creation but does not consider the interaction with past planting regimes and is likely to overestimate the scale of the sink in the CCC forestry scenarios as a result. Forestry in the UK GHG Inventory is now underpinned by the CARBINE model, which takes into account these interactions.

- Delivery of the CCC pathways for land is dependent on successful implementation of land-release measures in the agriculture sector (e.g. efficiency measures and reduced livestock farming as a result of dietary changes), land use change and an increase in sustainable land use measures. The land-based mitigation measures considered are: afforestation and improved management of existing broadleaf forests; increased production of bioenergy crops; restoration and sustainable management of degraded peatlands; and expansion of hedgerows and agro-forestry.

The CCC's Balanced Net Zero Pathway is the CCC's recommended scenario, with the 2020 model estimating that this pathway would result in a net sink by 2037.

Figure 2.1 CCC land use Pathways 2020-2050, original Sixth Carbon Budget advice (2020)



Source: CCC (2020) *The Sixth Carbon Budget.*
Notes: This chart presents the CCC Baseline and Balanced Pathway as originally presented in the Sixth Carbon Budget advice, in AR5 with carbon feedback.

(c) Analytical approach – updated pathway for this target advice

The CCC Sixth Carbon Budget analysis for land has been updated to reflect changes to reporting to the GHG inventory and methodology updates.

Since the Sixth Carbon Budget work was published, the GHG inventory and underlying data sets have undergone numerous revisions and changes. In this section we provide an overview of how we updated the land use sector analyses to reflect this.

(i) 1990-2020 inventory update

The CCC is expected to provide advice based on the most recent iteration of the GHG Inventory. The 1990-2020 inventory update relevant to the land sector included an improvement in the data and methodology used to estimate emissions. The inventory now takes a Bayesian data assimilation approach, integrating land use data sources with national-scale census data to construct emission estimates associated with land use change.[2]

The BEIS projections of land use emissions based on the 1990-2020 inventory had not been agreed at the time of this analysis. We have attempted to align the updated Scottish land use pathway to this by applying a constant offset for 2021 onwards, based on the known difference between 2020 and the projections from the 2019 inventory.

(ii) Forestry approach

The CCC pathways for forestry have focused on methodology updates.

Our approach for the forestry subsector has focused on updates to the methodology for estimating emissions. The underpinning assumptions regarding area, yield class, species and planting density remain unchanged from what was set out in the UK Sixth Carbon Budget advice.

Emissions from forestry in the GHG inventory is supported by the Forest Research CARBINE model. For the Sixth Carbon Budget the CCC used the C-Flow model. It was not possible to use CARBINE in the land analysis for this 2022 target advice to the Scottish Government. Therefore, we have taken steps for our pathways to become aligned to CARBINE. These include:

- The BEIS inventory-based land use projections use the CARBINE model; we have embedded these into our updated baseline and projections. This enables the projected forestry pathways to capture the impact of new planting on GHG emissions, as well as the continued impact of planting before 2019.

- For new planting we have used the 2022 Forest Research report 'Quantifying the sustainable forestry carbon cycle' (QFORC),[3] a CARBINE-based model approach that allows assessment of different options for woodland creation and management, from the perspective of their potential for CO_2 uptake and avoiding GHG emissions.

- Soil type is assigned to organo-mineral to represent Scottish conditions. It is assumed that, in line with UK Forestry Standards, planting on peat soils does not occur.

The methodology changes result in a reduction in the estimated forestry sink up until the mid-2030s compared to the CCC's Sixth Carbon Budget advice (Figure 2.2). Despite the Balanced Pathway setting high woodland planting rates, under the new modelling approach this takes longer to have a significant effect on emissions.

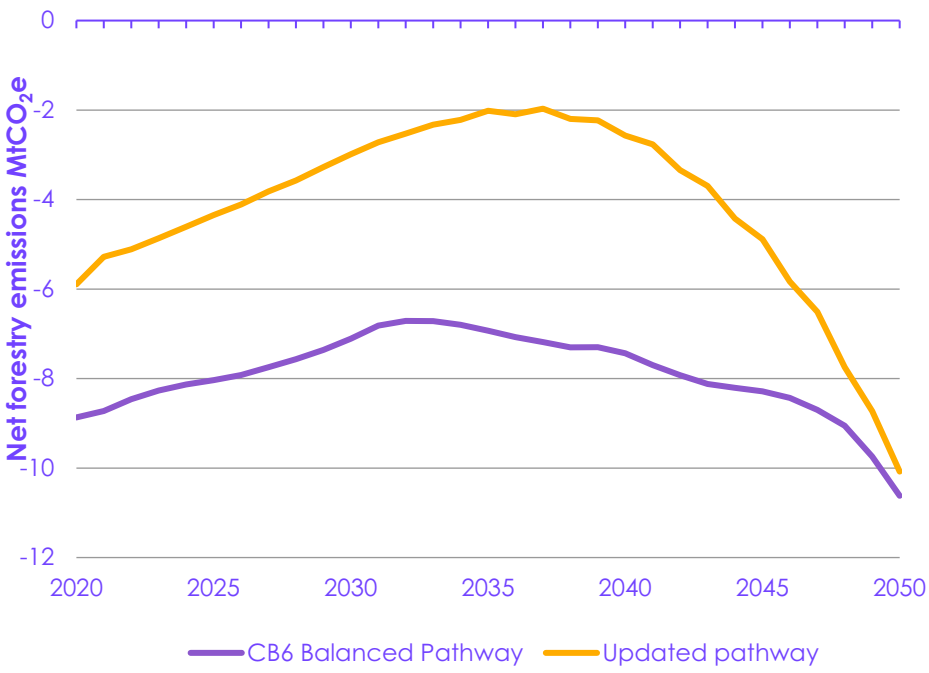
- **In 2030**, the forestry subsector (both existing woodland and new woodland creation) is a net sink at -3 $MtCO_2e$. This represents a reduction of the estimated sink between the CCC's previous advice by around 4 $MtCO_2e$. Around two-thirds of the difference is due to the weakening sink strength from established forests.

- **The lag effect** before new planting and natural regeneration reaches peak sequestration is evident until around 2037, when the forestry sink in Scotland begins to increase rapidly because of the high rates of woodland creation during the 2020s.

- **In 2045**, the forestry subsector is a net sink of almost -5 $MtCO_2e$. This represents a reduction of the sink by around 3.45 $MtCO_2e$ compared with the CCC's original forestry pathway. The rapid increase in the sink becomes evident beyond 2045, increasing to -10 $MtCO_2e$ in 2050 and becoming more aligned with CCC original estimates for this time period.

Forestry methodology changes result in a reduction of the forestry sink compared to the CCC's Sixth Carbon Budget advice.

Figure 2.2 Comparison of forestry pathways 2020–2050



Source: UK Centre for Ecology & Hydrology (CEH) and CCC analysis.
Notes: Emissions presented represent both existing woodland and new woodland creation as set out in the Balanced Net Zero Pathway. CB6 refers to CCC's Sixth Carbon Budget.

(iii) Peatland approach

Updates to the CCC peatland pathways have focused on embedding inventory updates by adjusting the relevant emission factors for organic soils and updating GWPs.

The analytical approach for the peatland subsector has focused on embedding inventory updates into the CCC Balanced Pathway scenario. The underpinning assumptions regarding peatland restoration and sustainable management remain unchanged from those set out in the 2020 advice on the UK Sixth Carbon Budget.*

Peatland representation in CCC models has been updated by adjusting the relevant emission factors within the UK for organic soils, updating the CCC Sixth Carbon Budget assessment (which used AR5-high GWPs) to incorporate the new emission factors and converting to AR5-low GWPs (Figure 2.3).

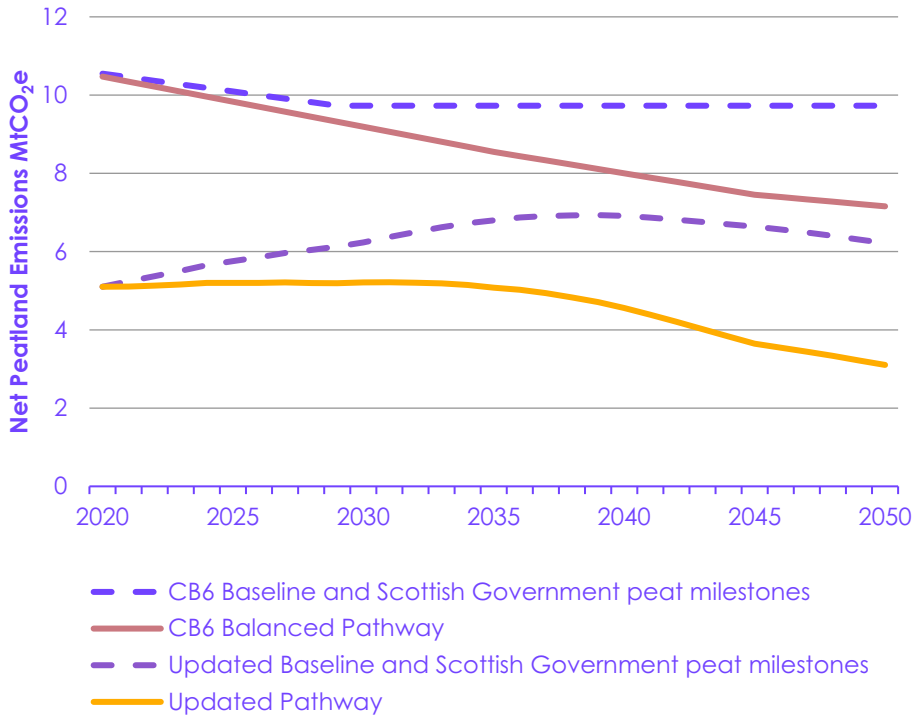
- **Scotland's restoration ambition is lower than the CCC's advice.** Although the CCC's advice is that restoration rates should reach 45 kha annually by 2022 to meet emission reduction targets, Scottish Government milestones include annual rates of only 20 kha per year up until 2030. Scotland's targets are therefore represented in the CCC baseline scenarios and are included here to set out the scale of impact of lower peatland restoration rates within our advice.

Changes to the inventory have led to an overall reduction in the net emissions associated with the peatland subsector for Scotland.

- **Impact on the peatland emission pathway.** The adjustments to how we account for peatlands within the CCC Balanced Pathway, to reflect the changes to the inventory, have led to overall lower estimated net emissions associated with the peatland subsector for Scotland.
  - This reduces the estimated emissions from peatlands in the CCC emission reduction pathways by 4 $MtCO_2e$ in 2030 compared to the Sixth Carbon Budget analysis.
  - The impact of Scotland's lower restoration ambition is significant, resulting in 1 $MtCO_2e$ greater emissions than the CCC's Balanced Pathway in 2030, rising to 3 $MtCO_2e$ in 2045.
  - The initial rise in peatland emissions in the adjusted baseline peatland pathway is associated with the decline in the net sink of forestry on organic soils.

* Due to the large areas of forestry on organic and peat soils in Scotland, there is an overlap in this subsector with the described methodology changes for forestry. Forestry on peatland is included in the peat subsector, to be consistent with the analysis in the CCC's Sixth Carbon Budget advice.

Figure 2.3 Comparison of forestry pathways 2020–2050



Source: CEH and CCC analysis.
Notes: 1) Sixth Carbon Budget (CB6) Pathways are presented in their original GWPs (AR5-high). The adjusted peatland pathways take into account the conversion to AR5-low and are aligned with the UK GHG Inventory with regards to the inclusion of organic soils / peatlands. 2) Due to the timing of the policy, the Scottish Government milestone to reach 20 kha of annual peatland restoration up until 2030 is included within the CCC baseline (see Peatland Approach section). The baseline therefore represents the emissions reduction pathway associated with peat restoration as set out by the Scottish Government. This is lower than the CCC's advice that rates of 45 kha annually should be reached by 2022.

(iv) Total impact of land use model updates on the CCC's land use pathway for Scotland

The update to the CCC land models to address inventory updates and improvements to methodology has resulted in a significant difference to the land use pathway (Figure 2.4).

Over the next decade the trajectory of the land use pathway is now one of increasing emissions, driven by the legacy of low planting rates in the 1990s reducing the forestry sink capacity. Emissions reach a peak in 2033 for the updated land pathway and then drop consistently from 2036 onwards. A plateauing of emissions is delayed until four years later, and at a higher level, if Scotland does not increase its peatland restoration target to be in line with CCC advice.

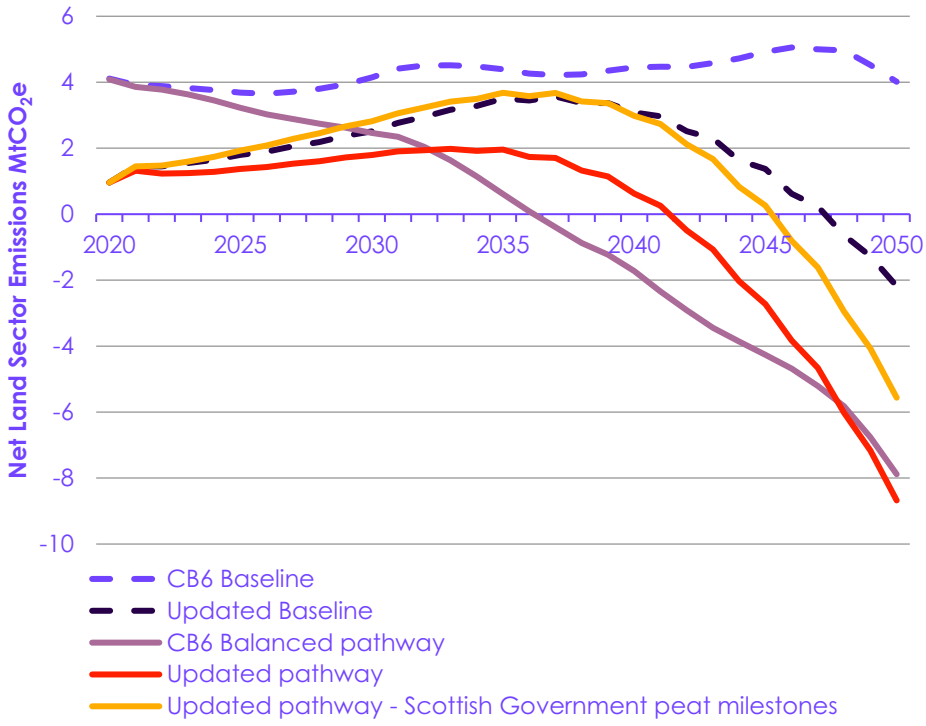
Under the methodology and inventory changes, the land use sector does not become a net sink until 2042, as opposed to 2037 in the CCC Sixth Carbon Budget advice.

- It is crucial that tree-planting targets are met in the near term. Further delay will lead to the continued increase of emissions due to young trees not reaching peak sequestration rates in time to offset the continuing decline of the sink strength from trees planted in previous decades.

- The impact of Scotland's lower peatland restoration target is evident on the trajectory of the land pathways. The annual emissions overall are increased, with a difference of 1 $MtCO_2e$ in 2030 and 3 $MtCO_2e$ in 2045 between the two levels of ambition. This pushes the date that Scotland's land sector can achieve sink status from 2042 out to 2046.

The land model update has resulted in a significant change to the CCC land pathway. The trajectory is now one of increasing emissions for the next decade and does not become a net sink until 2042.

Figure 2.4 Impact of inventory and methodology updates on CCC land use Scottish pathways 2020-2050



Source: CEH and CCC analysis
Notes: Based on expected updates in the 2020 inventory, generated by assigning an adjustment to 2019 inventory outputs. CB6 refers to CCC's Sixth Carbon Budget.

Endnotes

[1] CCC (2020) *The Sixth Carbon Budget,* https://www.theccc.org.uk/publication/sixth-carbon-budget/

[2] NAEI (2022) *UK Greenhouse Gas Inventory, 1990 to 2020: Annexes,* https://naei.beis.gov.uk/reports/reports?report_id=1072

[3] Forest Research (2022) *Quantifying the sustainable forestry carbon cycle,* https://cdn.forestresearch.gov.uk/2022/07/QFORC_Summary_Report_rv1e_final.pdf

Chapter 3

Engineered removals

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Introduction and key messages

Engineered greenhouse gas removals, also known as Negative Emissions Technologies, play a substantial role in meeting the Scottish Government's 2030 target, as set out in the update to the Climate Change Plan update (CCPu). Achieving this level of deployment of engineered removals would see Scotland delivering roughly two-thirds of the UK Government's overall engineered removals ambition in 2030. To assess whether this ambition is credible, we have constructed a pathway range for deployment of engineered removals in Scotland and compared this with the targets in the CCPu.

This chapter sets out the Scottish Government's current ambition for engineered removals, introduces the CCC's pathway range for Scotland and identifies next steps for this sector.

Our key messages are:

- **Potential for engineered removals.** Scotland has very good potential for deploying Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Capture with Carbon Capture and Storage (DACCS) due to its access to potential CO_2 storage sites in the North Sea, its ability to contribute to domestic BECCS feedstocks and its potential future supplies of low-carbon energy that could be used to power DACCS. This potential must be explored by the Scottish Government to produce a detailed and evidence-based view of how engineered removals in Scotland could grow over time. The upper and lower ends of the pathway range in this report allocate UK engineered removals from the Sixth Carbon Budget Balanced Pathway to Scotland in line with Scotland's proportion of the UK's land area and population respectively. This range estimates that 0.4 to 1.6 $MtCO_2$ could be removed in 2030 in Scotland.

- **Reliance on CCS infrastructure.** BECCS and DACCS plants in Scotland will require access to functioning CCS networks to begin removing CO_2. Scotland is reliant on UK Government action in this area and should consider the impact that delays from the Scottish Cluster project not being selected for Track 1 of the UK Government's cluster sequencing process will have on meeting 2030 engineered removals ambition in the CCPu.

- **Contingency measures.** Scotland's 2030 engineered removals target is very stretching and delays to the build out of CCS infrastructure would make it even harder to achieve. Scotland must identify opportunities for further emissions reduction in other sectors that can be pursued to make up any shortfalls in engineered removals in the late 2020s and early 2030s.

- **Coordination.** Improved coordination is needed between the UK Government and the devolved administrations on how engineered removals projects contribute to constituent nations' carbon budgets, specifically addressing the question of whether removals in one nation of the UK can contribute to the emissions reduction targets in another nation.

1. Engineered removals in the Climate Change Plan update

Scotland's planned volumes of engineered removals comprise roughly two-thirds of the UK Government's overall ambition in 2030.

The Scottish Government's CCPu targets significant deployment of engineered removals this decade, with CO_2 removed per year reaching 3.8 $MtCO_2$ in 2030 and increasing rapidly by roughly 50% from that figure by 2032. Targeting engineered removals at this scale in Scotland is highly ambitious, with Scotland's 2030 milestone comprising roughly two-thirds of the UK Government's 5.6 $MtCO_2$ overall ambition for removals for the same year.

A number of the planning and infrastructure levers for engineered removals involving CCS are reserved, which limits Scotland's ability to move faster than the rest of the UK in this area.

In 2021 the UK Government announced that it had placed the Scottish Cluster on the reserve list for Track 1 of its Carbon Capture, Utilisation and Storage sequencing programme and would therefore not immediately be moving forward with funding of that cluster and related projects. Although there is potential for the Scottish Cluster to be selected for Track 2 of the programme, the volume of engineered removals of CO_2 currently planned for that cluster and Scotland's limited opportunities for BECCS retrofits of existing biomass plants calls into question the feasibility of meeting the CCPu removals target, regardless of whether the Scottish Cluster is taken forward on Track 1 or Track 2 timelines.

2. CCC pathway for engineered removals in Scotland

We have constructed a pathway range to reflect the potential for engineered removals in Scotland based on our Sixth Carbon Budget analysis with varying assumptions about the proportion allocated to Scotland.

For this advice, we have constructed a pathway range to reflect the potential for engineered removals in Scotland (Figure 3.1). This pathway range aims to estimate the set of possible pathways for removals in Scotland, informed by a number of factors including CCC pathways for engineered removals across the UK, Scotland's natural resources and the current pipeline of potential projects:

- The lower end of the range is constructed by allocating UK engineered removals from the CCC's Sixth Carbon Budget Balanced Pathway to Scotland in line with Scotland's share of the UK population (8%).[1]

- The upper end of the range is constructed by allocating UK removals from the Balanced Pathway to Scotland in line with its proportion of UK land area (32%).[2] This represents an upper estimate of the potential for removals in Scotland, as Scotland's land area as a proportion of the UK is large compared to its population and GDP.

- To calibrate the pathway range to our expectations of likely timing for deployment of renewables in Scotland, both the upper and lower end only start removing CO_2 from 2030. The midpoint of the range acts as a central pathway which sees 1 $MtCO_2$/year being removed in 2030, in line with our best estimates for engineered removals in Scotland in that year.

The midpoint of our range in 2030 is in line with our best estimates for engineered removals in that year.

- The UK Government's Net Zero Strategy is more ambitious than the CCC's Balanced Pathway in terms of engineered removals. For illustrative purposes, the pathway range for Scotland has been reproduced using Net Zero Strategy data, allocating engineered removals ambition from the Net Zero Strategy Central Delivery Pathway to Scotland in line with the methodology set out in this chapter. As shown in Figure 3.1, this reproduction of the range demonstrates that higher assumptions on the overall level of UK engineered removals still leaves a gap between our pathways and the Scottish Government's CCPu ambition for 2030, even at the higher end of the range.

The pathway range sees Scotland's share of UK engineered removals being between 8% and 32%. This range reflects the fact that Scotland has relatively high suitability for deploying engineered removals, due to the following factors:

- Scotland has access to high volumes of potential geological CO_2 storage in the North Sea subsurface.

- If BECCS deployment is pursued in Scotland, its large land area and plans for afforestation mean that projects can draw on substantial potential biomass stocks, including through residues as part of forest management.

- As part of the overall decarbonisation of the GB energy system, Scotland is likely to be a substantial net exporter of renewable energy. Electricity grid constraints mean that production of green hydrogen to support DACCS – initially in limited quantities – might make the most sense in Scotland.

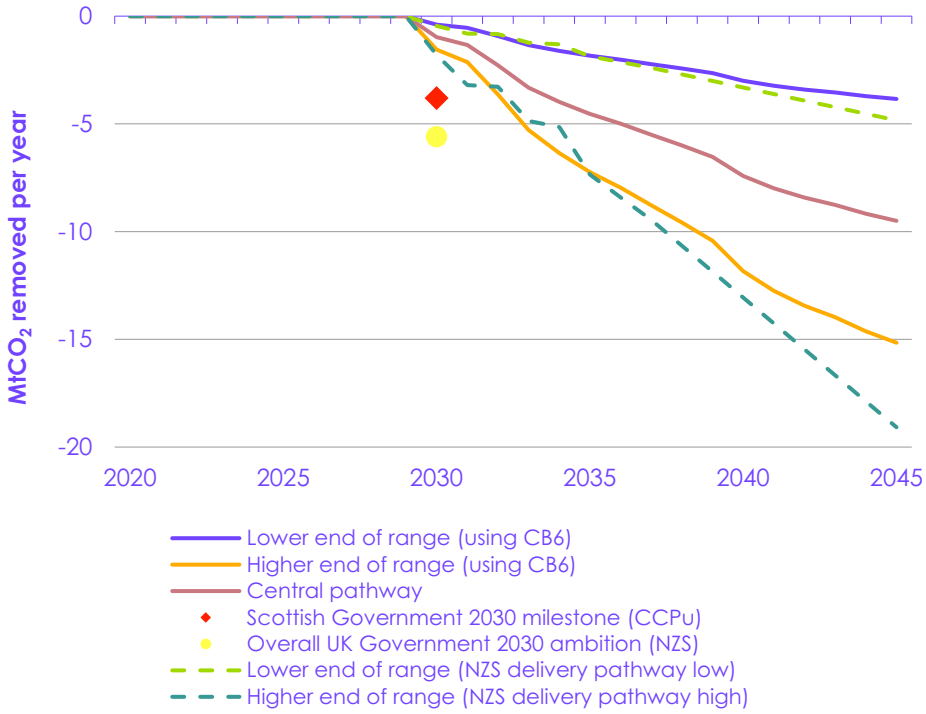
Developing a robust engineered removals pathway for Scotland would require detailed modelling.

This provides an indicative range for the potential for engineered removals in Scotland. Developing a robust engineered removals pathway for Scotland would require detailed modelling that considers factors including Scotland's energy networks, existing industry, proximity to likely biomass production and projections of future networks of CO_2 pipelines and geological storage. A detailed estimate must also consider best use of supplies of renewable energy across Scotland and other nations, prioritising the production of green hydrogen for use in hard-to-abate sectors over large-scale deployment of DACCS where appropriate. This work should be carried out in the next two years to avoid delay to deployment timelines for engineered removals in Scotland.

The mid-point of this range is used as a central pathway in our overall emissions pathway for Scotland.

The CCC's pathway range sees 8% – 32% of UK removals being deployed in Scotland. The higher end of the range is significantly less ambitious than Scotland's plans.

Figure 3.1 Scotland engineered removals pathway range



Source: CCC analysis.
Notes: The lower end of the range allocates a proportion of the UK Sixth Carbon Budget removals pathway to Scotland in line with its population relative to the overall UK population. The higher end of the range allocates a proportion of the UK Sixth Carbon Budget removals pathway to Scotland in line with its land area relative to the overall land area of the UK. Both pathways are adjusted in early years of deployment to only introduce removals from 2030. The pathway range has been recreated for illustrative purposes by allocating engineered removals from the UK Government's Net Zero Strategy ambition rather than the CCC's Sixth Carbon Budget Balanced Pathway. The lower and higher end of the range are reproduced by allocating overall UK ambition from the Net Zero Strategy Central Delivery Pathway to Scotland in line with its proportion of UK population and land area respectively.

3. Next steps

Scotland has substantial potential for deployment of engineered removals over the coming decades, but a robust estimate of this and optimal siting is needed.

Scotland has substantial potential for deployment of engineered removals over the coming decades. To ensure that this industry develops at the required pace, the Scottish Government should focus on detailed scoping of the removals potential in Scotland, the implications of future projects on other sectors and on emissions reduction pathways and coordination with the UK Government and other devolved administrations:

- **Scoping exercise.** Producing a robust estimate of the potential and optimal siting of engineered removals in Scotland will require a detailed scoping exercise to identify potential sites for new build and retrofit engineered removals projects that considers proximity to biomass stocks, access to future CCS networks and impacts on energy systems. This work should be completed by mid-2024 to ensure that potential developers are able to begin planning projects in time to dock into CCS networks once they are developed.

- **Implications on other sectors.** Given that Scotland is unlikely to meet the targets set out in the CCPu for engineered removals deployment by the late 2020s and early 2030s, re-evaluating the role of engineered removals in meeting the emissions targets will also mean identifying options for additional effort in other areas of the economy. Chapter 4 provides further detail on the cross-economy implications of the Scottish Government's 2030 emissions reduction target.

UK Government and devolved administrations should work together to coordinate the allocation of engineered removals towards meeting UK and constituent nations emissions reductions targets.

- **Cross-UK coordination.**

  – Improved coordination is needed between the UK Government and the devolved administrations to address target achievement issues that may arise from initial deployment of engineered removals in the UK being concentrated in a few sites and potentially in just one nation of the UK yet making up substantial parts of constituent nations 2030 targets.

  – By the end of 2023, the UK Government and the devolved administrations should work together to publish a joint position on the allocation of engineered and other removals towards contributing to UK-wide and constituent nation-targets. Specifically, the relevant governments should explore options for engineered removals in one nation to count towards the emissions reduction in another nation in the early years of deployment and discuss the legal, financial and governance-related questions associated with these potential arrangements.

Endnotes

[1] Office for National Statistics (2020) *Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland*, https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland

[2] Office for National Statistics (2013) *Region and Country Profiles (Archived)*, https://webarchive.nationalarchives.gov.uk/ukgwa/20150906051257/http://www.ons.gov.uk/ons/rel/regional-trends/region-and-country-profiles/region-and-country-profiles---key-statistics-and-profiles--october-2013/directory-of-tables.html

Chapter 4

Recommended targets and budgets

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Introduction and key recommendations

In this chapter we advise on whether Scotland's targets should be changed. Once Parliament has expressed its ambition by legislating targets, we apply the principle that methodological updates should only lead to a reduction in ambition in those targets where they have a material impact on their achievability. A recommendation for increasing ambition would only be given if there is a clear case that this is achievable.

Our key recommendations are:

- **Changes in emissions accounting methodology do not imply the need to change the Net Zero and 2030 and 2040 interim targets, as legislated by the Scottish Parliament.** Changes in emissions accounting methodology since the assumptions in our 2019 Net Zero advice[1] to Scotland have not significantly changed the feasibility of the targets. We continue to advise that these targets should be achieved through domestic action, without the use of emissions credits.
  - **The 2030 interim target.** In 2019, the Scottish Parliament legislated an interim target of a 75% reduction on 1990 levels by 2030, going beyond CCC advice. Our updated pathway to Net Zero by 2045 confirms that this remains extremely challenging and suggests a 65-67% reduction in Scotland's emissions by 2030 is both feasible and consistent with Scotland's Net Zero commitment. The legislated 2030 target means that policies must go further than the CCC's updated pathway.
  - **Net Zero and the 2040 interim target.** The Net Zero date of 2045 and 2040 target of a 90% reduction remain appropriate. Under the Climate Change (Scotland) Act, underperformance against targets (e.g. in the 2020s and early 2030s) requires equivalent outperformance of later targets (e.g. in the early 2040s) to compensate. Our updated pathway indicates that reductions beyond the legislated targets may be feasible from the mid-2030s onwards. However, until the extent of the required overperformance is clearer, we do not recommend that the targets be changed.
- **Scotland's annual targets in the 2020s should be adjusted.** The annual targets from 2021 to 2029 are set by a straight line between the 2020 and 2030 interim targets. However, the level of the 2020 interim target (which has already been achieved) was based on our 2017 advice[2] using an older accounting methodology, before significant changes to the treatment of peatland emissions in the inventory were introduced. We therefore recommend that the annual targets be adjusted to align with a translation of the legislated 2020 target to the new inventory basis. Without this adjustment, these already challenging annual targets will be made much more difficult to achieve, simply as an artefact of accounting.
- **The 'fair and safe' emissions budget (2010 to 2050)**. We recommend that the 'fair and safe' emissions budget be reduced to 1,028 $MtCO_2e$ from the currently legislated value of 1,240 $MtCO_2e$. This would make the budget consistent with the legislated target, assuming emissions remain at Net Zero from 2046-2050.

- **Crediting of carbon units.** Despite an extremely challenging 2030 target, we do not recommend crediting of carbon units (also known as carbon credits),* consistent with our established principle that emissions reduction targets should be met with domestic action.

- **Further policy action required.** If the 2030 target is to be met, major additional policy action, beyond that contained in any of our exploratory scenarios, is required immediately. We have considered some examples of additional steps that Scotland could take, which go beyond even our extremely ambitious Tailwinds scenario. These include increased heat pump roll-out, EV take-up and modal shifts in transport. We do not include these steps in our recommended pathway as we have not been able to demonstrate their feasibility. The Scottish Government must urgently quantify how it intends to achieve the 2030 target, including the feasibility of the measures in its plans.

- **Aviation multiplier.**

  – We recommend that the non-CO_2 warming effects from aviation are monitored and accounted for in climate policy. We recommend setting a minimum goal of no further warming after 2050 from non-CO_2 effects, in line with our advice to the UK Government.

  – However, we recommend that the aviation CO_2 emissions multiplier remains at one (equal to no multiplier). This is because of the short lifetime of non-CO_2 effects and their uncertainties, which mean that policies designed around a multiplier risk encouraging strategies (e.g. contrail avoidance or engine architecture changes) that may perversely increase CO_2 emissions.

The rest of the chapter is laid out as follows:

1. Target recommendations due to methodological changes
2. An updated pathway for Scotland
3. Sectoral contributions and traded emissions
4. Aviation multiplier

* Carbon credits come from funding GHG emission reductions in other countries, and the attribution of those reductions to the country funding them.

1. Target recommendations due to methodological changes

Changes in emissions accounting methodology do not significantly affect the achievability of the 2030, 2040 and Net Zero by 2045 targets.

Here we approach the question on whether targets should be changed, by considering only changes in emissions accounting methodology. We start from the legislated targets and translate these into the equivalent level of ambition using the latest emissions accounting methodology.

(a) The Net Zero date and the 2030 and 2040 interim targets

Our previous recommendation on the level of these targets was given in our 2019 Net Zero advice. We convert the legislated targets onto the new accounting methodology basis by the following steps:

- Start with the 1990-2016 inventory,[3] AR4 GWPs, and a high estimation of emissions from peatlands, as used in our 2019 Net Zero advice.*
- Adjust projected emissions to use AR5-low GWPs (to match international agreements at COP26). To make this adjustment, it is necessary to make an assumption about the balance of emissions of different GHGs in achieving a target set in $MtCO_2e$. To do this, we assume the level of non-CO_2 gas emissions in 2030, 2040 and 2045 in our Balanced Pathway for Scotland.
- Adjusting emissions in the land use sector to reflect various changes in the 1990-2017 inventory, recent changes to how peatlands are treated introduced in the 1990-2019 inventory[4] and reflecting a new method for estimating land use emissions introduced in the 1990-2020 inventory[5] (Chapter 2).
- Correcting for small changes to the inventory in non-land sectors since we set our advice by assuming the latest years (2020) proportional change in sectoral emissions to be constant throughout the pathway (Box 4.1).

These adjustments make very little difference to the level of the targets (Table 4.1, Figure 4.1). The reason the adjustments are so small is because our 2019 advice included a forward-looking estimate of the changes to how peatland emissions are estimated, which is the largest inventory update since our advice (Chapter 2). We therefore conclude that methodology updates do not make a significant difference to the achievability of the legislated targets. Since the legislated targets represent Scottish Parliament's ambition, we recommend they remain unchanged.

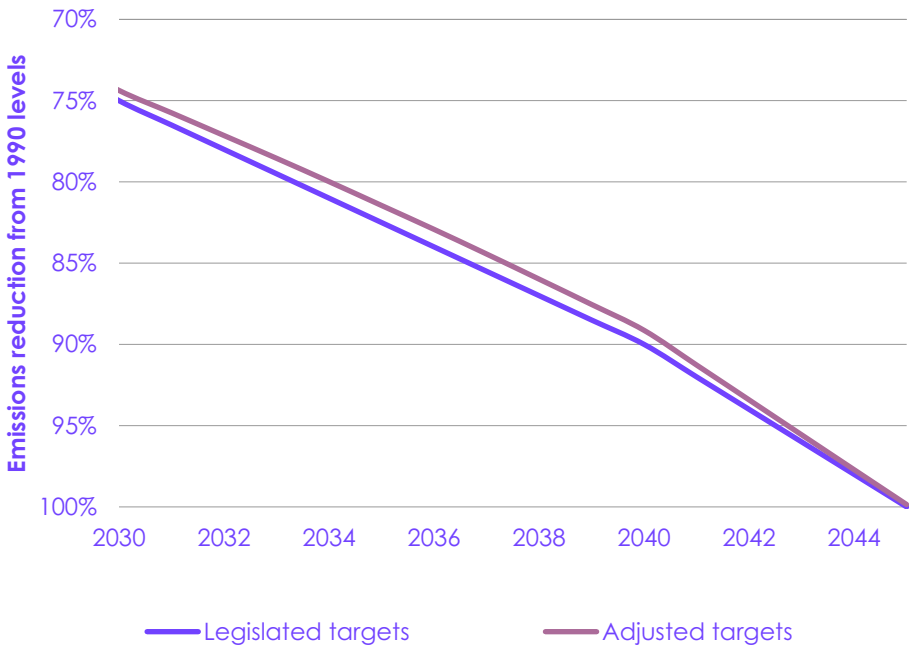
* Note that the high-peatland estimation in our 2019 Net Zero advice was slightly different to the estimation used in our Sixth Carbon Budget analysis, however both estimates significantly overestimated the corresponding increase in emissions.

Table 4.1
Consecutive changes to 2030, 2040 and Net Zero targets after adjusting for each methodology update

	1990 [$MtCO_2e$]	2030 [% reduction since 1990 / $MtCO_2e$]	2040 [% reduction since 1990 / $MtCO_2e$]	2045 [% reduction since 1990 / $MtCO_2e$]
Legislated targets	85	75% 21 $MtCO_2e$	90% 9 $MtCO_2e$	100% 0 $MtCO_2e$
Adjust for GWP change	87	74% 22 $MtCO_2e$	89% 9 $MtCO_2e$	99% 1 $MtCO_2e$
Adjust for GHGI land use change	84	74% 22 $MtCO_2e$	89% 10 $MtCO_2e$	99% 1 $MtCO_2e$
Adjust for GHGI changes in other sectors	**83**	**74%** **21 $MtCO_2e$**	**89%** **9 $MtCO_2e$**	**100%** **0 $MtCO_2e$**

Notes: 1) The emissions given in the first row are based on the 1990-2016 inventory with the estimate of peatland emissions from our 2019 Net Zero advice and GWPs from AR4. Each row gives emissions and percentage reductions for each consecutive adjustment. 2) The 2030, 2040 and 2045 emissions are mostly unchanged by the GHG Inventory land use change as the different changes cancel one another out, but this happens to a lesser extent for 1990 emissions.

Figure 4.1 Targets before and after methodological changes



Source: Scottish Government (2019) *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019;* CCC analysis.

(b) The annual targets in the 2020s

While the 2020 target has already been achieved, the level it is set at affects the level of the annual targets in the 2020s.

The 2020 interim target (which has already been achieved using the current GHG base inventory in the GHG Account) was based on our 2017 advice on the Scottish Climate Change Bill, which uses an older methodology for emissions accounting than our 2019 advice, with no forward-looking estimate of the upcoming changes to the treatment of peatland emissions in the inventory.

The annual targets for 2021 to 2029 are set by a straight line between the 2020 and 2030 interim targets. We therefore consider the effect on the annual targets in the 2020s due to the significant updates in methodology since we gave that advice.

- The legislated 2020 target for a 56% reduction equates to a reduction of 48.5% on the new basis.

- Setting the annual targets for 2021 onwards on the basis of a straight line from the 2020 target of 56% immediately makes the challenging annual targets from 2021 much harder to achieve. This is not about ambition, but rather an unfortunate and unforeseen consequence of the interplay between the procedure for setting the annual targets in the Climate Change (Scotland) Act and timing of this advice, which is one year too late to allow for a change to the 2020 interim target.

- Technical changes leading to the targets becoming unachievable is not the intention behind the Act. Indeed, the reason for its mechanisms around emissions accounting and the five-yearly reviews is to ensure that inventory changes on their own do not make the targets unachievable. There is a real risk that the targets being missed every year would undermine the credibility and strength of the Scottish framework for emissions reduction.

The annual targets in the 2020s should be adjusted to reflect recent changes in emissions accounting methodology, even if it requires a change to the Climate Change (Scotland) Act.

- We therefore recommend that the path for annual targets through the 2020s is drawn not based on the 56% target (which was on the old methodology) but on a translation of that 2020 target to the new inventory basis (i.e. 48.5%). This is appropriate, as these targets will be assessed against the new inventory methodology. The new recommended annual targets are given in Table 4.2. These should be updated even if it requires an adjustment to the Act to allow it, as without this change these already challenging annual targets will be made even more difficult to achieve, simply as an artefact of accounting. We also recommend that future advice on the level of the targets is requested in time to avoid a similar situation occurring again.

Table 4.2
Recommended annual targets in the 2020s

Year	Current target	Recommended target
2021	57.9%	51.1%
2022	59.8%	53.8%
2023	61.7%	56.4%
2024	63.6%	59.1%
2025	65.5%	61.7%
2026	67.4%	64.4%
2027	69.3%	67.0%
2028	71.2%	69.7%
2029	73.1%	72.3%

(c) Scotland's fair and safe emissions budget

Scotland's fair and safe emissions budget (2010-2050) should be consistent with the 2030 interim target.

The Climate Change (Scotland) Act currently sets a limit of total emissions in the period 2010 to 2050 to 1,240 $MtCO_2e$. This is the level we advised in our 2020 letter[6] to be consistent with our Balanced Net Zero Pathway, but this is inconsistent with Scotland's legislated 2030 target. We recommend it be changed to 1,028 $MtCO_2e$, making it consistent with the legislated interim targets and our recommended annual targets in the 2020s, assuming emissions remain at Net Zero from 2046 to 2050. This value is calculated using the latest GHG Inventory for 2010-2020 historical emissions, with AR5-low GWPs.

(d) Crediting carbon units

The usage of international carbon units to substitute for domestic emissions reductions could legitimise other countries to weaken their commitments to domestic actions.

To meet highly challenging targets presents risks in terms of the public acceptability of some measures, such as those rolled out at pace before full confidence in the supply chain has been achieved, or how the costs will be met and allocated fairly. However, we do not recommend the crediting of carbon units, either from within or outside the UK. Scotland has an internationally influential record of domestic emissions reductions. The usage of international carbon units to substitute for domestic emissions reductions could undermine this influence and legitimise other countries to weaken their commitments to the domestic actions required to meet their targets.

2. An updated pathway for Scotland

We present an updated pathway for Scotland including GHG removals and increased ambition compared to our Balanced Pathway in some sectors.

In this section we present an updated pathway for Scotland and compare it to the legislated targets and our recommended targets. We start with our Balanced Pathway from our Sixth Carbon Budget advice and make a series of technical adjustments (Box 4.1).

In addition to these technical adjustments, we make two substantive changes to the pathway:

- Allocation of a range for possible engineered GHG removals to Scotland assuming the Scottish CCS Cluster will be a Track 2 cluster (Chapter 3). Previously we had not specifically allocated UK removals to Scotland, but rather checked that Net Zero is achievable based on feasible emissions reduction plus potential for removals in Scotland. This introduces an uncertainty range in what level of emissions cuts will be possible.

- Going further in ambition than our updated Balanced Pathway by implementing measures from our highly ambitious Tailwinds scenario in sectors with sufficient devolved policy powers (Table 4.3). All other sectors retain the updated Balanced Pathway emissions.

The expected emissions reduction in 2030 in our updated pathway is 65-67%, significantly less the 75% legislated target.

The effect of the changes on the expected emissions reductions in 2030, 2040 and 2045 are summarised in Table 4.3 and Figures 4.2, 4.3 and 4.4, where they are also compared to the legislated targets and our recommended targets. The expected emissions reduction in 2030 from our most up to date pathway is 65-67%, which is significantly less than the 75% target. Conversely, emissions reductions by 2040 range from 91% to 101% and the Net Zero date ranges from 2040 to 2045, both broadly in line with the current targets of 90% by 2040 and Net Zero by 2045.

While the 2030 target continues to be more ambitious than our pathway, we do not recommend reducing the ambition of legislated targets chosen by the Scottish Parliament, unless methodology changes make them significantly harder to achieve. Reducing ambition of legislated targets for other reasons sends a potentially damaging international signal that it is acceptable to set ambitious targets and then later reduce ambition. This is not in line with the ratchet mechanism of the Paris Agreement, where ambition should only be raised in updated targets rather than lessened. A similar philosophy should be applied to domestic targets.

The 2040 and 2045 Net Zero targets are consistent with our updated pathway.

Our updated analysis indicates that it may be possible to slightly outperform the existing 2040 interim target and 2045 Net Zero target. However, given substantial risks to meeting the 2030 interim target, the anticipated outperformance of targets around 2040 may instead be needed to compensate for underperformance against targets around 2030. There also remains considerable uncertainty in these projections, for example on the extent of GHG removals in Scotland and on the emissions estimation methodology that will be used at the time of later targets.

Given the difficulties in reducing the ambition of a legislated target once set, we do not recommend increasing the ambition on these targets until there is more clarity on these issues.

Box 4.1
Technical updates to the Balanced Pathway

We have updated our pathway for Scotland, initially developed as part of our UK Sixth Carbon Budget analysis, by making a series of technical adjustments:

- Updates to our pathways for electricity supply and manufacturing and construction, to make corrections and updates to the input data and modelling assumptions.
- For electricity supply, this is to restart the Peterhead gas power station with CCS in 2030 rather than 2036.
- For manufacturing and construction, these include using a newer model version, assuming carbon capture rates of 90% rather than 95%, incorporating updated off-road mobile machinery data and resolving a double counting of wood in construction from the resource efficiency inputs.
- Adjustment to the residential buildings, fuel supply and manufacturing and construction emissions with a more realistic allocation of UK emissions between the four nations of the UK.
- Use of AR5-low GWPs (to match international agreements at COP26). The Sixth Carbon Budget analysis used AR5-high GWPs, as a decision on which to use had not yet been taken.
- Adjustment of emissions in the land use sector to reflect changes introduced in the 1990-2019 inventory to the treatment of peatlands and reflecting a new method for estimating land use emissions introduced in the 1990-2020 inventory (see Chapter 2).
- Update to the modelling of tree-planting cycles to be closer to that used in the inventory (see Chapter 2).
- Correction for other small changes in sectors other than land use in the inventory since we set our advice, by assuming the latest reported year's (2020) proportional change in sectoral emissions to be constant throughout the pathway:
  - Agriculture: revisions including some relating to beef cattle live weights, milk yields and livestock numbers (1990-2019 inventory).
  - Waste management: emissions reductions due to recalculations in industrial wastewater treatment, and incorporation of a BEIS review of models used to estimate emissions (1990-2019 inventory).
  - Domestic transport: revision in road transport emissions due to updates from minor roads data, leading to an increased estimate of vehicle-kms travelled (1990-2019 inventory).
  - Energy supply: revisions due to methodology improvements.
  - Business: integration of new mapping grids for the use of fuels at industrial sites, relocation of stationary combustion in iron and steel within the UK inventory, and recalculations in the Digest of United Kingdom Energy Statistics (DUKES) activity data.
  - Residential and public combustion: recalculations due to revisions to the mapping grid analysis of fuel used in domestic and public combustion, and DUKES recalculations.

Source: Scottish Government emissions statistics

Table 4.3
Extra abatement in 2030 by going as fast as the CCC's ambitious Tailwinds scenario in some sectors

Sector	Action in Balanced Pathway in 2030	Action in Tailwinds in 2030	Extra emissions reduction
Buildings (not including F-gases)	• 581,000 homes converted to low-carbon heating by 2030. • 3.2 million new energy efficiency measures installed in homes between 2023 and 2030.	• 616,000 homes converted to low-carbon heating by 2030, 35,000 more than the Balanced Pathway, although fewer than the Scottish Government's target. • 4.5 million new energy efficiency measures installed in homes between 2023 and 2030.	0.3 $MtCO_2e$
Surface transport	• Phase-out of fossil fuel car sales towards zero by 2032. • 5% increase in car-km demand relative to 2019 levels. • Increasing new vehicle sales for Battery Electric Vehicle (BEV) buses and HGVs towards 100% by 2044 and 2045, respectively. • In 2030, 84% of new freight trains are diesel-electric.	• Phase-out of fossil fuel car sales by 2030 • 5% decrease in car-km demand relative to 2019 levels. • Faster zero-emission HGVs/bus adoption. New vehicle sales for BEV buses and HGVs towards 100% by 2040. • Faster rate of rail electrification. • The number of diesel-electric passenger trains operating in 2050 in 33% lower than in the Balanced Pathway. • Increasing electric freight trains towards two-thirds of all new freight trains from the mid-2030s.	0.5 $MtCO_2e$
Aviation (limiting demand growth only)	• 4% reduction in demand relative to 2019 levels.*	• 13% reduction in demand relative to 2019 levels.	0.3 $MtCO_2e$
Agriculture	• Take up ranges between 50–75% for behavioural and innovation measures in low-carbon farming. • Wheat yields increase by 10% to 8.8 tonnes/ha. • Food waste is reduced to 50% of 2007 levels, and there is a 20% shift away from all meat and dairy products, substituted by plant-based proteins. • Decarbonisation of energy focuses on biofuels, heat pumps and hydrogen.	• Farmers adopt a higher uptake of low-carbon innovation measures (60-80%). • Wheat yields increase by 17% to 9.4 tonnes/ha, with the extra increase in yields relative to the Balanced Pathway due to developments in crop breeding. • Decarbonisation of energy use focuses on electrification, with biomass and biodiesel as a transition fuel.	0.6 $MtCO_2e$

* The reduction in demand relative to 2019 levels includes the lasting impact of the COVID-19 pandemic for both the Balanced Pathway and Tailwinds scenarios. Passenger demand is permitted to grow by 25% by 2050 under the Balanced Pathway but declines by 15% under the Tailwinds scenario.

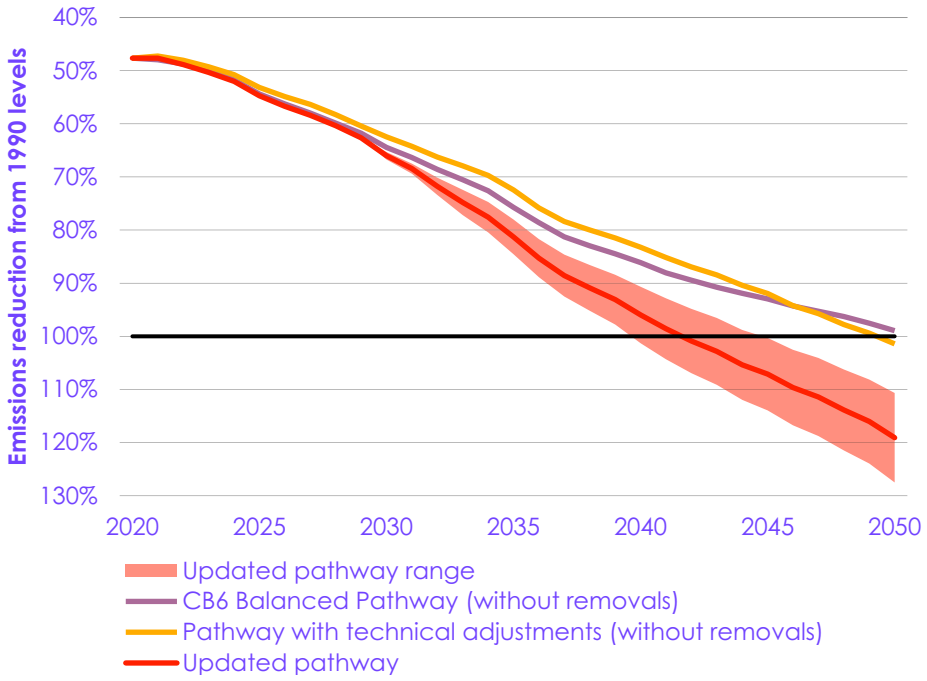
		• Ambition for diet change and food waste is the same as for the Balanced Pathway but diverges beyond 2030. Diet change substitutes meat and dairy with plant-based proteins and lab-grown meat.	
Waste	• 0.4 $MtCO_2e$ of landfill emissions abated in 2030. • Energy from Waste with CCS starts delivering carbon savings by 2045.	• 0.6 $MtCO_2e$ of landfill emissions abated in 2030 due to increased methane capture and oxidation rates at landfill sites. • Energy from Waste with CCS starts delivering carbon savings by 2032.	0.2 $MtCO_2e$
Total			**2.0 $MtCO_2e$**

Table 4.4
Expected emissions after each adjustment to our Balanced Pathway

	1990 [$MtCO_2e$]	2030 [% reduction since 1990 / $MtCO_2e$]	2040 [% reduction since 1990 / $MtCO_2e$]	2045 [% reduction since 1990 / $MtCO_2e$]
Sixth Carbon Budget Balanced Pathway (without removals allocated to Scotland)	91	64% 32 $MtCO_2e$	86% 13 $MtCO_2e$	93% 6 $MtCO_2e$
Adjusted for updates to our buildings, electricity supply, fuel supply and M&C pathways	91	63% 34 $MtCO_2e$	86% 13 $MtCO_2e$	93% 7 $MtCO_2e$
Adjusted for GWP change	87	63% 32 $MtCO_2e$	87% 11 $MtCO_2e$	95% 4 $MtCO_2e$
Adjusted for GHGI land use change	84	62% 32 $MtCO_2e$	83% 14 $MtCO_2e$	92% 7 $MtCO_2e$
Adjusted for GHGI changes in other sectors	83	62% 31 $MtCO_2e$	83% 14 $MtCO_2e$	92% 7 $MtCO_2e$
With allocated removals to Scotland	83	63-64% 30-31 $MtCO_2e$	87-97% 2-11 $MtCO_2e$	97-110% (-8)-3 $MtCO_2e$
Adjusted to Tailwinds in some sectors – our updated pathway	83	65-67% 28-29 $MtCO_2e$	91-101% (-1)- 8 $MtCO_2e$	101-114% (-12)- 0 $MtCO_2e$
Current target		**75%**	**90%**	**100%**

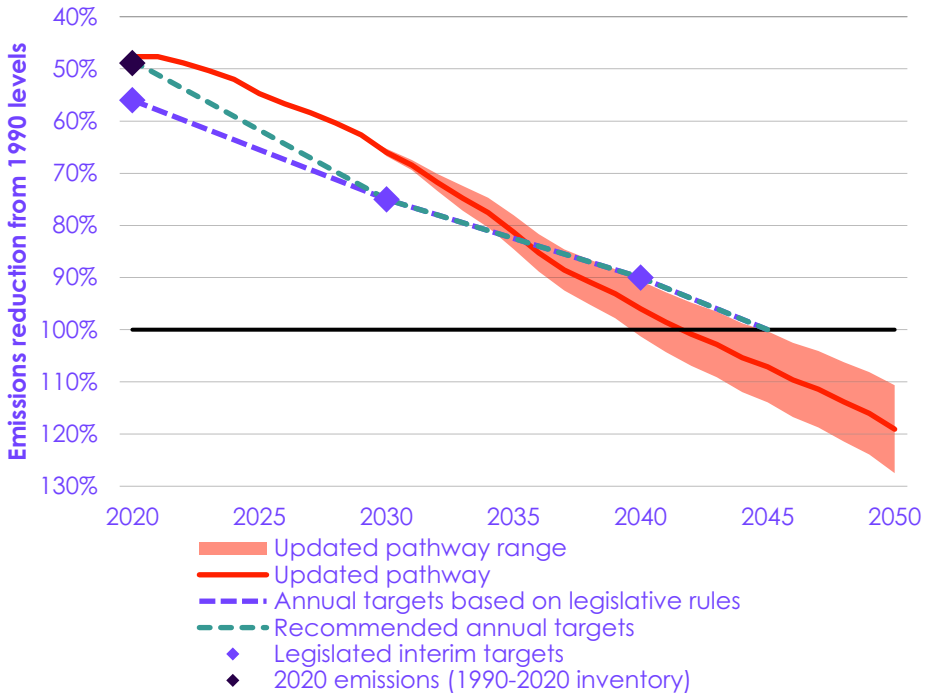
Our updated pathway continues to fall short of the legislated 2030 target. It would start meeting the annual targets from the mid-2030s.

Figure 4.2 Our updated pathway for Scotland compared to our Balanced Pathway



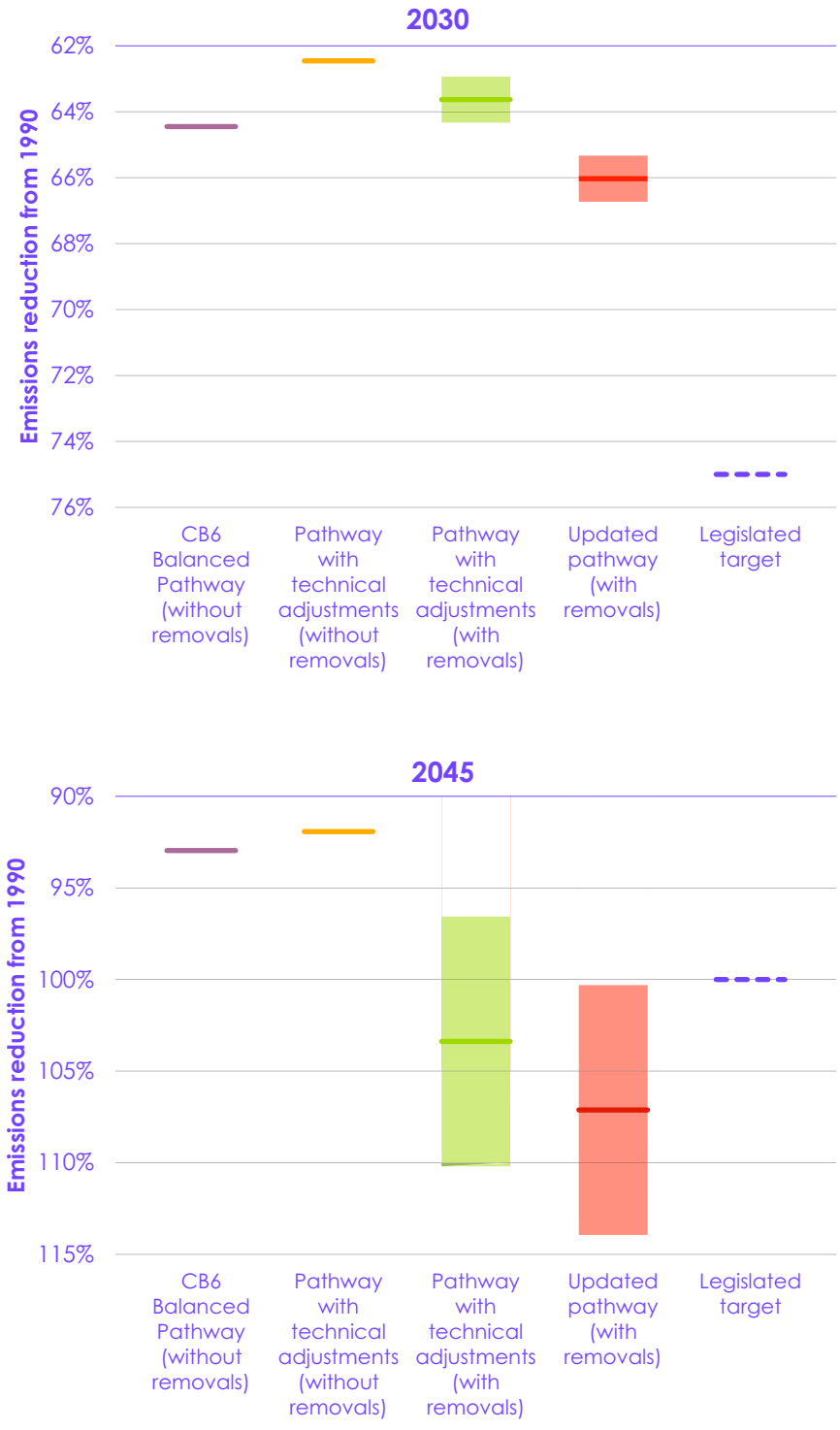
Source: CCC analysis.
Notes: The range in the updated pathway comes from a range in our pathway for engineered removals. CB6 refers to the CCC's Sixth Carbon Budget.

Figure 4.3 Our updated pathway for Scotland compared to 2020 emissions and the targets



Source: Scottish Government (2019), *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019;* CCC analysis.
Notes: The range in the updated pathway comes from a range in our pathway for engineered removals. The pathway values are based on 1990-2020 inventory methodology.

Figure 4.4 Our updated pathway for Scotland compared to our Balanced Pathway and the targets for 2030 and 2045



Source: Scottish Government (2019), *Climate Change (Emissions Reduction Targets) (Scotland) Act 2019;* CCC analysis.
Note: CB6 refers to the CCC's Sixth Carbon Budget.

(a) Going further than our recommended pathway by 2030

There is a remaining gap of 7-8 $MtCO_2e$ between our updated pathway and the 2030 75% target. The Scottish Government needs to quantify how its policies will meet its 2030 target.

Our updated pathway, which goes as far as our highly ambitious Tailwinds scenario in some sectors, does not reach a 75% reduction in emissions until 2033-2034, indicating that Scotland will need to decarbonise faster than we would recommend in the next eight years. There is a remaining gap of 7-8 $MtCO_2e$ required to meet Scotland's 2030 target.

In order to indicate the scale of this challenge, we have considered some extreme steps the Scottish Government could take by 2030, going even further than Tailwinds in some sectors, that might be able to bridge this remaining gap:

- 0.9 $MtCO_2e$ of extra abatement with a 20% reduction in car-km compared to 2019 levels by 2030 (as committed to in the CCPu). This is four times the 5% demand reduction assumed in our Tailwinds scenario.*
- 0.5 $MtCO_2e$ of extra abatement with 0.25 million more BEVs than the 1 million in the Tailwinds scenario. This equates to 47% of the total Scottish car fleet being BEVs by 2030. For comparison, the UK Net Zero Strategy assumes 24% of the UK car fleet being BEVs by 2030.†
- 1.0 $MtCO_2e$ of extra abatement by meeting the Scottish target of 1.2 million homes on low-carbon heat by 2030 (compared to 616k in Tailwinds).
- 0.1 $MtCO_2e$ of extra abatement by reducing aviation demand growth by 25%, compared to 15% in Tailwinds.
- 1.0 $MtCO_2$ of additional engineered removal of CO_2. This would be conditional on CCS networks in Scotland being developed at pace as part of the UK Government's Track 2 cluster process and should only be pursued if any Scottish BECCS projects are using sustainable feedstocks and any additional DACCS is not diverting green hydrogen or low-carbon electricity away from decarbonising industry.

It should be noted that we are not necessarily recommending these additional steps. As a minimum, there should be consideration of their achievability, the embodied emissions from scrappage, the build-up of the relevant workforce and supply chains, public acceptance and ensuring that the changes are implemented in a fair way. It is up to the Scottish Government to outline and quantify how it intends to achieve the extremely ambitious 2030 target.

* The demand reduction assumed in our Tailwinds scenario was higher than this, at 16% by 2030. However, this was relative to a baseline with increasing vehicle-kms from 2019 to 2030 and before considering the impacts of rebound effects, whereby cheaper-to-run EVs drive more miles. These two factors reduced the absolute level of demand reduction in Tailwinds to 5% by 2030 against 2019 levels.

† This abatement estimate assumes the 20% demand reduction has already occurred.

Table 4.5 shows our updated pathway for Scotland split by sector. It does not add up to what is needed to meet the legislated 2030 target, and it will be up to the Scottish Government to determine how to address the shortfall.

Under Scottish targets, emissions are counted on the basis of actual emissions in each sector. However, following the requirement of the Act to set out the balance between emissions covered and not covered by the ETS, we have included the split in our assessment of the targets. The sectors which are partly covered by the UK Emissions Trading Scheme (UK ETS) are electricity generation, industry and aviation.

Table 4.5
Updated pathway split by sector

Sector	1990 [$MtCO_2e$]	2019 measured [% reduction from 1990 / $MtCO_2e$]	2030 [% reduction from 1990 / $MtCO_2e$]	2040 [% reduction from 1990 / $MtCO_2e$]	2045 [% reduction from 1990 / $MtCO_2e$]	Covered by the UK ETS?
Transport	15	6% 14 $MtCO_2e$	44% 8 $MtCO_2e$	83% 3 $MtCO_2e$	93% 1 $MtCO_2e$	Partly
Industry	20	48% 11 $MtCO_2e$	67% 7 $MtCO_2e$	96% 1 $MtCO_2e$	98% 0 $MtCO_2e$	Partly
Buildings	11	23% 9 $MtCO_2e$	49% 6 $MtCO_2e$	86% 2 $MtCO_2e$	96% 0 $MtCO_2e$	Not covered
Agriculture	9	13% 8 $MtCO_2e$	39% 5 $MtCO_2e$	52% 4 $MtCO_2e$	57% 4 $MtCO_2e$	Not covered
Electricity	15	87% 2 $MtCO_2e$	97% 0 $MtCO_2e$	97% 0 $MtCO_2e$	97% 0 $MtCO_2e$	Partly
Waste	7	74% 2 $MtCO_2e$	90% 1 $MtCO_2e$	94% 0 $MtCO_2e$	95% 0 $MtCO_2e$	Not covered
Land use	6	78% 1 $MtCO_2e$	72% 2 $MtCO_2e$	91% 1 $MtCO_2e$	143% -3 $MtCO_2e$	Not covered
Engineered removals	0	n/a 0 $MtCO_2e$	n/a (-2)-0 $MtCO_2e$	n/a (-12)-(-3) $MtCO_2e$	n/a (-15)-(-4) $MtCO_2e$	Not covered
Shortfall		10% 9 $MtCO_2e$	8-10% 7-8 $MtCO_2e$	(-11)-(-1)% (-9)-(-1) $MtCO_2e$	(-14)-0% (-12)-0 $MtCO_2e$	

4. Aviation multiplier

We do not recommend the use of a multiplier to reflect the non-CO_2 climate change impacts of emissions at altitude from international aviation. Instead, we recommend setting a minimum goal of no further warming after 2050 from non-CO_2 effects.

We do not recommend the use of a multiplier to reflect the non-CO_2 climate change impacts of emissions at altitude from international aviation.

While non-CO_2 effects from aviation are substantial, combining CO_2 and non-CO_2 effects would involve mixing uncertain short and certain long-term effects. The climate impacts of non-CO_2 effects are shorter-lived than those of CO_2 and the magnitude varies with the level of aviation activity (unlike CO_2, which will continue to warm the climate even if emissions were stopped).

The short lifetime and uncertainty of non-CO_2 effects mean that policies designed around a multiplier risk encouraging strategies such as contrail avoidance or changes to engine design that might perversely increase CO_2 emissions:

- For example, flights can be re-routed to avoid climatic regions that are sensitive to the effects of non-CO_2 emissions. However, these new routes have the potential to raise CO_2 emissions due to their increased length.

- Similarly, improving thermal efficiency (the effectiveness with which available chemical energy is turned into mechanical energy) is associated with lower CO_2 emissions. However, the engine architecture adjustments used to address this can lead to higher peak temperatures and chemical reaction rates, enhancing NO_x formation.

- If there are incentives to reduce non-CO_2 effects from policies developed via an aviation multiplier, airlines may choose to address NO_x by using new engine technologies, e.g. which use intercooling and lean-burn combustion. However, relative to conventional engine design, the lean-burn concepts are slightly less efficient and heavier relative to more conventional combustor designs, thus potentially increasing CO_2 emissions.[7]

Instead, we recommend that the Scottish Government starts monitoring non-CO_2 effects of aviation and sets a minimum goal of no further warming after 2050 from non-CO_2 effects, in line with our advice to the UK Government.

Endnotes

1 Climate Change Committee (2019) *Net Zero – The UK's contribution to stopping global warming,* https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

2 Climate Change Committee (2017) *Advice on the new Scottish Climate Change Bill,* https://www.theccc.org.uk/publication/advice-on-the-new-scottish-climate-change-bill/

3 Scottish Government (2018) *Scottish greenhouse gas emissions 2016,* https://www.gov.scot/publications/scottish-greenhouse-gas-emissions-2016/documents/

4 Scottish Government (2021) *Scottish Greenhouse Gas Statistics 2019,* https://www.gov.scot/publications/scottish-greenhouse-gas-statistics-1990-2019/

5 Scottish Government (2022) *Scottish Greenhouse Gas Statistics 2020,* https://www.gov.scot/publications/scottish-greenhouse-gas-statistics-2020/

6 Climate Change Committee (2020) *Letter: Lord Deben, Climate Change Committee to Roseanna Cunningham MSP,* https://www.theccc.org.uk/publication/letter-lord-deben-climate-change-committee-to-roseanna-cunningham-msp/

7 Sustainable Aviation (2017) *Inter-dependencies between emissions of CO2, NOx & noise from aviation*, https://www.sustainableaviation.co.uk/wp-content/uploads/2018/06/FINAL__SA_InterDependencies_2017.pdf

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Scottish Emissions Targets - first five-yearly review

Climate Change Committee
1 Victoria Street
Westminster
SW1H 0ET

www.theccc.org.uk
@theCCCuk

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