March 2023

Advice report: The path to a Net Zero Northern Ireland

Climate Change Committee

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Contents

Acknowledgements

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Executive summary

Introduction and key messages

In 2022, Northern Ireland legislated an extremely stretching legal target to reach Net Zero greenhouse gas emissions by 2050, going significantly beyond the CCC's advice on what would be a fair and achievable contribution from Northern Ireland to the achievement of UK-wide Net Zero emissions.

In this report we provide advice to Northern Ireland on how the legislated target might be reached, and on the levels for the 2030 and 2040 interim targets and the First (2023-2027), Second (2028-2032) and Third (2033-2037) Carbon Budgets on the path to it.

There are essential new policy requirements for the Northern Ireland Executive in meeting the Net Zero legal target and the interim targets advised in this report. So far, the Committee has not seen evidence of policy ambition at this scale in Northern Ireland. That must change. This report is designed to illustrate the actions and outcomes that policies must drive to achieve decarbonisation at the pace required. The Committee will move to monitoring the progress of policy implementation after this report.

Our key messages are:

- The CCC's 2020 Balanced Pathway has been updated for this report, containing actions in Northern Ireland consistent with UK Net Zero by 2050. It only reaches an 83% reduction in Northern Ireland's emissions compared to levels in 1990 by 2050. This pathway is already very ambitious, with most sectors decarbonising almost completely. Residual emissions in 2050 come predominantly from the agriculture sector, which has a greater share of economic activity in Northern Ireland than in the UK as a whole, making Net Zero much more challenging to achieve for Northern Ireland. This is the implication of the new legal Net Zero target.

- We have developed a 'Stretch Ambition' pathway that reaches a 93% reduction in emissions on 1990 levels by 2050 and requires Northern Ireland to take the following stretching actions to bolster the contribution of greenhouse gas removals and therefore balance some of the residual emissions from agriculture:

  - A rapid ramp up in afforestation rates to reach 3,100 hectares per year by 2035, six times the rates reported in 2021/22.

  - Inclusion of engineered removals based on carbon capture and storage (CCS) from both solid biomass grown in Northern Ireland and anaerobic digestion of wastes to produce biomethane. This entails CO_2 capture in Northern Ireland and transportation (e.g. shipping) to store the CO_2 elsewhere, and would require significant investment and infrastructure development.

- These are radical actions, but even with their achievement we estimate that there remains a gap to the legislated Net Zero target. We have therefore considered two 'speculative' pathways, one with deployment of direct air capture of CO_2 (DAC) technology, which is expected to have high costs and may be difficult to deliver at scale in time, and another where livestock numbers are approximately halved by 2050, going significantly further than the reduction of almost a third in our Balanced Pathway.

Our assessment is that some DAC deployment would be required, but that the further reduction in livestock numbers would reduce this need significantly. It is up to Northern Ireland to decide whether to pursue other speculative options to reduce net emissions in addition to DAC.

- Using the 'speculative' option based on direct air capture of CO_2 without the further reductions in livestock numbers, we conclude that the targets consistent with the legislated Net Zero target are:
  - the First, Second and Third Carbon Budgets to be set at levels that have average annual reductions of 33%, 48% and 62%, on 1990 levels, respectively; and
  - the 2030 and 2040 interim targets to be set at reductions of 48% and 77% on 1990 levels, respectively.

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

1. Our updated Balanced Pathway for Northern Ireland
2. Going further to reach Net Zero
3. Near-term action required to get on track to the targets

1. Our updated Balanced Pathway for Northern Ireland

Northern Ireland does not reach Net Zero under our Balanced Pathway due to residual emissions from its large agriculture sector and it not being geologically optimal for engineered removals.

The Committee's Balanced Pathway, developed as part of our advice on the UK's Sixth Carbon Budget, reaches Net Zero greenhouse gas emissions for the UK as a whole by 2050. The pathway was developed by reconciling contributions to reductions of global emissions with practicalities such as the time to develop infrastructure and to build up skills and supply chains, while limiting early scrappage of existing assets such as boilers and cars. Net Zero for the UK as a whole relies on significant deployment of engineered greenhouse gas removals.

Northern Ireland does not reach Net Zero under the Balanced Pathway due to residual emissions from its large agriculture sector and the fact that none of the UK's engineered removals (i.e. those reliant on carbon capture and storage – CCS) were allocated to Northern Ireland, which is not geologically optimal for CO_2 storage.

After some technical updates and assuming a delayed start to the actions required in agriculture, land use and waste to reflect the lack of recent progress in these sectors, our updated Balanced Pathway for Northern Ireland leads to a total of 4.8 $MtCO_2e$ emissions in 2050, which is an 83% reduction in emissions compared to 1990 levels (Figure 1).

The updated Balanced Pathway is already extremely challenging, seeing most sectors almost completely decarbonised by 2050.

The updated Balanced Pathway is already extremely challenging, seeing most sectors almost completely decarbonised by 2050. This requires:

- Decarbonising electricity generation in Northern Ireland whilst meeting rising demand;
- All new car and van sales to be zero-emissions in the first half of the 2030s;
- All new heating appliances installed in Northern Ireland to be zero-carbon by 2033, and by 2030 for properties off the gas grid, with substantial improvements to the energy efficiency of buildings;
- A reduction in Northern Irish livestock numbers of almost a third and the widespread adoption of low-carbon farming practices; and
- A significant increase in peatland restoration and afforestation.

Even with all these ambitious actions, Northern Ireland would fall well short of Net Zero emissions. More radical action will be required to reach the 2050 target.

Northern Ireland's emissions in 2050 under the Balanced Pathway come predominantly from the agriculture sector.

Figure 1 Northern Ireland's emissions in 2050 in the updated Balanced Pathway

Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry.

2. Going further to reach Net Zero

Closing the gap to Net Zero in Northern Ireland must rely on deployment of greenhouse gas removals at scale and/or a further reduction in agriculture emissions.

Residual emissions in our updated Balanced Pathway in 2050 are mostly in the agriculture sector (Figure 1). There is extremely limited scope for additional action in most other sectors to contribute further to reaching Net Zero, as they are almost completely decarbonised already by 2050 in the Balanced Pathway. Closing the gap to Net Zero in Northern Ireland must therefore fall primarily to some combination of a reduction in agriculture emissions beyond that in the Balanced Pathway and/or deployment of greenhouse gas removals at scale.

To address this shortfall to Net Zero, we have developed a 'Stretch Ambition' pathway, including the following stretching actions that Northern Ireland could take to increase the role for both land-based and engineered greenhouse gas removals to balance residual emissions (Figure 2):

- Increasing annual afforestation rates to reach 3,100 hectares by 2035 and 4,100 hectares by 2039 remaining at this level until 2050. This is consistent with our Tailwinds scenario but with new planting delayed until 2024 given the slow progress since 2020. This relies on the land freed up by reducing cattle and sheep numbers by around 18% by 2030 as assumed in our Balanced Pathway for agriculture.

- Including engineered removals, sequestering carbon from both solid biomass grown in Northern Ireland and anaerobic digestion of wastes used to produce biomethane, together with CO_2 capture and transport infrastructure. Due to the lack of suitable storage locations within Northern Ireland, an agreement to store the CO_2 elsewhere would be needed. These options would require significant investment and infrastructure development.

Even with this additional radical action, Northern Ireland will need to consider further speculative actions to reach Net Zero.

These are radical options, but even with these included there is a remaining shortfall of 1.8 $MtCO_2e$ (Figure 2). We therefore consider a further set of 'speculative options'. It may be possible to close this remaining gap and reach Net Zero by 2050 with one or more of the following options:

- Balance the residual emissions with further engineered removals using direct air carbon capture technologies and transporting the CO_2 to be stored elsewhere. This would ramp up from 2035 and is expected to cost at least £180/tCO_2.

- Follow our Tailwinds scenario for agriculture, which would require livestock numbers to approximately halve by 2050. This would also involve a reduction in methane emissions of 56% on 1990 levels, going beyond the legislated requirement that reaching Net Zero in Northern Ireland does not rely on reducing methane emissions by more than 46% on 1990 levels by 2050, implying this requirement may need to be revised. This option alone does not fully bridge the gap to Net Zero, with 0.9 $MtCO_2e$ remaining in 2050.

- Consider other speculative options such as enhanced weathering (a form of greenhouse gas removal), although there is insufficient evidence at this point to enable us to advise on whether they can contribute and by how much.

While it is worth considering the roles that such alternative options could take, any plan now for delivery of Net Zero would not be credible with significant reliance on them.

It is up to Northern Ireland to determine the exact details of the actions to reach Net Zero, considering the benefits and challenges of these options. Figure 3 shows two pathways each with use of one of the first two speculative options. The option with direct air capture has a slightly slower decarbonisation rate initially. Choosing a set of targets based on this path for emissions on the way to Net Zero by 2050 would therefore enable Northern Ireland to choose a mix of the speculative options we have outlined.

This 'Speculative DAC' pathway is the only one that reaches Net Zero by 2050. It has similar agriculture emissions to our Balanced Pathway, but with a significant increase in sequestered CO_2 (Figure 4). The 'Speculative Agriculture' pathway has lower agricultural methane emissions and a somewhat lesser role for engineered greenhouse gas removals, and does not reach Net Zero by 2050 – it would need to be supplemented with additional removals to do so.

Our advice on the Carbon Budgets, interim and annual targets is based on the 'Speculative DAC' pathway (Table 1). The Carbon Budgets are defined as average annual percentage reductions of emissions compared to 1990 levels.

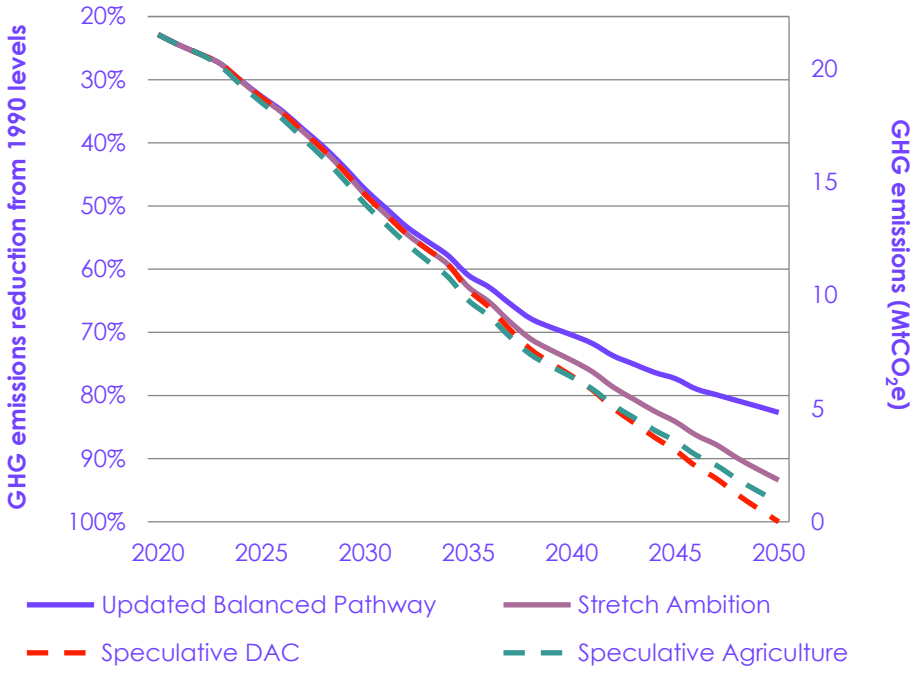
Even with the radical action in our Stretch Ambition scenario, there is a remaining shortfall to reaching Net Zero in Northern Ireland.

Figure 2 Emissions reductions in 2050 beyond the updated Balanced Pathway

Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas.

Our advice on the interim targets and Carbon Budgets is based on the speculative option with direct air carbon capture.

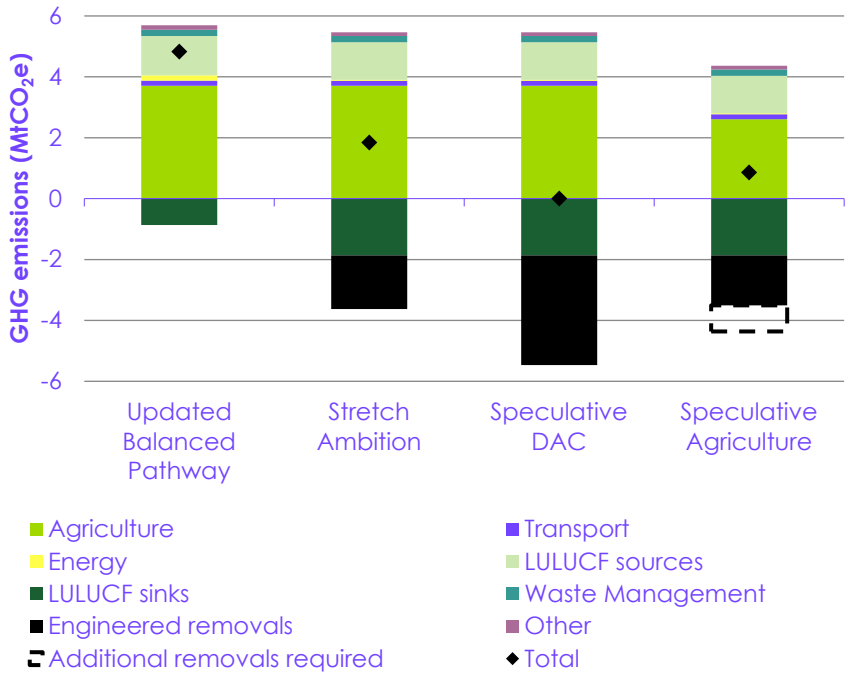
Figure 3 Pathways to 2050 for Northern Ireland



Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas.

Emissions in Northern Ireland in 2050 are predominantly a balance between agriculture and removals. The only speculative option that reaches Net Zero is that with direct air carbon capture and storage.

Figure 4 Northern Ireland's emissions in 2050



Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry.

Table 1
Advised Carbon Budgets and interim targets

	First Carbon Budget (2023-2027)	Second Carbon Budget (2028-2032)	2030 interim target	Third Carbon Budget (2033-2037)	2040 interim target
Target commensurate with Net Zero [% reduction since 1990]	33%	48%	48%	62%	77%

3. Near-term action required to get on track to the targets

Emissions need to reduce by around 35% in the next decade, compared to an average of 9% per decade since 1990. A step change in action is needed now.

Northern Ireland's First Carbon Budget period has just begun. Now policy and action on decarbonisation must ramp up. Under our Stretch Ambition pathway, average annual emissions will need to be 16% lower than 2019 levels by 2025 and 35% lower by 2030. With emissions having reduced only an average of 9% per decade since 1990, a step change in action is needed now.

Under our Stretch Ambition pathway, sizable emissions reductions will be required in all sectors in the next decade, requiring significant near-term action:

Rapid emissions reductions are needed across all sectors of the economy.

- **Agriculture: 6 $MtCO_2e$ in 2020 (up 6% since 2010); emissions will need to fall 21% from 2020 to 2030.** Livestock is the main source of Northern Ireland's agricultural emissions. In the Stretch Ambition pathway, numbers of livestock fall by 12% by 2030, with a rapid uptake in low-carbon farming.

- **Transport: 4 $MtCO_2e$ in 2019 (down 6% since 2010); emissions will need to fall 43% from 2019 to 2030.** New electric car sales were 10% in 2021. In the next decade this needs to scale up to all new cars and vans being zero-emission, underpinned by major investment to expand the electric vehicle charging infrastructure.

- **Buildings: 3 $MtCO_2e$ in 2020 (up 1% since 2009); emissions will need to fall 33% from 2020 to 2030.** By 2030 for homes off-gas grid and 2033 for homes on-gas grid, all new heating appliance installations should be zero-carbon. This has implications for supporting infrastructure, including the necessary strengthening of electricity networks.

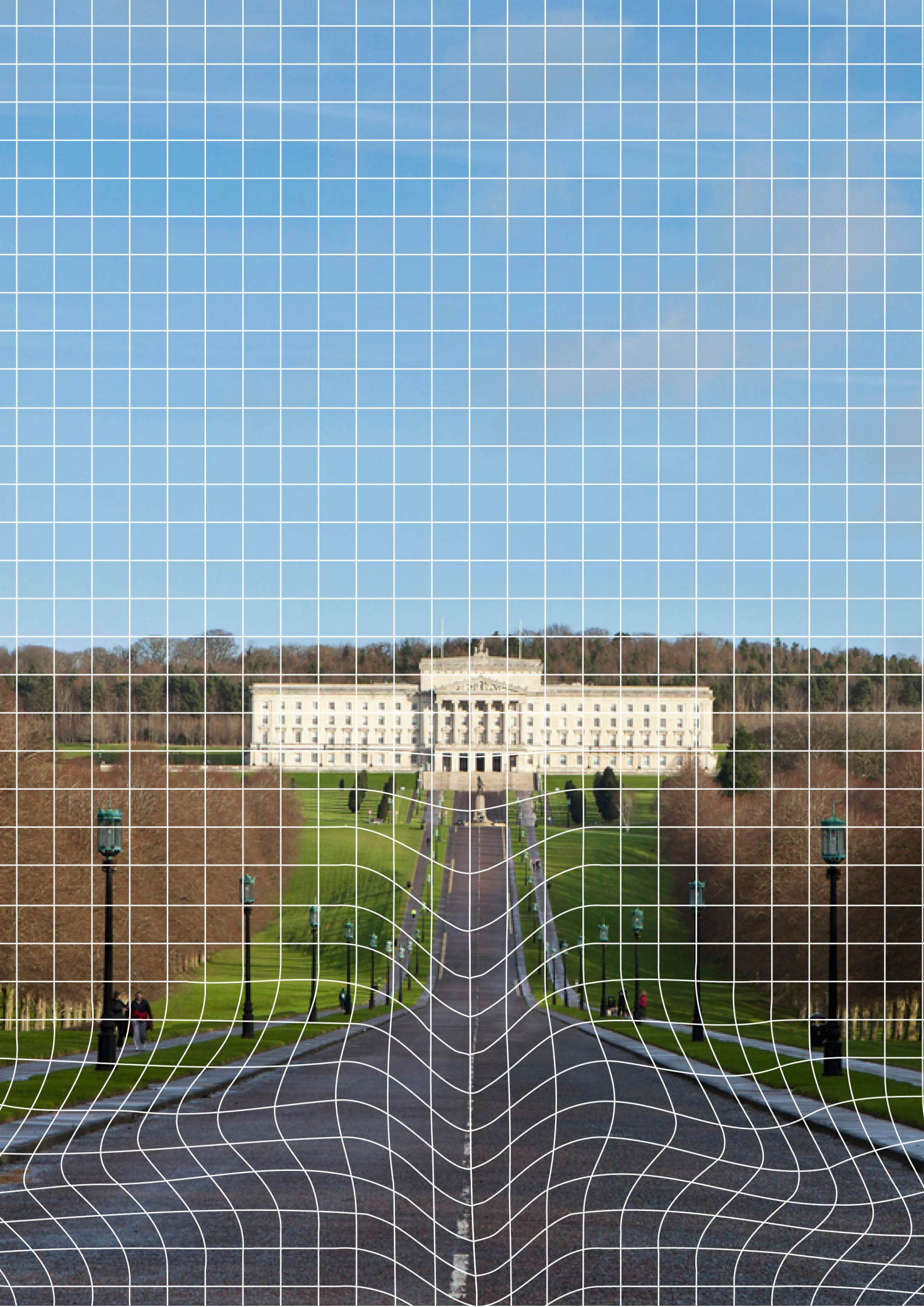
- **Business and industrial: 3 $MtCO_2e$ in 2020 (down 7% since 2010); emissions will need to fall 46% from 2020 to 2030.** Industry will need to reduce fossil fuel use by 45% by 2030. To achieve this, businesses must accelerate efforts to use energy and resources more efficiently and switch to low-carbon energy, with a focus on electrification of heat.

- **Energy: 3 $MtCO_2e$ in 2020 (down 28% since 2010); emissions will need to fall 51% from 2020 to 2030.** Deployment of new renewable electricity generation is required at scale, with appropriate energy storage and decarbonised back-up solutions, subject to ensuring security of supply.

- **Land use**: **2 $MtCO_2e$ in 2020 (down 4% since 2010); emissions will need to fall 22% from 2020 to 2030.** Afforestation rates will need to increase rapidly from the 540 hectares reported in 2021/22, reaching 3,100 hectares per year by 2035 and 4,100 hectares per year by 2039 with rates maintained at this level until 2050.

- **Engineered removals.** To reach its Net Zero target, Northern Ireland will need to develop engineered greenhouse gas removals, entailing CO_2 capture and geological sequestration in combination with bioenergy. This means developing anaerobic digestion (AD) now in a way that is compatible with Net Zero, including ensuring that only unavoidable wastes are used in AD and that methane leakage is kept to a minimum. It will also be necessary to identify the best way to develop carbon capture and CO_2 transportation infrastructure for deployment by 2035.

- **Plan for closing the gap to Net Zero.** If Northern Ireland is pursuing a strategy in line with the pathway we outline in this advice, it will need to demonstrate the feasibility of capturing and storing CO_2 emissions from Northern Ireland at the required scale by 2050. To do this, by 2035 it will need to install the first plant for CO_2 capture, transport the CO_2 to a storage site and store the CO_2. If this is not achieved, alternative options for reaching the Net Zero target must be explored, which are likely to include a significant further reduction in livestock numbers, higher afforestation rates and/or other options currently considered 'Speculative' such as enhanced weathering.



Chapter 1

Introduction and our approach to this advice

Introduction and key messages

In 2022, the Northern Ireland Assembly legislated for greenhouse gas emissions to reach Net Zero by 2050. In this report we provide advice to Northern Ireland on how it might achieve this target and on the level of interim targets and Carbon Budgets on the path to Net Zero.

The key messages in this chapter are:

- Reaching Net Zero greenhouse gas emissions by 2050 in Northern Ireland goes a long way beyond our previous advice that emissions should be reduced by 82% compared to 1990 levels by that time.

- The Balanced Pathway for Northern Ireland that underpinned this previous advice is already extremely challenging, with most sectors decarbonising almost completely by 2050. Residual emissions in 2050 are predominantly from the agriculture sector, which has a greater share of economic activity in Northern Ireland than in the UK as a whole, making Net Zero much more challenging to achieve for Northern Ireland.

- Northern Ireland's emissions have decreased by 24% in the last 30 years. To reach Net Zero, emissions reduction needs to speed up by more than a factor of three over the next 30 years, with rapid decarbonisation needed across all sectors of the economy.

In the rest of this chapter, we provide the necessary background to this advice, on the legislation, emissions in Northern Ireland and our previous advice, in four sections:

1. The Climate Change Act (Northern Ireland)

2. Historical emissions in Northern Ireland

3. The CCC's Balanced Pathway

4. Our approach to this advice

1. The Climate Change Act (Northern Ireland)

Northern Ireland has a legislated target to meet Net Zero emissions by 2050. Legislated interim targets and Carbon Budgets consistent with Net Zero are now required by the Act.

In 2022, the Northern Ireland Assembly legislated for greenhouse gas emissions to reach Net Zero by 2050. The Climate Change Act (Northern Ireland) 2022 (hereafter 'the Act') requires the Northern Ireland Government to set greenhouse gas emission reduction targets in line with Net Zero in 2050 for the First (2023-2027), Second (2028-2032) and Third (2033-2037) Carbon Budget periods, and to do so by the end of 2023. It also requires it to set targets for 2030 and 2040 (the 2030 target should be at least 48% below 1990 levels) by June 2024. A climate action plan must be published by this date, setting out how each sector will contribute to the meeting of the overall targets. Emissions from international aviation and shipping are not included in the targets.

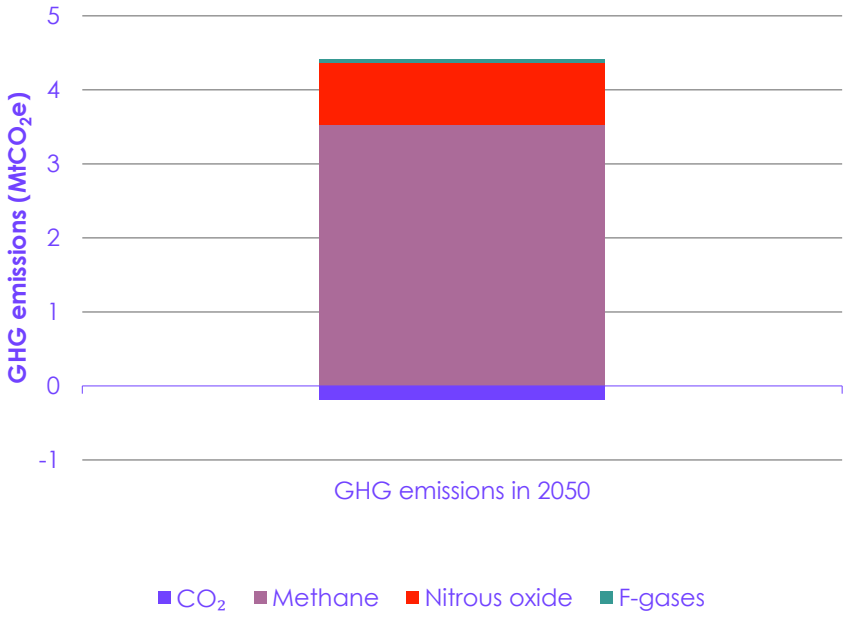
The Act includes a requirement that reaching Net Zero in Northern Ireland does not rely on reducing methane emissions by more than 46% below the 1990 baseline by 2050, which is in line with the reduction in methane emissions under our Balanced Pathway for Northern Ireland (which falls well short of Net Zero). This caveat was designed to mitigate the impact of decarbonisation on Northern Irish agriculture, the region's biggest economic sector and the source of most residual emissions in 2050 under our Balanced Pathway.

None of our published pathways see Northern Ireland achieve Net Zero by 2050. Most emissions in 2050 for our Balanced Pathway are methane, (Figure 1.1), indicating that the two main ways to further reduce overall emissions are to reduce methane emissions and, to offset any remaining emissions, to increase greenhouse gas removals. One option for doing this would be to further reduce agriculture emissions (which is also responsible for most of the residual nitrous oxide emissions, shown in Figure 1.1), leading to a reduction in methane emissions by more than 46% on 1990 levels.

We summarise the powers devolved to Northern Ireland in Box 1.1.

Projected Northern Irish emissions in 2050 are dominated by methane and nitrous oxide due to the large contribution from the agriculture sector.

Figure 1.1 Balanced Pathway emissions in Northern Ireland in 2050 by pollutant



Source: CCC (2020) *Sixth Carbon Budget*.
Notes: GHG stands for greenhouse gas.

Box 1.1
Powers devolved to Northern Ireland

The powers Northern Ireland has to design and implement policy are determined by The Northern Ireland Act 1998.[1] The policy areas largely devolved to Northern Ireland are:

- **Planning** and **consenting**, including policy and local planning authority guidance.
- **Waste** (policy and management).
- **Agriculture, forestry** and **fisheries**.

The policy areas partially devolved to Northern Ireland (with the devolved parts in brackets) are:

- **Energy** and **buildings** (generation, transmission, distribution and supply of electricity; oil and gas policy and exploration; coal ownership, exploitation and mining; production, distribution and supply of heat and cooling; energy conservation; building standards and ratings; energy efficiency schemes; and fuel poverty).
- **Transport** (highway code, vehicle standards, driver training and testing, driver and vehicle licensing, road signs, strategic rail matters, operation of the rail network, highway construction and maintenance, bus services, rail transport, rail services and regulation, active travel and freight transport).
- **Infrastructure** (nationally significant infrastructure and EV charging infrastructure).

The policy areas largely reserved to the UK Government are:

- **Industry**, including competition, import and export control, product standards and regulation of sea fishing outside devolved zones.
- **F-gases.**

Source: Cabinet Office and Northern Ireland Office (2019), *Devolution settlement: Northern Ireland*, https://www.gov.uk/guidance/devolution-settlement-northern-ireland.

2. Historical emissions in Northern Ireland

Emissions in Northern Ireland have fallen 24% since 1990, roughly half the decrease seen in the UK. Agriculture is now the highest emitting sector.

Greenhouse gas emissions in Northern Ireland fell by 5% in 2020 to 21.5 $MtCO_2e$. They have fallen by 24% since 1990, which is roughly half the rate of decrease seen in the UK as a whole (Figure 1.2). The fall in 2020 was driven by a decrease in transport emissions during the COVID-19 pandemic. The average annual fall in emissions in the decade prior to the pandemic was only 1%.

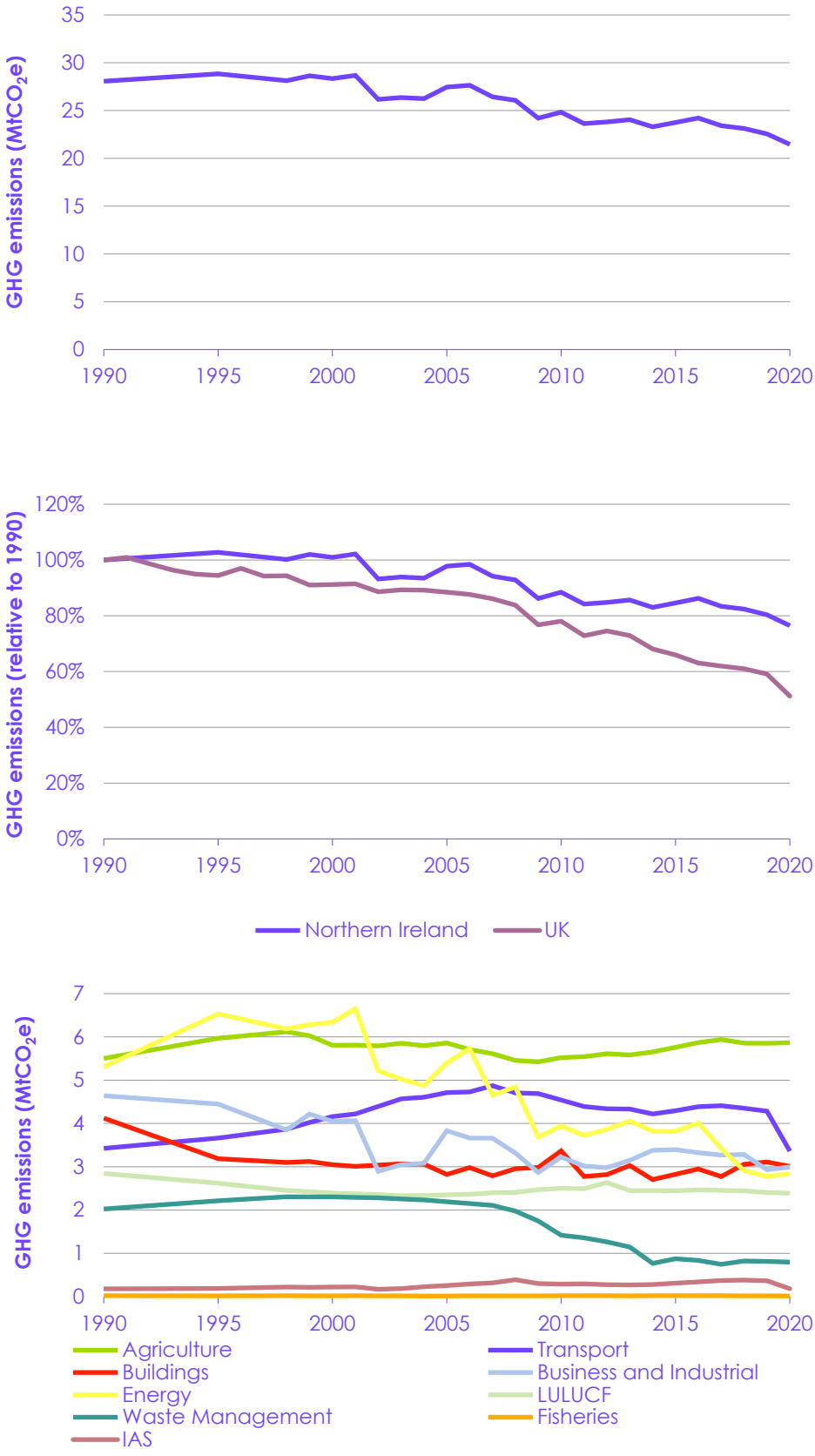
The fall in emissions since 1990 comes largely from a fall in buildings emissions in the early 1990s, steady decreases in the energy, business and industrial sectors since 2000, and a decrease in waste management emissions in the last decade. These are slightly offset by an increase in agriculture emissions, which is currently the highest-emitting sector.

To reach Net Zero by 2050 a step change in decarbonisation action is needed. Emissions reductions will need to be more than three times faster and action will be required across all sectors of the economy.

Box 1.2 summarises the differences between the sectors specified in the Act and those that we have used in our previous reports.

To reach Net Zero by 2050 emissions reductions will need to occur three times faster than in the previous three decades and will need to happen across all sectors of the economy.

Figure 1.2 Historical emissions in Northern Ireland in total and by sector



Source: Northern Ireland Government.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry, and IAS stands for international aviation and shipping.

Box 1.2
Differences between Northern Ireland and CCC sectors

Here we summarise how the sectors specified in the Climate Change Act (Northern Ireland) map onto the sectors we have used in previous reports:

- **Agriculture** is the same as our agriculture sector.
- **Transport** is the combination of our surface transport sector with the non-international parts of aviation and shipping, but not including fisheries emissions.
- **Buildings** is the same as our buildings sector, but not including commercial buildings and including a small amount from our F-gas, manufacturing and construction, surface transport and waste sectors.
- **Business and industrial** is most of our manufacturing and construction sector and commercial building emissions from our buildings sector.
- **Energy** is a combination of our electricity supply and fuel supply sectors, with a small amount of manufacturing and construction emissions.
- **LULUCF** is the same as our LULUCF sector.
- **Waste management** is the same as our waste sector, but not including home composting emissions.
- **Fisheries** is a small part of emissions from our shipping sector.
- **International Aviation and Shipping** refers to the share of such emissions that result from Northern Irish activity. These emissions are not included in any of the Northern Ireland sectors nor in the targets under the Act.

Source: Northern Ireland Government and CCC analysis.

3. The CCC's Balanced Pathway

The Committee's Balanced Pathway, developed as part of our 2020 advice on the UK's Sixth Carbon Budget, reaches Net Zero greenhouse gas emissions for the UK as a whole by 2050. A similar pathway has since been adopted by the UK Government. The Balanced Pathway was developed by reconciling contributions to reductions of global emissions with practicalities such as the time to develop infrastructure and to build up skills and supply chains and limiting early scrappage of existing assets such as boilers and cars. Net Zero in the UK relies on significant deployment of engineered greenhouse gas removals.

Northern Ireland does not reach Net Zero under our Balanced Pathway due to residual emissions from its large agriculture sector and it not being geologically optimal for engineered removals.

Northern Ireland does not reach Net Zero in the Balanced Pathway due to residual emissions from its large agriculture sector and the fact that none of the UK's engineered removals were allocated to Northern Ireland, which is not geologically optimal for CO_2 storage.

The Balanced Pathway is already highly challenging, seeing most sectors almost completely decarbonised by 2050.

Our Balanced Pathway is already highly challenging, seeing most sectors decarbonise almost completely by 2050. This requires, amongst other things:

- **Electricity generation.** Unabated fossil-fuelled electricity generation to be phased out and replaced with generation largely from renewables, with appropriate energy storage and decarbonised back-up solutions. Demand for electricity will grow, perhaps doubling. Production or imports of hydrogen from low-carbon sources are also likely to be important.

- **Surface transport.** Every car and van in Northern Ireland to be zero-emission by 2050, requiring these solutions to meet 100% of vehicle sales in the early 2030s. An increased proportion of journeys needs to be made by walking and cycling. Rail services to be largely electrified.

- **Buildings.** All heating appliances being zero-carbon in 2050, with a significant improvement in the energy efficiency of buildings.

- **Agriculture.** A significant reduction in livestock numbers together with widespread adoption of low-carbon farming practices and improved farm productivity.

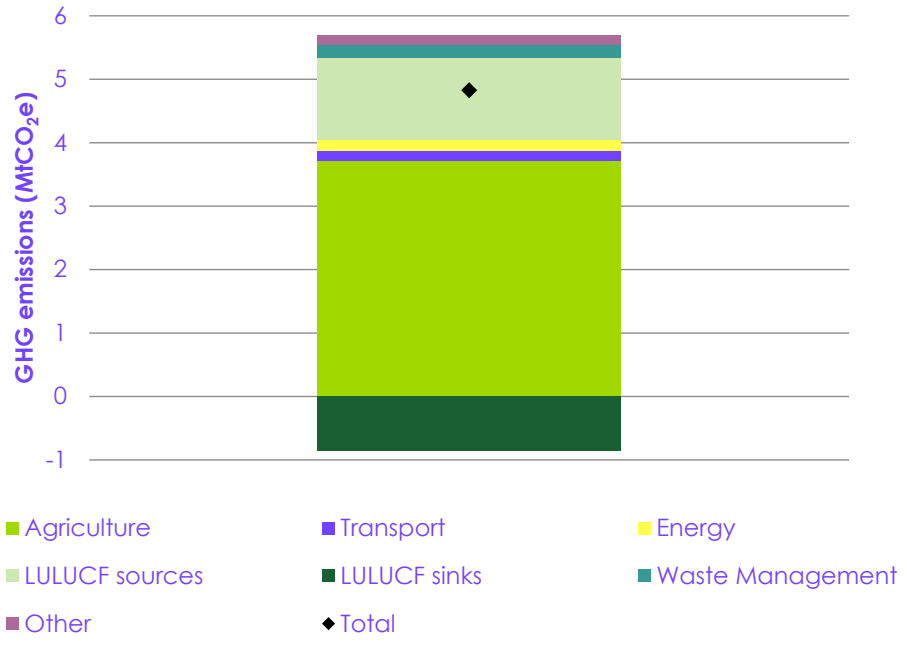
- **Land use.** Afforestation to increase rapidly so that by 2050, woodland cover would increase from the current 9% of the country's land area to around 14%. More than half of Northern Ireland's peatland to be restored.

- **Business and industrial.** Industry to replace over 90% of fossil fuel use with low-carbon energy.

In 2020, we estimated that this pathway would achieve an 82% reduction on 1990 levels by 2050, with 5 $MtCO_2e$ of residual emissions. After making several updates, the reduction is now 83% (Figure 1.3) – see Chapter 3 for an overview of those updates. To reach Net Zero, there needs to be substantially lower agricultural emissions and/or substantially more removals to offset these emissions.

Northern Ireland's emissions in 2050 in the updated Balanced Pathway come predominantly from the agriculture sector.

Figure 1.3 Northern Ireland's emissions in 2050 in the updated Balanced Pathway



Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry.

4. Our approach to this advice

Our advice for interim targets and Carbon Budgets includes an increase in ambition in some sectors to reduce the gap to Net Zero and a list of speculative options to close the remaining gap.

Northern Ireland's legislated Net Zero by 2050 target goes beyond the emissions reduction recommended by the Committee. The Committee has not previously been able to identify how Net Zero could be achieved within Northern Ireland.

In this report we provide advice to Northern Ireland on how this Net Zero target might be reached and on the levels for the 2030 and 2040 interim targets and the First (2023-2027), Second (2028-2032) and Third (2033-2037) Carbon Budgets on the path to it.

To do this, we start from our Balanced Pathway for Northern Ireland. We then:

- Make a series of technical adjustments and updates to our sectoral pathways and delay the starts of pathways in sectors showing slow recent progress to reflect that the First Carbon Budget starts this year.
- Increase ambition in some sectors to reduce the gap to Net Zero in 2050.
- List a set of speculative options that could be investigated to close the remaining gap to Net Zero.

The largest changes are in the land use sector, the use of bioenergy with carbon capture and storage and the use of anaerobic digestion of wastes. These are described in Chapter 2. Chapter 3 covers the rest of the changes and presents the results of the analysis, and our final advice on the targets and actions required to meet them are given in Chapter 4.

Endnotes

[1] Cabinet Office and Northern Ireland Office (2019), *Devolution settlement: Northern Ireland,* https://www.gov.uk/guidance/devolution-settlement-northern-ireland.

Chapter 2

Changes in land use, BECCS and anaerobic digestion

Introduction and key messages

This chapter describes changes to our emissions pathway for the land use sector, considering both methodological changes and an increase in ambition. We also estimate potential contributions to reduce emissions with bioenergy with carbon capture and storage (CCS), and anaerobic digestion of wastes.

The key messages in this chapter are:

- Methodological updates to the modelling of forestry and peatland emissions result in an increase in estimated land use emissions compared to our previously published Balanced Pathway from the mid-2030s to 2050.

- Reaching Net Zero will require radical action in the land use sector in Northern Ireland, going further than our Balanced Pathway and implementing actions consistent with our Tailwinds scenario – the CCC's steepest emissions pathway to Net Zero – but with a delay to reflect slow current progress on new forestry planting (as explained below) this will require a rapid ramp up of afforestation and peatland restoration rates.

- Using biomass grown in Northern Ireland together with CCS could lead to 1.1 $MtCO_2e$ of sequestered CO_2 attributed to Northern Ireland annually by 2050.

- Anaerobic digestion of wastes can be used to produce biomethane which can both replace fossil gas and be used with carbon capture and storage to sequester CO_2. This could lead to a reduction in emissions of around 0.8 $MtCO_2e$ a year by 2050. It is essential that this is done strategically, to maximise emissions reduction and avoid perverse outcomes.

- Capturing and transporting CO_2 in Northern Ireland comes with significant costs and developments in infrastructure.

The rest of this chapter is set out in three sections:

1. Land use

2. Bioenergy with carbon capture and storage

3. Anaerobic digestion

(a) Northern Ireland's land use emissions

Northern Ireland will need to go beyond our proposed Balanced Pathway to increase the size of land-use sinks in line with the demands of the Net Zero target.

The land use sector is a net emitter in Northern Ireland. There has been little progress in cutting emissions from the sector over the last decade. Setting a Net Zero target means that Northern Ireland will need to rely heavily on land use as a key form of the greenhouse gas removals required to balance residual emissions from the agricultural sector, which will be the main source of residual emissions by 2050. As a result, Northern Ireland will need to go beyond our proposed Balanced Pathway to increase the size of those sinks in line with the demands of the new target (see Chapter 3).

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

The CCC's analysis for the UK Sixth Carbon Budget in 2020 produced specific outputs for Northern Ireland.[1] For the land use sector, this took a bottom-up approach, producing a series of emissions reduction pathways that set out how land can work towards UK Net Zero by 2050. In these original 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.

Our original Balanced Pathway resulted in net emissions from the land sector in Northern Ireland of 1.9 $MtCO_2e$ in 2030 and 0.9 $MtCO_2e$ in 2040. In this pathway, the land use sector has net emissions above zero all the way to 2050, with emissions falling to around 0.1 $MtCO_2e$ by mid-century.

Cutting emissions from land use in Northern Ireland, however, will need to go further than the Balanced Pathway to increase the size of carbon sinks and offset some of the substantial emissions remaining in 2050. Our original Tailwinds scenario saw land use emissions fall to 1.9 $MtCO_2e$ in 2030, 0.3 $MtCO_2e$ in 2040, and eventually crossing over to a sink in 2043. By 2050, the size of the sink is -1.2 $MtCO_2e$.

(c) Methodological and analytical updates to our pathways

Since our UK Sixth Carbon Budget advice, the GHG inventory has undergone numerous revisions and changes in the land-use sector.

Methodology changes to the UK greenhouse gas (GHG) inventory are designed to increase the transparency, accuracy, consistency, comparability and completeness of emissions estimates. For the land use sector, the level of uncertainty in emission factors and activity data used in estimating emissions is higher than for other sectors. Work to address this by improving the current state of knowledge has resulted in large revisions to the GHG inventory in recent years and future changes can be expected as work continues to refine emission estimates.

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

(i) 1990-2020 inventory update

The 1990-2020 inventory (published in 2022) 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.

The Government projections of land use emissions based on the 1990-2020 inventory had not been agreed at the time of this analysis. We have aligned the updated Northern Ireland land use pathways 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

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

Our analysis has factored in a delay in new tree planting in Northern Ireland until 2024 to reflect current low planting rates.

Our analysis has factored in a delay in new tree planting in Northern Ireland until 2024. This is to reflect the current low planting rates reported in the early 2020s. From 2024 onwards planting rates are assumed to follow the CCC trajectories. We refer to these pathways as 'delayed Balanced Pathway' and 'delayed Tailwinds'. These delays result in higher estimated net emissions in 2050 in these pathways.

Our forestry pathways have been aligned with the Forest Research CARBINE model.

Emissions from forestry in the GHG inventory are estimated based on the Forest Research CARBINE model. For the UK Sixth Carbon Budget analysis, the CCC used an alternative model (C-Flow).* It was not possible for the CCC to use the CARBINE model to inform the land analysis for this target advice. Therefore, we have taken steps for our pathways to become aligned to CARBINE. These include:

- The UK Government's land use projections use the CARBINE model and are aligned with the methodology used in the emissions inventory. Net emissions from existing forest in the 2019 inventory projections calculated by the CARBINE model have been embedded into the updated baseline and emissions projections to capture the continued impact of historical forestry planting.

- New planting (from 2021 onwards) is represented by data from the 2022 Forest Research report 'Quantifying the sustainable forestry carbon cycle' (QFORC), a CARBINE-based model approach.[2] Data tables were derived from the CARBINE model and allows assessment of different options for woodland creation and management, from the perspective of their potential for CO_2 uptake and avoiding GHG emissions.

- The updated methodology has improved representation of carbon stock losses associated with the establishment of new forests. A mid-point between mineral and organo-mineral soils is used, and it is assumed that no afforestation of organic soils occurs.

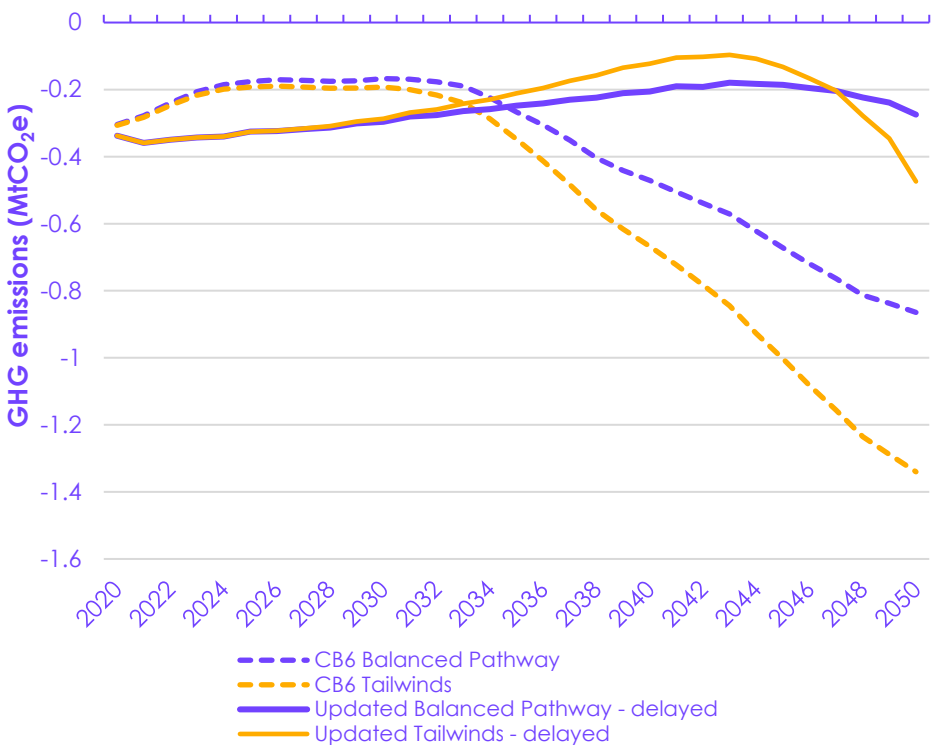
As a result, the size of the sink from forestry emissions decreases between the mid-2030s and 2050, largely due to the lag in new forest creation becoming a net sink (Figure 2.1). This causes a divergence between the original pathways and the updated ones, reaching a peak in the late 2040s before starting to converge.

* The representation of the CCC 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 accounts for historical planting differences more extensively and takes into account interactions between them and new woodland creation to project the impact on GHG emissions.

The reverse is true for the early years, with the new pathways having a larger, albeit declining, sink until the mid-2030s. In addition, the improved representation of carbon stock losses associated with the establishment of new forests means that the higher rates of tree planting under delayed Tailwinds generates higher emissions compared to the delayed Balanced Pathway until the mid-2040s.

Forestry methodology and timing delays in tree planting have decreased the size of the emissions sink between the mid-2030s and 2050.

Figure 2.1 Forestry emissions in Northern Ireland



Source: CCC (2020) *Sixth Carbon Budget*; Forest Research (2022) *Quantifying the sustainable forestry carbon cycle*; UKCEH (2023) *Updating of CCC Land Use Scenarios*[3]; CCC analysis.
Notes: GHG stands for greenhouse gas.

(iii) Peatlands

Peatland representation has been updated by adjusting the relevant emission factors within the UK for organic soils and updating the global warming potentials.

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

The peatland representation has been updated by adjusting the relevant emission factors within the UK for organic soils and updating the global warming potentials (GWPs) compared to those used in the UK Sixth Carbon Budget assessment:

- At the time of our UK Sixth Carbon Budget analysis, a decision had not yet been taken at the international level as to whether the updated GWP values presented in the IPCC's Fifth Assessment report (AR5) would account for climate-carbon feedbacks or not. It was also unknown as to whether the UK GHG inventory would adopt the higher or lower emission factors for forestry peat.

We therefore took a cautious approach on how both might be included and adopted the higher values for both the GWPs (AR5-high with climate-carbon feedback) and forestry peat emission factors for our analysis.

- Subsequent to our UK Sixth Carbon Budget advice, it was agreed at COP26 to use the lower AR5 GWPs (i.e. with no climate-carbon feedbacks), while the UK GHG inventory went on to use lower emission factors for forestry peat than we adopted.

As a result, emissions due to peatlands are estimated to be lower in the updated Balanced Pathway and Tailwinds. This difference peaks in 2036, when peatland-related emissions are approximately 0.3 $MtCO_2e$ lower (for both scenarios). The peatland pathways begin converging again after 2040, but emissions in the updated pathways remain lower through to 2050.

(d) The impact of land use model updates to the CCC's land use pathway for Northern Ireland

The methodological changes outlined in the above sections impact our pathways for land use emissions in Northern Ireland in a number of ways:

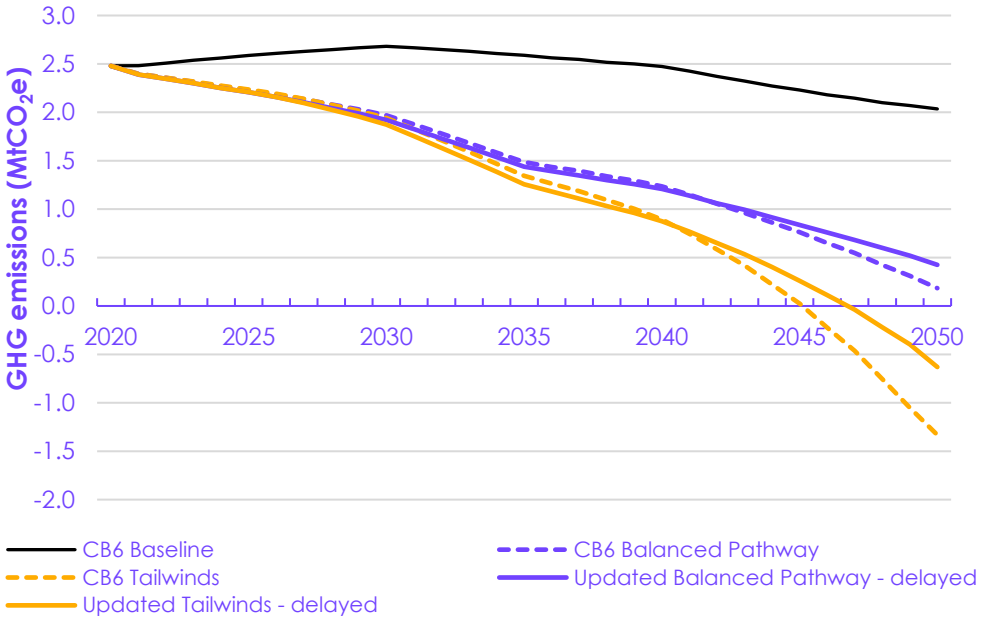
- The updated pathways indicate higher land-related emissions between the early-2040s and 2050 than those used for the UK Sixth Carbon Budget analysis (Figure 2.2). This is due to changes in the estimated sink capacity in Northern Ireland, estimates of soil-related emissions and the estimated impact of other land-use change.*

- Overall, net emissions continue to fall, but the updated analysis underlines the urgency of making early decisions on forestry due to the impact on emissions. In the updated pathways, new forest creation turns into a sink much later than the original timescale (after 2050 for the Balanced Pathway and in 2049 for Tailwinds), affecting the size of forestry sinks (Figures 2.3 and 2.4). Ensuring these sinks have sufficient capacity by 2050 to balance out part of the residual emissions, particularly in line with Tailwinds, requires urgent action.

* Other LULUCF emissions include those from LUC and management of non-forest soils and biomass, and biomass burning.

Methodology updates and delays to planting rates lead to higher emissions between the early 2040s and 2050 in our pathways.

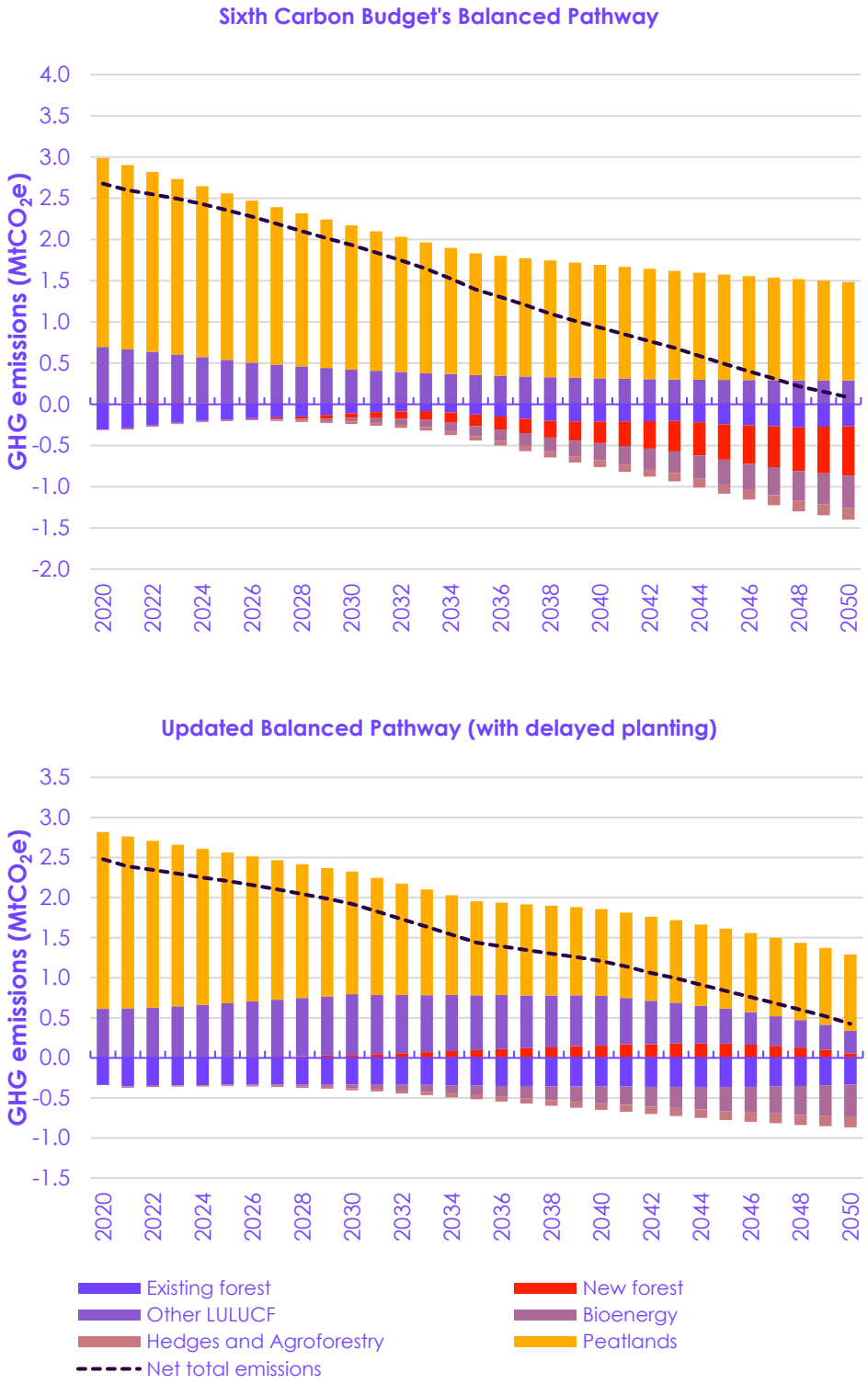
Figure 2.2 Methodology updates and delays to pathways



Source: CCC (2020) *Sixth Carbon Budget*; UKCEH (2023) *Updating of CCC Land Use Scenarios*; CCC analysis.
Notes: GHG stands for greenhouse gas.

New forest in the Balanced Pathway only becomes a net sink after 2050 following methodological updates and delays to planting rates.

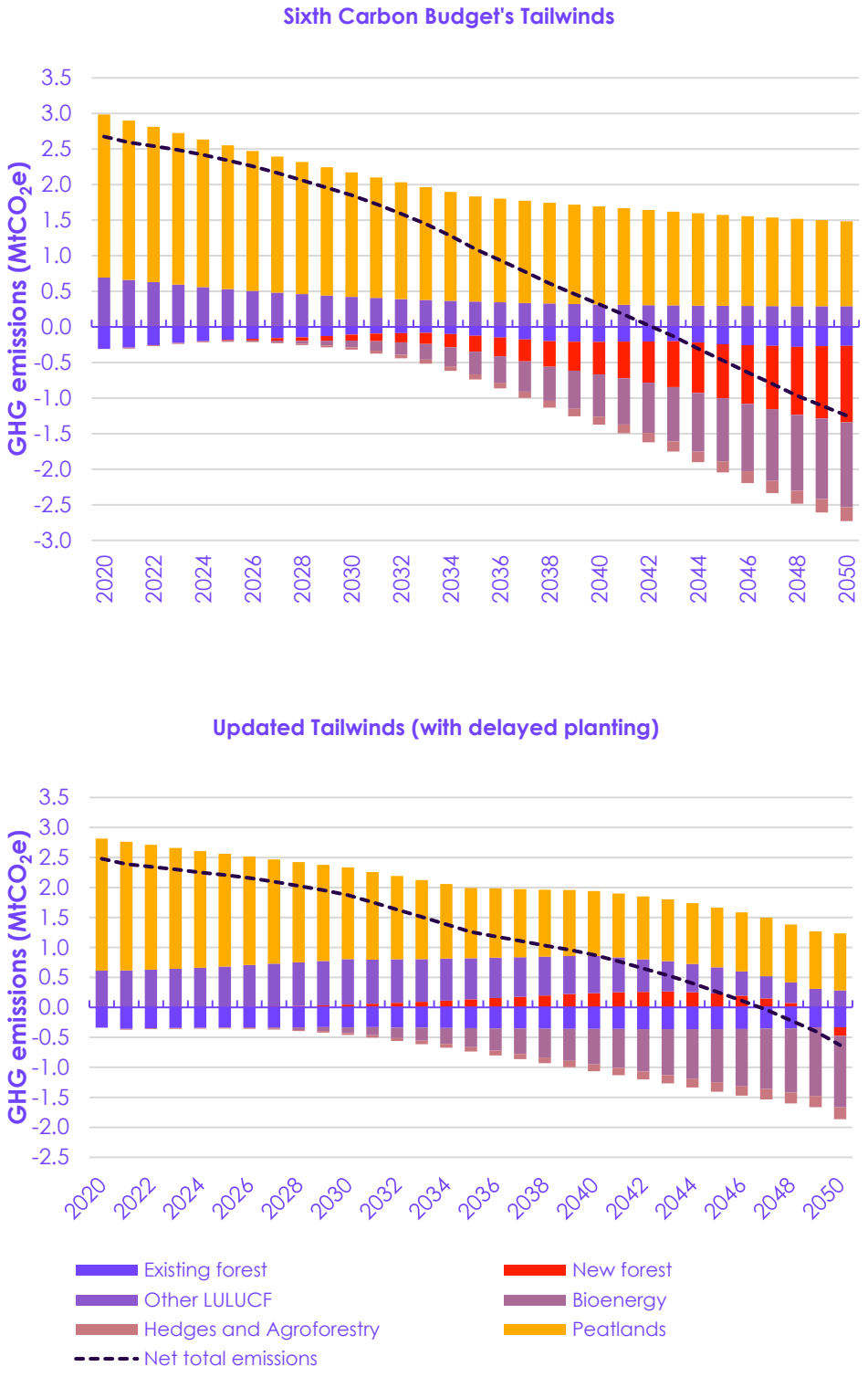
Figure 2.3 Breakdown of land-use emissions – Balanced Pathway



Source: CCC (2020) *Sixth Carbon Budget*; UKCEH (2023) *Updating of CCC Land Use Scenarios*; CCC analysis.
Notes: GHG stands for greenhouse gas.

In the new Tailwinds pathway land use becomes a net sink in 2047 and new forest in 2049 following methodological updates and delays to planting rates.

Figure 2.4 Breakdown of land-use emissions – Tailwinds



Source: CCC (2020) *Sixth Carbon Budget*; UKCEH (2023) *Updating of CCC Land Use Scenarios*; CCC analysis.
Notes: GHG stands for greenhouse gas.

(e) Increasing ambition for land use in Northern Ireland

Given the scale of the Net Zero challenge, Northern Ireland will need to go beyond our Balanced Pathway and attempt to implement Tailwinds for land use, albeit with a delay in tree planting to reflect current low rates.

Given the scale of the challenge posed by the Net Zero target and the slow rate of delivery in the land sector in the early 2020s, our assessment is that Northern Ireland will need to go beyond our Balanced Pathway and attempt to implement Tailwinds for land use, albeit with a delay in upscaling rates of tree planting (see Chapter 3). This will allow Northern Ireland to increase sink capacity to counteract residual emissions by 2050.

Although there will be sufficient land released from agriculture under the Balanced Pathway to meet the land-use change required for Tailwinds, the increased ambition in terms of the scale and pace of tree and energy crop planting together with increased productivity will be challenging to meet in practice:*

Annual afforestation rates need to reach 3,100 hectares by 2035, compared to the 540 hectares delivered in 2021/22.

- Annual afforestation rates will need to reach 3,100 hectares by 2035 and 4,100 hectares by 2039 remaining at this level until 2050. This represents a substantial increase compared to afforestation rates delivered to date, which were 540 hectares in 2021/22 and on average around 290 hectares annually between 2018 and 2022.

- The productivity of conifers as measured by Yield Class (YC) will need to increase from the current average YC14 to YC18 by 2030. This requires moving beyond the adoption of best practice in silviculture to innovation in breeding, with theoretical gains translated into real gains.

- Planting of energy crops and short rotation forestry will need to ramp up from zero currently to 3,500 hectares/year by 2030, which is more than double the level of planting in the Balanced Pathway. There is also a higher reliance on innovation to boost the productivity of energy crops by 33% by 2050 compared to the Balanced Pathway.

Though challenging, and this must be considered alongside trade-offs with other land uses, Tailwinds does offer increased capacity to sequester carbon. Decisions should be made early, particularly where tree-planting is concerned, to allow for the measures to come into full effect in time to meet the legislated targets.

Delivery of these pathways for land is dependent on successful implementation of land-release measures in the agriculture sector.

Delivery of these pathways for land is dependent on successful implementation of land-release measures in the agriculture sector (e.g. improving efficiency and reduced livestock farming), 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 agroforestry.

* Peatland restoration under Tailwinds is aligned to the ambition set out in the Balanced Pathway.

2. Bioenergy with carbon capture and storage

In our UK Sixth Carbon Budget advice, negative emissions from biomass grown in Northern Ireland were not allocated there.

The pathways produced for our UK Sixth Carbon Budget advice include bioenergy with carbon capture and storage (BECCS) to remove CO_2 from the atmosphere while also producing energy. However, in that advice we did not allocate these negative emissions across different parts of the UK.

Under internationally agreed rules for emissions accounting, the greenhouse gas removals resulting from CO_2 capture from biomass combustion are accounted for in the country in which the CO_2 is captured (rather than, for example, where the biomass is grown or where the CO_2 is ultimately sequestered). So, for BECCS to contribute to Northern Ireland's emissions targets, any BECCS plants would need to be located in Northern Ireland, although the CO_2 could then be transported elsewhere for storage.

There are high volumes of potential CO_2 storage under the seabed surrounding the UK in saline aquifers and in depleted oil and gas fields. However, the storage sites with best potential are mostly under the North Sea or off the coast of the Northwest of England. Though Northern Ireland has poor access to geology for CO_2 storage, capturing CO_2 in BECCS plants and transporting it to storage sites elsewhere in the UK could help to close the gap between our previous assessment for net emissions in Northern Ireland by 2050 and the legislated Net Zero target.

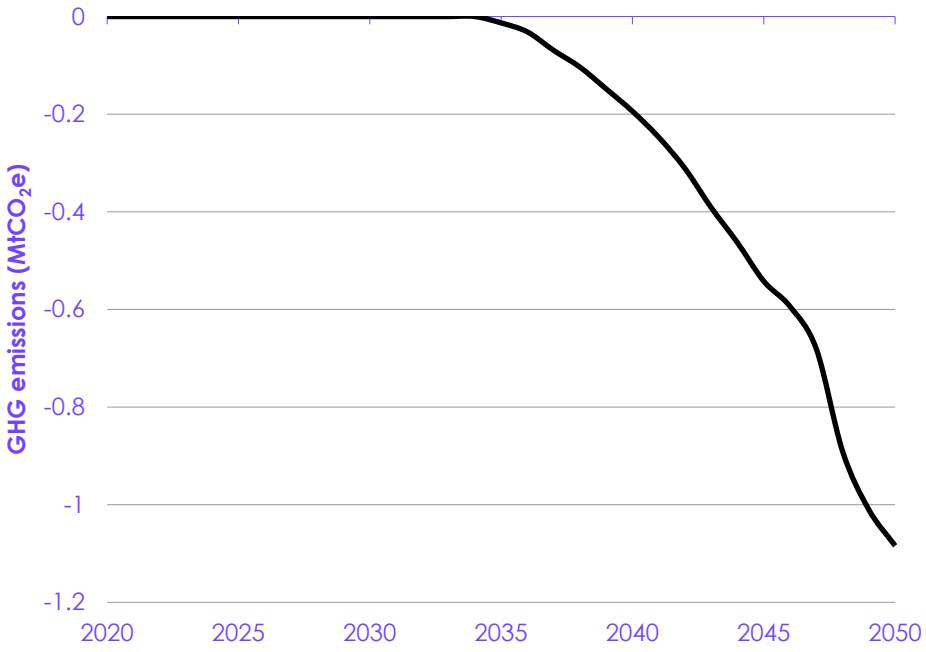
Greenhouse gas removals from biomass grown in Northern Ireland could reach 1.1 $MtCO_2$ in 2050, which can be allocated to Northern Ireland if infrastructure is developed to capture and transport the CO_2.

For this report, we have calculated how much CO_2 could be removed using biomass grown in Northern Ireland, which our pathway assumes is 2-3% of total UK-grown biomass (depending on the year). Greenhouse gas removals from BECCS reach 1.1 $MtCO_2$ in 2050 (Figure 2.5). We have not assumed that any bio-resource is imported and used in BECCS, as many other countries are better placed to do this.

This would need infrastructure to capture and transport CO_2, as well as an agreement to store the CO_2 outside Northern Ireland (as there are no suitable storage locations in Northern Ireland).* Capturing and storing CO_2 is expected to be more expensive to do in Northern Ireland than in Great Britain. This is because in Great Britain there will be more CO_2 going into each CCS network, leading to lower unit costs due to economies of scale, and the CO_2 transport distance from source to storage location will be shorter.

* CO_2 removals only count as negative emissions for Northern Ireland if the capture of CO_2 occurs within Northern Ireland, so it needs to be captured in Northern Ireland even though there is not anywhere in Northern Ireland to store it.

Figure 2.5 BECCS removals pathway



Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas.

3. Anaerobic digestion

Anaerobic Digestion (AD) can be used to produce biogas from food waste, sewage sludge, silage and animal manures. The biogas can be upgraded via scrubbing technologies into biomethane and subsequently injected into the gas network.

Since our 2020 advice on the UK Sixth Carbon Budget, further evidence has estimated a higher biogas potential of 3,500 GWh in Northern Ireland.

In our 2020 analysis, our Balanced Pathway included almost 1,000 GWh of biogas production in Northern Ireland in 2050 with its use split across industry, combined heat and power (CHP) and upgrading into biomethane for injection into the gas network. Since then, further evidence has been developed that estimates that Northern Ireland has a higher potential for biogas.

We judge the use of biogas and biomethane in our Balanced Pathway to be a likely and cost-effective approach to achieve UK Net Zero. However, given that the Northern Ireland Net Zero target is more stretching, we have assumed uses of biomethane that maximise the contribution to Net Zero of the finite potential for anaerobic digestion.

The following updates have been made to our pathway:

- Manure and silage account for the majority of biogas feedstocks and these numbers have been revisited based on insights from the latest published research and aligned with our Sixth Carbon Budget scenarios.[4] This gave an updated figure for Northern Ireland's maximum biogas potential from sustainable feedstocks of around 3,500 GWh.
  - Annual manure feedstocks have been calculated for different livestock categories based on published literature values for volume of excreta produced per animal.[4] Manures have been scaled over time with poultry and livestock numbers from the agriculture sector in our Balanced Pathway scenario.
  - We have used the surplus grassland released in the Tailwinds scenario to determine silage feedstocks. Putting this surplus land back into agricultural production will lead to some N_2O emissions associated with fertiliser use. We have not included this in our calculations. We have assumed that all silage from permanent grasslands is used for livestock feed, whilst silage produced on rough grasslands cannot be harvested for AD.
  - Biogas produced from food waste, sewage sludge and landfill gas has not changed from our Sixth Carbon Budget analysis assumptions.

Due to the dispersed nature of feedstock sources, it is not expected that all biogas potential could be upgraded to biomethane.

- Due to the dispersed nature of feedstock sources, it is not expected that all biogas potential could be upgraded to biomethane.
  - Whilst further abatement would be achieved by upgrading biogas for use as biomethane, we have maintained the same amount of biogas for industry and CHP as we used in our Sixth Carbon Budget analysis to reflect the fact that some biogas would be used on-farm. In 2050, this accounts for 13% of the maximum biogas potential.

  - All remaining biogas has been allocated to biomethane upgrading, providing 3,000 GWh of biomethane available for grid injection or other uses.*

To maximise the abatement potential of using anaerobic digestion to produce biomethane, carbon capture and transport infrastructure is required in Northern Ireland.

- In our Sixth Carbon Budget pathways, we did not include any carbon capture and transportation in Northern Ireland. However, to maximise the abatement potential of using AD to produce biomethane, CCS is required.
  - In our analysis, we have assumed that CCS is available for both the upgrading of biogas to biomethane and the subsequent use of biomethane in gas power stations or hydrogen production plants from 2035.
  - Introducing CCS to Northern Ireland would require infrastructure to capture and transport CO_2. There are also no suitable storage locations in Northern Ireland and the captured CO_2 would therefore need to be stored elsewhere.

Producing and utilising biomethane with AD can reduce net greenhouse gas emissions via the following (Figure 2.6):

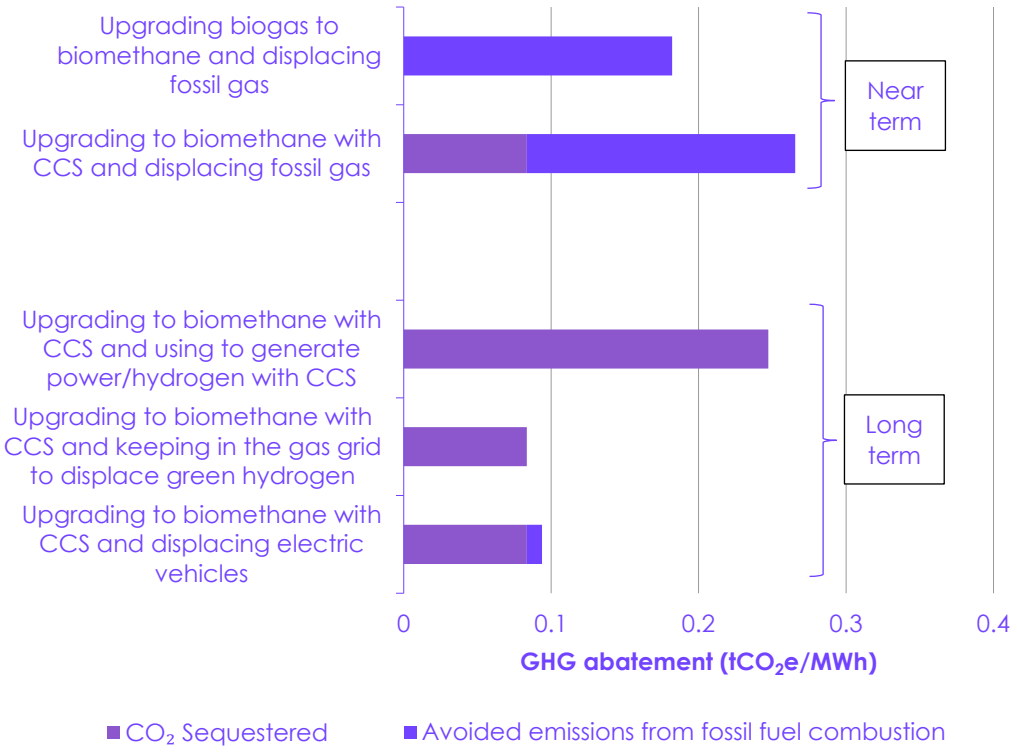
Biomethane can be used to displace fossil gas in the short term and as greenhouse gas removals by producing electricity or hydrogen with carbon capture and storage in the longer term.

- Biogas produced via AD can be upgraded to network-quality biomethane. As biogas is around 40% CO_2, this can be separated and captured as part of the upgrading process. Transporting this CO_2 to an appropriate location for permanent sequestration is a form of greenhouse gas removal and contributes to reducing net emissions.
- The biomethane can be injected into the gas network, displacing fossil gas. These avoided emissions from fossil fuel combustion further reduce overall net emissions. However, this should only be seen as an interim measure and biomethane should only be injected into the gas network to replace fossil gas and not at the expense of other low-carbon energy (e.g. hydrogen produced from electrolysis) or maintaining unabated consumption of methane (e.g. for heating buildings).
- Once there is no more scope to displace fossil methane from the gas network (e.g. once supply exceeds gas demand, which will be falling), any remaining biomethane can be used for electricity or hydrogen production, with CCS used to capture the resultant CO_2. This use of biomethane primarily achieves this reduction through sequestration of CO_2, which acts as a form of greenhouse gas removal.

* The efficiency of biogas to biomethane upgrading is assumed to be 90% in 2050.

More carbon is sequestered per MWh of energy if biogas is used with carbon capture and storage to replace fossil gas or to produce electricity or hydrogen.

Figure 2.6 Estimated GHG abatement for different biogas applications



Source: CCC analysis.
Notes: GHG stands for greenhouse gas. This chart shows estimates of GHG abatement provided by different uses of 1 MWh of biogas. We have shown abatement broken down by sequestered carbon (the amount of CO_2 stored and/or not released into the atmosphere due to CCS technology) and avoided emissions from fossil fuel combustion carbon (the amount of CO_2 that would have been emitted to the atmosphere in the counterfactual case that the biogas had not been used). Near term refers to decisions taken up to the point where all fossil gas has been displaced from the gas system and long term refers to decisions taken after this point. The underlying calculations do not include biogas lifecycle emissions, which are the same for each of the options presented. The emissions factor for upgrading biogas to biomethane with CCS was taken from our analysis for the Sixth Carbon Budget. In 2035, the emissions factor is -84 gCO_2e/kWh with this improving to -118 gCO_2e/kWh in 2050 with improvements in CO_2 capture rates and plant efficiency improvements with the 2035 value used for all options. The 2035 grid intensity has been used for the avoided emissions of displacing electric cars and the value taken from our Sixth Carbon Budget.

It is essential that the use of anaerobic digestion is strategic and that perverse outcomes, such as increasing livestock to produce more manure, are avoided.

Whilst the use of AD and biomethane has some potential to reduce Northern Ireland's net emissions, it is essential that this is done strategically to maximise its contribution to the legislated emissions targets and avoid perverse outcomes:

- **Feedstocks.** Biogas should only be produced from waste feedstocks. Growing dedicated 'first generation' (i.e. food) crops as an additional feedstock or maintaining livestock numbers for biogas is an inefficient use of land in climate and economic terms. For example, one dairy cow contributes 3,470 $kgCO_2e$ per year in enteric emissions, whilst its manure would generate 0.64 MWh of biogas which, even with the most optimal abatement use, would constitute an abatement of only 192 $kgCO_2e$ – offsetting less than 6% of the climate impact of the dairy cow.

- **Methane leakage.** Methane can leak from AD plants and steps must be taken to monitor and address methane leaks to ensure that this does not nullify the climate benefits of biogas production. Methane leakage from AD plants has been estimated to be between 0.05% and 2.5%.[5] However, there are concerns that methane leaks are underestimated.[6]

It will be important to ensure that the monitoring of anaerobic digestors and associated infrastructure is undertaken to ensure that any significant methane leaks are caught quickly.

- **Utilise the produced biogas in an optimal manner.** The flexibility of bioenergy as a low-carbon energy vector means there are a large number of possible end-uses. However, many of these are sub-optimal in the long term and likely to reduce overall levels of ambition on emissions reduction and/or increase costs (Figure 2.6).

Sub-optimal uses of biogas, such as in road transport, should be avoided.

  - Our analysis has identified upgrading biogas to biomethane with CCS (once available) and using it to displace fossil gas as the most optimal use in the short term. However, once the potential to displace fossil gas has been exhausted the biomethane should be used to generate power or hydrogen with CCS used on the emitted CO_2.

  - Sub-optimal uses include keeping the biomethane in the gas network once all fossil gas has been displaced and gas demand can be lowered further, as reducing this gas consumption and using the gas with greenhouse gas removals would lower net emissions. Other sub-optimal uses include expanding the use of methane as a fuel (e.g. in road transport) given the availability of carbon-free alternatives and the high value of biomethane in reducing emissions.

  - Methane consumption wherever possible should still be reduced. This initially reduces fossil gas consumption and subsequently frees up biomethane for use with CCS.

The extremely stretching nature of the Net Zero target rules out using biomethane for things such as heating homes in 2050 as it is required for greenhouse gas removals.

While it may be considered desirable to use the biomethane to support the gas system and existing methane uses (e.g. to heat homes) once all fossil gas demand in our pathway has been displaced, the extremely stretching nature of the Net Zero target rules this out. On a 2050 timescale this additional biomethane resource must be used for greenhouse gas removal. This may mean either shutting down gas distribution networks or switching them to hydrogen, while higher-pressure parts of the methane network only serve CCS facilities by 2050.

To maximise the abatement potential of biomethane in Northern Ireland, a significant increase in production and injection is required and there may be opportunities for learning from other countries that are already utilising biomethane for injection into the gas network.

- There is currently no injection of biomethane into the gas network occurring in Northern Ireland, although there is extensive use of AD:

  - In 2021, there were 76 operational AD facilities producing biogas in Northern Ireland. Of these, 64 predominantly use agricultural feedstock and 12 use municipal, commercial and industrial waste feedstocks.[7]

  - The biogas produced is currently used to generate heat and electricity onsite with surplus electricity sold to export suppliers.

- The less-developed (compared to the rest of the UK) gas network in Northern Ireland means that biomethane generated on-farm would likely require transport to a centralised point for injection into the network. Alternatively, the feedstock or the biogas could be transported to larger plants that have a direct connection to the gas network.

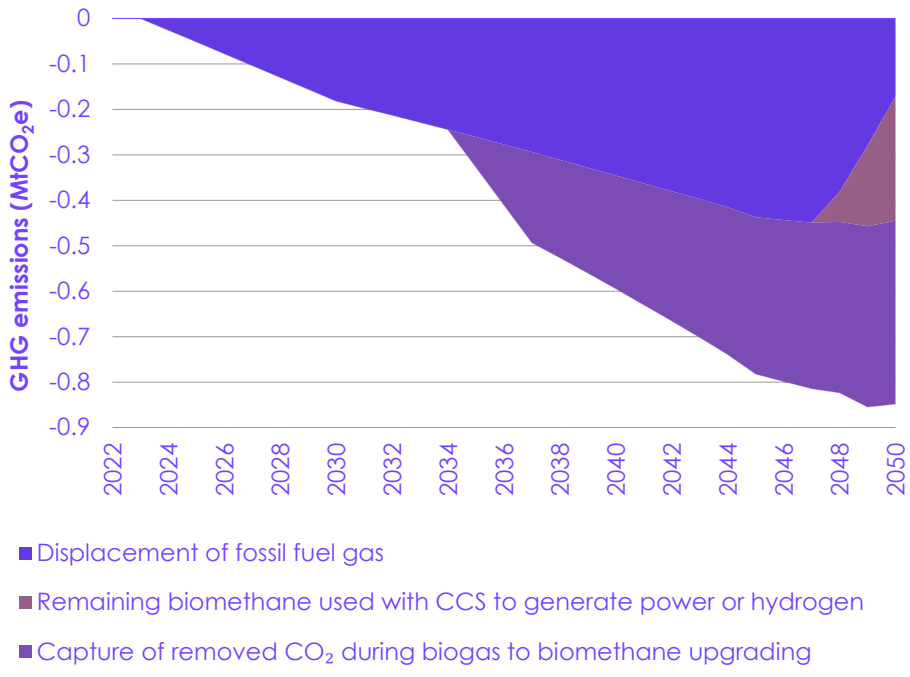
Other European countries have developed biomethane production industries or have set policies to facilitate development.

- Other European countries have developed biomethane production industries or have set policies to facilitate development.
  - Injection of biomethane into the gas network is being done in Great Britain and by other European countries including Germany, France, Italy and Denmark and there are around 1,000 biomethane production plants in operation.[8]
  - The UK Heat and Building Strategy sets out plans to increase the amount of biomethane in the gas system and aims for the Green Gas Support Scheme to deliver 2.8 TWh of renewable heat per year in Great Britain by 2031.[9]
- The Northern Ireland Executive has outlined its intention to establish a cross-departmental working group on biomethane production. The group will aim to assess the future role of AD in Northern Ireland and determine the potential to produce biomethane at scale.

Our modelling estimates that our updates to our pathway can further reduce emissions relative to our Balanced Pathway by 0.3 $MtCO_2e$ by 2035 and by 0.8 $MtCO_2e$ by 2050 (Figure 2.7). Up to 2035, we assume that no CCS is utilised and all abatement is provided by the displacement of natural gas.

With the strategic use of anaerobic digestion, emissions in Northern Ireland could be reduced by 0.3 $MtCO_2e$ by 2035 and by 0.8 $MtCO_2e$ by 2050.

Figure 2.7 Additional abatement potential from anaerobic digestion relative to our Balanced Pathway



Source: CCC analysis.
Notes: GHG stands for greenhouse gas. Based on projections from Northern Ireland's gas distribution network operators, 1,270 GWh of biomethane is assumed to be injected into the gas system by 2030. Once biomethane production exceeds the gas demands, we have assumed that the leftover biomethane is replacing existing zero-carbon electricity or green hydrogen production. However, if the biomethane is used to replace blue hydrogen production, then additional abatement would be achieved.

Endnotes

[1] Climate Change Committee (2020), *The Sixth Carbon Budget; The UK's path to Net Zero,* https://www.theccc.org.uk/publication/sixth-carbon-budget/.

[2] Forest Research (2022) *Quantifying the sustainable forestry carbon cycle*.

[3] UKCEH (2023) *Updating of CCC Land Use Scenarios.*

[4] Mehta, N., Anderson, A., Johnston, C. & Rooney, D (2022*) Evaluating the opportunity for utilising anaerobic digestion and pyrolysis of livestock manure and grass silage to decarbonise gas infrastructure: A Northern Ireland case study,* Renewable Energy, 196, 343-357.

[5] BEIS (2019) *Methodology to assess methane leakage from anaerobic digestion,* https://www.gov.uk/government/publications/methodology-to-assess-methane-leakage-from-anaerobic-digestion-plants.

[6] Bakkaloglu, S., Cooper, J. & Hawkes, A. (2022*) Methane emissions along biomethane and biogas supply chains are underestimated.* OneEarth, 5 (6), 724-736.

[7] Energy Ireland (2021) *Anaerobic digestion in Northern Ireland*, https://www.energyireland.ie/anaerobic-digestion-in-northern-ireland/.

[8] European Biogas Association (2021) *Biomethane Map 2021*, https://www.europeanbiogas.eu/biomethane-map-2021/.

[9] HM Government (2021) *Heat and Buildings Strategy*, https://www.gov.uk/government/publications/heat-and-buildings-strategy.

Chapter 3

Achieving Net Zero by 2050

Introduction and key messages

Northern Ireland has a legislated Net Zero target date of 2050. However, our Balanced Pathway for Northern Ireland, developed for our report on the UK's Sixth Carbon Budget, falls well short of Net Zero for Northern Ireland, largely due to significant residual emissions in the agriculture sector.

In this chapter we summarise some technical updates to our pathway and increase ambition in certain areas to reduce emissions further in 2050. We also discuss 'Speculative' options to go further in 2050 to achieve the legislated Net Zero target. Finally, we present our updated sectoral pathways up to 2050.

The key messages in this chapter are:

- We have developed a 'Stretch Ambition' pathway for Northern Ireland, which reaches a 93% reduction in emissions by 2050 on 1990 levels and entails Northern Ireland to take the following radical action to bolster the contribution of greenhouse gas removals and therefore balance some of the residual emissions from agriculture:
  - A rapid ramp up in annual afforestation rates to reach 3,100 hectares by 2035, which is significantly higher than the rate of 540 reported in 2021/22.
  - Inclusion of engineered removals from both solid biomass grown in Northern Ireland and anaerobic digestion of waste used to produce biomethane, together with CO_2 capture and transportation (e.g. shipping) to store the CO_2 elsewhere. This would be costly and would require significant investment and infrastructure development.

Even with these extra actions, there remains an estimated gap of 1.8 $MtCO_2e$ to the legislated Net Zero target in 2050. To close this, we consider two 'Speculative' pathways, one with deployment of direct air carbon capture technology, which is expected to have high costs, and another with a further reduction in the size of Northern Ireland's livestock farming sector. The second of these does not reach Net Zero by 2050, it would need to be supplemented by additional removals to do so, but the amount of removals required is smaller than for the direct air capture pathway. It is up to Northern Ireland to decide whether to pursue other speculative options in addition to these.

(a) Technical and timing updates

A series of technical and timing updates to decarbonisation action have been made to our Balanced Pathway.

A series of technical and timing updates to our Balanced Pathway have been made for this report:

- **Business and industrial**. Updates to the input data and modelling assumptions in our manufacturing and construction pathway. These include a newer model version, incorporating updated data on off-road mobile machinery and resolving a double counting of wood in construction from the resource efficiency inputs. We have also adjusted the emissions with a more realistic allocation of UK emissions between the four nations of the UK.

- **Buildings.** Adjustment of the rate of residential buildings decarbonisation to match that of our UK Tailwinds pathway and make adjustments to make our estimates more accurate.

  – Our original analysis assumed that, across the UK, off-gas grid buildings would generally be transitioned to low-carbon heating before those on-gas, with new domestic oil boilers phased out by 2028. This enabled off-gas buildings to become lead markets, to help ramp up heat pump supply chains ahead of deployment across a wider set of buildings in the 2030s.

  – However, due to the relatively high number of off-gas grid homes in Northern Ireland (~65% of homes compared to ~12% in England), this meant that buildings emissions in Northern Ireland fell much faster than for the UK as a whole.[1,2] Scaling up low-carbon heat so quickly in Northern Ireland could have issues with local workforce skills and supply chains, so we have slowed down the residential buildings decarbonisation rate to match that of the UK Tailwinds scenario, which is faster than the UK's Balanced Pathway (Figure 3.1).

  – We have also adjusted the residential buildings emissions to account for our previous underestimate of the proportion of UK dwellings in Northern Ireland and for Northern Ireland having lower outside temperatures than the UK average. This means more heating is needed and therefore emissions are higher.

- **Surface transport.** Adjustment to surface transport emissions to incorporate new data in our modelling assumptions on vehicle-km in Northern Ireland.

- **Energy.** Adjustment incorporating a better allocation of UK fuel supply emissions between the four nations of the UK.

- **LULUCF**. Delay of new forestry planting until 2024 (see Box 3.1 for an explanation of this). Also, 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 and an update to the modelling of tree-planting cycles to be closer to that used in the inventory (see Chapter 2 for details).

- **Agriculture**. Delay of the emissions pathway in the agriculture sector by two years (see Box 3.1 for an explanation of this).

- **Waste**. Delay of the emissions pathway in the waste sector by two years (see Box 3.1 for an explanation of this).

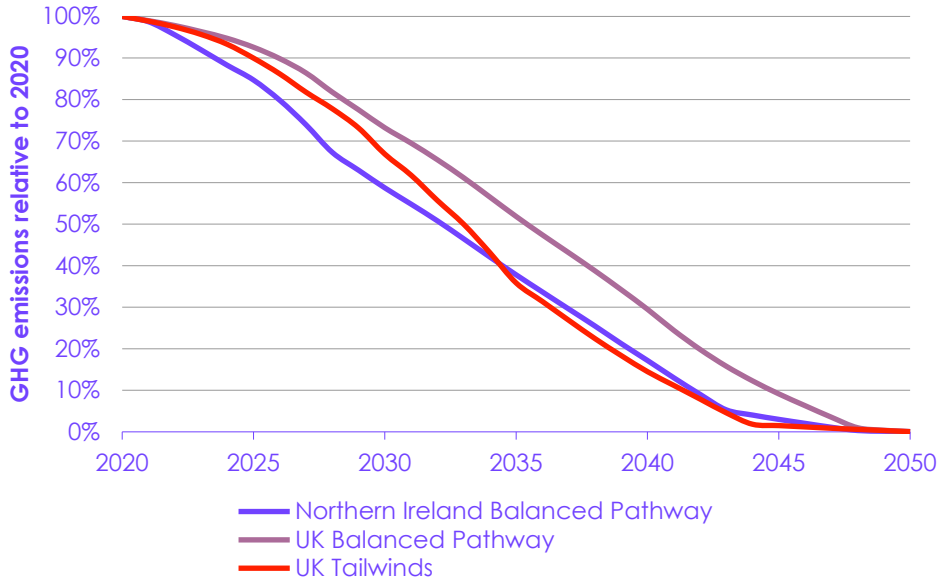
- **Greenhouse gas inventory updates**. Correction for other small changes in sectors other than land use in the inventory since we set our advice, assuming the latest report year's (2020) proportional change in sectoral emissions to be constant throughout the pathway. All sectors are affected by these updates, but the business and industrial sector accounts for most of the change, which is largely due to an integration of new mapping grids for the use of fuels at industrial sites and recalculations in the DUKES activity data.

- **Global warming potentials (GWPs)**. Use of Fifth Assessment Report without climate-carbon feedback (AR5-low) GWPs (to match international agreements at COP26). The Sixth Carbon Budget analysis used Fifth Assessment Report with climate-carbon feedback (AR5-high) GWPs as a decision on which of the AR5 GWPs to use had not yet been taken.

These updates result in very minor changes in emissions in 2050 (Table 3.1), with emissions reduction in 2050 being 83% less than in 1990 in the updated Balanced Pathway.

Our residential buildings pathway for Northern Ireland has been reprofiled to the slower rate of our UK-wide Tailwinds scenario to account for the time it will take to build up supply chains and a skilled workforce.

Figure 3.1 Emissions relative to 2020 for residential buildings



Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas.

Box 3.1
Reasoning for delaying our pathway for certain sectors

Our Balanced Pathway was developed in 2020 with pathways that started in that year. Looking at the historical emissions for the few years before the COVID-19 pandemic had its impact, there has been no progress in reducing emissions in the agriculture and waste sectors (Figure 1.2). We have therefore updated the Balanced Pathway for these sectors to reflect a delay of two years in the start of emissions reductions.

Progress in decarbonisation action in the land use sector has also been insufficient in recent years. For example, tree planting rates of 280 and 540 hectares were delivered in 2020/21 and 2021/22 respectively, which are well short of the 1,000 hectares/year required under the Balanced Pathway for those two years. We have therefore delayed our new tree planting to start in 2024 rather than 2020.

Source: CCC analysis.

(b) Stretch Ambition

Since the updated Balanced Pathway does not reach Net Zero, the following three options for increasing abatement to reduce emissions in 2050 have been investigated (set out in detail in Chapter 2):

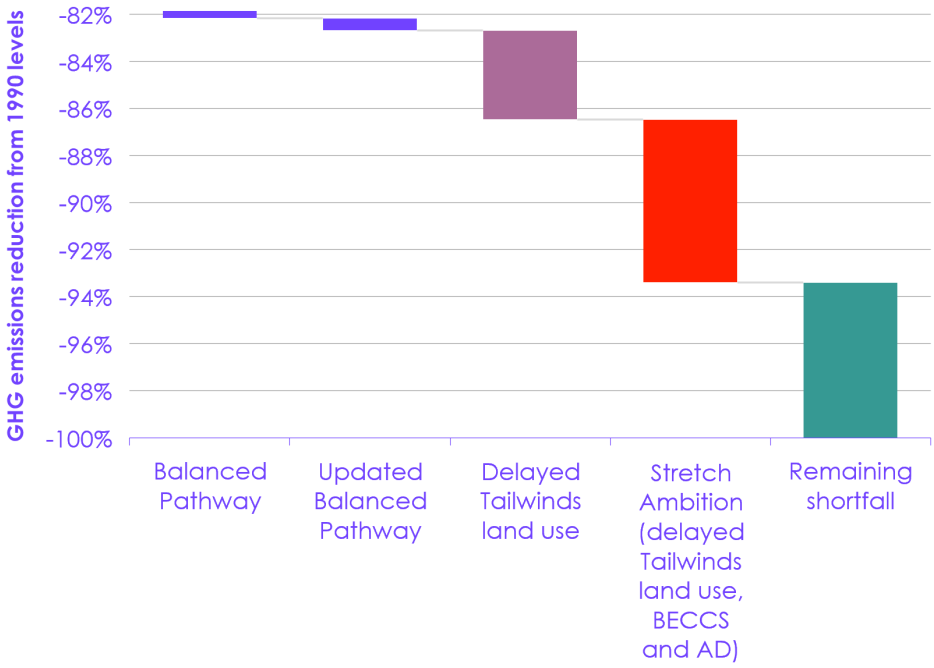
Our Stretch Ambition scenario increases greenhouse gas removals by increasing ambition in the land-use sector and introducing engineered removals via bioenergy and anaerobic digestion with CCS.

- **Shifting the land use sector actions from our Balanced Pathway to Tailwinds.** This will impact both the scale of action needed within the sector and the speed at which policy needs to be delivered. To reflect low current tree-planting rates in Northern Ireland, the delayed Tailwinds pathway has been used, which begins new planting in 2024 rather than 2020.
  - Tree-planting will need to increase to 3,100 ha/year by 2035 (compared to the average rate of around 290 ha/year in the last five years and 540 ha/year reported in 2020/21).
  - Afforestation focuses on productive forestry, with a higher mix of conifers at higher yields, supported by plant breeding approaches. Energy crops and short rotation forestry will have to be scaled up from zero within the next eight years.
  - Tailwinds represents the highest level of ambition for technological progress and speed of delivery. Given the current baseline of afforestation and the absence of energy crop planting in Northern Ireland, the scale of effort required to meet the pathway will be highly challenging.
- **BECCS.** Having bioenergy with carbon capture and storage (BECCS) in Northern Ireland, using Northern Ireland's bio-resources. Previously we assumed that some of these resources would be used for BECCS, but we had only allocated these to the UK as a whole and not to Northern Ireland, given the greater challenges of deploying CCS in Northern Ireland than some other parts of the UK.
- **Anaerobic digestion.** Scaling up anaerobic digestion of wastes in Northern Ireland and converting the resulting biogas to biomethane, including capturing the CO_2 from upgrading biogas to biomethane. The resulting biomethane is assumed to be used to displace fossil gas use, abating the emissions associated with this, and any leftover biomethane is assumed to be used for electricity or hydrogen production, using CCS on the emitted CO_2.

Figure 3.2 shows the impacts of our technical updates and Stretch Ambition pathway on the emissions in 2050.

Even with the radical action in our Stretch Ambition scenario, there is a remaining shortfall to reaching Net Zero in Northern Ireland.

Figure 3.2 Pathway emissions in 2050 before and after technical updates and ambition increase



Source: CCC (2020) *Sixth Carbon Budget*; CCC analysis.
Notes: GHG stands for greenhouse gas.

(c) Speculative options

A set of extreme speculative options have been considered to close the remaining gap to Net Zero. It is up to Northern Ireland to decide which combination of these options to explore.

Despite the increased ambition, our Stretch Ambition pathway does not reach Net Zero, achieving a 93% reduction on 1990 levels by 2050, with 1.8 $MtCO_2e$ of residual emissions. The following additional speculative options for reducing emissions in 2050 have been considered, although we are not necessarily recommending them without further consideration of achievability, cost and social implications.

- **Direct air capture with CCS (DACCS).** Direct air capture of CO_2 uses machines to suck CO_2 out of the air. This CO_2 can then be transported and stored in the ways described for BECCS elsewhere in this report.
  - This could potentially be implemented in Northern Ireland, especially if CCS infrastructure is being built for BECCS and anaerobic digestion as described above.
  - We have previously estimated DACCS in Great Britain to cost £180/tCO_2 once the technology has developed and scaled up.[3] However, this would be more expensive to do in Northern Ireland than elsewhere in the UK because any captured CO_2 would need to be shipped to a storage facility away from Northern Ireland rather than being stored locally, which might add a further £10-20/tCO_2.[4]

The speculative options include direct air capture with carbon capture and storage, further extreme reduction of Northern Ireland's agriculture sector and other ideas such as enhanced weathering or the addition of biochar to agricultural land.

- **Agriculture.** Increasing ambition in the agriculture sector to our Tailwinds scenario. This would involve deeper emissions cuts from agriculture, which is Northern Ireland's biggest economic sector, with potentially significant economic and social implications.

  - Livestock numbers would need to reduce by almost half by 2050, accompanied by technological and efficiency improvements in the sector (e.g. widespread use of feed additives).

  - Our emissions projections for Tailwinds depend on bigger dietary changes across the UK, with meat and dairy consumption falling by 47%, compared to the 34% for meat and 20% for dairy assumed in the Balanced Pathway.

  - A fundamental assumption is that this shift to plant-based diets combined with some lab-grown meat will be reflected in greater consumption of UK products (including from Northern Ireland), but it will also drive down total meat and dairy production, as most meat (over 80% in 2019) and dairy (over 50% in 2019) produced in Northern Ireland is sold within the UK.

  - Tailwinds presents a particular challenge in this case, as it requires major behavioural shifts to happen not only in Northern Ireland, but across the UK.

- **Enhanced weathering on croplands.** 'Enhanced weathering' involves spreading crushed basalt rock onto croplands, which over time reacts with CO_2 in the air and removes it from the atmosphere. Northern Ireland has local basalt deposits that could be used for this, but most of agricultural land in Northern Ireland is grazing pasture rather than cropland and most research in this area has focused on cropland. It is therefore not yet possible to estimate how much CO_2 could be sequestered. There are also potential negative environmental impacts to consider, such as contamination of soils, water and crops with hazardous trace metals, and rock dust in the air.

- **Addition of biochar to agricultural land.** This involves spreading biochar, a charcoal-like substance made from biomass, onto agricultural land. However, biomass supplies are finite and our analysis indicates that BECCS is likely to be a more efficient use of biomass to sequester carbon. Given the constraint on bio-resources, use of this option would be likely to reduce the contribution from BECCS outlined in Chapter 2 and therefore increase the gap to meeting Net Zero rather than help to close it.

- **Purchasing removals from elsewhere.** In its current form, the Act limits carbon credits to no more than 25% of residual emissions in any given year. By 2050, when allowed net emissions are zero, this implies that while credits could reduce the gap, they could not reduce it to zero. By implication, credits cannot be used to achieve Net Zero emissions without changing the Act, even if they are based on greenhouse gas removals elsewhere in the UK. Removals from BECCS outside Northern Ireland using biomass produced within Northern Ireland would also not count towards Northern Ireland's targets based on existing emissions accounting conventions.

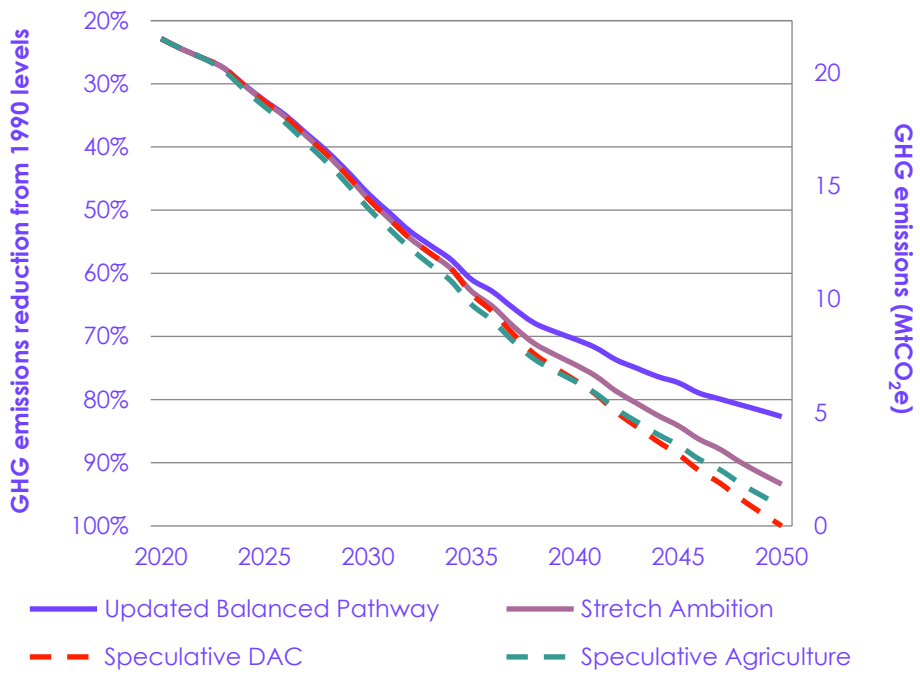
Out of these Speculative Options, the only ones we are currently able to quantify the emissions abatement potential of are using DACCS (our 'Speculative DAC' scenario) and increasing agriculture ambition to our Tailwinds scenario (our 'Speculative Agriculture' scenario). Only DACCS is enough on its own to reach Net Zero by 2050. Our 'Speculative Agriculture' scenario does not reach Net Zero by 2050, it would need to be supplemented with additional removals to do so, but less than that in our 'Speculative DAC' scenario. It is up to Northern Ireland to decide whether to pursue other speculative options in addition to this one. To allow for Northern Ireland to choose between these options and, should they end up being feasible, others of our speculative options, we use a linear ramp up of DACCS to set our advised targets. However, this does not constitute a recommendation that DACCS is used at this scale; this is only one of several options available to Northern Ireland.

(d) Implications for the pathway to 2050

Figure 3.3 shows the emissions pathway at different stages in the adjustment process. Expected emissions after each adjustment to the Balanced Pathway are shown in Table 3.1 for 1990, 2030, 2040 and 2050, both in $MtCO_2e$ and as a percentage reduction on 1990 levels.* Also shown is the effect of removing international aviation and shipping emissions to align with the scope of the Act.

Our advice on the interim targets and Carbon Budgets is based on the speculative option with direct air carbon capture.

Figure 3.3 Economy-wide emissions pathway



Source: CCC analysis.
Notes: GHG stands for greenhouse gas.

* The baseline year is 1990 for most pollutants but is 1995 for F-gases.

Table 3.1
Expected greenhouse gas emissions after each adjustment to our Balanced Pathway

	1990 [$MtCO_2e$]	2030 [% reduction since 1990 / $MtCO_2e$]	2040 [% reduction since 1990 / $MtCO_2e$]	2050 [% reduction since 1990 / $MtCO_2e$]
Sixth Carbon Budget Balanced Pathway (without engineered removals allocated to Northern Ireland)*	**28.6**	**47% 15.0 $MtCO_2e$**	**69% 8.9 $MtCO_2e$**	**82% 5.1 $MtCO_2e$**
Technical and timing changes				
Adjusted for updates to our buildings, electricity supply, fuel supply, manufacturing and construction, and surface transport pathways	28.6	47% 15.0 $MtCO_2e$	69% 8.8 $MtCO_2e$	82% 5.2 $MtCO_2e$
Adjusted for GWP change	27.0	48% 14.0 $MtCO_2e$	71% 7.9 $MtCO_2e$	84% 4.3 $MtCO_2e$
Adjusted for GHGI land-use change	27.4	48% 14.2 $MtCO_2e$	70% 8.3 $MtCO_2e$	83% 4.5 $MtCO_2e$
Adjusted for GHGI changes in other sectors	28.1	48% 14.7 $MtCO_2e$	70% 8.5 $MtCO_2e$	83% 4.6 $MtCO_2e$
Take out international aviation and shipping emissions	27.9	49% 14.4 $MtCO_2e$	71% 8.2 $MtCO_2e$	84% 4.5 $MtCO_2e$
Shift agriculture and waste management sector pathways back by two years and delay new forestry planting until 2024	**27.9**	**47% 14.7 $MtCO_2e$**	**70% 8.3 $MtCO_2e$**	**83% 4.8 $MtCO_2e$**
Stretch Ambition				
Land use sector adjusted to Tailwinds	27.9	48% 14.6 $MtCO_2e$	72% 7.9 $MtCO_2e$	86% 3.8 $MtCO_2e$
BECCS added	27.9	48% 14.6 $MtCO_2e$	72% 7.7 $MtCO_2e$	90% 2.7 $MtCO_2e$
Anaerobic digestion with CCS added	**27.9**	**48% 14.5 $MtCO_2e$**	**74% 7.1 $MtCO_2e$**	**93% 1.8 $MtCO_2e$**
Speculative options				
Option 1: DACCS added	27.9	48% 14.5 $MtCO_2e$	77% 6.4 $MtCO_2e$	100% 0.0 $MtCO_2e$
Option 2: Agriculture sector adjusted to Tailwinds	27.9	50% 14.0 $MtCO_2e$	77% 6.4 $MtCO_2e$	97% 0.9 $MtCO_2e$

* This includes a correction to an error in the historical F-gas emissions published in our Sixth Carbon Budget work, which does not affect the $MtCO_2e$ values in our pathway but does affect the percentage reduction figures.

The updated pathway emissions for each of the sectors specified in the Act (Box 1.2) are shown in Figure 3.4 and Table 3.2. This table also shows emissions in 1990 and 2019 – the latest year before the COVID-19 pandemic – for comparison and sets out which sectors have their emissions partly covered by the UK/EU Emissions Trading Scheme (ETS).* A breakdown of emissions in 2050 is given in Figure 3.5.

Emissions from international aviation and shipping are excluded as they are excluded from the Act. However, it remains our advice that these emissions are included in targets. The CO_2 removed from the atmosphere with BECCS and AD are added as a separate 'engineered removals' sector.

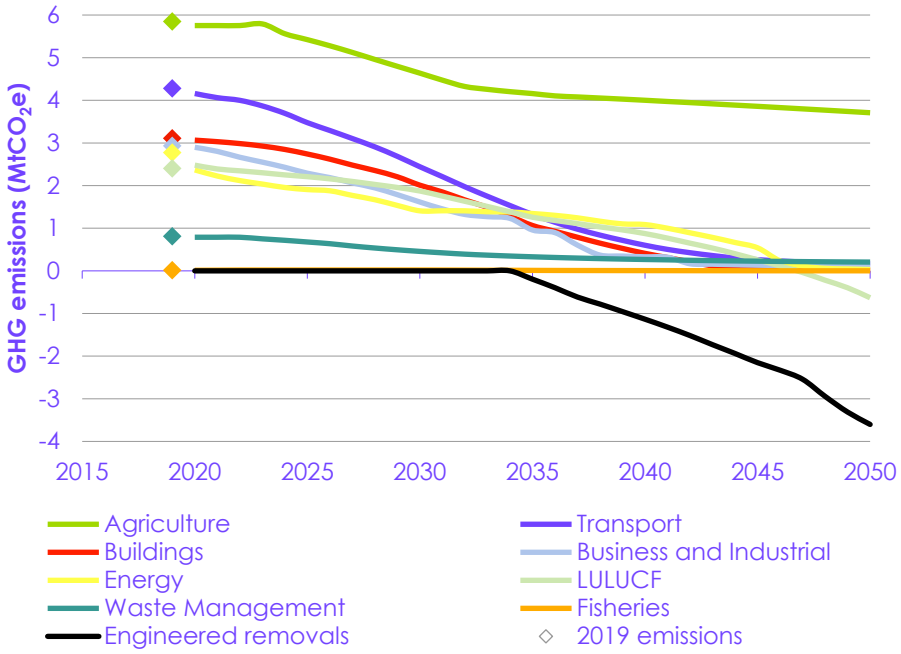
Table 3.2
Updated pathway split by the sectors specified in the Act

Sector	Sixth Carbon Budget pathway based on	1990 measured [$MtCO_2e$]	2019 measured [% reduction from 1990 / $MtCO_2e$]	2030 [% reduction from 1990 / $MtCO_2e$]	2040 [% reduction from 1990 / $MtCO_2e$]	2050 [% reduction from 1990 / $MtCO_2e$]	Covered by the UK/EU ETS?
Agriculture	Balanced Pathway	5.5	up 6% 5.9 $MtCO_2e$	16% 4.6 $MtCO_2e$	27% 4.0 $MtCO_2e$	33% 3.7 $MtCO_2e$	Not covered
Transport	Balanced Pathway	3.4	up 25% 4.3 $MtCO_2e$	29% 2.4 $MtCO_2e$	82% 0.6 $MtCO_2e$	95% 0.2 $MtCO_2e$	Partly covered
Buildings	Balanced Pathway	4.1	25% 3.1 $MtCO_2e$	51% 2.0 $MtCO_2e$	90% 0.4 $MtCO_2e$	100% 0.0 $MtCO_2e$	Not covered
Business and Industrial	Balanced Pathway	4.6	37% 2.9 $MtCO_2e$	65% 1.6 $MtCO_2e$	93% 0.3 $MtCO_2e$	98% 0.1 $MtCO_2e$	Partly covered
Energy	Balanced Pathway	5.3	48% 2.8 $MtCO_2e$	73% 1.4 $MtCO_2e$	80% 1.1 $MtCO_2e$	99% 0.0 $MtCO_2e$	Partly covered
LULUCF	Tailwinds	2.8	15% 2.4 $MtCO_2e$	34% 1.9 $MtCO_2e$	69% 0.9 $MtCO_2e$	122% -0.6 $MtCO_2e$	Not covered
Waste Management	Balanced Pathway	2.0	60% 0.8 $MtCO_2e$	77% 0.5 $MtCO_2e$	87% 0.3 $MtCO_2e$	90% 0.2 $MtCO_2e$	Not covered
Fisheries	Balanced Pathway	0.02	17% 0.02$MtCO_2e$	7% 0.02 $MtCO_2e$	72% 0.01 $MtCO_2e$	94% 0.00 $MtCO_2e$	Not covered
Engineered removals	n/a	0.0	n/a 0.0 $MtCO_2e$	n/a 0.0 $MtCO_2e$	n/a -1.1 $MtCO_2e$	n/a -3.6 $MtCO_2e$	Not covered

* Emissions covered by the UK/EU ETS should be reduced over time as the number of emissions permits issued per year decreases.

Our sectoral emissions pathways show that rapid decarbonisation is required across all sectors of the economy for Northern Ireland to be on track to meet its Net Zero target.

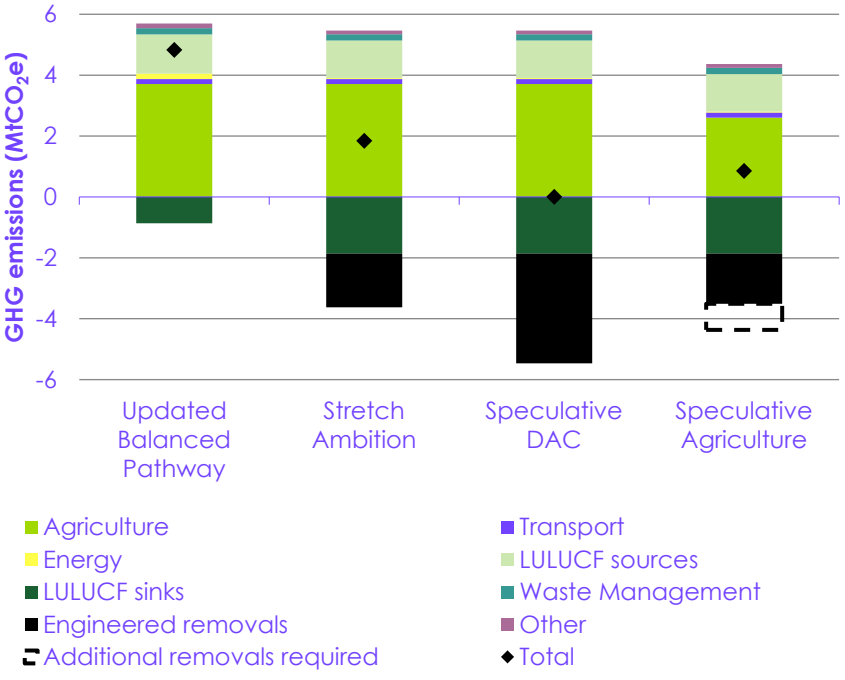
Figure 3.4 Sectoral emissions in Northern Ireland 2020-2050



Source: CCC analysis.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry.

Emissions in Northern Ireland in 2050 are predominantly a balance between agriculture, land use and removals. The only speculative option that reaches Net Zero is that with direct air carbon capture and storage.

Figure 3.5 Sectoral emissions in Northern Ireland in 2050



Source: CCC analysis.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry.

As explained in Chapter 2, the Act includes a requirement that reaching Net Zero in Northern Ireland does not rely on reducing methane emissions by more than 46% on 1990 levels by 2050. The pathway on which our Carbon Budget and interim target advice is based requires a cut in methane emissions of only 41%, so is compatible with this restriction.*

* This is less ambitious than the 46% figure from our published Balanced Pathway because of changes in emissions accounting methodologies and the delays to the agriculture and LULUCF pathways, which increase methane emissions in 2050.

Endnotes

[1] Northern Ireland Housing Executive (2016) *House Condition Survey*, https://www.nihe.gov.uk/working-with-us/research/house-condition-survey.

[2] Department for Levelling Up, Housing and Communities (2022) *English Housing Survey data on energy performance*, https://www.gov.uk/government/statistical-data-sets/energy-performance.

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

[4] Element Energy and Business, Energy & Industrial Strategy Department (2018) *Shipping CO_2 – UK Cost Estimation Study*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761762/BEIS_Shipping_CO2.pdf.

Chapter 4

Advised target levels

Introduction and key messages

This chapter presents the emissions targets that we advise are consistent with Northern Ireland's legislated Net Zero target. We advise on the level of the 2030 and 2040 interim target as well as the first three Carbon Budgets. These targets are extremely challenging and will be unachievable without immediate policy actions. We therefore also set out the set of near-term actions required for Northern Ireland to get on track for the 2030 target and Net Zero target.

The key messages in this chapter are:

- The First (2023-2027), Second (2028-2032) and Third (2033-2037) Carbon Budgets should be set at levels that are average annual reductions of 33%, 48% and 62%, on 1990 levels, respectively. The 2030 and 2040 interim targets should be set at reductions of 48% and 77% on 1990 levels, respectively.

- Northern Ireland should not use carbon credits to meet any of its targets, which should be met with domestic action, consistent with our previous advice.

- With Northern Ireland's first Carbon Budget period having just begun, decarbonisation action needs to ramp up immediately. Average annual emissions will need to be 16% lower than 2019 levels by 2025 and 35% lower by 2030. With emissions having reduced only an average of 9% per decade since 1990, a step change in action is needed across all sectors of the economy.

In this section, we present our advised emissions targets. We give these as percentage reductions on 1990 levels (averaged over the five-year period for the Carbon Budgets), rather than in $MtCO_2e$, as percentage reductions give some protection against changes in the greenhouse gas inventory methodology impacting the required ambition.

The interim targets should be set at a 48% reduction by 2030 and a 77% reduction by 2040 on 1990 emissions levels.

(a) Target levels: 2030 and 2040

The target levels for 2030 and 2040 should be set at 48% and 77% reductions from 1990 levels respectively, based on our updated analysis (Table 3.1, Figure 3.3).

(b) Carbon Budgets

The target levels for the First (2023-2027) and Second (2028-2032) Carbon Budgets should be set to 33% and 48% reductions from 1990 levels, respectively (on an average annualised basis).

The target levels for the First (2023-2027), Second (2028-2032) and Third (2033-2037) Carbon Budgets should be set to 33%, 48% and 62% reductions from 1990 levels, respectively (on an average annualised basis). Our analysis is based on the latest available data. The latest reported year of greenhouse gas emissions is 2020, which is a year that is significantly affected by largely short-term effects from the COVID-19 pandemic. Data for Northern Ireland's emissions in 2021 will be available later this year and this will give a better indication of the feasibility of the decarbonisation required for our advised First Carbon Budget. It may be possible that a slightly less ambitious First Carbon Budget is appropriate to account for a slower start in the first two years, but decarbonisation rates towards the end of the First Carbon Budget would need to be at the level of our pathway if Northern Ireland is to be on track to meet the 2030 target and the ultimate target of Net Zero by 2050.

2. Use of carbon credits

Carbon credits cannot be used to bridge the gap to Net Zero under the current legislation. We recommend that they are not used for interim targets, as their use would pose a risk to the Net Zero target.

The extremely stretching nature of Northern Ireland's legislated Net Zero target means that the effort required to achieve it necessarily goes beyond that required for Net Zero across the UK as a whole, which can be achieved with the actions in the Balanced Pathway. Furthermore, aiming for Net Zero in Northern Ireland may lead to distorting actions such as undertaking BECCS in Northern Ireland despite its greater challenges.

It might therefore in principle have been appropriate to use credits based on greenhouse gas removals elsewhere in the UK to help bridge some of the gap between our previous advice and Net Zero in 2050 for Northern Ireland. However, the Act rules out this possibility, limiting carbon credits to no more than 25% of allowed net emissions in any given year. By 2050, this implies that while credits could reduce the gap, they could not reduce it to zero. By implication, credits cannot be used to achieve Net Zero emissions, even if they are based on greenhouse gas removals elsewhere in the UK.

Given the constraint on credit use for 2050, it is essential that Northern Ireland makes the necessary progress in its transition to avoid the need for credits to be used in meeting Net Zero. We therefore recommend that carbon credits are not used to meet any of Northern Ireland's interim climate change targets, as their use would pose several risks:

- Usage of credits could impair the clarity of the sectoral actions required to meet the budget by suggesting possible flexibility in the need to deliver emissions reductions.
- Substituting domestic effort with purchased emissions reductions from outside Northern Ireland could make it more difficult to achieve the necessary domestic transitions needed to reach Net Zero by 2050.
- The international signal sent by Northern Ireland setting a Net Zero target would be undermined by use of international carbon units to substitute for emissions reductions that could be achieved domestically.

3. Near-term action required

Northern Ireland's First Carbon Budget period has now begun and a step change in decarbonisation action must begin immediately.

In this section, we summarise the near-term actions required by Northern Ireland to meet our advised targets over the rest of this decade and to be on track for Net Zero by 2050. These must be driven with new, ambitious policies. Northern Ireland's First Carbon Budget period has now begun and decarbonisation action must ramp up immediately. Average annual emissions will need to be 16% lower than 2019 levels by 2025 and 35% lower by 2030. With emissions having reduced only an average of 9% per decade from 1990 to 2020, a step change in action is needed across all sectors of the economy (Figure 4.1).

Current action and deployment rates are insufficient across all sectors of the economy and rapid ramp up needs to start now.

- **Energy generation.** The electricity system in Northern Ireland is part of a single system and electricity market on the island of Ireland. Deployment of new renewable electricity generation is required at scale in Northern Ireland, with access to appropriate energy storage and decarbonised back-up solutions (e.g. gas turbines burning hydrogen manufactured from low-carbon sources) is needed to allow the carbon intensity of electricity generation to reduce significantly while ensuring that demand is met sufficiently reliably.

- **Surface transport.** By 2032, every new car and van sold in Northern Ireland should be zero-emission. This implies substantial investment to expand the electric vehicle charging infrastructure in Northern Ireland, and major scale-up of plug-in vehicles' share of new car sales from the current 10% to 100% within a decade. Enabling an increased proportion of journeys made by walking and cycling will be important to improve public health and air quality alongside reducing greenhouse gas emissions. Rail services should also be largely electrified, with the proportion of diesel freight trains in operation falling to below 15% by 2050, from 87% in 2020.

- **Buildings.** Concerted action will be required to decarbonise Northern Ireland's buildings over this decade. All newly constructed homes should be zero-carbon as soon as practicable, with no requirement for later retrofit. Substantial improvement is also required in the energy efficiency of existing buildings. By 2030 for homes off-gas grid and 2033 for homes on-gas grid, all new heating appliance installations should be zero-carbon. This has implications for supporting infrastructure, including the necessary strengthening of electricity networks. It is unlikely to be compatible with further extension to the Northern Ireland gas network.

- **Business and industrial.** Industry in Northern Ireland should cut fossil fuel use by 45% by 2030. Achieving this will require a coordinated combination of resource efficiency, energy efficiency and fuel switching. By 2030 it is unlikely that sites in Northern Ireland will have direct access to carbon storage and hydrogen networks, suggesting a greater role for electrification. This sector will need strong support to make the required changes and ensure that production is not transferred overseas.

- **Agriculture.** Reductions in methane emissions are given special protections in the new legislation, but very significant reductions in emissions from Northern Irish agriculture are still necessary. This will only be achieved through widespread adoption of low-carbon farming practices and with improved farm productivity.

Our pathway rests on a reduction in livestock numbers with a 22% reduction in numbers of dairy cattle, 17% in beef cattle and 18% in sheep by 2030 compared to 2020. Farmland freed-up by this change can be turned towards greater carbon sequestration. Reduction in demand for meat within Northern Ireland leads to healthier diets.

- **Land use.** Northern Ireland has an area of 240,000 hectares classed as peatland soils, with around 80% of the peat area classified as degraded in 2020.

  – To increase the land use sink capacity, the management of peat must shift fundamentally: low-yielding trees must be removed from peat soils by 2030, all extraction sites must be restored by 2035, and by 2050 more than half of peatland in Northern Ireland should be under restoration in addition to that already under sympathetic management.

  – Under the CCC's Tailwinds scenario, afforestation will also need to increase substantially: average tree-planting rates need to increase from an average of 226 hectares per year over the last decade to 1,000 by 2024, and 3,100 by 2035. This needs to be undertaken in a just manner to ensure there is no negative effect on food security or prices.

is our assessment that engineered removals will be required if Northern Ireland is to meet its legislated Net Zero target.

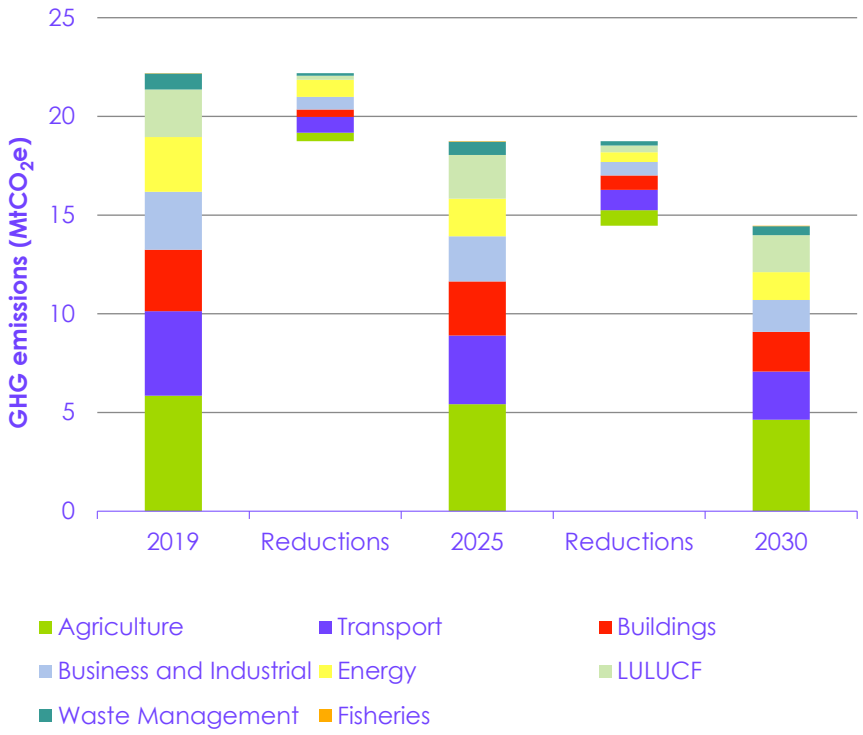
- **Engineered removals.** Within the constraints imposed by other uses of land, Northern Ireland must scale up bioenergy plants, biogas generation with anaerobic digestion of wastes and conversion of this biogas into biomethane, while developing the capability to capture and store the CO_2 generated in these processes.

  – To start CCS in plenty of time to achieve the necessary removals in 2050, Northern Ireland should start developing CCS this decade, achieving the first installation of CO_2 capture plants, transportation of CO_2 to a storage site and storage of CO_2 by 2035.

  – As the storage of CO_2 would need to be outside Northern Ireland, CCS projects in Northern Ireland will need to either join a UK CCS cluster as part of the UK Government process or establish an agreement with a CCS project outside of the UK. If it becomes clear that this timeline is not possible, then Northern Ireland will need to do something else to achieve the necessary emissions cuts, such as even faster agriculture emission reductions than in our Tailwinds scenario.

The sectors with most emissions reductions needed in the next few years are transport, energy and business and industrial.

Figure 4.1 Near-term emissions reductions



Source: CCC analysis.
Notes: GHG stands for greenhouse gas, LULUCF stands for land use, land-use change and forestry.

4. Deployment rates

Table 4.1 shows the deployment rates of some key measures and technologies for achieving our Stretch Ambition pathway.

Table 4.1
Deployment rates of some key measures and technologies

Measure/technology	2025	2030	2035	2040	2045	2050
Gas demand (TWh/year)	19	14	11	8	4	1
Electricity emissions intensity (gCO_2e/kWh)	250	150	115	80	45	10
Proportion of cars on the road that are battery electric vehicles	9%	34%	64%	87%	97%	100%
Proportion of vans on the road that are battery electric vehicles	12%	39%	68%	87%	97%	100%
Proportion of HGVs on the road that are zero-emission vehicles	0%	4%	33%	67%	88%	97%
Proportion of buses and coaches on the road that are zero-emission vehicles	4%	17%	38%	57%	73%	92%
Distance travelled by cars (billion vehicle-km/year)*	16.0	16.5	17.0	17.3	17.5	17.6
Distance travelled by vans (billion vehicle-km/year)*	0.9	1.0	1.1	1.1	1.2	1.2
Distance travelled by HGVs (billion vehicle-km/year)*	0.9	0.8	0.9	0.9	0.9	0.9
Annual heat pump installations (including hybrids)	15,857	33,000	38,000	36,500	4,903	1,327
Homes connected to district heating networks (annual)	500	1,582	2,267	1,168	748	850

* The 'distance travelled' measures for different vehicles are reduced compared to our projected 'business as usual' or baseline figures, which show larger increases.

Livestock numbers (millions)	27	24	23	22	22	21
Cropland area (kha)	43	40	38	37	35	33
Percentage of total peatland that is degraded	69%	53%	37%	32%	26%	24%
Afforestation (kha/year)	1	2	3	4	4	4
Emission reductions from low-carbon agricultural measures ($MtCO_2e$/year)	0.3	0.5	0.6	0.6	0.5	0.5

Endnotes

There were no endnotes in this chapter.

March 2023

Advice report:
The path to a Net Zero Northern Ireland

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