December 2020

Advice Report:
The path to a Net Zero Wales

Climate Change Committee

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The Committee

The Rt. Hon John Gummer, Lord Deben
Chairman

Lord Deben was the UK's longest-serving Secretary of State for the Environment (1993 to 1997). He has held several other high-level ministerial posts, including Secretary of State for Agriculture, Fisheries and Food (1989 to 1993). Lord Deben also runs Sancroft, a corporate responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues.

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Deputy Chair

Baroness Brown of Cambridge DBE FREng FRS (Julia King) is an engineer, with a career spanning senior engineering and leadership roles in industry and academia. She currently serves as Chair of the CCC's Adaptation Committee; non-executive director of the Offshore Renewable Energy Catapult; and Chair of the Carbon Trust.

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Rebecca Heaton is responsible for Drax Group's efforts to mitigate climate change, ensuring that sound science underpins climate change polices and business strategy. She is also responsible for developing sustainability and climate change research programmes. Rebecca has a 20-year global career working at the interface between business, science and policy.

Professor Keith Bell

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

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Nick Chater is Professor of Behavioural Science at Warwick Business School. He has particular interests in the cognitive and social foundations of rationality, and applying behavioural insights to public policy and business. Nick is Co-founder and Director of Decision Technology Ltd, a research consultancy.

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Paul Johnson is Director of the Institute for Fiscal Studies and a visiting professor at University College London (UCL). He is widely published on the economics of public policy, and he co-wrote the 'Mirrlees review' of tax system design. He was previously Chief Economist at the Department for Education (2000 to 2004).

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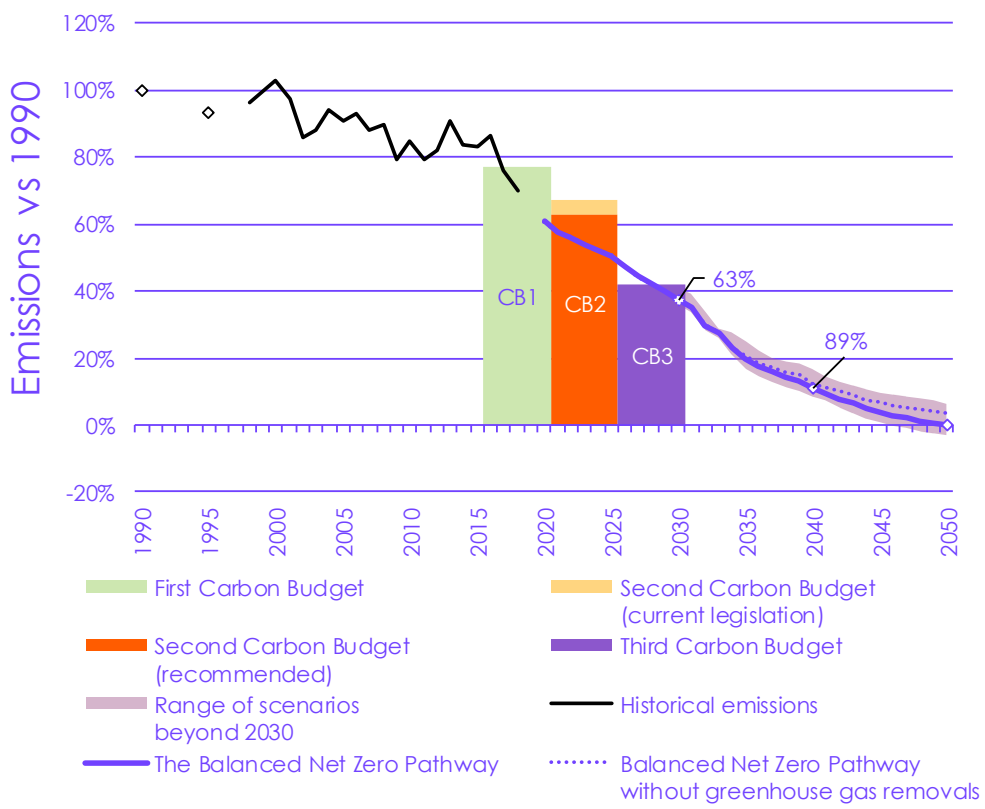
Corinne Le Quéré is Royal Society Research Professor of Climate Change Science at the University of East Anglia (UEA), where she conducts research on the interactions between climate change and the carbon cycle. Corinne is currently the Chair of the French Haut Conseil pour le Climat

In 2019, the Committee advised the Welsh Government to set a target to reduce emissions by 95% in 2050. The Welsh Government accepted that advice, and declared its intention to bring forward a target for Wales to achieve Net Zero emissions no later than 2050.

The Welsh Government is now in a position to realise that goal. The Committee's updated evidence and analysis now supports a recommendation for Wales to set and pursue an ambitious target to **reduce all greenhouse gas emissions to Net Zero by 2050**, backed up by a stretching set of targets on the pathway to that goal.

This represents Wales' fair and credible contribution to the UK Net Zero goal, and is consistent with our recommendations on the UK's Sixth Carbon Budget and the UK's nationally determined contribution (NDC) for 2030 to the UN process.*

Figure 1 Recommendations for Wales' climate targets



Source: NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.

Notes: Historical emissions data are not available for 1991-1994 and 1996-1997. Emissions shown are presented including all emissions from peatlands and using AR5 global warming potentials including carbon-cycle feedbacks. GGRs = greenhouse gas removals. Range is defined by other exploratory scenarios.

* Our Sixth Carbon Budget recommendation for the UK (-78%) includes emissions from international aviation and shipping, but UN convention is to report these separately, so they are not included in our recommended NDC for 2030 (-68%). On an equivalent basis (i.e. including international aviation and shipping), the 2030 NDC would be a 64% reduction relative to 1990.

Our recommended targets for Wales would achieve nearly two-thirds of the required emissions reduction from 2020 to 2050 in the next 15 years (Figure 1). This early action is vital to support the required increase in global ambition, especially ahead of the UK hosting the next UN climate talks. It can feasibly be achieved at low overall cost and would bring multiple benefits and opportunities for the UK.

Achieving Net Zero requires average annual reductions in Welsh emissions of 1.3 $MtCO_2e$ from 2018, similar to those achieved since 2008 (1.2 $MtCO_2e$ per year). The analysis in this report shows this is clearly feasible, provided effective policies are introduced across the economy without delay.

Our advice to the Welsh Government this year is set out in two parts:

- ***Advice Report: The Path to a Net Zero Wales*** sets out recommendations for the actions that are needed in Wales, including the legislation of a Net Zero target and package of policies to deliver it.
- ***Progress Report: Reducing emissions in Wales*** looks back at the progress made in Wales since the 2016 Environment (Wales) Act was passed, and assesses whether Wales is on track to meet its currently legislated emissions reductions targets.

This report has been developed in conjunction with our advice to the UK Government on the Sixth Carbon Budget. More detail on the analysis that has informed this advice to the Welsh Government are available on the in the *UK Sixth Carbon Budget Report* and accompanying material on the CCC website.

Box 1 set out the Committee's recommendations on Wales' targets. The rest of this summary is set out in four parts:

a) Net Zero in 2050 is right for the climate and right for Wales

b) How the Net Zero goal can be met in Wales

c) Recommendations for action

d) Progress towards Wales' existing targets

Box 1
CCC recommendations on Wales' climate targets

- **Net Zero in 2050.** Wales should legislate as soon as possible to reach Net Zero greenhouse gas emissions by 2050. The target can be legislated as a 100% reduction in greenhouse gases (GHGs) from 1990 and should cover all sectors of the economy.
- **Climate targets on the path to Net Zero.** Wales should legislate a stretching series of targets on the pathway to Net Zero:
  - **The Third Carbon Budget (2026-2030)** should be set at an average 58% reduction compared to 1990 levels.
  - **Interim targets for 2030 and 2040** should be set on the Balanced Pathway to Net Zero at 63% and 89% respectively compared to 1990 levels.
  - **The Second Carbon Budget (2021-2025)** must be tightened to a 37% reduction compared to 1990 levels as an absolute minimum to account for the early closure of Aberthaw power station (as set out in our 2017 advice). Emissions will likely have to fall more quickly than this to meet the Third Carbon Budget. However, it is extremely difficult to identify precisely the appropriate level of emissions reduction over this period:
    - Future performance of the economy – and hence the level of economic activity that could cause emissions – is always uncertain to some degree. However, uncertainty over emissions in the next few years is much greater than usual, relating to how the economy will recover after the COVID-19 pandemic, together with any lasting societal and behavioural changes.
    - Much of the emissions reduction that we expect in Wales over the next few years, which could take Wales significantly beyond the 37% reduction in our previous advice, is anticipated to occur in the power sector (i.e. through reduced gas-fired generation) and is not in the control of the Welsh Government.
    - These two factors are likely to make a considerably bigger difference to emissions in Wales than new policies developed and implemented by the Welsh Government, especially given the lead-times to do so. Strong policies to reduce emissions should be developed and implemented by the Welsh Government over a timeframe that enables them to make a significant difference (i.e. aimed at the ambitious reduction of 58% for the Third Carbon Budget).
  - We therefore recommend that as a minimum the level of the Second Carbon Budget is revised in line with our 2017 advice to require a reduction of 37%, but that the clear aim of the Welsh Government is to outperform this on the way to meeting the ambitious Third Carbon Budget and 2030 target.
- **A Net Zero delivery plan.** We recommend that the next low-carbon delivery plan in Wales sets out a long-term vision for meeting the Net Zero goal, with a particular focus on the Third Carbon Budget and the 2030 target. Policies and proposals to reduce emissions take time to implement and to have impacts in the real world; the focus of Wales' should not be limited to emissions targets in the next five years. The expected impact of policies, including those in early planning, should be clearly quantified and in sum be enough to meet the third carbon budget.
- **Engineered removals.** We recommend that engineered CO_2 removal is allowed to contribute to meeting Welsh carbon targets under the Environment (Wales) Act. Achieving Net Zero will require sustainable, verified greenhouse gas removals.
- **Domestic action.** The aim should be to meet the target through domestic effort in Wales, without relying on international carbon units (or 'credits'). Emissions trading – including potentially within a UK scheme – can be a useful policy lever to reduce actual Welsh emissions (net of removals) as required to meet the recommended targets.

a) Net Zero in 2050 is right for the climate and right for Wales

A globally responsible Wales: supporting global climate action

Our recommended targets for Wales – alongside our recommendations for the UK Sixth Carbon Budget and the newly-set UK Nationally Determined Contribution (NDC) (Box 2) – reflect the goals and requirements of the Paris Agreement, recognising Wales' responsibility as a richer developed nation and its respective capabilities:

- Our recommended pathway has been explicitly designed to reflect Wales' **'highest possible ambition'** within Wales' particular capabilities, as required by the Paris Agreement.
- It would reduce Wales' annual **per-capita emissions** to under 3 tCO_2e per person before 2040, in line with global pathways consistent with meeting the Paris 1.5°C goal (Figure 2).

Our pathways have been developed to support the required pathways for reducing global emissions.

- The **actions** required to meet the recommended targets – including full decarbonisation of the power sector, full switchover to electric vehicle sales and installation of low-carbon heating, and decarbonisation of manufacturing – would go beyond those required from the world on average, in line with Wales' responsibility as a richer nation with larger historical emissions. The timing of these actions would align to that required from the rest of the UK and other climate leaders.
- Comparable action from other developed countries with developing countries following slightly later (i.e. where they generally adopt low-carbon measures later, achieve lower percentage reductions to 2030 and reach Net Zero emissions after 2050) would limit warming well below 2°C. The emissions pathways set out in this report for Wales contribute to a **'leadership-driven' global pathway**.
- We have highlighted where policies and actions have important crossovers with the need to **adapt to climate change**, which is also included as a key part of the long-term response to climate change in the Paris Agreement.

While many countries have followed the UK in adopting Net Zero as a long-term emissions target, global ambition to 2030 remains far short of what is required. As President of the next UN climate talks (and of the G7) in 2021, the UK is in a position to influence others, but to do so must itself adopt an ambitious 2030 goal. Reducing emissions early matters as it is global cumulative emissions that drive climate outcomes.

The UK's climate goals cannot be met without the right action in Wales. The Welsh Government can support UK action by setting equally stretching targets into Welsh law and pursuing ambitious devolved policies that are well aligned to both Wales' Net Zero goal and the UK's path to Net Zero via the Sixth Carbon Budget.

Box 2
The UK's Nationally Determined Contribution (NDC) for 2030

The UK will host the next UN climate talks – the 26th Conference of the Parties (COP26) – in Glasgow in November 2021. The period leading up to these talks is vital for increasing global ambition. It was of vital importance that the UK set a world-leading NDC that reflects best practice under the Paris Agreement.

On 3 December, following advice from the Committee by letter,[1] based on the advice on the UK Sixth Carbon Budget published the following week,[2] the Prime Minister announced that the UK NDC would follow the Committee's advice for it to require at least a 68% reduction in territorial emissions from 1990 to 2030 (excluding emissions from international aviation and shipping, IAS, in line with UN convention), to be delivered through domestic action.

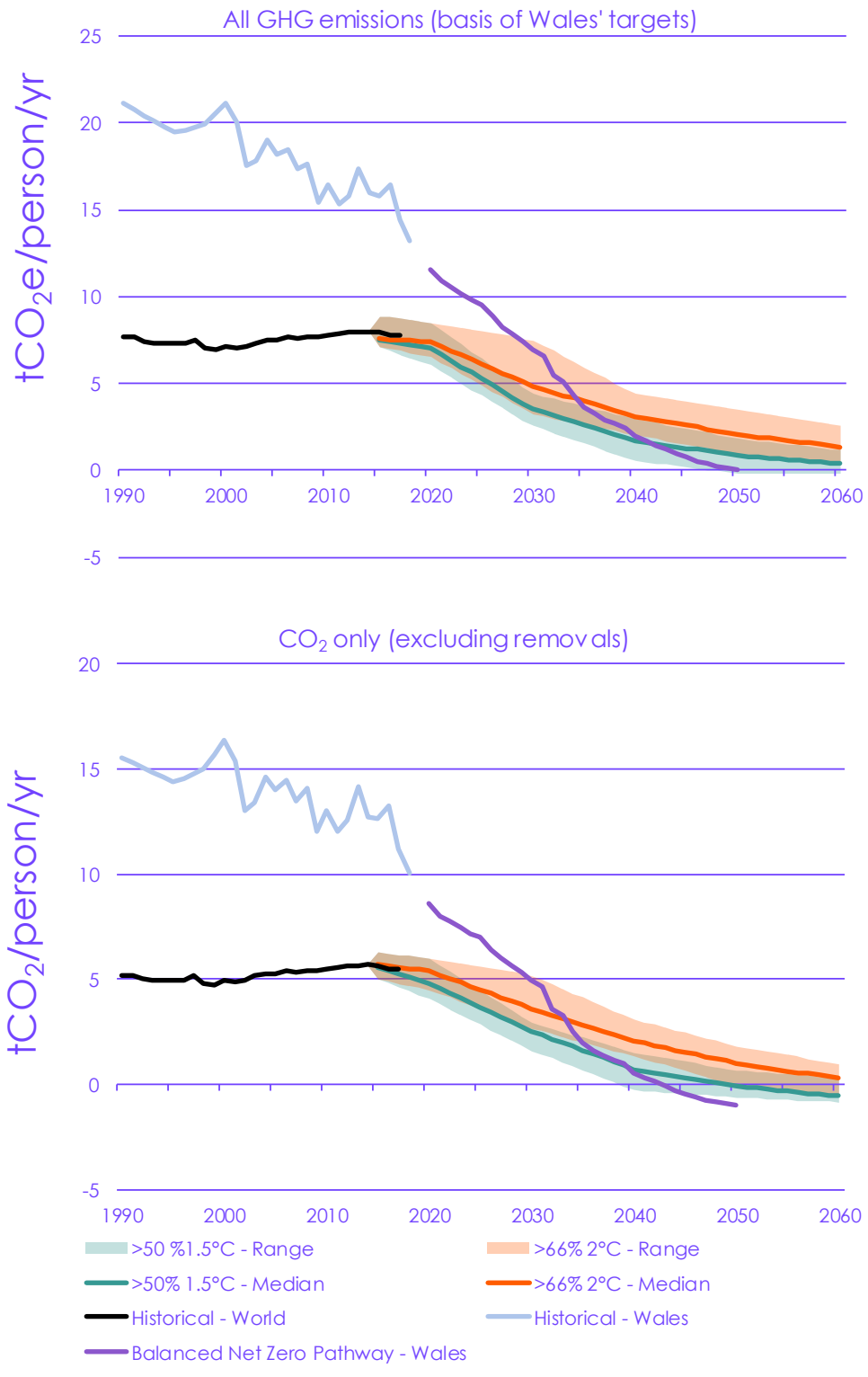
- This is a clear progression from the UK's pre-existing commitments: its expected effort share of the EU's existing NDC (-53%), the existing fifth carbon budget (-57%), and the expected reduction in actual emissions under the fifth carbon budget (-61%).*
- It is world-leading compared to existing NDCs, and amongst the front-runners for proposals for increased ambition. For example, if the EU adopts its proposed 55% reduction for 2030, the UK's NDC would be towards the top of the range that we estimate for the UK's possible effort share had it still been a Member State.
- It aligns with the published pathways from the Intergovernmental Panel on Climate Change (IPCC) for a 1.5°C goal. UK emissions would fall by 54% from 2010 to 2030, compared to the 45% that the IPCC identifies for the world as a whole.
- It is equivalent to a 64% reduction including international aviation and shipping emissions, the basis of our recommended Sixth Carbon Budget.

The Committee made further recommendations alongside the headline reduction in emissions:

- **International aviation and shipping.** While these emissions are treated separately by the UN, they must be addressed if the temperature goal of the Paris Agreement is to be met. The UK's NDC should include clear commitments to act on emissions from international aviation and shipping, including both long-term and interim targets.
- **Adaptation.** Even if the Paris goals are delivered in full and global temperature rise is limited to 1.5°C, there will be further impacts from climate change beyond those already occurring today. If the Paris goals are missed, the global impacts will become much more severe. The UK needs to increase its ambition on climate change adaptation, as it is not even prepared even for the 1.5-2°C world. The UK's NDC should signal how national adaptation plans will be strengthened, as well as highlighting how the UK is supporting climate adaptation overseas.
- **International collaboration.** The UK has been a strong contributor to international climate finance, recently doubling its commitment to £11.6 billion in aggregate over 2021/22-2025/26. The UK's NDC should highlight this commitment, along with other UK contributions to technology development and capacity building.

* The existing EU ambition is for a 40% reduction by 2030 relative to 1990; an increase to 55% is being considered. The fifth budget goal of -57% refers to the net carbon account, which adjusts for emissions trading in the EU Emissions Trading System.

Figure 2 Global emissions pathways (per person) consistent with the Paris Agreement



Source: CCC analysis. Huppmann, D, et.al. (2018) A new scenario resource for integrated 1.5°C research. *Nature Climate Change*, 8 (12), 1027; Olivier, J. & Peters, J. (2019) *Trends in global CO_2 and total greenhouse gas emissions*. Notes: Aggregation of greenhouse gas emissions is done using the global warming potential metric at time horizon of 100 years. Values from the IPCC 5th Assessment report (with climate-carbon feedbacks) are used. Minimum and maximum ranges are used across the global emissions scenario categories used by the IPCC Special Report on Global Warming of 1.5°C. These figures do not include the uncertain of COVID-19 on 2020 emissions. CO_2 figures do not include any greenhouse gas removals technology in Wales. Emissions data are not available for 1991-1994 and 1996-1997; we have interpolated emissions in Wales for these years based on the levels in 1990, 1995 and 1998.

Supporting UK ambitions for Net Zero

Under the 2008 Climate Change Act, Wales is required to contribute to the UK 2050 Net Zero target and the UK's carbon budgets. The Act assigns to Welsh Ministers the duty to report on the Welsh Government's objectives, actions and future priorities regarding the impacts of climate change to the Welsh Parliament.

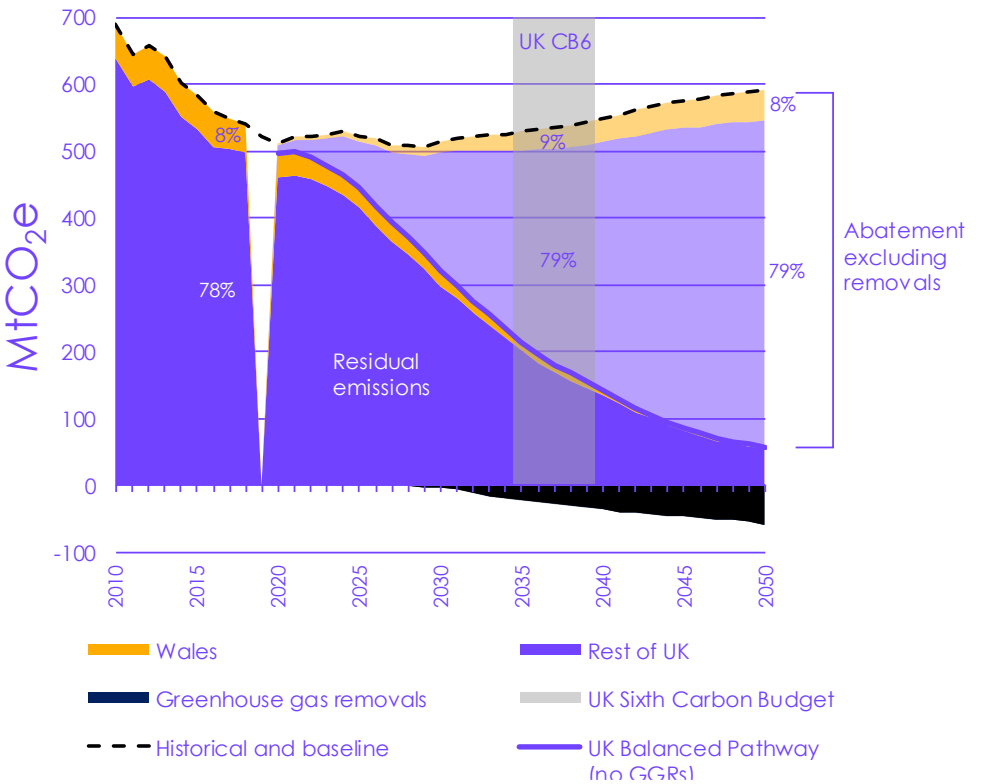
The credibility of the UK's Sixth Carbon Budget (covering 2033-37) and Net Zero rests on action in all parts of the UK, including Wales. Around 9% of the action in our Balanced Net Zero Pathway for the UK during the Sixth Carbon Budget period will be delivered in Wales (Figure 3).

The technical and behavioural challenges and solutions to tackling greenhouse gas emissions are broadly similar across the UK. This does not mean that Wales will follow the exact same emissions reduction pathway as the rest of the UK, nor does it lessen the need for policies that are tailored for national, regional and local needs.

Our pathways for each part of the UK entail consistent amounts of effort, but lead to different overall reductions in emissions.

Equal effort towards UK Net Zero will lead to different emissions pathways. The balance of activity across different sectors - particularly aviation, agriculture and land use, manufacturing and construction, fuel supply and greenhouse gas removals - means different levels of emissions reduction are possible in different parts of the UK through the Sixth Carbon Budget period and by 2050.

Figure 3 Wales' share of UK emissions and abatement during the Sixth Carbon Budget period and by 2050



Source: BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.

The context for Net Zero in Wales

When the Committee provided its 2019 advice, we demonstrated that any negative economic impact of achieving very deep emissions reductions in Wales was likely to be small and the overall impact could turn out to be positive. Our analysis of the full pathway to Net Zero in Wales for this report reinforces that finding. An ambitious budget is preferable to an unambitious one, given the range of risks and costs from unchecked climate change, and in some cases could even be cost-saving (e.g. with an earlier switch to electric vehicles).

The economic and social context for climate action has changed in important ways since our 2019 advice:

Low-carbon investment can support the economic recovery.

- **The COVID-19 pandemic** and measures taken in response to it have sharply changed the economic backdrop in Wales, across the rest of the UK, and globally. These effects imply considerable spare capacity in the economy and therefore that increasing investment could support Wales' recovery.
- **UK Net Zero and NDC.** The UK Government has formally adopted a Net Zero target into law and set an enhanced NDC for 2030, strengthening the case for Wales' existing targets to be tightened in line with the UK goals.
- **Wider Net Zero commitments** by other countries and businesses clearly demonstrate momentum building towards more climate action. This should drive down low-carbon technology costs that themselves can enable further commitments to action. These commitments are a demonstration that future markets lie with low-carbon products. Business models that are not compatible with a Net Zero future are increasingly risky.

Costs of low-carbon technologies continue to fall.

- **Costs of key low-carbon technologies** have continued to fall. For example, the contracted price for electricity generated by offshore wind fell again in the latest auction round by around a third compared to the previous auction two years earlier. These cost reductions are driven by scale manufacturing, investor confidence and 'learning-by-doing' during deployment within an effective low-risk policy framework. These effects can be replicated in other areas of the economy, as markets scale up globally and the costs of low-carbon technologies continue to fall.

This background favours a decisive transition for the UK and for Wales, quickly switching resources away from high-carbon activity and into low-carbon investments with lower operating costs than high-carbon alternatives. This is reflected in our proposed pathway, which transitions as rapidly as possible within constraints of stock turnover, supply chain capacity and time required to design effective policy.

Investment and cost estimates

The Balanced Pathway to deliver our recommended targets in Wales involves a large sustained increase in investment in Wales, adding around £3 billion annually by 2030, as part of UK-wide required investments of around £50 billion by 2030 (compared to current UK-wide investment of nearly £400 billion). The largest increases are for low-carbon power capacity, retrofit of buildings and the added costs of batteries and infrastructure for electric vehicles.

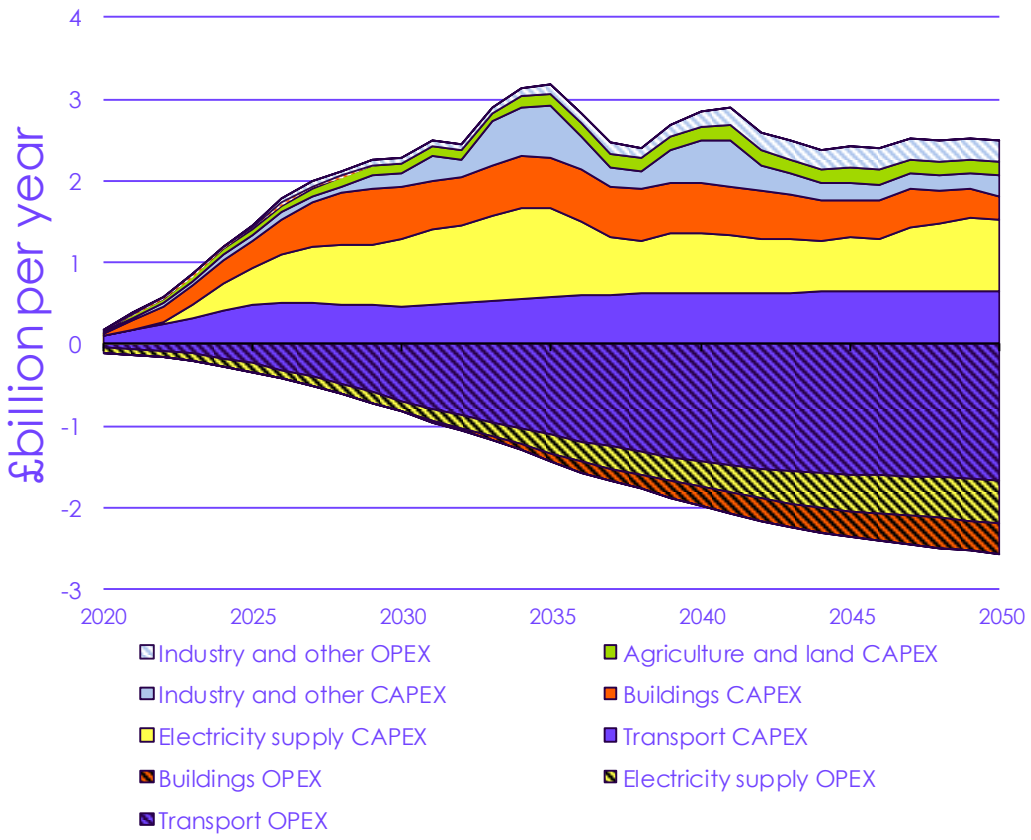
This required increase in investment can, and should, be delivered largely by the private sector. These investment costs should not be interpreted as capital expenditure that would be delivered solely through the Welsh Government budget, nor as costs that only Welsh businesses and consumers have to bear. Many of the actions to reduce emissions will likely be paid for at UK level and/or socialised across the whole of the UK.

This level of investment is well within the range of historical changes in UK total investment. The sectoral increases have broadly been seen before, for example, in the transport sector as car-buyers shifted towards larger cars, in the power sector as renewable investment increased in the last decade, and in the housing sector as spending on refurbishments increased. It can be financed at low cost if policies are constructed to give long-term clarity to consumers and confidence to investors.

We are now able to demonstrate that savings in fuel costs (Figure 4) will very largely offset the investment costs in later years. As a result, our central estimate of the annualised resource cost (which measures the net additional cost each year to deliver the same services with lower emissions) has fallen to less than £1.5 billion per year in Wales through to 2050. This is a reduction since our 2019 estimate (of £3-5 billion) for Wales to meet the Net Zero 2050 target, reflecting our more detailed modelling and further falls in the costs of low-carbon technologies.

This added resource cost will not necessarily reduce GDP by an equivalent amount, particularly given the spare capacity in the economy following the COVID-19 pandemic. Modelling commissioned for this report suggests that the level of UK GDP would be around 2% higher than it would have been by 2035 as resources are redirected from fossil fuel imports to UK investment.

Figure 4 Capital investment costs and operating costs savings in the Balanced Pathway for Wales



Source: CCC analysis.
Notes: Costs of electricity are included in the energy supply sector, whereas costs of other low-carbon fuels such as hydrogen and bioenergy are included in the sectors that use these fuels. Wales' share of UK electricity costs is allocated based on electricity consumption rather than where generation takes place. The 'Industry and other' category includes manufacturing, construction, fuel supply, waste and F-gases. CAPEX refers to additional annual capital investment. OPEX refers to costs and savings due to operational cost changes.

Improving well-being for current and future generations

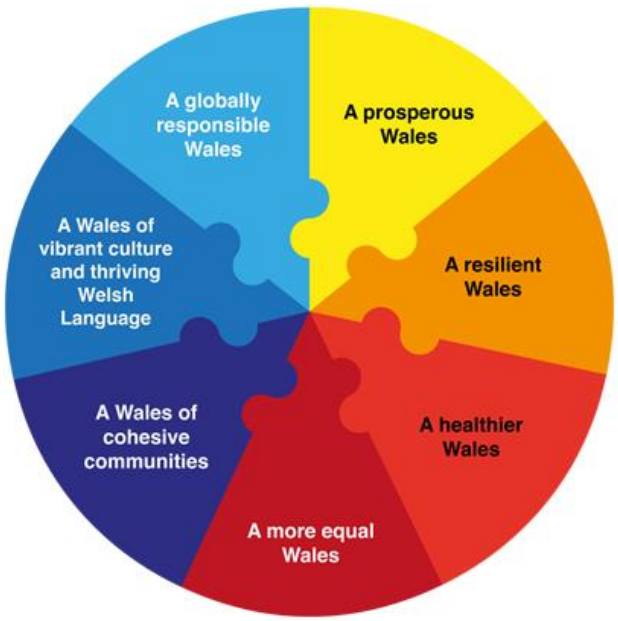
In addition to supporting Wales' global responsibilities, the pathway to Net Zero in Wales is well-aligned to the other Well-being Goals (Box 3) under the Well-being of Future Generations (Wales) Act 2015:

- **A prosperous Wales.** Legislating our recommended targets would send a clear signal that Wales is open for low-carbon investment. This will help to encourage private investment at low cost at a time when it is needed to support Wales' economic recovery from the COVID-19 health crisis. It could also help Wales secure competitive positions in growing global markets for low-carbon goods and services. Our pathway involves considerable opportunities for job creation. An important challenge for both UK and Welsh Government is to identify where jobs may be lost in Wales (for example in fossil power generation and refining) and to support workers to transition to being a part of the new low-carbon workforce (e.g. energy efficiency retrofits in buildings or industrial carbon capture and storage).

- **A healthier Wales.** The near-term benefits to health of taking action on climate change are manifold, but good policy is needed to ensure those benefits can be experienced by all. Meeting Net Zero in Wales can bring improved air quality, healthier ways of travelling, more comfortable and efficient homes and workplaces, and better-quality diets.
- **A resilient Wales.** The changing climate poses risks to meeting Wales' economic, social and environmental goals. Efforts to move to a Net Zero economy should be supported by actions to strengthen focus on climate adaptation and prepare for the climate change. Accelerating action on climate change now can help to support the recovery from COVID-19 and rebuild the Welsh economy to be more resilient to the changing climate and future economic shocks.
- **A just transition to support other well-being goals.** Fairness is fundamental to public support and must be embedded throughout policy. Only a transition that is perceived as fair, and where all people, places and communities in Wales are well-supported, will succeed. A just transition to Net Zero can support a **more equal Wales**, **a Wales of cohesive communities**, and **a Wales of vibrant culture and thriving Welsh language**. UK and Welsh Government policy, including on skills and jobs, must join up with local and regional policy on the just transition. Vulnerable people must be protected from the costs of the transition and the benefits must be shared widely.

Box 3
Wales' Well-being Goals

The Well-Being of Future Generations (Wales) Act 2015 puts in place seven well-being goals, which should guide public sector bodies in their decision making. They are not to be taken individually but as a holistic set of goals that all public sector bodies should work towards achieving.



Source: Future Generations Commissioner (2020) The Well-being of Future Generations Act.

b) How the Net Zero target can be met in Wales

Emissions in Wales primarily result from the burning of fossil fuels (mostly oil and gas) to run vehicles, heat buildings, produce electricity, and for energy use in industry. Further emissions arise from other industrial and agricultural processes, changes in land use, waste disposal and leakage from various sources.

Net Zero requires a transformation across these areas. No single solution or single sector can meet the budget alone; action is required across all areas and all sectors, without delay. The 2020s are the crucial decade: with effective action starting now, by 2030 Wales will be firmly on track to Net Zero.

A large part of meeting Net Zero is a technological and investment challenge. But it also requires a fundamental response from *people*: as consumers, workers, homeowners, tenants and landlords, motorists, farmers, citizens and families. The UK and Welsh Governments should lead that response and will have most success where proposals are seen to be fair and where people have been involved in developing the proposed solutions. The UK Climate Assembly provided useful insights on the priorities of a representative cross-section of the UK population. These priorities are reflected in this report.

At the core of our advice for this report are multiple scenarios exploring the actions required in each area and every year in order to reduce Welsh and UK emissions to Net Zero by 2050 at the latest. The scenarios for Wales are compatible with our UK scenarios, and represent Wales' fair contribution to the UK's obligations under the Climate Change Act and Paris Agreement.

These pathways, which feed directly into our UK-level analysis, are based on specific factors that determine the rate and overall level of decarbonisation achievable in each nation. This includes:

- different levels of activity and emissions in each sector today;
- existing usage of land, and opportunities for land-based removals;
- existing infrastructure;
- opportunities to remove CO_2 from the atmosphere; and
- existing policies.

The detailed scenarios explore uncertainties, particularly over how far people will change their behaviours, how quickly technology will develop and the balance between options where credible alternatives exist.

All the scenarios are ambitious while bounded by realistic assumptions over the speed at which low-carbon technologies can be developed and rolled out, allowing time for supply chains, markets and infrastructure to scale up. They are self-consistent and recognise other priorities – for example, our energy analysis maintains security of supply, our housing analysis considers the need for flood protection and to avoid over-heating, our land analysis supports the natural environment.

Based on the insights of these scenarios, we have developed a Balanced Net Zero Pathway as the basis for our recommended targets for Wales. This pathway makes moderate assumptions on behavioural change and innovation, and takes actions in the coming decade to develop multiple options for later roll-out (e.g. use of hydrogen and/or electrification for heavy goods vehicles and buildings). While it is not a prescriptive path that must be followed exactly, it provides a good indication of what needs to be done over the coming years.

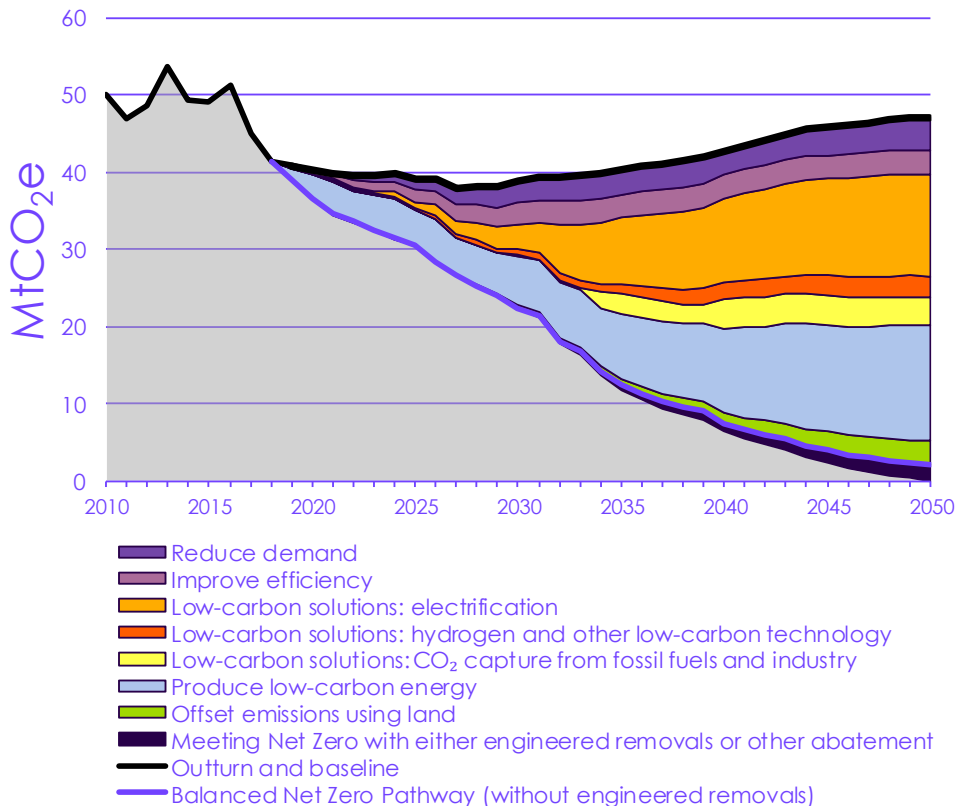
Meeting the Net Zero target in Wales requires action across four key areas in line with those from our Balanced Net Zero Pathway (Figure 5, Table 1):

- **Reducing demand for carbon-intensive activities.**
  - *Reduced demand.* Around 9% of the emissions savings in our Balanced Net Zero Pathway for Wales comes from changes that reduce demand for carbon-intensive activity. Particularly important in our scenarios are an accelerated shift in diets away from meat and dairy products, reductions in waste, slower growth in flights and reductions in travel demand. While changes are needed, these can happen over time and overall can be positive for health and well-being.
  - *Improved efficiency.* A further 7% comes from improving efficiency, in use of energy and resources, especially by better insulation of buildings, improving vehicle efficiency and improving efficiency in industry.
- **Take-up of low-carbon solutions.** Around 40% of the emissions saving is from people and businesses adopting low-carbon solutions as high-carbon options are phased out (Table 1). By the early 2030s all new cars and vans and all boiler replacements in homes and other buildings must be low-carbon – we expect largely electric. By 2040, all new heavy goods vehicles should be low-carbon. The South Wales industrial cluster (as well as other industrial sites in Wales) must either must either switch away from fossil fuels to low-carbon alternatives and/or install carbon capture and storage (CCS) at scale from the mid-2030s.
- **Expansion of low-carbon energy supplies.**
  - *Low-carbon electricity* can now be produced more cheaply than high-carbon electricity in the UK and globally. In our Balanced Pathway the low-carbon share of generation in Wales increases from 27% now to 100% by 2035, cutting Welsh emissions by more than 95% compared to our baseline. We are not prescriptive about where in the UK new low-carbon generation is located or the precise mix of generation that is used in Wales, but all unabated gas-fired generation should cease in the whole of the UK by 2035. New demands from transport, buildings and industry (moderated by improving energy efficiency) mean electricity demand in Wales doubles by 2050.
  - *Low-carbon hydrogen* scales up to 90 TWh by 2035 at UK level (i.e. nearly a third of the size of the current power sector), produced using electricity or from natural gas or biomass with carbon capture and storage. It is used in areas less suited to electrification, particularly shipping and parts of industry, and is vital in providing flexibility to deal with intermittency in the power system. It may also have a material longer-term role in buildings and other transport, such as heavy goods vehicles.

- **Land.** A transformation is needed in Wales' land while supporting Welsh farmers. By 2030, our Balanced Pathway involves planting a cumulative 43,000 hectares of mixed woodland in Wales to remove CO_2 from the atmosphere as they grow, increasing to a total of 180,000 hectares by 2050. A further 56,000 hectares of agricultural land can shift to bioenergy production (including short rotation forestry) by 2050. Peatlands must be restored widely and managed sustainably. Low-carbon farming practices must be adopted widely, while raising farm productivity.
- **Flexibility to meet Net Zero,** Alongside the nature-based removals, by 2035 the UK should be using bioenergy (largely grown in the UK) with CCS to deliver engineered removals of CO_2 at scale – though these technologies may not necessarily be located in Wales. Wales can credibly meet Net Zero either with a 4% share of total UK engineered removals, or through increased action in other areas including land use and behavioural changes.

The Balanced Pathway (Figure 6) sees the most rapid emissions reductions over the period 2025 to 2035. Before 2025, newer markets (e.g. for electric vehicles and low-carbon heating) are still scaling up from low levels, so potential for large-scale deployment and therefore rapid emissions reductions is more limited. Beyond 2035 some opportunities have been exhausted, so progress slows down (e.g. all power generation is low- or zero-carbon by 2035).

Figure 5 Types of abatement in the Balanced Net Zero Pathway for Wales



Source: CCC analysis.
Notes: 'Other low-carbon technology' includes use of bioenergy and waste treatment measures.
'Producing low- carbon electricity' requires the use of CCS in electricity generation.

Table 1
Key metrics for actions in the Balanced Pathway to meet the Sixth Carbon Budget

		2018	2025	2030	2035	2050	Trend
Wales greenhouse gas emissions	Wales greenhouse gas emissions ($MtCO_2e$)	41	31	22	12	0	
	Wales greenhouse gas emissions per person (tCO_2e/capita)	13.2	9.5	6.9	3.7	0	
Demand reduction (UK average)	(UK) Weekly meat consumption (g) (includes fresh and processed meat)	960	880	770	730	630	
	(UK) Weekly dairy consumption (g)	2,020	1,840	1,620	1,620	1,620	
	(UK) Plane-km per person	11,700	11,000	11,000	11,400	13,700	
	(UK) Average car-km per driver	12,900	12,600	12,400	12,200	11,700	
	(UK) remaining waste per person, after prevention & recycling (kg)	490	400	310	280	300	
Efficiency (UK average)	(UK) Average carbon-intensity of a new HGV (gCO_2/km)	680	580	420	20	0	
	(UK) Increase in longevity of electronics	0%	30%	80%	120%	120%	
Electrification, hydrogen and carbon capture and storage	(UK) Carbon intensity of electricity (gCO_2e/kWhe)	220	125	45	10	2	
	(UK) Offshore wind (GWe)	10	25	40	50	95	
	(UK) Share of BEVs in new car sales	1%	48%	97%	100%	100%	
	Wales heat pump installations (per year, includes replacements)	2,000	21,000	52,000	68,000	75,000	
	Manufacturing energy use from electricity or hydrogen in Wales	22%	22%	32%	58%	71%	
	Low-carbon hydrogen demand in Wales (TWh)	<0.1	0.1	1.6	6.5	11.5	
	CCS in manufacturing in Wales ($MtCO_2$)	0	<0.1	0.1	1.6	1.9	
	CCS in other sectors in Wales ($MtCO_2$) (Excludes use in hydrogen production)	0	0	1	3	4	
Land	Cumulative trees planted in Wales (kha)	2	21	43	69	180	
	Cumulative energy crops planted in Wales (kha)	<1	1	8	20	56	
	Peat area restored in Wales	38%	45%	55%	64%	84%	
	Land-based carbon sinks ($MtCO_2$)	1.1	1.2	1.5	2.0	4.2	
Removals	(UK) Greenhouse gas removals ($MtCO_2$)	0.0	<1	5.0	23.0	58.0	

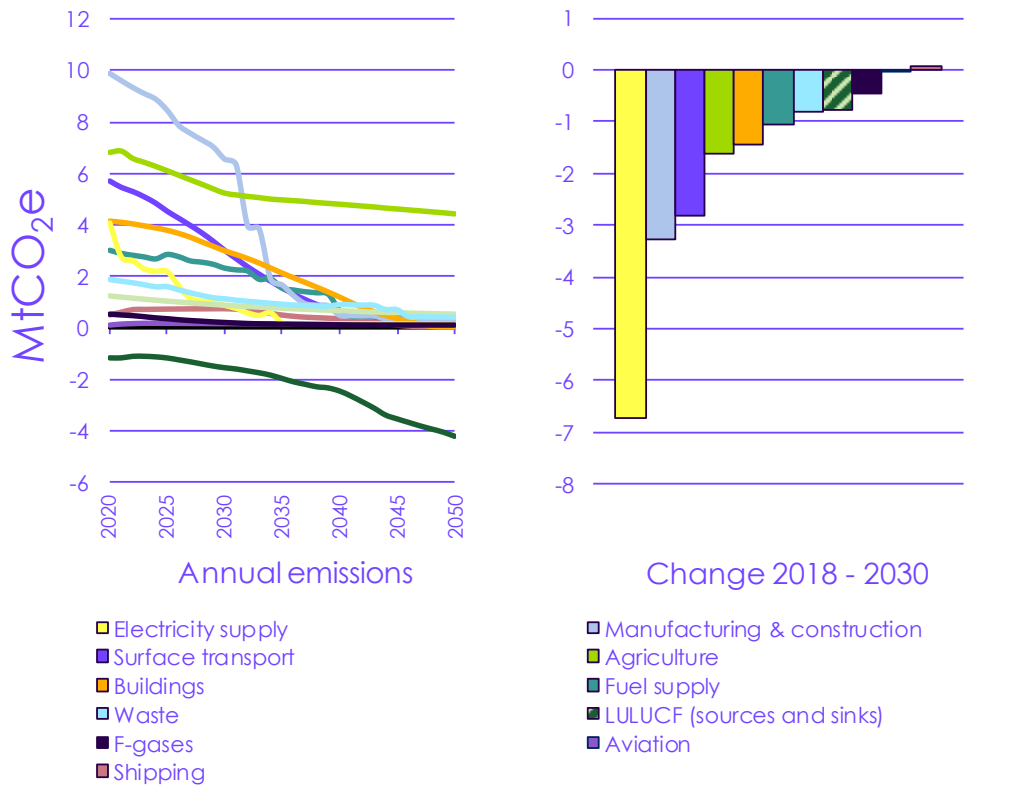
Notes: Metrics in orange rows are specific to Wales, grey rows are either the average or total values for the whole of the UK.

Table 2
Phase-out dates of high-carbon activities under the Balanced Pathway in Wales and the UK

Technology/behaviour	Phase out date (sales)	Backstop date (operation)
New fossil-fuelled cars and vans	2032	2050
Gas boilers	2033 (in residential homes) 2030-33 (in commercial properties)	2050
Oil boilers	2028 (in residential homes) 2025-26 (in commercial properties)	2050
Unabated gas power generation	2030 (no new build of unabated gas plants)	2035
HGVs	2040	Beyond 2050
Biodegradable waste sent to landfill	N/A	2025 ban on all municipal & non-municipal biodegradable waste going to landfill
Unabated energy-from-waste plants	From today, new plants and extensions should be built with CCS or CCS ready	2050

Different sectors decarbonise at different rates, reflecting the relative opportunities.

Figure 6 Sectoral emissions under the Balanced Net Zero Pathway in Wales



Source: CCC analysis.
Notes: LULUCF = Land-use, land-use change and forestry

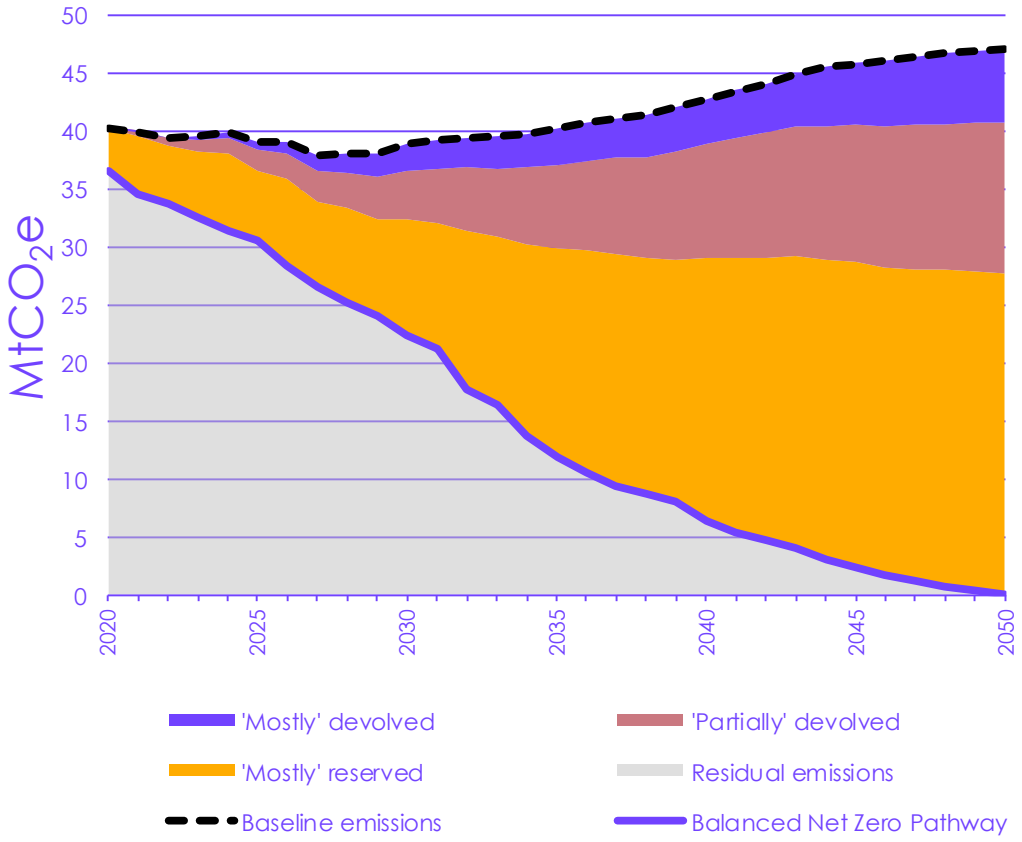
c) Recommendations for action

The next year will be crucial for policy in Wales. Following elections in May 2021, the next Welsh Government will face the challenge to deliver an ambitious plan for Net Zero by the end of 2021.

Wales' next Low Carbon Delivery Plan must set out a long-term vision for meeting the Net Zero goal, with a particular focus on the Third Carbon Budget and 2030, and the path to Net Zero by 2050. Policies and proposals to reduce emissions take time to implement and to have impacts in the real world; the focus of Wales' climate strategy should not be limited to emissions targets in the next five years. The expected impact of policies, including those in early planning, should be clearly quantified and in sum be enough to meet the third carbon budget.

Nearly 40% of all abatement required in Wales in the next thirty years will take place in sectors where key powers are 'partially' or 'mostly' devolved (Figure 7). Priority sectors for Welsh policy include agriculture and land use, buildings efficiency and heat, demand-side transport measures and waste management. Key enabling policies that cut across sectors – such as public engagement, education and skills, planning and consenting, public sector operations, and measures to enable a just transition – will also be crucial.

Figure 7 Abatement in the Balanced Pathway for Wales is shared by the UK and Welsh Governments



Source: CCC analysis.
Notes: The significant portion of abatement in the early 2020s is abatement of electricity supply that falls under 'mostly' reserved policy.

The Committee's key recommendations for Wales are:

- **Legislate ambitious targets for a whole-economy transition to Net Zero by 2050.** The shift from a target of 80% reduction to Net Zero will require significant effort from all sectors of the Welsh economy. Legislating a set of ambitious long-term targets for Wales is the first step, providing a clear signal to Welsh people and businesses. Policies must then be implemented to target all sectors of the economy.

- **The full range of devolved and reserved policy levers must be used together.** Delivering the transition in Wales will require effective collaboration between the Welsh and UK governments, and a strong policy framework that works across all levels of government. The UK cannot achieve Net Zero in 2050 without strong policy from Wales across key areas – including planning, agriculture, land use, housing regulations, and local government – and the Welsh Government cannot meet its target without the right policy and financial commitments from Westminster.

- **Net Zero and adaptation are the responsibility of all ministers and public bodies.** Historically, climate action has been led by the parts of government which deal with energy and the environment. Increasingly, action on reducing emissions to Net Zero and ensuring policies are resilient to climate change will need to be led by all parts of Welsh Government and driven from the centre.

- **Support a resilient recovery from COVID-19.** There is evidence that a range of low-carbon and climate adaptation 'green stimulus' measures fulfil both the short-term and long-term requirements of policies to support an economic recovery from COVID-19, while also building resilience to climate change and driving the transition to Net Zero.

- **Deliver a just transition for Future Generations**. Climate policies that fail to consider the need for a just transition and the fair distribution of costs in their formulation, announcement and delivery, risk being derailed due to public concern over regressive impacts (either real or perceived).

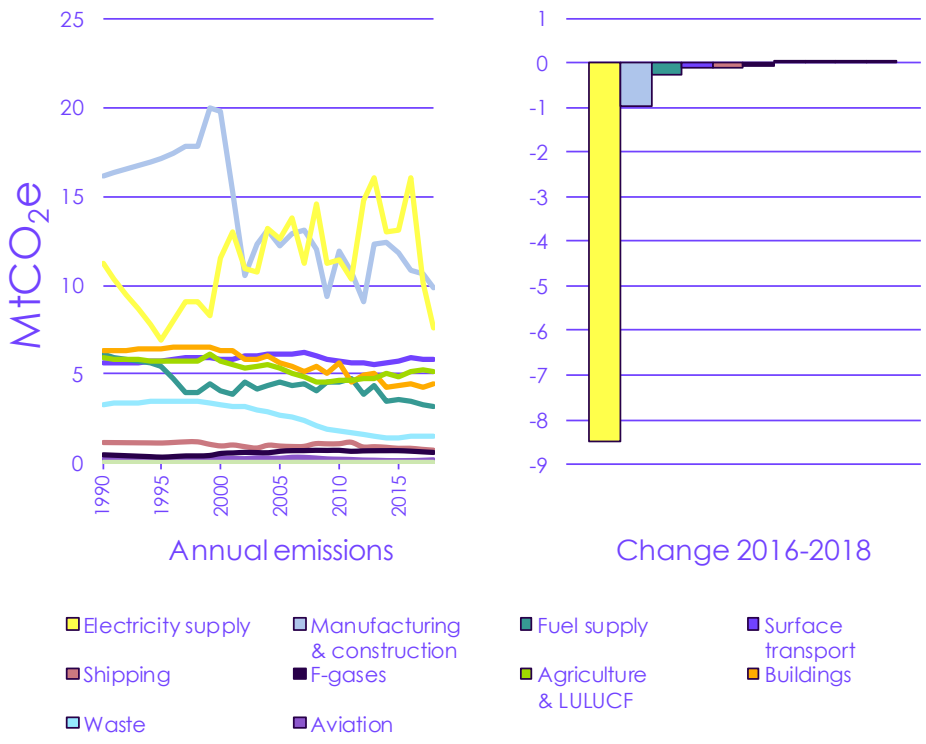
d) Progress towards Wales' existing climate targets

Our Progress Report monitors progress towards Wales' existing targets using the latest available emissions data for Wales, with a focus on trends in emissions across Wales' First Carbon Budget period from 2016 to 2020 (Figure 8).

We cannot say for certain whether Wales is on track to meet the first carbon budget. There are no published emissions data for 2019 and 2020, and there is great uncertainty associated with emissions in the budget period due to both the impacts of COVID-19 and forthcoming methodological changes in estimating emissions under the emissions inventory.

On the current inventory basis, average emissions for the period 2016 to 2018 were 23% below the 1990 baseline – already meeting with the average reduction required to meet the budget. Wales is therefore on track to meet its First Carbon Budget on the current inventory basis, as long as emissions do not increase in 2019 and 2020.

Figure 8 Changes in sectoral emissions in Wales since 1990 and in the First Carbon Budget period



Source: NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.
Notes: LULUCF = land use, land-use change and forestry. Emissions data are not available for 1991-1994 and 1996-1997; we have interpolated emissions in Wales for these years based on the levels in 1990, 1995 and 1998.

The key messages from the Progress Report are:

- **Emissions are falling in Wales.** Emissions have fallen by 31% since 1990. Since 2016, during Wales' First Carbon Budget period, emissions fell by 20%. This was almost entirely due to reductions in fossil-fired power generation.
- **Policy progress has been made.** The Welsh Government has made significant policy improvements since 2017 and it is clear it is taking the climate challenge seriously. This includes:
  - A low-carbon delivery plan for the First Carbon Budget.
  - A draft Transport Strategy that includes a clear focus on the provision of accessible active travel and public transport while supporting the transition to electric vehicles.
  - Achieving the UK's highest recycling rate, with food waste collection in all parts of Wales, and setting very ambitious long-term targets to further reduce waste and increase recycling.
  - Support for large low-carbon electricity generation projects in Wales.
  - The inclusion of 'green recovery' principles in the Welsh Government's response to the pandemic.
- **Gaps remain.** Underlying indicators and the lack of a cohesive, economy-wide strategy for 2050 – at both UK and Welsh Government level – mean that Wales is not currently on track for the existing 80% target, let alone Net Zero.

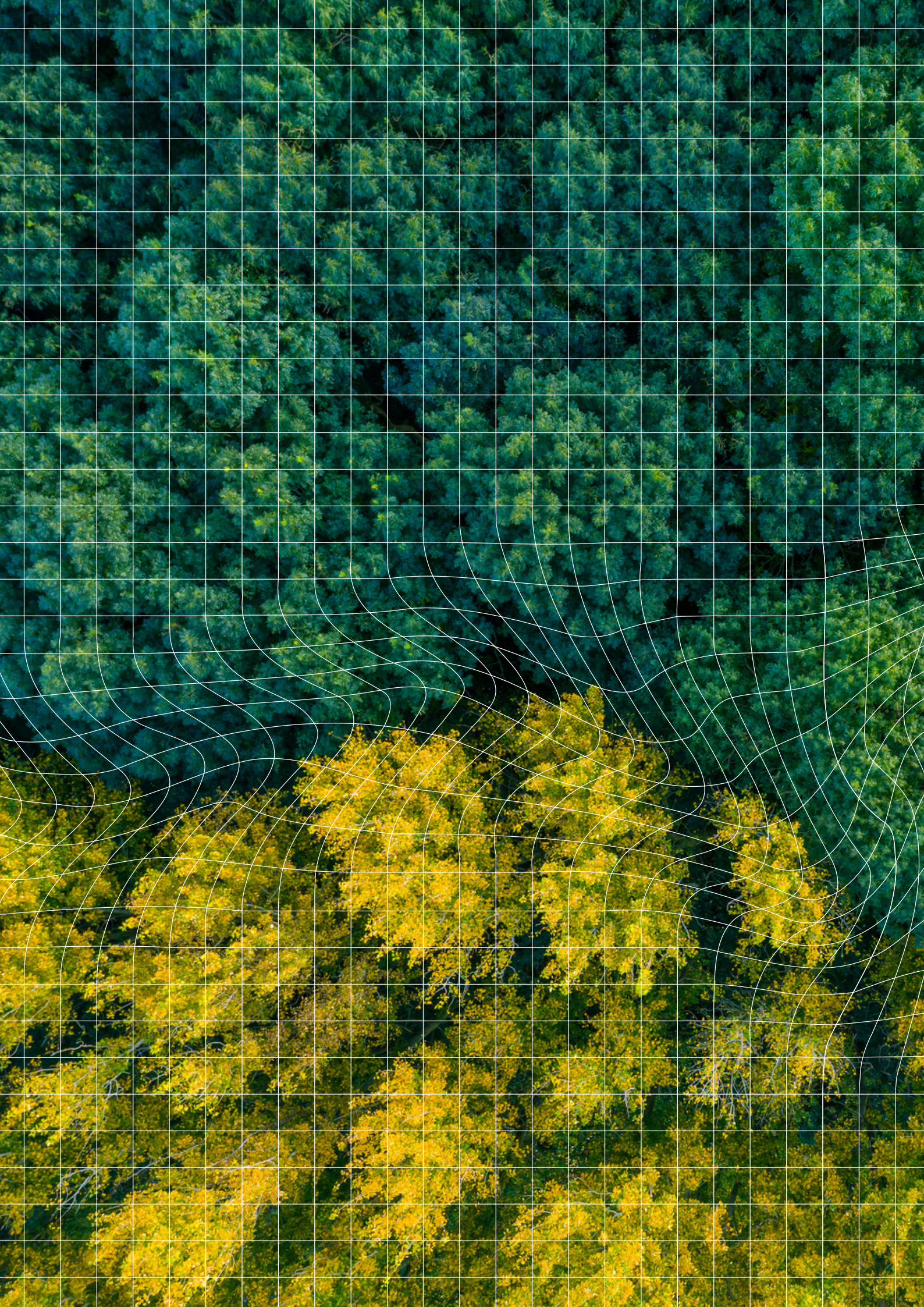
Endnotes

[1] CCC (2020) *Letter to The Rt Hon Alok Sharma MP: Advice on the UK's 2030 NDC*
[2] CCC (2020) *The Sixth Carbon Budget: The path to Net Zero*

Contents

Chapter 1

Overview and approach



Introduction

In 2019, the Committee advised the Welsh Government to set a target to reduce emissions by 95% in 2050. The Welsh Government accepted that advice, and declared their ambition to bring forward a target for Wales to achieve Net Zero emissions no later than 2050.

The Welsh Government has requested new advice on the appropriate level of the third carbon budget (2026-2030), as well as changes to the existing targets in 2030 and 2040 targets and the second carbon budget (2021-2025). They have also requested that we assess the options for Wales to set and achieve a Net Zero goal.

This advice effectively sets the path for emissions on the way to Net Zero.

Our advice on Wales' climate targets builds on the advice in our *Net Zero* report from May 2019, but goes much further:

- This is the first set of targets that Wales will legislate since the UK's Net Zero target for 2050 was placed in law in summer 2019.
- The 2019 *Net Zero* 'Further Ambition' scenario focused on the end point, whereas this advice looks at the whole pathway and effectively provides the trajectory for emissions over the coming three decades on the way to Net Zero.

We have explored five different ways of getting to Net Zero.

- We have gone beyond the 'proof of concept' Further Ambition scenario presented in our 2019 *Net Zero* advice, to look at different ways of achieving Net Zero. We present five scenarios for Wales, which explore how developments on behavioural and societal change and on technology may affect the path over the next 30 years.

This advice comes at a critical juncture – the opportunity is there for Wales to contribute to UK efforts provide international leadership in the run up to COP26, while also driving a resilient recovery through the low-carbon investments that will get us on track to Net Zero.

This chapter introduces our advice in five sections:

1. Reaching Net Zero in Wales
2. Context for this advice
3. Developing emissions scenarios for Wales and the UK
4. Contribution to the UK Climate Change Act
5. A globally responsible Wales

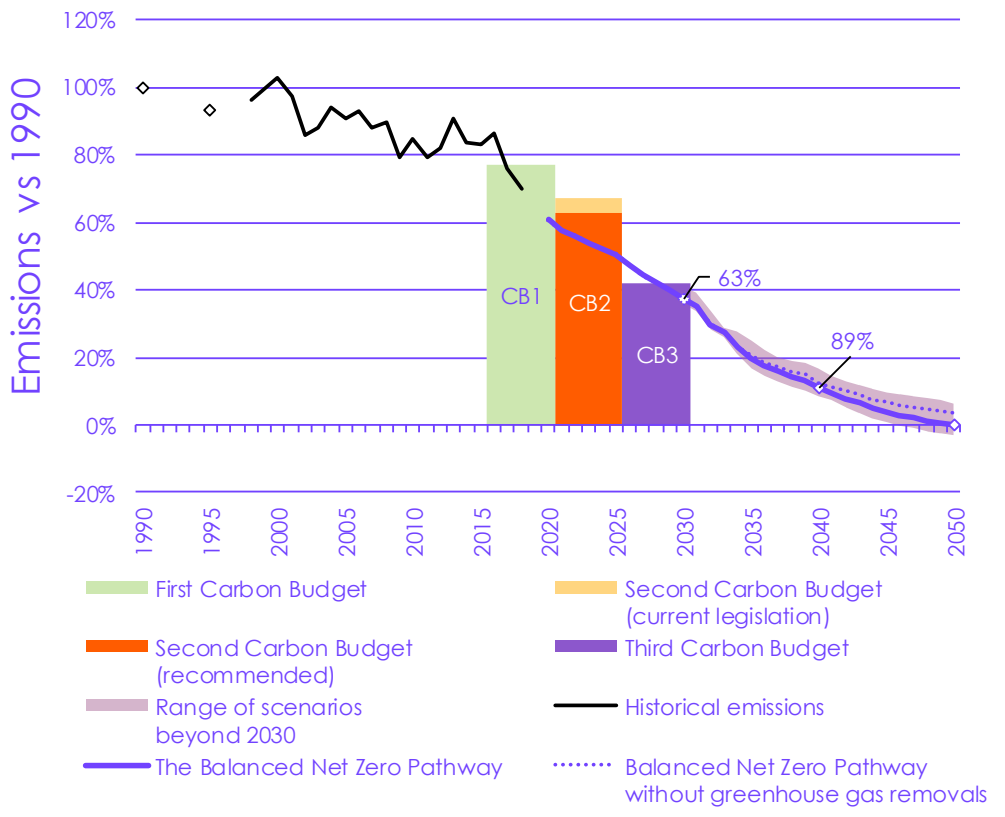
In May 2019, the Committee recommended that Wales increase its ambition under the Environment (Wales) Act to require greenhouse gas emissions to reach at least a 95% reduction compared to 1990 levels by 2050. Our scenarios for Wales showed that getting to very deep emissions reduction was possible, but there was not sufficient evidence at the time that the Committee could confidently recommend a Net Zero target.

The Welsh Government accepted that advice, and set the ambition to "go further… to bring forward a target for Wales to achieve net zero emissions no later than 2050."[1]

Wales is now in a position to realise that ambition. The Committee's updated evidence and analysis now supports a recommendation for Wales to set and pursue a target to reduce all greenhouse gas emissions to Net Zero by 2050, backed up by a stretching set of targets on the pathway to that goal (Figure 1.1).

This advice resets the path for emissions out to 2050.

Figure 1.1 The recommended pathway for Wales



Source: NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.
Notes: Historical emissions data are not available for 1991-1994 and 1996-1997. Emissions shown are presented including all emissions from peatlands and using AR5 global warming potentials including carbon-cycle feedbacks. GGRs = greenhouse gas removals. Range is defined by our other exploratory scenarios.

The Net Zero target requires deep reductions in all sources of emissions, with any remaining sources offset by removals of CO_2 from the atmosphere (e.g. by afforestation). Net emissions, after accounting for removals, must be reduced by at least 100%, to zero.

Our 'Balanced Net Zero Pathway' is the basis of the Committee's advice on the level of Wales' climate targets, and reduces emissions in Wales by 2050 to a level at which the remaining emissions can feasibly be balanced by greenhouse gas removals. This pathway requires a fairly steep path for emissions especially over the next two decades, going from 31% below 1990 levels in 2018 to 63% below by 2030 and 89% in 2040.

Our new scenario analysis, the results of which are presented in Chapter 2, provides new evidence that Wales can set a credible target to reach Net Zero in 2050 in line with the rest of the UK. We make recommendations on Wales' targets on the pathway to Net Zero in Chapter 4.

The Balanced Net Zero Pathway for Wales was built on multiple lines of evidence, and takes into account what is feasible over time, what is necessary to get on track to Net Zero by 2050, and what needs to happen in the rest of the UK to meet the Net Zero target in the Climate Change Act.

We assess it to be a fair pathway that is compatible with global efforts to limit the rise in global average temperature to well below 2°C and to pursue efforts to limit warming to 1.5°C. It would reduce Wales' per-capita emissions to well below the global average level from the median of the IPCC's pathways for limiting warming to 1.5°C with a 50% probability by the end of the 2030s.

All emissions data presented in this Advice Report account for forthcoming changes to the UK Greenhouse Gas Inventory for Global Warming Potentials (GWPs) and for peatlands. These changes have not been precisely determined yet, so we assume changes at the higher end of the currently estimated range – this ensures that the targets will remain feasible once those changes are determined.

All values reported use GWPs from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) with carbon-cycle feedbacks and we assume accounting for all peatland emissions adds around 0.5 $MtCO_2e$ per year to the current Welsh inventory (Box 2.1). Changes to GWPs and estimates for peatland emissions will be implemented within the next five years.

a) Wider context for this advice

The economic and social context for climate action has changed in important ways since our 2019 *Net Zero* report. Our advice on Wales' climate targets comes at a time of heightened uncertainty due to the impacts of COVID-19, but also with increased action from the UK Government and widespread public support for climate action. This context represents a major opportunity for low-carbon investment to be at the heart of the recovery in Wales and support UK leadership internationally.

UK Net Zero and the Sixth Carbon Budget

Our advice to Wales in 2019 was contingent on the UK Government taking action on climate change. Without the full range of reserved and devolved powers, Wales cannot achieve the deep decarbonisation required to get to even an 80% target. The UK Government's adoption of the Net Zero goal gives increased certainty and confidence for climate action in Wales.

Following the legislation of the Net Zero target in 2019, the UK Government has rightly been accelerating the development of strategy and policy, much of which will have important consequences for Wales. We welcome the Prime Minister's Ten Point Plan for a Green Industrial Revolution. It remains urgent to align the policy framework with the raised ambition under Net Zero, and for a Net Zero strategy to be published prior to COP26.

The Committee recently advised the UK Government on the level of the Sixth Carbon Budget. Our recommended UK Sixth Carbon Budget requires a policy framework that enables investment and delivery to be ramped up with immediate effect. It will be crucial to set that budget as soon as possible to get the UK on track as soon as possible towards meeting its statutory Net Zero target by 2050 and meeting its commitments under the Paris Agreement. That is particularly important this year, as the UK will host the next UN climate talks (the 26th Conference of the Parties: COP26) in Glasgow in November 2021.

Uncertainty: COVID-19 and Brexit

Our advice on the path to Net Zero in Wales comes at a time of heightened uncertainty due to recent and ongoing extraordinary developments and events for Wales.

Climate policy and emissions will be impacted in ways that are difficult to predict by the response to COVID-19 and its lasting effects, and by the ending of the transition period following the UK's departure from the European Union. At the same time, widespread public support for climate action and a major opportunity for low-carbon investment to be at the heart of the recovery and support UK leadership internationally create unique circumstances for progress.

COVID-19 is a public health crisis with tragic consequences for many. It brings uncertainty for the future, but also shows how rapidly things can change when necessary and highlights the role of investment in driving economic recovery. The period ahead is therefore an opportunity to make rapid progress:

- The steps that Wales takes to rebuild from the COVID-19 pandemic and its economic damage can also accelerate the transition to low-carbon activities and improve our climate resilience. Climate investments can support the economic recovery and secure good jobs for the long term, while taking advantage of low interest rates.
- The pandemic has also demonstrated how quickly social change can occur, and the role of government in driving that change. Social and behavioural change can make a very important contribution to meeting Net Zero.
- Setting climate targets during the COVID-19 pandemic brings with it the risk that the projections we have used for the level and nature of economic activity in Wales are significantly out of line with the reality that emerges as we recover from its impacts. Due to major uncertainty over how the recovery will play out, our analysis has assumed no lasting impact on Wales' level of economic (and potentially emitting) activity.

The Brexit context. Another important development that will shape UK and Welsh climate policy in the next few years is the UK's exit from the EU. Some of the impacts of Brexit are already visible through the ramp-up of policy-making and legislative activity in the environmental sector to replace or transfer powers that until now resided in Brussels. The full scale of adjustments required will likely only be known after the end of the transition period, but a number of structural changes are already underway (Box 1.1), some of them of particular importance to Wales (e.g. leaving the EU emissions trading system and the Common Agricultural Policy).

As we establish a new trading relationship with the EU and leave the EU emissions trading system (EU ETS) and other mechanisms, clarity and confidence will be valued, and well-designed climate policy should provide investment opportunities across a range of sectors. Nonetheless, coherence with the wider trading system of the EU ETS is important.

Box 1.1
The impact of Brexit on Wales' climate objectives

The UK's departure from the European Union will have implications for the UK's and Wales' environmental and decarbonisation policies. Key implications include:

- **Leaving the EU's Emissions Trading System** (EU ETS). Current Government proposals are to replicate this scheme, with a smaller UK ETS, with a view to linking to the EU ETS. A carbon tax has also been proposed.
- **Product standards set at an EU level** have been an important driver of energy efficiency, and emissions reductions in lights, appliances and vehicles.
- **Leaving the Common Agricultural Policy (CAP)**, which provides direct income support for farmers, as well as payments for environmental services. Wales' replacement scheme, 'Sustainable Farming', aims to transition to rewarding farmers more for public goods including mitigating and adapting to climate change.
- **Environmental governance** to replace the role of the European Commission in enforcing environmental regulations in Wales. The Welsh Government has stated their preferred option is to establish a new environmental governance body in Wales, but this will not be legislated before the next Parliamentary term.[2]

As we noted in 2016, in areas where EU mechanisms are working effectively – such as product standards, which reduce emissions and save consumers' money, or targets for waste reduction - the aim should be to replicate them at UK or Welsh level. Some areas, such as leaving the Common Agricultural Policy, present an opportunity to better target public funds towards environmental goals.

The social and international context

Public support for action to tackle climate change is rising globally, although without enough clarity so far over the steps that are needed to do so. In the UK, the Climate Assembly has given us a valuable insight into the public's preferences over how we meet Net Zero.

During 2020, we have continued to see the impacts of climate change that are already here, both in the UK and globally. Atmospheric CO_2 concentrations are at record levels, and compound risks are building. As the UK prepares to host the 26th United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP26), ambition is growing internationally, with a wave of Net Zero targets now being set, and updated Nationally Determined Contributions (NDCs) for 2030 are expected as we approach COP26.

COP26 was originally envisaged as a key moment in efforts to raise global climate ambition, with countries expected to resubmit their Nationally Determined Contributions (NDCs) for emissions reductions to 2030, and adaptation strategies, before the end of this year. As co-host and incoming G7 president, the UK has the opportunity to demonstrate leadership on a global scale on both climate change mitigation and adaptation, and to help catalyse the necessary efforts to increase climate ambition around the world. Wales has an important role to play in this by demonstrating the UK's consistent approach and commitment to Net Zero are shared across the Nations.

Additionally, the US re-commitment to the Paris Agreement and the shifting international ambition on global emissions targets are creating very favourable circumstances for the next year to become a turning point in tackling global emissions. When assessed prior to COVID-19 in 2019, global emissions pathways, based on contributions pledged at the time, were found to be inconsistent with the goal of the Paris Agreement to limit global warming to below 2°C above preindustrial levels, with estimates indicating a likely 3°C increase instead.

The circumstances changed rapidly, however, following a series of mid-century Net Zero target announcements by major economies, covering more than 60% of global emissions. If they are fully implemented, global pathways are pointing towards a drop in temperature increase estimates to 2.1°C. Updated Nationally Determined Contributions (NDCs) for 2030 are now expected as we approach COP26.

b) Existing legislative framework in Wales

Welsh climate policy is made by both the Welsh and UK governments, with relevant powers divided following devolution in 1998.

Devolution

Following the 1998 and 2006 Government of Wales Acts, which created the National Assembly for Wales (now known as Senedd Cymru – Welsh Parliament) and the Welsh Government, law-making powers for matters concerning the environment were transferred to Wales. These powers were extended to include more environmental issues and consolidated through the Wales Act 2017.

In Wales, policy areas relevant to decarbonisation that are partially or fully devolved to the Welsh Government include agriculture and land use, planning, transport, energy efficiency for new-builds, and waste (Table 1.1).

Reducing emissions in these areas is, therefore, a matter for the Welsh Government. Policymaking in other sectors, such as energy generation, industrial production and aviation, is among the powers reserved by the UK government. Economic and fiscal policy are also mostly reserved.

Table 1.1
Balance of devolved and reserved powers in Wales for different sectors

'Mostly' devolved	'Partially' devolved	'Mostly' reserved
• Agriculture • Land use, land-use change and forestry • Waste management • F-gases*	• Buildings • Surface transport	• Electricity supply • Fuel supply • Manufacturing & construction • Aviation • Shipping • BECCS for power generation

The Environment (Wales) Act 2016 and the Climate Change (Wales) Regulations 2018

Setting targets for greenhouse gas emissions is a devolved matter, although Wales is required to contribute to the UK Net Zero target in 2050 and the UK carbon budgets under the 2008 Climate Change Act. Welsh emissions targets have been put into law with the Environment (Wales) Act 2016.

The Act states that the 2050 target is 'at least' an 80% reduction in emissions from 1990 (baseline year) levels, and sets out the requirement for interim targets.

These interim targets for 2020, 2030 and 2040 were introduced into law through the Climate Change (Interim Emissions Targets) (Wales) Regulations 2018 (Figure 1.2):

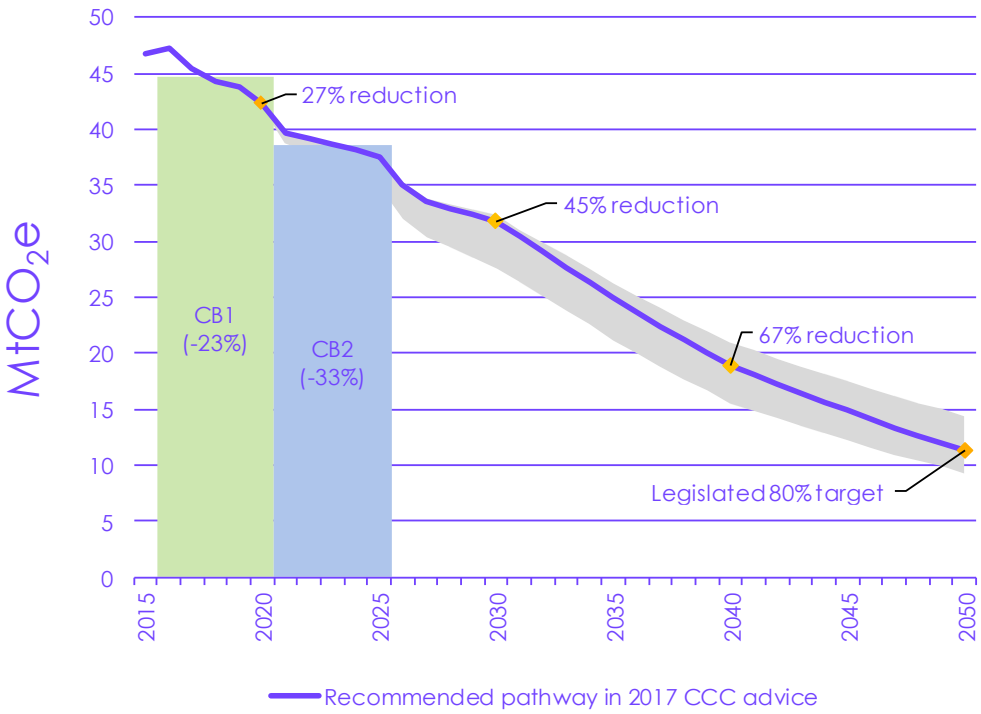
- Emissions must be at least 27% lower than the 1990 baseline by 2020.
- Emissions must be at least 45% lower than the 1990 baseline by 2030.
- Emissions must be at least 67% lower than the 1990 baseline by 2040.

* A GB-wide cap scheme is due to be implemented.

The Act also places an obligation on Welsh Ministers to set carbon budgets for Welsh emissions covering five-year periods to 2050. So far, Wales has legislated for the first two carbon budgets:

- The First Carbon Budget (2016-2020) requires average emissions across the budget period to be 23% below 1990 levels.
- The Second Carbon Budget (2021-2026) requires average emissions across the budget period to be 33% below 1990 levels.

Figure 1.2 Wales' existing targets for reducing greenhouse gas emissions



Source: Adapted from CCC (2017) *Building a low-carbon economy in Wales*.
Notes: The Second Carbon Budget is shown as legislated. In our 2017 advice, we recommended that if Aberthaw closed in 2020 the Second Carbon Budget should be tightened to 37%. The scenario range presented was from Wales's contribution to meeting the UK Fifth Carbon Budgets and the UK 80% target to the 'maximum' scenario identified for Wales.

Well-being of Future Generations Act

In 2015, Wales passed the Well-being of Future Generations Act. Its aim is to ensure that all public bodies are working towards the same vision of improving the economic, cultural and environmental well-being of Wales while tackling some of the biggest long-term challenges, such as climate change, poverty and inequalities.

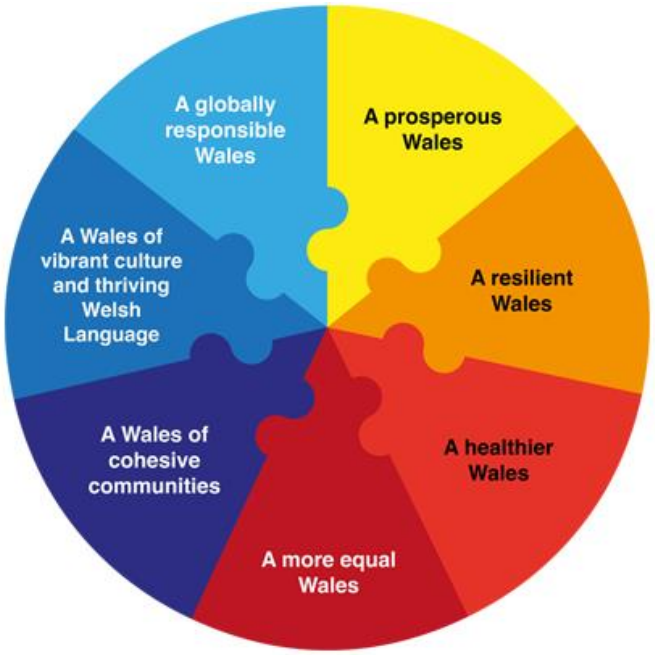
Sustainable development is a central concept. The Act places a legal duty on public bodies to set "well-being objectives" that maximise their contribution to the Act's seven well-being goals (Box 1.2) in order to carry out sustainable development. Taking steps to then achieve these objectives will ensure that the work of public bodies is aligned with the vision for Wales set out by the Act.

The Well-being of Future Generations Act is unique in the UK. It provides a policy framework that is potentially well-suited to addressing many of the cross-cutting issues caused by climate change and identifying co-benefits to decarbonisation (see Chapter 5).

The Act has a prominent place in the Welsh Government's plans for decarbonisation, and Wales' Low Carbon Delivery Plan includes well-being objectives for each of the sectors' policy plans.

Box 1.2
Wales' Well-being goals

The Well-Being of Future Generations (Wales) Act 2015 puts in place seven well-being goals, which should guide public sector bodies in their decision making. They are not to be taken individually but as a holistic set of goals that all public sector bodies should work towards achieving.



Source: Future Generations Commissioner (2020) *The Well-being of Future Generations Act.*

c) Previous advice to Welsh Government

The Committee provided advice to the Welsh Government on Wales' emissions targets and decarbonisation pathways on two previous occasions: our 2017 *Building a low-carbon economy in Wales* report,[3] and our 2019 *Net Zero* report.[4]

Following the 2016 Environment (Wales) Act, which set a 2050 target for an emissions reduction of at least 80%, the 2017 advice recommended that Wales set interim emissions targets for a 27% reduction on 1990 levels by 2020, a 45% reduction by 2030 and a 67% reduction by 2040 (Figure 1.2).

In the 2019 Net Zero report, we produced a 'Further Ambition' scenario for Wales, capable of delivering a 95% reduction in emissions by 2020 (see Section 3 of Chapter 2). That advice recognised the challenges of decarbonising the Welsh economy to Net Zero, and we highlighted the importance of the Welsh and UK governments working together and using the full range of devolved and reserved levers available in order to deliver it.

We recommended that the Welsh Government legislate the new 2050 target in parallel with the Third Carbon Budget (2026-2030) in 2020. The Welsh Government accepted the recommendation of a 95% target and stated its ambition to go beyond it, aspiring to set a Net Zero target.

3. Developing emissions scenarios for Wales and the UK

We have developed scenarios for the UK to explore a range of ways to achieve Net Zero by 2050 at the latest, and used those exploratory scenarios to identify a 'Balanced Pathway' towards Net Zero that keeps in play a range of ways of getting there based on central assumptions.

Our scenarios demonstrate that there are multiple ways for the UK meet the Net Zero 2050 target and many routes to our recommended UK Sixth Carbon Budget. While our Balanced Pathway is the basis for our recommended budget it is not intended to be *prescriptive*. Rather it is *illustrative* of what a broadly sensible path based on moderate assumptions would look like. A little more or a little less may be achieved in any area, or alternative low-carbon options could be used, but the overall level of ambition and delivery must match.

The precise future pathways to Net Zero for Wales and for the rest of the UK are unknowable, but are certain to include shared factors. This includes technology availabilities and costs, UK-wide regulations (e.g. on the sale of petrol cars), the cost and average carbon intensity of electricity on the GB network, and UK Government choices on the future of road freight and the gas grid.

It therefore does not make sense to develop scenarios for Wales in isolation from our scenarios for the whole of the UK. Our scenarios for Wales are consistent with each of the equivalent UK-wide scenarios for Net Zero.

However, the scenarios also reflect genuine options for Wales to take a different pathway to the UK as a whole. For example, people living in Wales may be more or less willing to change their behaviour in climate-friendly ways, or ambitious Welsh Government policy could push emission reductions further in certain areas including buildings efficiency, agriculture and land use, or waste management.

a) Our scenarios framework for Wales and the UK

In our 2019 advice on setting the Net Zero target, we presented a single ('Further Ambition') scenario for 2050 for the UK and for Wales – this acted as a 'proof of concept', providing confidence that Net Zero can be achieved at reasonable cost without relying on major breakthroughs in technologies and behaviours.

In this year's advice, we have developed three exploratory scenarios that reach Net Zero emissions by 2050 in quite different ways, illustrating the range of pathways that are currently available. We also present a further, highly optimistic, scenario that enables Net Zero to be achieved prior to 2050. This allows exploration of a range of approaches over the next three decades.

We use these scenarios to guide judgements on the achievable and sensible pace of decarbonisation in the face of uncertainty, and to understand how less success in one area can be compensated for elsewhere.

Our 2019 Further Ambition scenario made relatively conservative assumptions on the extent of cost reductions as a result of innovation, and on societal and behavioural change. Making conservative assumptions was appropriate in the context of *setting* the target, as it was important to ensure that a legally binding target could be met. But in the context now of *achieving* Net Zero, and setting a pathway to match, we must consider success can be maximised on these fronts.

Exploring how to meet Net Zero means looking at bolder assumptions on behaviour and innovation.

Greater contributions from societal/behavioural change and from innovation would reduce the challenges in achieving Net Zero emissions by 2050, by reducing emitting activities (e.g. flying, livestock farming) and making emissions reduction cheaper and/or easier. The Government should therefore ensure that policy frameworks are designed in a way that encourages both behavioural change and innovation to contribute strongly to decarbonisation.

However, even with well-designed policies, it remains uncertain how large a contribution each will make. Our scenarios therefore reflect potential ranges for their contributions, together with the sets of choices (e.g. on HGVs and low-carbon heat) that are necessary in this decade.

- **Societal and behavioural change** across all scenarios illustrates how choices by people and businesses can affect emissions. In many cases these choices align with the findings of the recent UK Climate Assembly.
- **Innovation.** The costs and efficiencies of low-carbon technologies varies in our scenarios, according to the latest available evidence and projections for these technologies.

Our scenarios also explore choices around how to reach Net Zero.

- **Choices are also prevalent in our scenarios**, where the clearest low-carbon option is not currently evident. For example, hydrogen takes the place of electrification in HGVs and home heating in some scenarios. Similarly, our scenarios try to reflect preferences, such as a preference for nature-based removals over engineered removals in the Widespread Engagement scenario, or the use of synthetic fuels in aviation instead of only offsetting aviation emissions via emission removals.

Our pathways use known solutions where they exist and minimise use of greenhouse gas removals.

As a general principle, consistent with the preferences expresses in the Climate Assembly,[5] our pathways prioritise emissions reductions where known solutions exist and thereby minimise the need for minimise the use of greenhouse gas removals. This will tend to lead to lower overall cumulative Welsh and UK emissions and limit risks of over-reliance on the ability to deploy removals sustainably at scale.

We initially constructed three 'exploratory' scenarios that reach Net Zero by 2050, one of which is similar to Further Ambition while the other two are more optimistic either on developments regarding behavioural change or improvements in technology costs and performance (Figure 1.3). Although to some extent these reflect choices on the way to Net Zero, they primarily reflect greater or lesser degrees of success on key policy priorities on the path to Net Zero – engagement of the public and businesses, and innovation:

- In the **Headwinds** scenario, we have assumed that policies only manage to bring forward societal/behavioural change and innovation at the lesser end of the scale, similar to levels assumed in our 2019 Further Ambition scenario. People change their behaviour and new technologies develop, but we do not see widespread behavioural shifts or innovations that significantly reduce the cost of green technologies ahead of our current projections. This scenario is more reliant on the use of large hydrogen and carbon capture and storage (CCS) infrastructure to achieve Net Zero.
- In the **Widespread Engagement** scenario, we assume higher levels of societal and behavioural changes. People and businesses are willing to make more changes to their behaviour. This reduces the demand for the most high-carbon activities and increases the uptake of some climate mitigation measures. Assumptions on cost reductions are as in Headwinds.

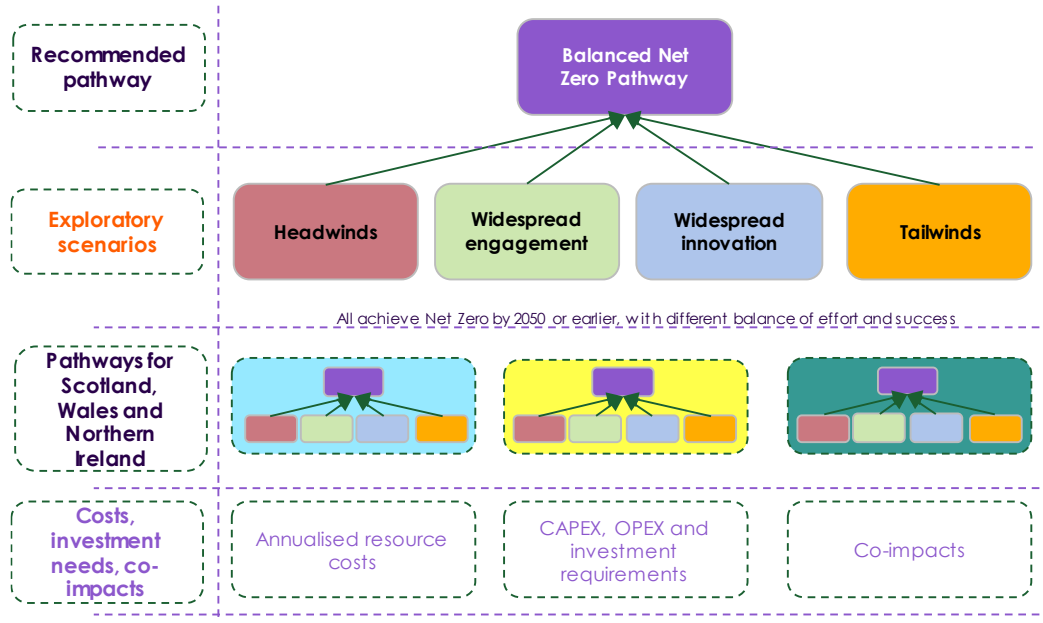
- In the **Widespread Innovation** scenario, we assume greater success in reducing the costs of low-carbon technologies. This allows more widespread electrification, a more resource- and energy-efficient economy, and more cost-effective technologies to remove CO_2 from the atmosphere. Assumed societal/behavioural changes are as in Headwinds.

Our Balanced Pathway navigates through the range of possibilities we have identified.

We then constructed the '**Balanced Net Zero Pathway**', as a further scenario that reaches Net Zero by 2050. It was designed to drive progress through the 2020s, while creating options in a way that seeks to keep the exploratory scenarios open. We also constructed a further exploratory scenario ('**Tailwinds**') that assumes considerable success on both innovation and societal / behavioural change and goes beyond the 6th Carbon Budget Pathway to achieve Net Zero before 2050.

Our scenarios are not specifically designed to meet any given target for Wales in 2050. They represent a fair contribution to the UK Net Zero goal and reflect Wales' capabilities to decarbonise. The results in Chapter 2 of this report show that reaching Net Zero by 2050 – at the same time as the UK – is appropriate for Wales, but the equivalent pathways show different results to the UK for Scotland (Net Zero in 2045) and for Northern Ireland (at least 82% reduction in GHGs by 2050).

Figure 1.3 Our analytical framework includes five costed pathways for Wales and for the UK



Source: CCC.

Our 'Balanced Net Zero Pathway' is informed by the range of solutions across the 'exploratory' scenarios, that would put the UK on track to Net Zero and would meet the recommended carbon budget. This pathway:

- Represents a sensible strategy to underpin policy on over coming years, based on known technologies and behaviours, with potential to be adapted as we learn more about the most effective ways to cut emissions (see the *Sixth Carbon Budget Policy Report*).

- Takes a whole-system approach to decarbonisation, reflecting the range of opportunities across behaviour, efficiency, land, low-carbon energy supply and end-use technologies, and how these potentially interact.
- Develops key options for decarbonisation in the 2030s and 2040s, with action in the 2020s, accepting that some things will not work but that it is necessary to try things out to find the best options and develop effective policies.
- Includes some measures that are not cost-effective only when considering emissions reductions, where they support other objectives (e.g. some higher-cost improvements to energy efficiency of homes, due to benefits on fuel poverty, health and employment).
- Is designed to be delivered in a way that works for *people* – reflects their priorities and choices, and aligns very well to the preferences expressed by the Climate Assembly, which was called by six Select Committees of the UK House of Commons to understand public views on how the UK should tackle climate change.
- Works in the real world and at the local level, providing good quality jobs, and benefits to health and wellbeing.
- Allows time for societal choices to contribute and the necessary scale-up of supply chains, skills, business models and infrastructure during the 2020s.
- Puts the UK on track to Net Zero, and supports the required global path for decarbonisation by reflecting the highest possible ambition on emissions reduction as a necessary contribution the Paris Agreement.

While these scenarios are designed to have self-consistent narratives, there is some potential to 'mix and match' strategies or compensate for under-delivery in one area with greater delivery elsewhere based on another scenario. Our sectoral analysis takes a 'bottom-up' approach which allows a detailed assessment of the options that are most relevant to each source of emissions within each sector. The methodology used for each sectoral analysis is described in the Methodology Report that accompanies the UK Sixth Carbon Budget report.[6]

We have tried to ensure that each of the scenarios represents a coherent view of a possible future.

Our scenarios allow for both the impacts of climate change (e.g. rising global temperatures reduce heating demand in Wales) and the need to adapt to those impacts (e.g. we include shading and ventilation measures alongside insulation). This is particularly important for the buildings and land use sectors. We have also taken into consideration a range of detailed responses to our Call for Evidence on the Sixth Carbon Budget and Welsh emissions targets (Box 1.3).

Box 1.3
Call for evidence and wider engagement

The Committee launched a Call for Evidence to inform its advice on the Sixth Carbon Budget and Welsh interim targets which ran between 5 December 2019 and 5 February 2020. The Call for Evidence included 37 questions on five topics:

A. Climate science and international circumstances

B. The path to the 2050 target

C. Delivering carbon budgets

D. Wales, Scotland and Northern Ireland

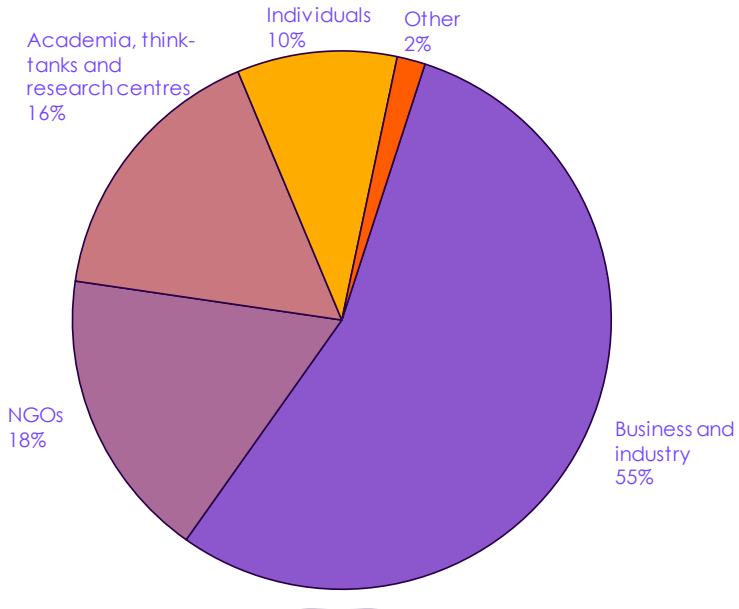
E. Sector-specific questions

The Call for Evidence received 177 responses from across business and industry, NGOs, academia and from individuals (Figure B1.4), and also hosted stakeholder events in Llandudno and Cardiff. The Committee published a summary of responses to the Call for Evidence in July 2020. The summary, including a list of respondents and links to responses in full, is available on the Committee's website. Several common themes emerged from the Call for evidence. In particular:

- Decarbonisation pathways for Wales should **take into account specific characteristics** such as land use and geographical characteristics, socio-economic factors and industrial composition.
- Similarly **Wales' current climate ambitions - including the ambition to set a Net Zero target for 2050 - should be taken into account**, while reflecting the UK-wide and devolved frameworks allow for delivery of climate action at both levels, and that a greater level of devolution could enhance the delivery of climate action in the UK.
- Several respondents noted **the link between climate action and well-being**, including the opportunity to improve Welsh lives as part of a programme of climate action in Wales.
- However, respondents also noted **the need for a level of consistency between Wales' climate targets and the UK's climate targets**, including the need for shared standards, coordination around planning and infrastructure development, and means of accounting for carbon budgets.

The Call for Evidence was an important part of the Committee's engagement programme, but not the only one. We also held a large number of roundtable discussions and bilateral meetings, including with groups that did not respond to the Call for Evidence.

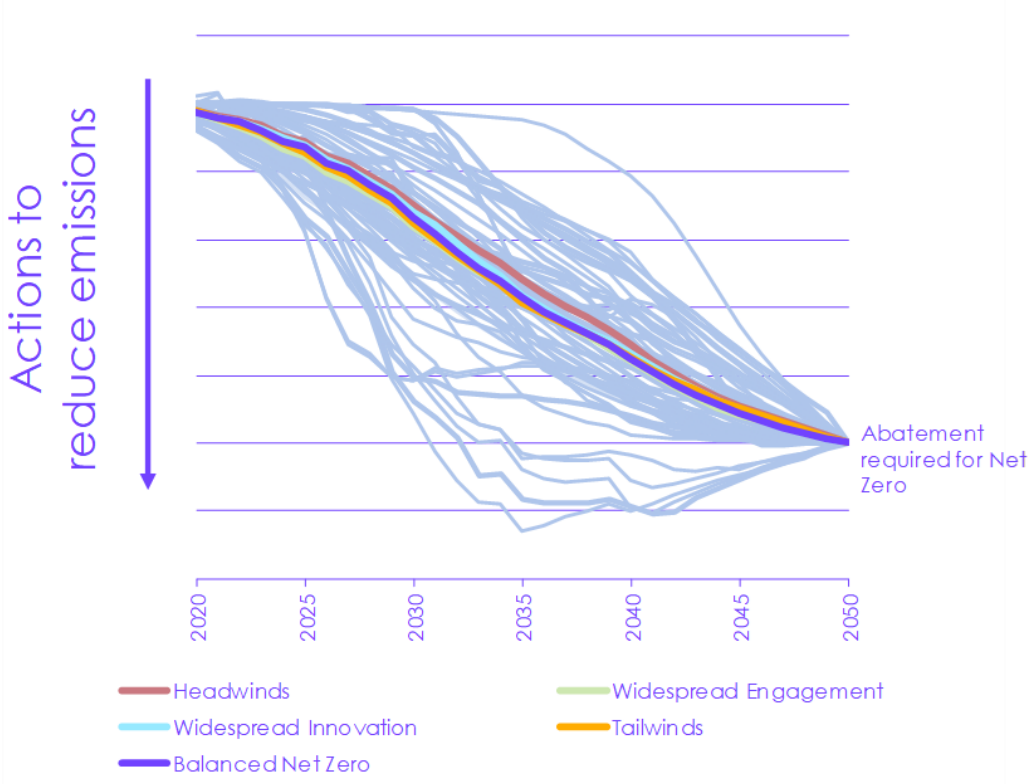
Figure B1.3 Responses to the Call for Evidence by type of respondent



Source: CCC analysis.
Notes: 'Business and industry' includes consultancies and industry/trade bodies; 'Other' includes public and parliamentary bodies.

In the process of developing five scenarios, we have produced a total of 70 sectoral pathways at both Wales and UK level (Figure 1.4). We have taken steps to ensure that each of the sectoral scenarios represents a coherent picture at the economy-wide level (Box 1.4), including what happens to infrastructure and operation of the electricity system (Table 1.2).

Figure 1.4 The five economy-wide scenarios are constructed from 70 individual scenarios for action across every sector of the economy



Source: CCC analysis.
Notes: Each individual line represents the path for new abatement in a sector between 2020 (effectively zero) and by 2050 where all sectors reach a level of abatement that is consistent with the UK getting to Net Zero. Not all sectors will get to zero emissions. Abatement in the fuel supply is greater in the 2030s than by 2050. Figure shows UK-wide pathways; an equivalent set of scenarios are produced for Wales.

We have tried to ensure that each of the scenarios represents a coherent view of a possible future.

Box 1.4
Developing self-consistent scenarios for each sector of the economy

In developing the scenarios, we have made efforts to ensure they are self-consistent:

- The residual emissions in each sector have been aggregated to obtain the level of total Welsh emissions, ensuring that the decarbonisation of energy carriers that are used in multiple sectors (e.g. electricity, hydrogen, bioenergy) is accounted for once and once only.
- Aggregated energy demand across all sectors is a key input to our analysis of the production, transportation and consumption of low-carbon electricity, hydrogen, fossil fuels, waste and bioenergy.
- We have considered the overall use of biomass in the UK (and Wales) so that it does not exceed limits that we judge could be sustainably sourced and available by 2050.
- We have considered the shared use of infrastructure across sectors, including specific areas of the gas grid and the co-location of industrial carbon capture and storage with hydrogen production.
- CO_2 capture requirements are aggregated across all sectors to investigate the scale of storage required for the UK.
- We have drawn on findings from our extensive use of energy system models to date and incorporated them into this analysis.
- Each sectoral scenario uses a shared set of assumptions about the future, including economic and demographic factors such as the growth rate of the economy, population growth and energy prices.

Table 1.2
Summary of key differences in the economy-wide scenarios

	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Diet change (UK average)	**35% reduction in all meat and dairy by 2050**	20% reduction in all meat and dairy by 2050	50% reduction in all meat and dairy by 2050	50% reduction in all meat and dairy by 2050	50% reduction in all meat and dairy by 2050
Tree-planting rates (Wales)	**7.5 kha/year from 2035**	4.5 kha/year from 2025	10.5 kha/year from 2035	7.5 kha/year from 2030	10.5 kha/year from 2035
Wholesale electricity cost* (UK)	**2035: £60/MWh 2050: £50/MWh**	2035: £65/MWh 2050: £60/MWh	2035: £65/MWh 2050: £55/MWh	2035: £55/MWh 2050: £40/MWh	2035: £60/MWh 2050: £35/MWh
Natural gas grid (UK)	**Hydrogen grid conversion trials in 2020s.** **Patchwork large-scale conversions start from 2030 near industrial clusters.** **Some buildings in those areas switch to hydrogen.** **Conversion continues to 2050.**	Hydrogen grid conversion trials in 2020s. Large-scale conversions start from 2030 around industrial clusters and radiate out at 10km/yr. 20% of homes on gas grid with hydrogen by 2035.	Gas grid not converted to hydrogen. Full electrification in buildings. Industry hydrogen sourced via private pipelines.	Hydrogen grid conversion trials in 2020s. Large-scale conversions start from 2030 around industrial clusters and radiate out at 10km/yr. Most buildings within radius convert to hydrogen. After 2035 no further buildings convert – further radial expansion beyond 2035 only applies to parts of grid to supply some industrial users.	

* Shown for residential users. Larger users are assumed to receive a discount on the wholesale electricity price.

b) Developing self-consistent scenarios for Welsh and UK action

More detail on sector-specific methodologies for deriving sectoral pathways for Wales is available in each chapter of the *Methodology Report* that was produced as part of the package of advice on the UK Sixth Carbon Budget.

Broadly, our approach for deriving Welsh emissions scenarios entails:

- Deriving a baseline emissions projection for each sector to 2050 for each of the devolved administrations that takes into account, as far as possible, differences in current and projected trends in Wales.
- Analysing the amount of abatement in Wales that is consistent with the UK-wide scenario in each sector.
- Combining these to provide five scenarios for Wales for the period 2020-2050.
- Assessing the costs, savings and co-impacts of these actions.

The pathways for Wales are based on specific factors which determine the rate and overall level of decarbonisation achievable under every scenario for the UK (Table 1.3). This includes:

- different levels of activity and emissions in each sector today;
- existing usage of land, and opportunities for land-based removals;
- existing infrastructure;
- opportunities to remove CO_2 from the atmosphere; and
- existing policies.

A challenge in defining these scenarios has been to determine where greenhouse gas removals in the UK scenarios could be located geographically as – unlike reductions in existing emissions – these are not tied to a specific geographical location or existing activities and could be located anywhere in the UK.

The Committee's pathway analysis does not allocate specific levels of greenhouse gas removals that are used in UK scenarios. This includes the combustion of biomass to generate electricity with CCS (BECCS power) or the use of direct air capture with carbon capture and storage (DACCS).

Due to the difficulty of allocating UK removals to different parts of the UK, we present results for Wales without removals.

However, we do provide a partial analysis of the potential for the use of wood in construction and the use of biomass, biogas and biogenic wastes with CCS to generate process heat in industry.

Table 1.3
Developing pathways for Wales

CCC sector	Methodology for allocating emissions and costs in UK scenarios to Wales
Surface transport	• Road vehicle traffic (including HGVs) is based on the Department for Transport (DfT) National Transport Model (NTM), which produces forecasts at Wales-level. • Line-specific rail electrification. • National Travel Survey (NTS) data are no longer collected, but our assumption on UK-average changes in travel behaviour is not expected to have a significant impact on Wales' emissions pathways.[7]
Electricity supply	• Our analysis uses a model of the GB network. To allocate electricity supply emissions to Wales, we sum the existing plant-level capacity and projected retirement dates for each generating technology and apply load factors to these based on changes in GB-wide load factors.
Aviation	• Emissions are disaggregated by type of flight (international, domestic) and split by Wales' existing share of emissions in the inventory. DfT projections of individual airport demand, including the impact of airport expansion, impact overall UK demand management.
Shipping	• Emissions are disaggregated by type of journey (international, domestic) split by Wales' current share of emissions in the inventory.
Residential buildings	• Low-carbon heat and energy efficiency measures are deployed in our scenarios using a housing stock model of the UK which integrates regional national housing survey data for Wales, with an accurate mix of building attributes. District heating is also modelled at Wales-level.[8] • Measures for new-build, cooking decarbonisation and energy efficiency relating to lighting and appliances are modelled separately and scaled for Wales based on current energy demand for these services.
Non-residential buildings	• Analysis carried out at a UK level with abatement based on the Buildings Energy Efficiency Survey (BEES) for England and Wales, BEIS's heating study for England and Wales and UK-level district heat analysis. • Emissions pathways are based on Wales' existing share of direct emissions from non-residential buildings.
Manufacturing, construction and fuel supply	• Analysis of industry decarbonisation is based largely around site-level emissions data, so the analysis reflects the composition of industry in Wales.[9] • Assumptions about availability of hydrogen and CO_2 storage also include some (limited) site-specific considerations.
Agriculture	• UK baseline emissions projections are split based on share of emissions in the current inventory. • On-farm measures are based on technical potential and cost effectiveness of measures at country level, based on SRUC modelling (including new measures in a 2019 update (for the Net Zero report) and a further 2020 update for the CCC).[10] • Abatement savings from energy use, diet change and food waste reduction based on existing sub-sector share of emissions in the inventory (Agricultural soils, Enteric fermentation, Livestock wastes, Liming & urea application, Machinery)
LULUCF	• Land use scenarios for Wales are based on modelling of land across each country of the UK. This accounts for differences in existing land use and in land acquisition costs. It includes peatland, energy crops, afforestation (including on-farm) and forest management, with land released through more efficient farming, food waste reduction and diet changes.
Hydrogen use and production	• Various scenarios for hydrogen roll-out in different distribution networks of the GB gas-grid and industrial clusters over time, including the South Wales industrial cluster. UK hydrogen production likely located near carbon capture and storage (CCS) clusters (if produced by methane reformation) or near sources of low-carbon electricity generation (if produced by electrolysis).
Waste	• Landfill fugitive emissions are based on Wales-specific methane modelling resulting from landfill volumes and banning certain streams from landfill.[11] • Other waste sector emissions (e.g. wastewater, composting) are split from UK pathways based on historical share in the greenhouse gas inventory.
F-gases	• Emissions are split based on the share of sub-sector F-gas emissions in latest inventory.

4. Contribution to the UK Climate Change Act

Under the 2008 Climate Change Act, Wales is required to contribute to the UK Net Zero target in 2050 as well as the UK's carbon budgets. The Act assigns to Welsh Ministers the duty to report on the Welsh Government's objectives, actions and future priorities regarding the impacts of climate change to the Welsh Parliament.

The credibility of the UK's Sixth Carbon Budget and Net Zero rests on action in all parts of the UK, including Wales.

The technical and behavioural challenges and solutions to tackling greenhouse gas emissions are broadly similar across the UK. This does not mean that Wales will follow the exact same emissions reduction pathway as the rest of the UK, nor does it lessen the need for policies that are tailored for national, regional and local needs.

Our pathways for each part of the UK entail consistent amounts of effort, but lead to different overall reductions in emissions.

Equal effort towards UK Net Zero will lead to different emissions pathways. The balance of activity across different sectors - particularly aviation, agriculture and land use, manufacturing and construction, fuel supply and greenhouse gas removals - means different levels of emissions reduction are possible in different parts of the UK through the Sixth Carbon Budget period and by 2050.

a) Factors affecting Wales' emissions pathways relative to the UK

The key factors determining the rate at which Wales can reduce its emissions relative to the UK are: different levels of activity and emissions in each sector today; existing land usage and opportunities for land-based removals; existing infrastructure; opportunities to remove CO_2 from the atmosphere; and existing policy.

Existing levels of emissions and activity in each sector

The current sectoral shares of total emissions are different in Wales to the UK as a whole (Figure 4.1), due to different levels of activity and output in these areas.

Higher or lower shares of current emissions and activity each sector mean that the pace and scale of mitigation actions - or failures to act - will have a proportionally higher or lower impact on the economy-wide emissions pathways for Wales. Higher shares of emissions in sectors that can decarbonise rapidly in the next decade will mean that economy-wide emissions will fall more quickly.

The following sectors differ from the UK share by more than five percentage points in Wales:

- **Agriculture.** Wales has a significantly higher proportion of total emissions from agriculture compared to the UK. Around 10% of all UK emissions are from agriculture, compared to 16% in Wales.
- **Aviation** comprises a much smaller share of emissions in Wales (<1%) compared to the UK as a whole (7%).
- **Electricity supply.** Wales is a net exporter of gas-fired electricity to the rest of the Great Britain network, so decarbonisation of the electricity generation in the 2020s will have a greater proportional impact on the Welsh emissions pathway.

- The **manufacturing & construction** sector has a much larger role to play in Wales, with the proportional contribution of Welsh emissions from this sector (23%) double the contribution for the UK as a whole (12%).
- **Surface transport** emissions make up a smaller proportion of total emissions in Wales (14%) than in the UK (21%). However, this is not due to a more carbon-efficient surface transport sector but rather because Wales has higher overall per-capita emissions than the UK as a whole, making the share of transport emissions of the total smaller. Per person, surface transport emissions are actually higher in Wales than the UK average.

Existing land use and opportunities to remove CO_2 from the atmosphere

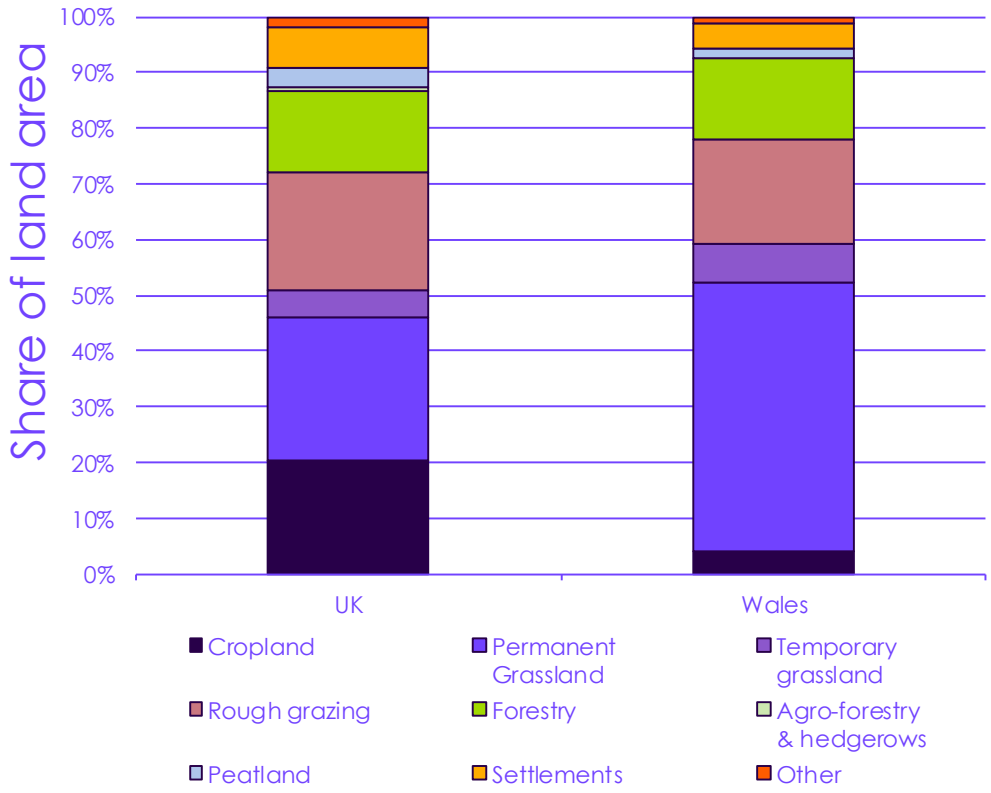
Emissions from land use, land-use change and forestry (LULUCF) are inherently location-specific. Across the UK, there are differences in the types of existing land use, as well as in the types of land use change needed to deliver the UK Net Zero target and the costs associated with those changes (Figure 1.5).

As a result, the costs and benefits for Wales differ to the results for the UK as a whole. The two main differences across the UK that have been incorporated in our analysis are:

- Different combinations of measures that can be deployed in Wales based on **differences in geographies and existing land use**. Wales has a comparable level of forest coverage to the UK, and has a very low amount of emissions associated with degraded peatland, which is expected to add around 0.5 $MtCO_2e$ to estimates of emissions in Wales once it is included in the inventory (compared to over 20 $MtCO_2e$ for the whole of the UK). Wales has a much lower proportion of land area used for crops compared to grasslands.
- **Differences in land acquisition costs in Wales**. Other costs are also likely to vary (e.g. based on remoteness of land) but it has not been possible to take this into account.

Our 2020 Land Use Policy Report[12] found that the set of measures to reduce emissions from agriculture and land use in our scenarios deliver a higher ratio of benefits to costs in Wales compared to in England.

Figure 1.5 Existing land use in Wales compared to the UK



Source: Centre for Ecology and Hydrology (2020) and CCC analysis.
Notes: Does not include land used for agro-forestry and hedgerows (<1% at UK level) for Wales. 'Forestry' includes small woodlands.

Existing infrastructure

Some differences in infrastructure will continue as far as 2050. This is particularly important for the gas and electricity networks, existing housing stock, and clusters of heavy industry:

Properties off the gas grid in are likely to go straight to low-carbon heating rather than connect to the gas grid.

- **The gas network**. Wales has a higher proportion of homes off the gas grid than the UK average. Heat decarbonisation options that rely on the gas network will not be possible in these particular properties, and will require a greater use of other options such as heat pumps and smart storage heating.
- **The existing building stock,** including current levels of energy efficiency, ownership or tenancy type, heating technology, suitability for low-carbon district heating, and the proportion of buildings that are 'hard-to-treat' or heritage properties.

  Our analysis takes into account the different characteristics of buildings in Wales using a detailed model of the housing stock. Differences in population density also affects the number of miles driven by people in different parts of the UK.

The timing with which industrial clusters in Wales decarbonise will have a big impact on total emissions.

- **Large point sources of emissions.** Existing fossil-fuelled power stations and industrial clusters (e.g. the South Wales industrial cluster) are large point-sources of emissions that will continue to pollute until effective measures to decarbonise them are put in place. Reducing emissions from any large point-source of emissions will have a larger proportional impact on Welsh emissions than it will on the UK total. The timing and pace of the transition to low-carbon technologies at individual locations will therefore have larger impact on the total emissions pathway for Wales than the UK as a whole.
- The UK's **airport infrastructure** is concentrated in England, particularly around London. This means that successful abatement of – or failures to act on – aviation emissions will have a smaller impact on the total emissions pathways for Wales.

Potential to store CO_2

Unlike emissions reductions, deployment of greenhouse gas removals is not tied to specific location.

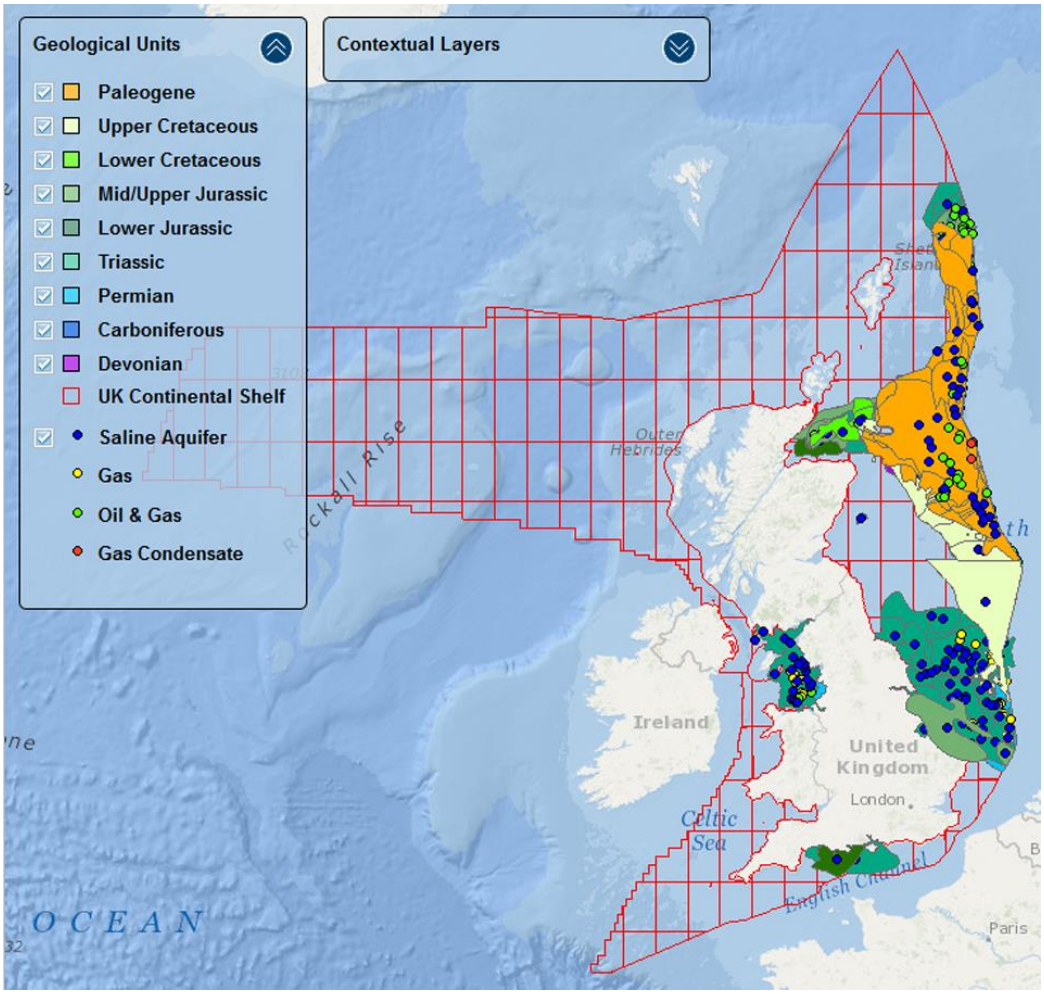
Carbon capture and storage (CCS) is crucial for the transition to Net Zero. In addition to playing a central role in reducing emissions from industrial processes and combustion, as well in electricity generation and potentially hydrogen production, CO_2 will also need to be removed from the atmosphere through greenhouse gas removals technologies, such as bioenergy with CCS (BECCS) and direct air CO_2 capture with storage (DACCS).

Under IPCC accounting rules the emissions credit for BECCS removals is allocated where the CO_2 capture occurs (i.e. where the biomass is combusted), rather than where the biomass is grown. Greenhouse gas removal technologies could – in theory – be located anywhere in the UK and would count towards UK emissions reductions.

It would be sensible for engineered removals to be located close to CO_2 stores.

However, there are reasons why BECCS and DACCS might be best located in certain areas of the country – such as co-location with industrial CCS clusters, in close proximity to CO_2 storage sites (Figure 1.6), or in close proximity to sources of biomass.

Figure 1.6 Map of potential CO_2 storage locations around offshore UK



Source: Energy Technologies Institute LLP, NERC and The Crown Estate (2020) *CO_2 Stored Database*.

The emissions pathway for Wales is therefore highly dependent on carbon storage capabilities:

- If CCS is used in places that are not located near to CO_2 storage sites, the CO_2 that is captured must be used or transported to a storage site. This will incur higher costs (e.g. the additional costs of shipping CO_2 at around £10-20/tCO_2)[13] and may make other solutions that do not require CCS such as electrification more cost-competitive.

Wales is less well-placed for CO_2 storage than England and Scotland.

- Large parts of Wales have more limited access to CO_2 storage sites and therefore do not appear to be the best places to locate BECCS power plants.

Particularly in the 2020s and early 2030s, the location of existing biomass power generation capacity in the UK will be important as these sites could be retrofitted with carbon capture and storage and be among the first UK BECCS facilities.

Existing policies

Existing and planned policies will have lasting effects for emissions pathways for Wales. To the extent possible, we include these impacts in our analysis. These include:

- **Long-term contracts for electricity production** that will drive new offshore wind capacity in the 2020s and recent UK Government decisions on other low-carbon electricity generation projects, including nuclear and tidal energy.
- **Tree planting.** The trees that are planted today will continue to sequester carbon over time. In Wales planting rates been low in recent years and a supply chain and funding mechanism will take time to develop.
- **Waste management policy** is mostly devolved. This has been reflected in our analysis, with Wales achieving higher recycling rates than England in our scenarios before 2030. Waste sent to landfill today can continue to emit greenhouse gases for decades, so recent waste policy in Wales will have an impact on long-term emissions pathways in the waste management sector.

Wales is outperforming the rest of the UK on recycling.

b) Contribution to Net Zero emissions for the UK

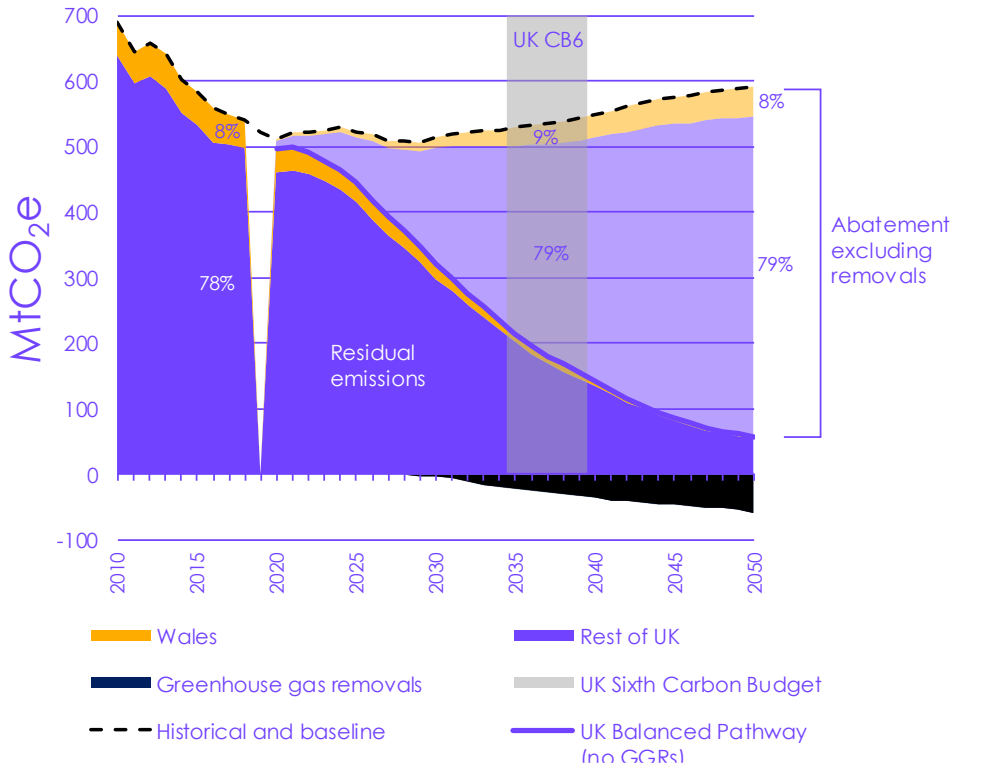
Reductions in positive emissions are similar across the UK.

Across the Balanced Net Zero Pathway for the UK, Wales' contribution of emissions reductions is comparable to its existing share of emissions (Figure 1.7).

Wales contributes to 9% of all action to reduce emissions (excluding greenhouse gas removals) across the UK Sixth Carbon Budget period and 8% by 2050 in our Balanced Net Zero Pathway, compared to 8% of UK emissions in 2018.

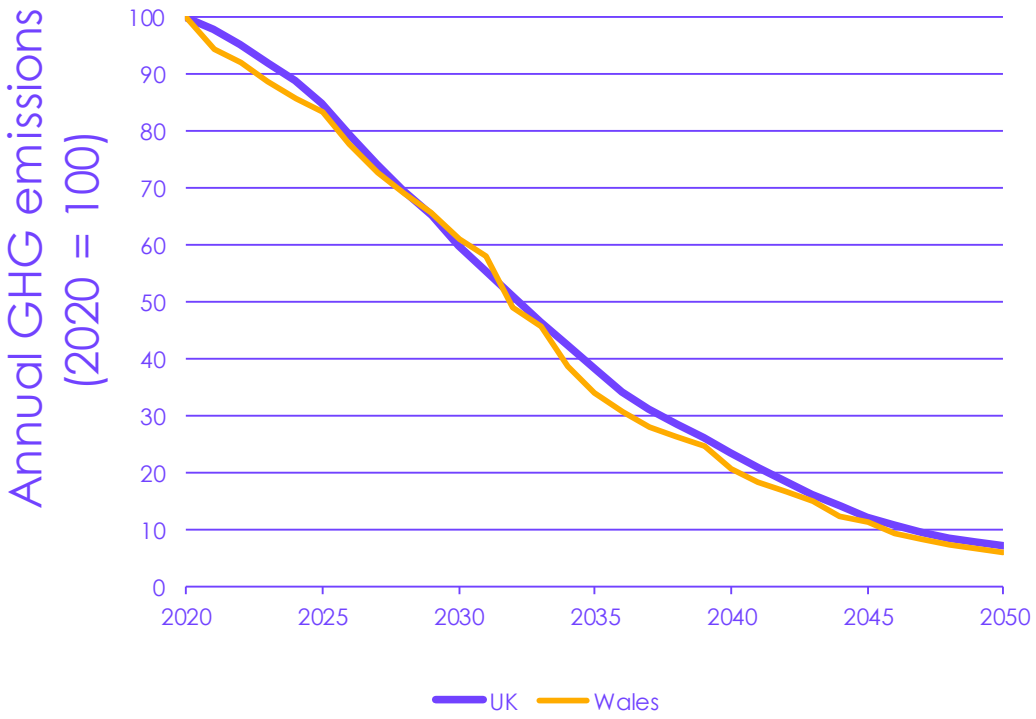
The dynamics of the transition in Wales is very similar to the rest of the UK, with Welsh emissions falling at a similar rate over time to similar levels by 2050 (Figure 1.8).

Figure 1.7 Share of UK emissions and abatement during the Sixth Carbon Budget period and 2050



Source: BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.

Figure 1.8 Comparison of UK and Welsh emissions pathways - excluding aviation and greenhouse gas removals



Source: CCC analysis.
Notes: Emissions from aviation and emissions removals from greenhouse gas removal technologies are not included in this chart. This allows a more equal comparison of the underlying changes in the Balanced Net Zero Pathways for the UK and for Wales.

Our recommended targets for Wales – alongside our recommendations for the UK Sixth Carbon Budget and the newly-set UK Nationally Determined Contribution (NDC) (see Box 1.5) – reflect the goals and requirements of the Paris Agreement, recognising Wales' responsibility as a richer developed nation and its respective capabilities:

- Our recommended pathway has been explicitly designed to reflect Wales' **'highest possible ambition'** within Wales' particular capabilities, as required by the Paris Agreement.
- It would reduce Wales' annual **per-capita emissions** to under 3 tCO_2e per person before 2040, in line with global pathways consistent with meeting the Paris 1.5°C goal (Figure 1.9).

Our pathways have been developed to support the required pathways for reducing global emissions.

- The **actions** required to meet the recommended targets – including full decarbonisation of the power sector, full switchover to electric vehicle sales and installation of low-carbon heating, and decarbonisation of manufacturing – would go beyond those required from the world on average, in line with Wales' responsibility as a richer nation with larger historical emissions. The timing of these actions would align to that required from the rest of the UK and other climate leaders.
- Comparable action from other developed countries with developing countries following slightly later (i.e. where they generally adopt low-carbon measures later, achieve lower percentage reductions to 2030 and reach Net Zero emissions after 2050) would limit warming well below 2°C. The emissions pathways set out in this report for Wales contribute to a **'leadership-driven' global pathway**.
- We have highlighted where policies and actions have important crossovers with the need to **adapt to climate change**, which is also included as a key part of the long-term response to climate change in the Paris Agreement.

While many countries have followed the UK in adopting Net Zero as a long-term emissions target, global ambition to 2030 remains far short of what is required. As President of the next UN climate talks (and of the G7) in 2021, the UK is in a position to influence others, but to do so must itself adopt an ambitious 2030 goal. Reducing emissions early matters as it is global cumulative emissions that drive climate outcomes.

The UK's climate goals cannot be met without the right action in Wales. The Welsh Government can support UK action by setting equally stretching targets into Welsh law and pursuing ambitious devolved policies that are well aligned to both Wales' Net Zero goal and the UK's path to Net Zero via the Sixth Carbon Budget.

The Well-being of Future Generations Act incorporates considerations of Wales' global responsibilities to all policy in Wales. Wales should be striving, according to the Act, to "…take into account whether improving the economic, social, environmental and cultural well-being of Wales can make a positive contribution to global well-being."

Wales' global responsibilities, therefore, are enshrined in Welsh law. Supporting the UK NDC by adopting the highest ambition scenario for decarbonisation currently available is an important way through which it can demonstrate that it has integrated the goals of the Well-being of Future Generations Act in national policy.

For a more detailed discussion of NDCs and the Paris Agreement, see Chapter 7 of the CCC's *Sixth Carbon Budget* report.

Box 1.5
The UK's Nationally Determined Contribution (NDC) for 2030

The UK will host the next UN climate talks – the 26th Conference of the Parties (COP26) – in Glasgow in November 2021. The period leading up to these talks is vital for increasing global ambition. It was of vital importance that the UK set a world-leading NDC that reflects best practice under the Paris Agreement.

On 3 December, following advice from the Committee by letter,[14] based on the advice on the UK Sixth Carbon Budget published the following week,[15] the Prime Minister announced that the UK NDC would follow the Committee's advice for it to require at least a 68% reduction in territorial emissions from 1990 to 2030 (excluding emissions from international aviation and shipping, IAS, in line with UN convention), to be delivered through domestic action.

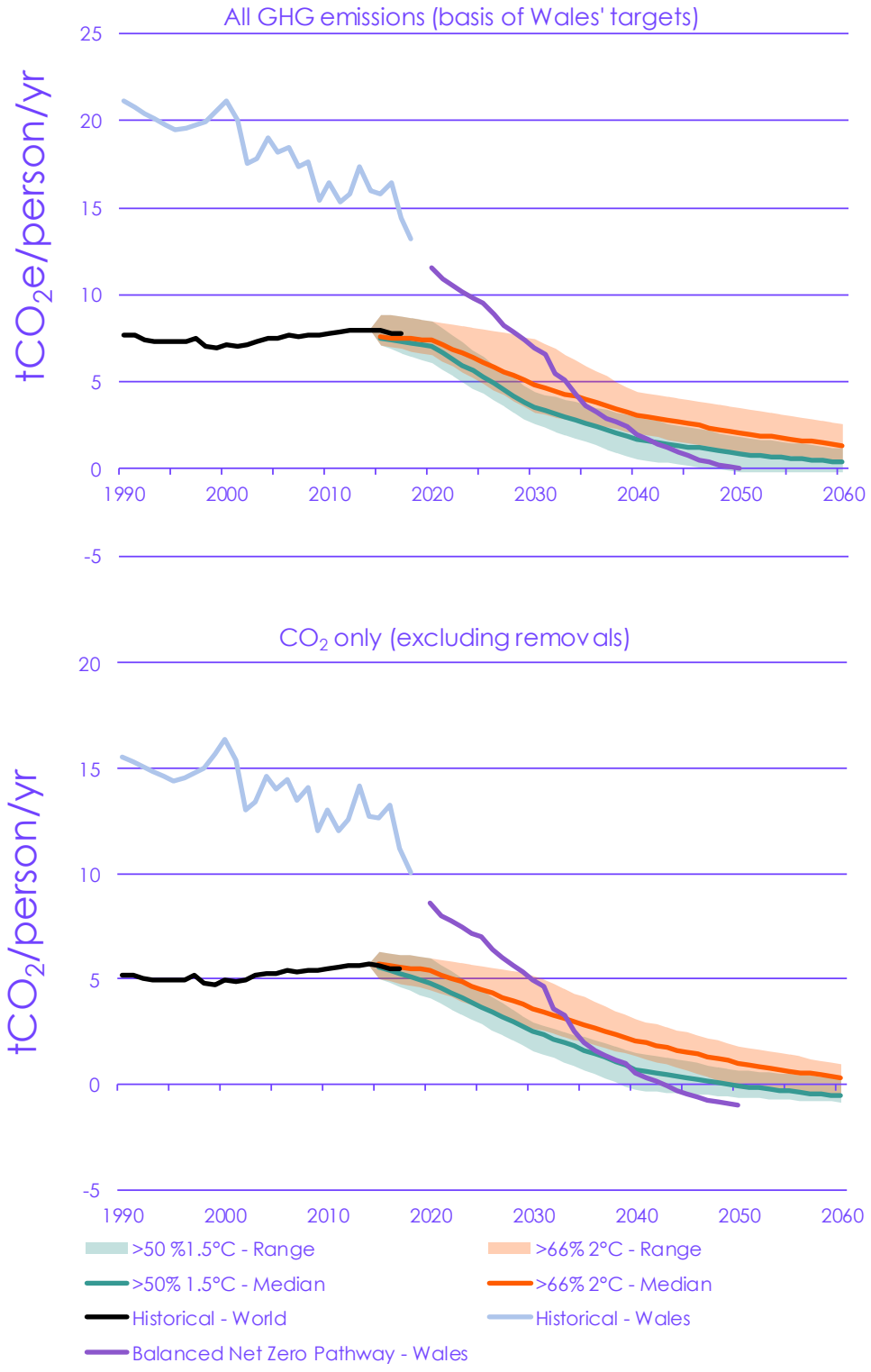
- This is a clear progression from the UK's pre-existing commitments: its expected effort share of the EU's existing NDC (-53%), the existing fifth carbon budget (-57%), and the expected reduction in actual emissions under the fifth carbon budget (-61%).*
- It is world-leading compared to existing NDCs, and amongst the front-runners for proposals for increased ambition. For example, if the EU adopts its proposed 55% reduction for 2030, the UK's NDC would be towards the top of the range that we estimate for the UK's possible effort share had it still been a Member State.
- It aligns with the published pathways from the Intergovernmental Panel on Climate Change (IPCC) for a 1.5°C goal. UK emissions would fall by 54% from 2010 to 2030, compared to the 45% that the IPCC identifies for the world as a whole.
- It is equivalent to a 64% reduction including IAS emissions, the basis of our recommended Sixth Carbon Budget.

The Committee made further recommendations alongside the headline reduction in emissions:

- **International aviation and shipping.** While these emissions are treated separately by the UN, they must be addressed if the temperature goal of the Paris Agreement is to be met. The UK's NDC should include clear commitments to act on emissions from international aviation and shipping, including both long-term and interim targets.
- **Adaptation.** Even if the Paris goals are delivered in full and global temperature rise is limited to 1.5°C, there will be further impacts from climate change beyond those already occurring today. If the Paris goals are missed, the global impacts will become much more severe. The UK needs to increase its ambition on climate change adaptation, as it is not even prepared even for the 1.5-2°C world. The UK's NDC should signal how national adaptation plans will be strengthened, as well as highlighting how the UK is supporting climate adaptation overseas.
- **International collaboration.** The UK has been a strong contributor to international climate finance, recently doubling its commitment to £11.6 billion in aggregate over 2021/22-2025/26. The UK's NDC should highlight this commitment, along with other UK contributions to technology development and capacity building.

* The existing EU ambition is for a 40% reduction by 2030 relative to 1990; an increase to 55% is being considered. The fifth budget goal of -57% refers to the net carbon account, which adjusts for emissions trading in the EU Emissions Trading System.

Figure 1.9 Global emissions pathways (per person) consistent with the Paris Agreement



Source: CCC analysis. Huppmann, D, et.al. (2018) A new scenario resource for integrated 1.5°C research. *Nature Climate Change*, 8 (12), 1027; Olivier, J. & Peters, J. (2019) *Trends in global CO_2 and total greenhouse gas emissions*. Notes: Aggregation of greenhouse gas emissions is done using the global warming potential metric at time horizon of 100 years. Values from the IPCC 5th Assessment report (with climate-carbon feedbacks) are used. Minimum and maximum ranges are used across the global emissions scenario categories used by the IPCC Special Report on Global Warming of 1.5°C. These figures do not include the uncertain of COVID-19 on 2020 emissions. CO_2 figures do not include any greenhouse gas removals technology in Wales. Emissions data are not available for 1991-1994 and 1996-1997; we have interpolated emissions in Wales for these years based on the levels in 1990, 1995 and 1998.

Chapter 8 of the Advice Report on the Sixth Carbon Budget provides a detailed analysis of the scientific context for setting the UK's Sixth Carbon Budget and NDC - which also applies to Wales' climate targets.

Our conclusions are:

- **Fundamental understanding of climate change and its causes continues to strengthen.** The conclusions of our UK Sixth Carbon Budget assessment are strengthened by the latest developments in the scientific literature. The recent Special Report on Global Warming of 1.5ºC (SR1.5) has improved the understanding of how future greenhouse gas emissions affect the climate and what is required to keep warming to the Paris Agreement long-term temperature goal. We have drawn on this strengthening knowledge base to inform the construction of our emissions pathways for Wales and the UK.

- **Understanding of climate sensitivity has continued to progress since our fifth carbon budget advice and IPCC-AR5.** A new community synthesis (published in 2020) of multiple lines of evidence regarding how sensitive the climate is to atmospheric carbon dioxide have suggested narrower ranges for uncertainties in the climate sensitivity than IPCC-AR5. The range of climate sensitivity from a new generation of complex climate models extends to higher values than previously. This new knowledge base will be reviewed by the IPCC next year. The global emissions pathways assessed by IPCC-SR1.5 currently remain the best indicators of the global ambition expected to achieve the Paris Agreement temperature goal.

- **Minimising cumulative emissions of long-lived greenhouse gas emissions will help minimise additional climate impacts along the pathway to Net Zero.** Estimates of the remaining global cumulative CO_2 emissions consistent with keeping warming to the Paris Agreement long-term temperature goal ultimately depend on a set of choices and definitions, which imply a wide range could be consistent. This means it is challenging to use these estimates to constrain national emissions pathways robustly. National emissions pathways should however seek to minimise cumulative long-lived greenhouse gas (GHG) emissions on the pathway to Net Zero to minimise additional climate impacts, highlighting the need for ambitious near-term emissions reductions to fully align with the Paris Agreement.

- **Adapting to climate risks is essential given the wide ranges of climate futures that remain possible.** Climate impacts are already being felt in the UK and around the world. These will increase with further warming – and some is inevitable even under the most ambitious global emissions reductions. Warming in excess of 2ºC cannot be ruled out even under global emissions scenarios expected to satisfy the Paris Agreement and warming in excess of 4ºC by 2100 remains possible if the current ambition for reduction in global emissions is not increased. This demonstrates the importance of considering a wide range of climate outcomes in adaptation planning and implementation.

Endnotes

[1] Welsh Government (2019) *Wales accepts Committee on Climate Change 95% emissions reduction target.*

[2] Welsh Government (2020) *Letter from Lesley Griffiths AS/MS to Professor Robert Lee in response to recommendations of the Environmental Governance Stakeholder Task Group.*

[3] CCC (2017) *Building a low-carbon economy in Wales.*

[4] CCC (2019) *Net Zero – The UK's contribution to stopping global warming.*

[5] Climate Assembly UK (2020) *The path to Net Zero.*

[6] CCC (2020) *The Sixth Carbon Budget – Methodology Report.*

[7] CCC (2017) *Building a low-carbon economy in Wales.*

[8] Element Energy for the CCC (2020) *Development of trajectories for residential heat decarbonisation to inform the Sixth Carbon Budget.*

[9] Element Energy (2020) *Deep decarbonisation pathways for UK industry.*

[10] Scottish Rural College (2020) *Non-CO2 abatement in the UK agricultural sector by 2035 and 2050* and Centre for Ecology and Hydrology (2020) *Updated quantification of the impact of future land use scenarios to 2050 and beyond.*

[11] Based on Ricardo's MELMod model for the National Atmospheric Emissions Inventory (NAEI).

[12] CCC (2020) *Land use: Policies for a Net Zero UK.*

[13] BEIS (2018) *Shipping CO_2 – UK Cost Estimation Study.*

[14] CCC (2020) *Letter to The Rt Hon Alok Sharma MP: Advice on the UK's 2030 NDC.*

[15] CCC (2020) *The Sixth Carbon Budget: The path to Net Zero.*

Chapter 2

Scenarios for Wales to reduce emissions by 2050

Introduction and key messages

This chapter sets out the results of the detailed bottom-up scenario analysis that the Committee has developed for Wales. A more detailed set of results – including all scenarios for each sector of the economy – is published on the CCC website.

Our key messages are:

- **There is good evidence that Wales can reach Net Zero emissions by 2050**, at the same time as the whole of the UK. This may require the use of greenhouse gas removal technologies, but it could also be achieved in other ways.
- **A decisive transition to Net Zero.** The Balanced Net Zero Pathway – the basis for our recommendations for the UK and for Wales – sees over 65% of the necessary reduction to Net Zero in Wales achieved in the coming 15 years.
- **Systematic changes are needed** in individual and business behaviours, the energy system, carbon capture and storage and how land is used in Wales.
- **Success is contingent on taking actions in the 2020s** across every sector of the economy.
- **There is flexibility to meet Net Zero in different ways** depending on societal changes and technologies.
- **All sectors have multiple options** to reduce emissions by 2050; some sectors face key decision points in the 2020s.
- **There are limits to what is feasible in Wales.** Our Tailwinds scenario gets to Net Zero in 2044, but it is a highly optimistic scenario, stretching feasibility in a wide range of areas and going beyond the current evidence in others.

This Chapter is set out in three sections:

1. The Balanced Net Zero Pathway for Wales
2. Flexibility on the route to Net Zero in Wales
3. Meeting Net Zero in Wales

The Committee's pathway analysis does not allocate specific levels of greenhouse gas removals that are used in UK scenarios. This includes the combustion of biomass to generate electricity with CCS (BECCS power) or the use of direct air capture with carbon capture and storage (DACCS).

All of the emissions pathways in Sections 1 and 2 of this chapter are therefore presented without the inclusion of any engineered greenhouse gas removals.

When recommending targets, we consider pathways without engineered removals and then consider ranges for the share of removals.

In Section 3 of this chapter, we consider these pathways without greenhouse gas removals and then what different shares of total UK removals might mean for what level of emissions reduction is feasible.

This chapter considers some discussion of sectoral trends and emissions. For more detailed on the assumptions in each sector of the economy, see Chapter 3 of the UK Sixth Carbon Budget Advice Report.

This section sets out the actions the Committee has assessed as being required in the 2020s to get on track to Net Zero and to meet our recommended Sixth Carbon Budget. It is set out in five parts:

a) The scale of the challenge in Wales

b) Emissions in the Balanced Net Zero Pathway

c) Actions in the 2020s and beyond

d) Key phase-out dates

e) Energy, carbon capture and storage, and land use requirements

All emissions data in this section are presented without engineered greenhouse gas removals (see Section 3 for more details).

a) The scale of the challenge in Wales

The majority of emissions in 2018 – the most recent year for which emissions data are published for Wales – were associated with the combustion of fossil fuels in the energy system: electricity production, transport, heat in buildings, and industry.

Adjusted for future changes to the UK's greenhouse gas inventory, Welsh greenhouse gas emissions were 41.4 $MtCO_2e$ in 2018, 8% of the UK's emissions.* If the Welsh Government is to set a Net Zero target for 2050 in line with our advice, this will require net emissions to fall by 100% from current levels, with any residual emissions offset by actions that remove CO_2 from the atmosphere.

Action must be taken in all sectors of the economy, not just the power sector.

Emissions must fall more quickly to meet our recommended Third Carbon Budget for Wales (by around 1.6 $MtCO_2e$ per year, compared to 1.2 $MtCO_2e$ per year from 2008 to 2018). The power sector can no longer be relied upon to deliver the majority of these reductions; progress must extend to all sectors of the economy (Figure 2.1).

Wales is already meeting some of its energy and economic needs with low-carbon technologies, but these are not yet deployed at the scale that is consistent with Net Zero:

- Emissions from electricity production have fallen by 33% since 1990 – and more than halved from 2018 to 2016 – as coal-fired power stations have closed, electricity demand has fallen, and renewable generation capacity has increased. Half of Wales' gross electricity consumption in 2019 was met by renewable sources – but Wales was a net exporter of (primarily gas-fired) generation to the GB grid.

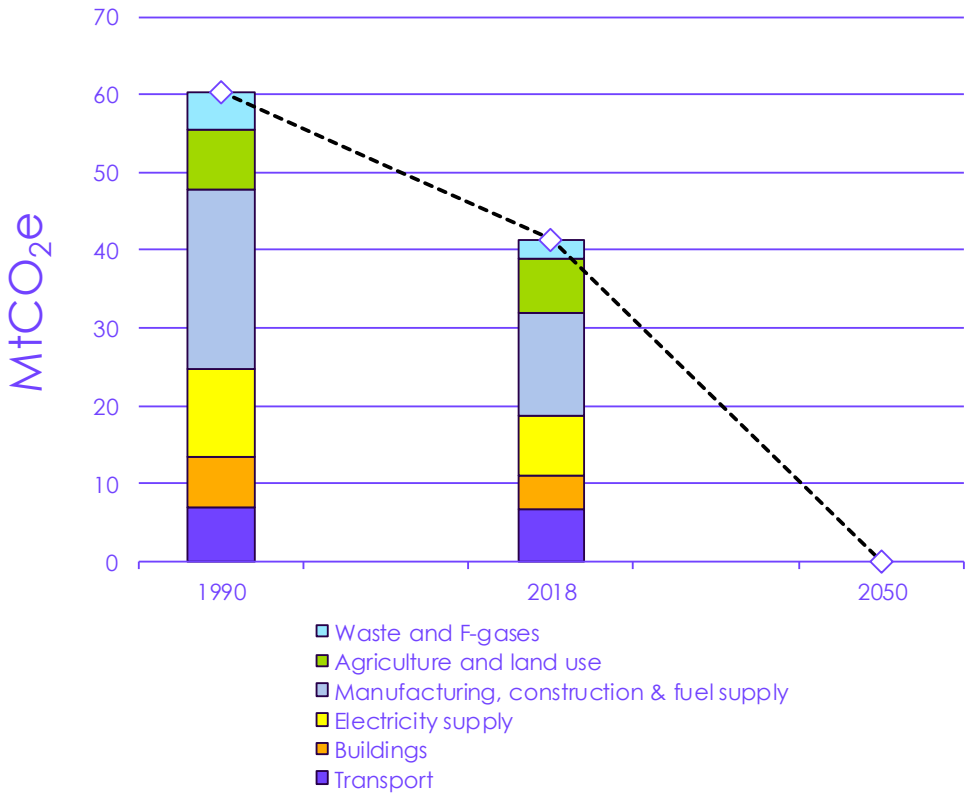
* Throughout this Advice Report, our figures for UK and Welsh emissions include those from international aviation and shipping (45 $MtCO_2e$ for the UK in 2019). We also incorporate expected changes to the inventory to reflect higher estimates for emissions from peatlands and higher global warming potentials (GWP) proposed by the IPCC (and agreed at the UNFCCC) for non-CO_2 greenhouse gases. As a result, our estimate for UK emissions in 2019 is a further 42 $MtCO_2e$ higher than in the UK's official inventory. Box 2.1 sets out more details on these issues for Wales.

- In other sectors, 99% of all miles driven on Welsh roads are in vehicles with petrol and diesel engines, less than 1% of Wales' 1.4 million homes were heated by heat pumps, and less than 25% of industrial energy demand in Wales is met by electricity or hydrogen.

Some low-carbon technology has been deployed in the Wales not at a level which is consistent with Net Zero.

- Outside of energy use sectors, current levels of tree planting and peatland restoration are well below the required rate for Net Zero, emissions from agriculture have not fallen in the last decade, and large volumes of biodegradable waste are still sent to landfill.

Figure 2.1 To meet Net Zero in Wales, emissions must fall in all sectors and at a faster rate than the last thirty years



Source: NAEI (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; CCC analysis.
Notes: Net Zero emissions in 2050 will require any residual emissions to be offset by the UK land use sink and greenhouse gas removals.

b) Emissions in the Balanced Net Zero Pathway

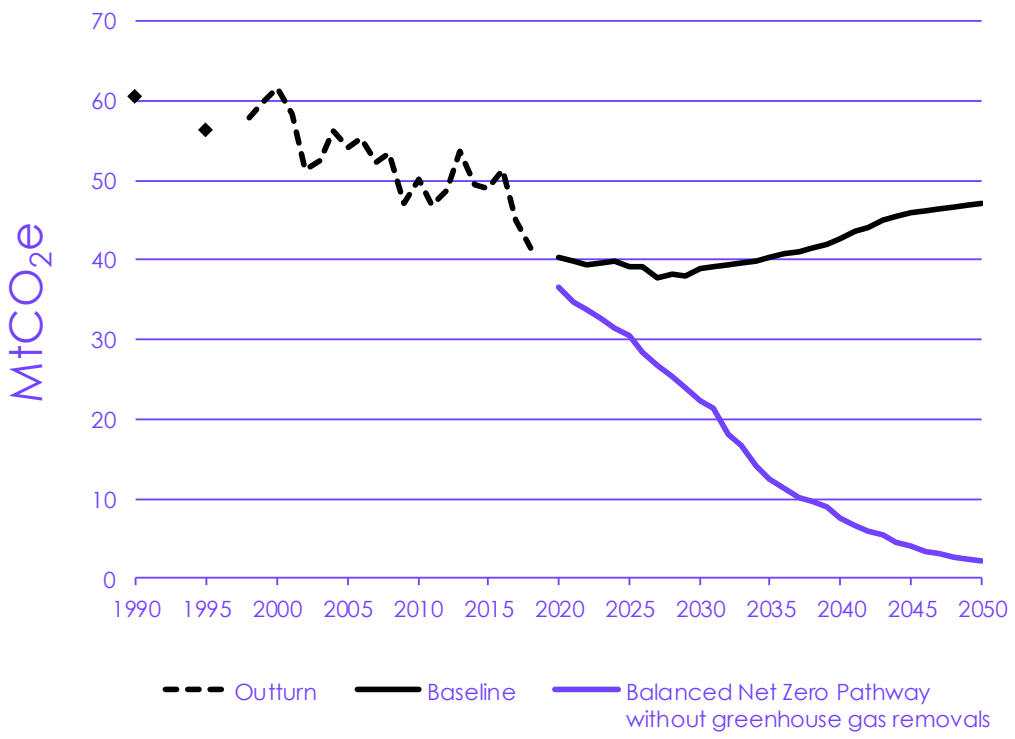
Our Balanced Pathway reaches a 96% reduction for all greenhouse gases compared to 1990 (Figure 2.2) before the potential use of greenhouse gas removals is accounted for.

The Balanced Pathway represents a decisive transition, with 66% of the necessary reduction to Net Zero achieved in the coming 15 years and the fastest rate of decarbonisation occurring in the early 2030s.

Emissions would be lower on other measurement bases that are for CO_2 rather than the full range of greenhouse gases* and/or assume the lower range of changes to the inventory (Table 2.1).

The Balanced Net Zero Pathway has the steepest transition in the period 2025 to 2035. 66% of the total emissions reductions required for Net Zero are in the next fifteen years.

Figure 2.2 The Balanced Net Zero Pathway for Wales without greenhouse gas removals



Source: NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.
Notes: The fall in 2020 is largely due to COVID-19 impacts on aviation and shipping.

* Although all of the greenhouse gases (GHGs) contribute to warming temperatures, peak temperature change is determined by when emissions of long-lived GHGs reach net-zero (assuming that short-lived GHG emissions are not rising). Of the long-lived GHGs, CO_2 contributes most to warming and therefore the date of net-zero CO_2 is closely linked with when the contribution to rising temperatures ends.

The Balanced Pathway may get to Net Zero slightly earlier if a different methodology base were used.

Table 2.1
Where the Balanced Pathway (excluding removals) reaches on different bases

	'High-high' inventory changes*	'Low-low' inventory changes
All greenhouse gases	**96% reduction by 2050 without engineered removals**	98% reduction by 2050 without engineered removals
CO_2 only	Net Zero in 2043	Net Zero in 2043

Box 2.1
Forthcoming changes to the Welsh greenhouse gas inventory

Future changes to the emissions inventory include the addition of emissions from peatland and revision of the Global Warming Potentials (GWPs) used to aggregate greenhouse gas emissions:

- **Peatland (expected to be included in the inventory by 2022).**[1] The current inventory only captures around 1.3 $MtCO_2e$ of emissions from peatlands, but all sources of peatland emissions will be included in the inventory in the near future:
  - The 'high' range of emissions from peatland would add around 0.5 $MtCO_2e$ to the inventory in 2018 and would also increase the 1990 baseline by 0.5 $MtCO_2e$. This is the basis upon which targets in this report are recommended.
  - The 'low' range of emissions from peatland does not differ significantly from the 'high' range in Wales. The low range would add around 0.4 $MtCO_2e$ to the inventory in both 1990 and 2018.
- **Global Warming Potentials (expected to be updated in the Welsh inventory by 2024).** These are used to aggregate different greenhouse gases together into a common metric, showing their equivalence to carbon dioxide. At COP24 in December 2018 the international community decided to standardise reporting under the Paris Agreement transparency framework using the GWP_{100} metric.[2] The values to be used are those from the IPCC Fifth Assessment Report (AR5). There are two methodologies, and it is not yet clear which will be used. Both are different from the values used in the current emissions inventory and will lead to an increase in the estimate of UK emissions:
  - The 'high' estimate of GWPs include climate-carbon feedbacks. Under this methodology, the size of the existing inventory would increase Welsh emissions by around 1.9 $MtCO_2e$ while the 1990 baseline would increase by nearly 3.4 $MtCO_2e$. This is almost entirely due to a 36% increase in the estimated global warming impact of methane (CH_4) emissions, plus smaller changes to F-gas emissions. This is the basis upon which targets in this report are recommended.
  - The 'low' GWPs do not include climate-carbon feedbacks, and would lead to a smaller increase in the size of the UK emissions inventory. The estimate of the existing inventory would increase Welsh emissions by around 0.5 $MtCO_2e$ while the 1990 baseline would increase by 0.9 $MtCO_2e$. Under this methodology CH_4 methane emissions have a 12% higher warming impact than the current estimate, while the warming impact of N_2O emissions is 11% lower.

The two changes overlap because peatlands are a source of both CH_4 and N_2O emissions. The range for the total combined impact of the peatland and GWP changes is around an additional 1.3 – 4.0 $MtCO_2e$ in 1990 and 0.8 – 2.5 $MtCO_2e$ in 2018 compared to the current inventory.

* High-high' refers to AR5 GWPs with climate-carbon feedbacks and a higher estimate of emissions from peatlands. 'Low-low' refers AR5 GWPs without climate-carbon feedbacks and a lower estimate of emission from peatlands.

c) Actions in the 2020s and beyond

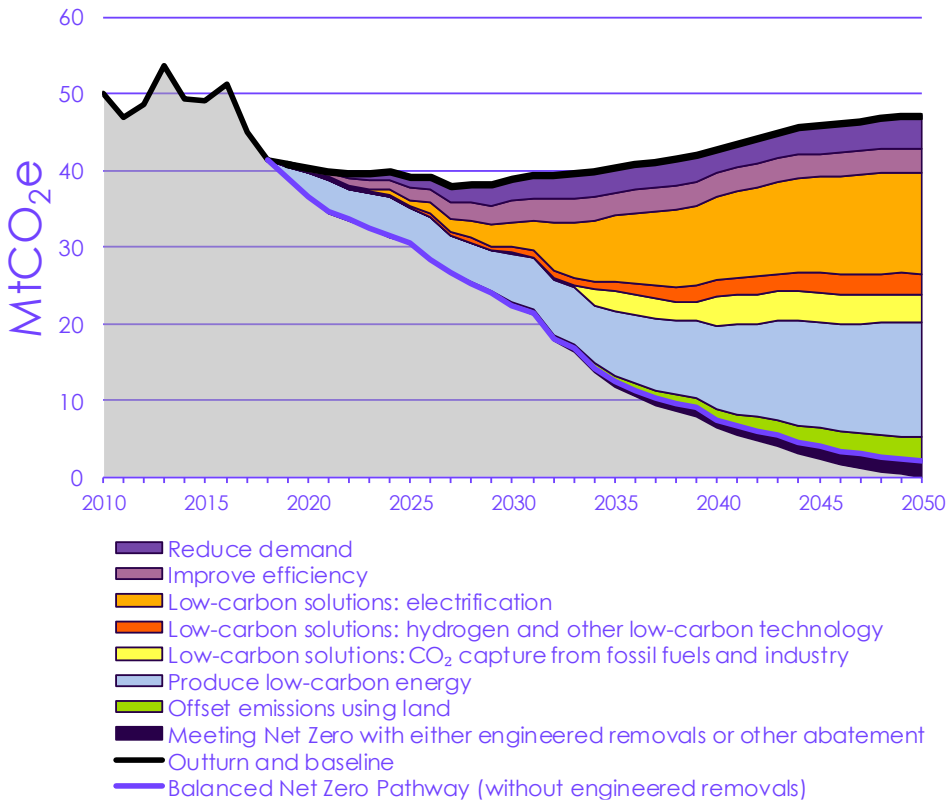
Meeting the Net Zero target in Wales requires action across four key areas in line with those from our Balanced Net Zero Pathway (Figure 2.3, Table 2.2):

- **Reducing demand for carbon-intensive activities.**
  - *Reduced demand.* Around 9% of the emissions savings in our Balanced Net Zero Pathway for Wales comes from changes that reduce demand for carbon-intensive activity. Particularly important in our scenarios are an accelerated shift in diets away from meat and dairy products, reductions in waste, slower growth in flights and reductions in travel demand. While changes are needed, these can happen over time and overall can be positive for health and well-being.
  - *Improved efficiency.* A further 7% comes from improving efficiency, in use of energy and resources, especially by better insulation of buildings, improving vehicle efficiency and improving efficiency in industry.
- **Take-up of low-carbon solutions.** Around 40% of the emissions saving is from people and businesses adopting low-carbon solutions as high-carbon options are phased out (Table 2.2). By the early 2030s all new cars and vans and all boiler replacements in homes and other buildings must be low-carbon – we expect largely electric. By 2040, all new heavy goods vehicles should be low-carbon. The South Wales industrial cluster (as well as other industrial sites in Wales) must either must either switch away from fossil fuels to low-carbon alternatives and/or install carbon capture and storage at scale from the mid-2030s.
- **Expansion of low-carbon energy supplies.**
  - *Low-carbon electricity* can now be produced more cheaply than high-carbon electricity in the UK and globally. In our Balanced Pathway the low-carbon share of generation in Wales increases from 27% now to 100% by 2035, cutting Welsh emissions by more than 95% compared to our baseline. We are not prescriptive about where in the UK new low-carbon generation is located or the precise mix of generation that is used (e.g. new renewables, nuclear or BECCS capacity), but all unabated gas-fired generation should cease in the whole of the UK by 2035. New demands from transport, buildings and industry (moderated by improving energy efficiency) mean electricity demand in Wales doubles by 2050.
  - *Low-carbon hydrogen* scales up to 90 TWh by 2035 at UK level (i.e. nearly a third of the size of the current power sector), produced using electricity or from natural gas or biomass with carbon capture and storage. It is used in areas less suited to electrification, particularly shipping and parts of industry, and is vital in providing flexibility to deal with intermittency in the power system. It may also have a material longer-term role in buildings and other transport, such as heavy goods vehicles.

- **Land.** A transformation is needed in Wales' land while supporting Welsh farmers. By 2030, our Balanced Pathway involves planting a cumulative 43,000 hectares of mixed woodland in Wales to remove CO_2 from the atmosphere as they grow, increasing to a total of 180,000 hectares by 2050. A further 56,000 hectares of agricultural land can shift to bioenergy production (including short rotation forestry) by 2050. Peatlands must be restored widely and managed sustainably. Low-carbon farming practices must be adopted widely, while raising farm productivity.
- **Flexibility to meet Net Zero,** Alongside the nature-based removals, by 2035 the UK should be using bioenergy (largely grown in the UK) with CCS to deliver engineered removals of CO_2 at scale – though these technologies may not necessarily be located in Wales. In Section 3, we set out how Wales can credibly meet Net Zero either with a 4% share of total UK engineered removals, or through increased action in other areas including land use and behavioural changes.

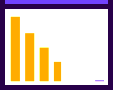
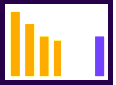
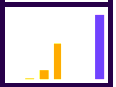
The Balanced Pathway (Figure 2.2) sees the most rapid emissions reductions over the period 2025 to 2035. Before 2025, newer markets (e.g. for electric vehicles and low-carbon heating) are still scaling up from low levels, so potential for large-scale deployment and therefore rapid emissions reductions is more limited. Beyond 2035 some opportunities have been exhausted, so progress slows down (e.g. all power generation is low- or zero-carbon by 2035).

Figure 2.3 Types of abatement in the Balanced Net Zero Pathway for Wales



Source: NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.
Notes: 'Other low-carbon technology' includes use of bioenergy and waste treatment measures. 'Producing low-carbon electricity' requires the use of CCS in electricity generation. There are no emissions data for Wales in 2019 and our scenarios begin in 2020. This chart shows 2019 emissions as halfway between the 2018 and 2020 values.

Table 2.2
Key metrics for actions in the Balanced Pathway to meet the Sixth Carbon Budget

		2018	2025	2030	2035	2050	Trend
Wales greenhouse gas emissions	Wales greenhouse gas emissions ($MtCO_2e$)	41	31	22	12	0	
	Wales greenhouse gas emissions per person (tCO_2e/capita)	13.2	9.5	6.9	3.7	0	
Demand reduction (UK average)	(UK) Weekly meat consumption (g) (includes fresh and processed meat)	960	880	770	730	630	
	(UK) Weekly dairy consumption (g)	2,020	1,840	1,620	1,620	1,620	
	(UK) Plane-km per person	11,700	11,000	11,000	11,400	13,700	
	(UK) Average car-km per driver	12,900	12,600	12,400	12,200	11,700	
	(UK) remaining waste per person, after prevention & recycling (kg)	490	400	310	280	300	
Efficiency (UK average)	(UK) Average carbon-intensity of a new HGV (gCO_2/km)	680	580	420	20	0	
	(UK) Increase in longevity of electronics	0%	30%	80%	120%	120%	
Electrification, hydrogen and carbon capture and storage	(UK) Carbon intensity of electricity (gCO_2e/kWhe)	220	125	45	10	2	
	(UK) Offshore wind (GWe)	10	25	40	50	95	
	(UK) Share of BEVs in new car sales	1%	48%	97%	100%	100%	
	Wales heat pump installations (per year, includes replacements)	2,000	21,000	52,000	68,000	75,000	
	Manufacturing energy use from electricity or hydrogen in Wales	22%	22%	32%	58%	71%	
	Low-carbon hydrogen demand in Wales (TWh)	<0.1	0.1	1.6	6.5	11.5	
	CCS in manufacturing in Wales ($MtCO_2$)	0	<0.1	0.1	1.6	1.9	
	CCS in other sectors in Wales ($MtCO_2$) (Excludes use in hydrogen production)	0	0	1	3	4	
Land	Cumulative trees planted in Wales (kha)	2	21	43	69	180	
	Cumulative energy crops planted in Wales (kha)	<1	1	8	20	56	
	Peat area restored in Wales	38%	45%	55%	64%	84%	
	Land-based carbon sinks ($MtCO_2$)	1.1	1.2	1.5	2.0	4.2	
Removals	(UK) Greenhouse gas removals ($MtCO_2$)	0.0	<1	5.0	23.0	58.0	

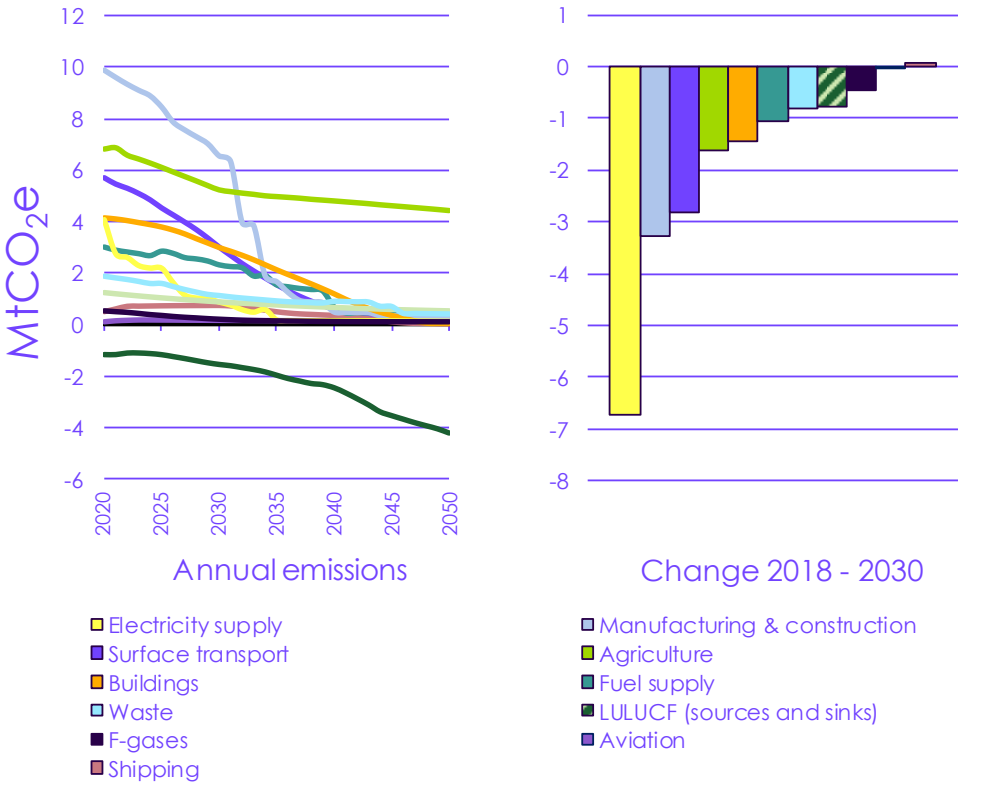
Notes: Metrics in orange rows are specific to Wales, grey rows are either the average or total values for the whole of the UK.

The electricity supply sector can decarbonise first because of the progress already made in the last ten years. Most sectors see the fastest rate of change in the 2030s.

Emissions under the Balanced Pathway fall at different rates in different sectors (Figures 2.4 and 2.5), depending on the maturity of decarbonisation options and the policy framework, as well as sector-specific dynamics:

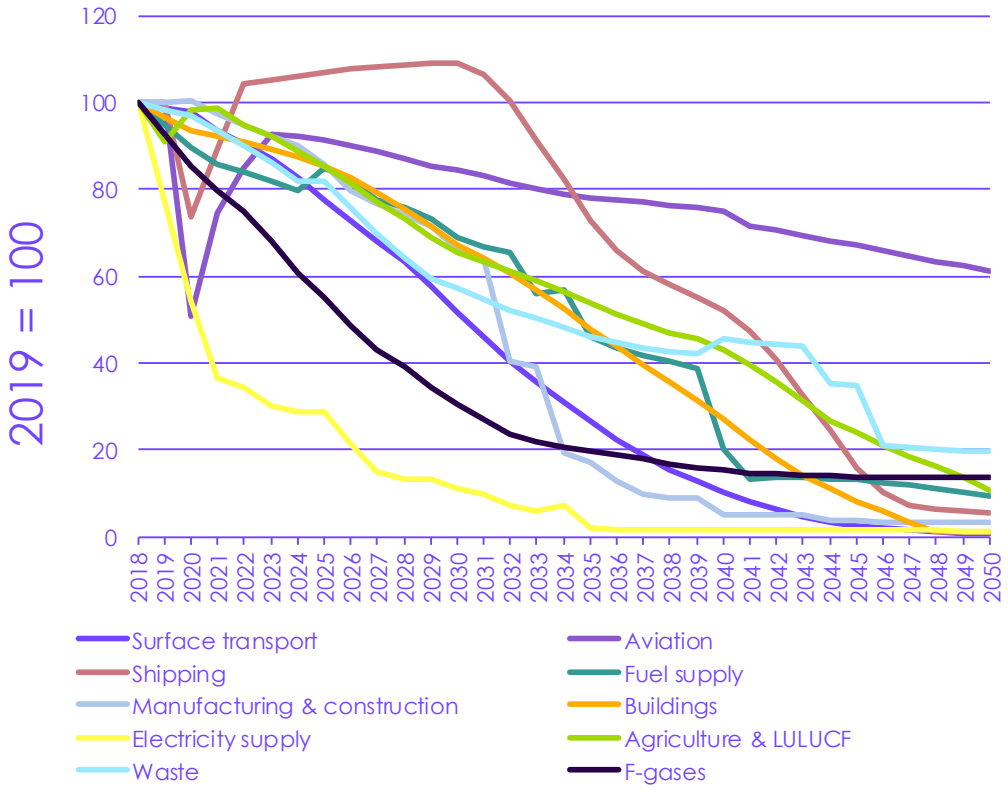
- Emissions under the Balanced Pathway fall most rapidly in the electricity supply sector. Mature decarbonisation options already exist for replacing fossil fired generation with renewables, combined with a well-developed policy approach that provides long-term certainty to the sector.
- Other sectors, including buildings and transport, build up to peak rates of decarbonisation during the 2030s. Markets and supply chains for low-carbon technologies such as heat pumps and electric vehicles develop in the 2020s, reaching the peak replacement rate of high-carbon capital stock turnover in the 2030s.
- Emissions from manufacturing and construction and fuel supply also start to fall faster from the late 2020s as industry switches to low-carbon production, enabled by electrification and new hydrogen and carbon capture and storage technology.
- Emissions from agriculture and aviation do not reach zero emissions and need to be offset by removals from the forestry carbon sink – which grows steadily over time with tree planting – and greenhouse gas removals, which are deployed at scale starting in the 2020s.

Figure 2.4 Sectoral emissions under the Balanced Net Zero Pathway for Wales



Source: CCC analysis.
Notes: LULUCF = Land-use, land-use change and forestry.

Figure 2.5 Change in sectoral emissions in the Balanced Net Zero Pathway in Wales compared to 2018 levels



Source: CCC analysis.
Notes: Aviation and shipping pathways are lower in 2020 due to COVID-19. LULUCF = Land-use, land-use change and forestry. No emissions data are available for 2019 in Wales. This chart draws a straight line between 2018 and 2020 for all sectors apart from aviation and shipping emissions, which are held constant at 2018 levels.

d) Key phase-out dates

The sale and construction of new high-carbon assets should be phased out by specific dates to ensure that they are removed from the economy before 2050.

The dynamics of each sector, and the principle of minimising early scrappage, point to common timings on the phase-out of high-carbon assets on the path to Net Zero, regardless of what low-carbon solution replaces them (Table 2.3):

- Boiler lifetimes of 15 years imply a phase-out date for the installation of fossil fuel boilers in advance of 2035, in order for uptake of low-carbon heat to be sufficient to decarbonise buildings by 2050. Sales of oil boilers should be phased out by 2028, and gas boilers by 2033 in residential homes, with the exception of hydrogen-ready gas boilers in areas where the gas grid is set to convert to low-carbon hydrogen.
- Sales of new fossil fuel cars, vans and motorbikes phased out by 2032 at the latest.

Where possible, new equipment should be designed to allow retrofit of low-carbon technologies like CCS or hydrogen.

- Building on the phase-out of coal-fired power generation by 2024, no new unabated gas plants should be built after 2030, and the burning of unabated natural gas for electricity generation should be phased out entirely by 2035. Any gas plant built before 2030 should be made ready for a switch to CCS or hydrogen (i.e. this should be both technically feasible and the plant should be located in a part of the country that will be served by the necessary infrastructure).
- Emissions from Wales' growing fleet of energy-from-waste plants will need to be captured in order for energy-from-waste to be sufficiently low-carbon by 2050. Waste should be minimised, and any new plants should be built with CCS or CCS-ready.

It is likely that if any of these phase-out dates were to be enforced through legislation, this would be through reserved powers.

Table 2.3
Phase-out dates of high-carbon activities under the Balanced Pathway in Wales (and the UK)

Technology/behaviour	Phase out date (sales)	Backstop date (operation)
New fossil-fuelled cars and vans	2032	2050
Gas boilers	2033 (in residential homes) 2030-33 (in commercial properties)	2050
Oil boilers	2028 (in residential homes) 2025-26 (in commercial properties)	2050
Unabated gas power generation	2030 (no new build of unabated gas plants)	2035
HGVs	2040	Beyond 2050
Biodegradable waste sent to landfill	N/A	2025 ban on all municipal & non-municipal biodegradable waste going to landfill
Unabated energy-from-waste plants	From today, new plants and extensions should be built with CCS or CCS-ready	2050

e) Energy, carbon capture and storage, and land use requirements

The Balanced Pathway sees a significant fall in the consumption of fossil fuels, replaced by low-carbon electricity, hydrogen and bioenergy.

In our Balanced Net Zero Pathway, the economy becomes much more energy efficient as a whole, with total energy demand falling by around 33% in end-use sectors between now and 2050. The energy system moves almost entirely from the existing, high-carbon energy to low-carbon alternatives (Figure 2.6):

- **Fossil fuels largely phased out.** Demand falls significantly to 2050 for oil (-95%) and natural gas in Wales (-60%) as the energy system makes the transition to Net Zero. Petroleum use is mainly restricted to the aviation sector, while natural gas use is limited to combustion with CCS for power generation and industrial processes and phased out of use in buildings. Opportunities for high-efficiency electrification (e.g. moving to EVs and heat pumps that are three times the efficiency of conventional vehicles and boilers) mean that demand for oil and gas falls more rapidly than the increase in electricity demand.

Electricity consumption would more than double under the Balanced pathway.

- **Low-carbon electricity** becomes the dominant energy vector for Wales, with output increasing to more than double current levels by 2050. This rapid expansion in low-carbon electricity is used to support electrification of other sectors.

A new hydrogen economy develops to a scale comparable to today's electricity system by 2050.

- **Hydrogen.** From the 2030s onwards, a hydrogen economy develops from virtually zero use in the energy system today to a scale that is comparable to existing electricity use by 2050.

Bioenergy transitions to applications with CCS.

- **Bioenergy and waste use** is expected to grow modestly by 30% to 2050 at UK level. Resources are increasingly diverted to the most carbon-efficient uses, including with carbon capture and storage (BECCS), which uses 85% of UK bioenergy supplies by 2050. There may be a fall in total bioenergy use to 2030 if unabated uses decline before BECCS applications ramp up, and it is not clear how much of this BECCS activity will be located in Wales.

Our Balanced Pathway has CCS deployed at scale, primarily in manufacturing & construction, hydrogen and electricity production, and greenhouse gas removals.

At the same time, carbon capture and storage (CCS) is used to avoid further emissions from industry, alongside a role in permanent removal of CO_2 from the atmosphere and in electricity and hydrogen production (Figure 2.7):

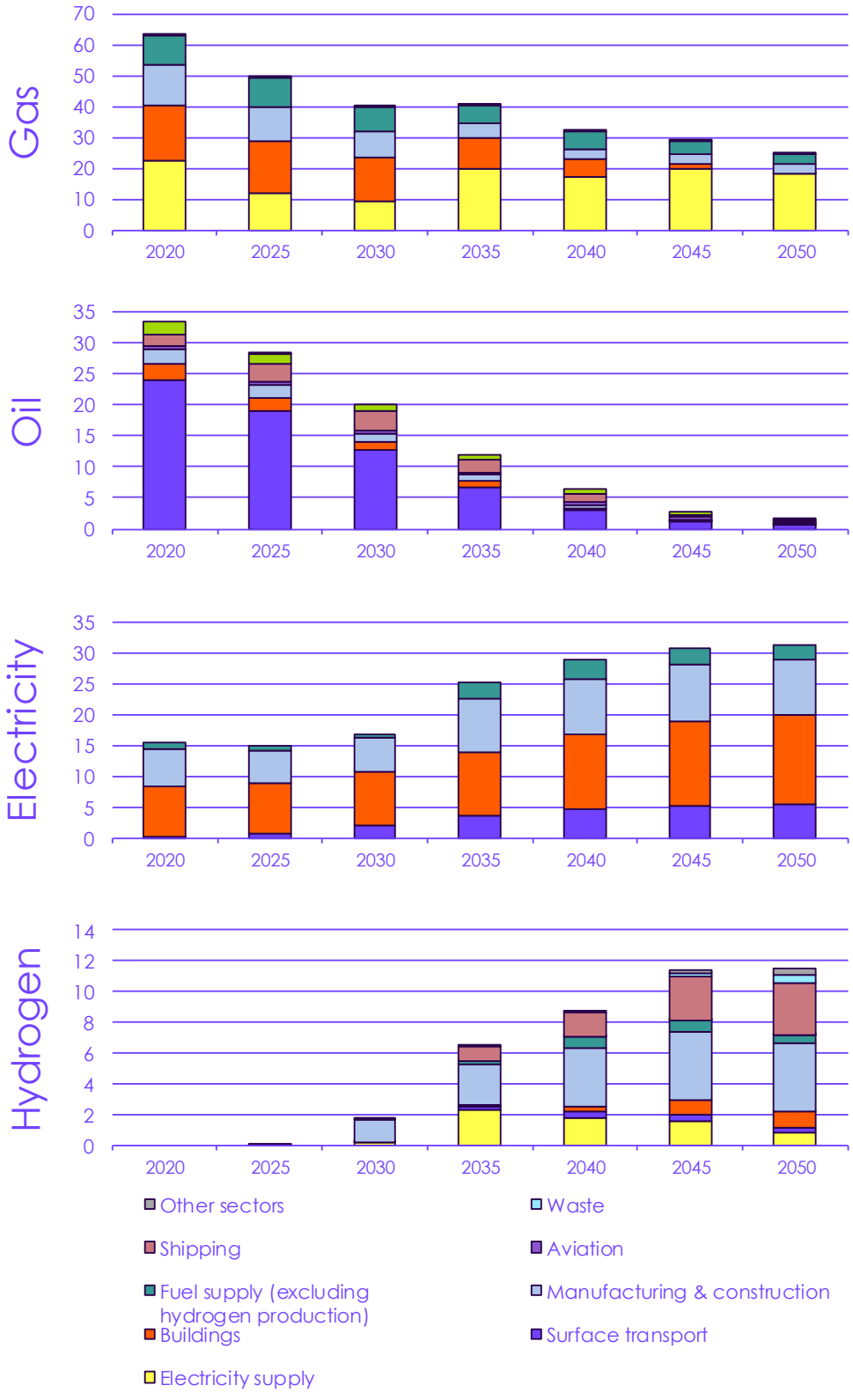
- CCS is applied to the manufacturing & construction sector at scale in the 2030s in Wales and continues to remove CO_2 at similar levels out to 2050. CCS is also applied to fossil gas to contribute to production of hydrogen and electricity generation in Wales.
- By 2050, around 60% of the CO_2 captured at UK level is for greenhouse gas removals, primarily through the combustion of biomass for electricity generation. We do not allocate these removals to Wales in our scenarios.

Wales' land also has a crucial role to play, with changes in land use from today and some agricultural land shifting to uses that sequester carbon (Figure 2.8):

- Around one-fifth of agricultural land is freed up through reduced output and more efficient farming practices.
- In total, a total of 180,000 hectares of trees are planted by 2050 (with a further 27,000 hectares of open ground left unplanted to promote biodiversity), causing woodland to increase from 15% today to 24% in 2050. A further 56,000 hectares of agricultural land can shift to bioenergy production (including short rotation forestry) by 2050.
- Harmful peat extraction is ended, and nearly 85% of the Wales's peatlands are restored to their natural state.

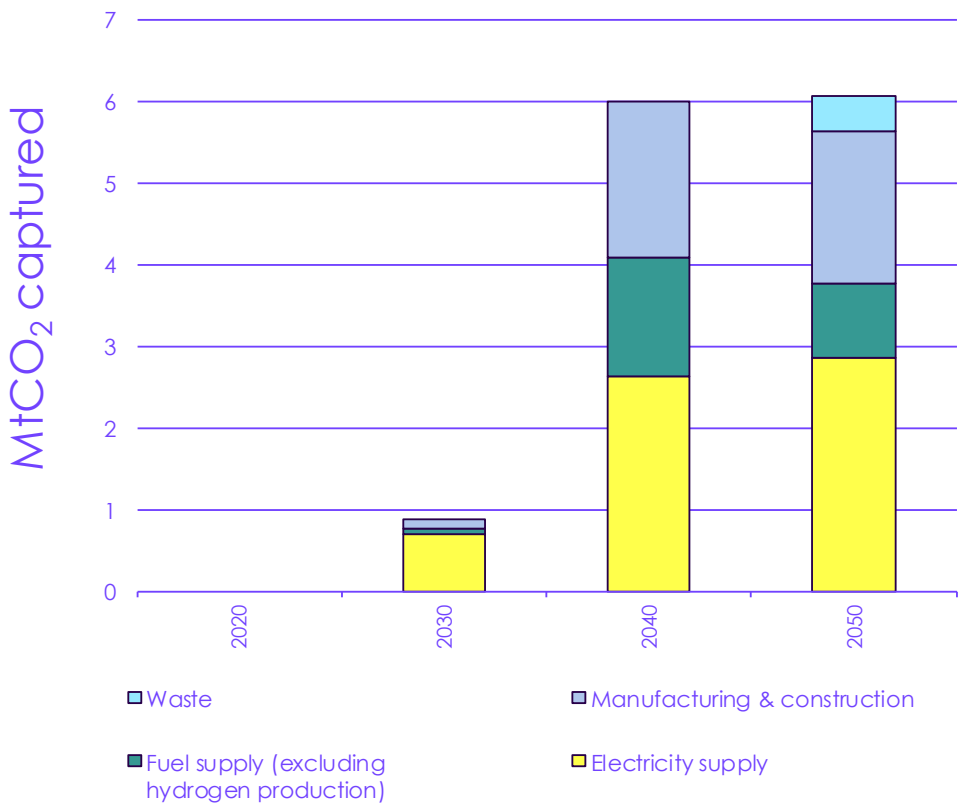
Energy demand falls on aggregate, with fossil fuels replaced by low-carbon electricity and hydrogen.

Figure 2.6 Energy demand (TWh) by sector in The Balanced Net Zero Pathway in Wales



Source: CCC analysis.
Notes: 'Fuel supply' is shown excluding energy demand for the production of low-carbon hydrogen production in Wales, due to uncertainty over where the hydrogen consumed in Wales will be produced.

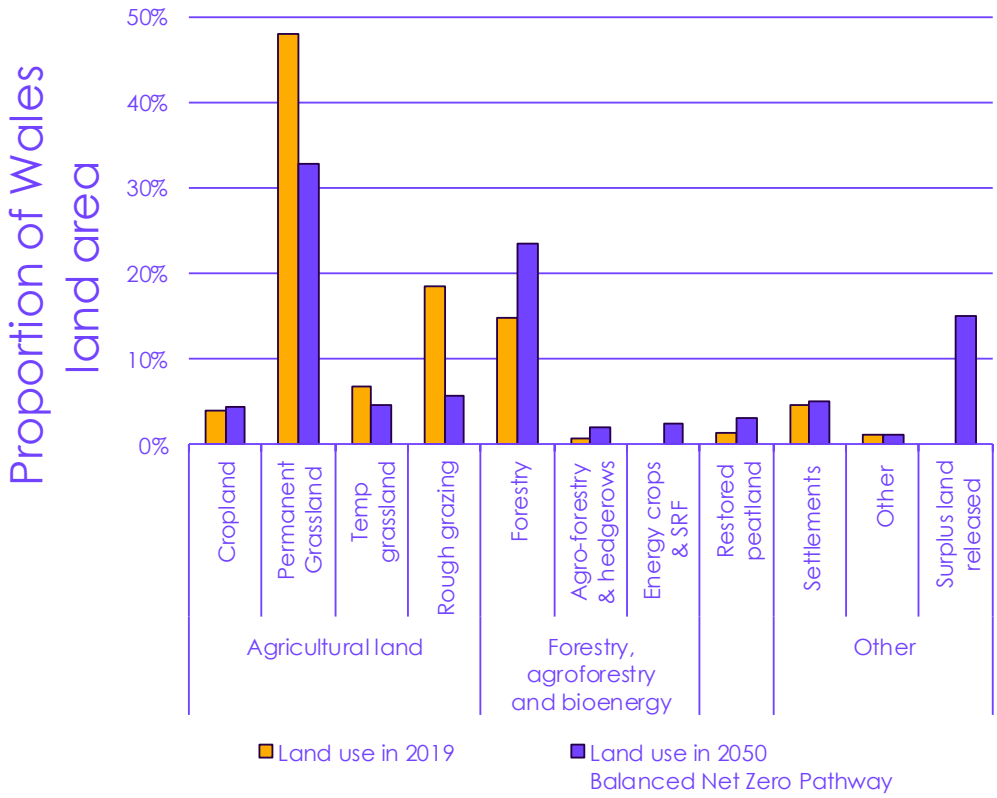
Figure 2.7 Total amount of CO_2 captured in the Balanced Net Zero Pathway in Wales (excluding greenhouse gas removals)



Source: CCC analysis.
Notes: 'Fuel supply' is shown excluding CCS demand for the production of low-carbon hydrogen production in Wales, due to uncertainty over where the hydrogen consumed in Wales will be produced.

The Balanced Net Zero Pathway involves a transformation in how Wales' land is used.

Figure 2.8 Land uses in Wales in 2019 and under the Balanced Net Zero Pathway in 2050



Source: Centre for Ecology and Hydrology (2020) and CCC analysis.
Notes: Forestry area includes small woodland areas (less than 0.5 ha or less than 20m in width) which are assumed to stay at current area. These areas are not accounted for in the Forestry Commission stats of forest coverage.

2. Flexibility on the route to Net Zero in Wales

This section addresses the implications of different pathways to Net Zero on the level of the Sixth Carbon Budget. It is set out in three parts:

a) Different emissions pathways for Wales

b) Contributions of different decarbonisation options

c) Flexibility in different sectors of the economy

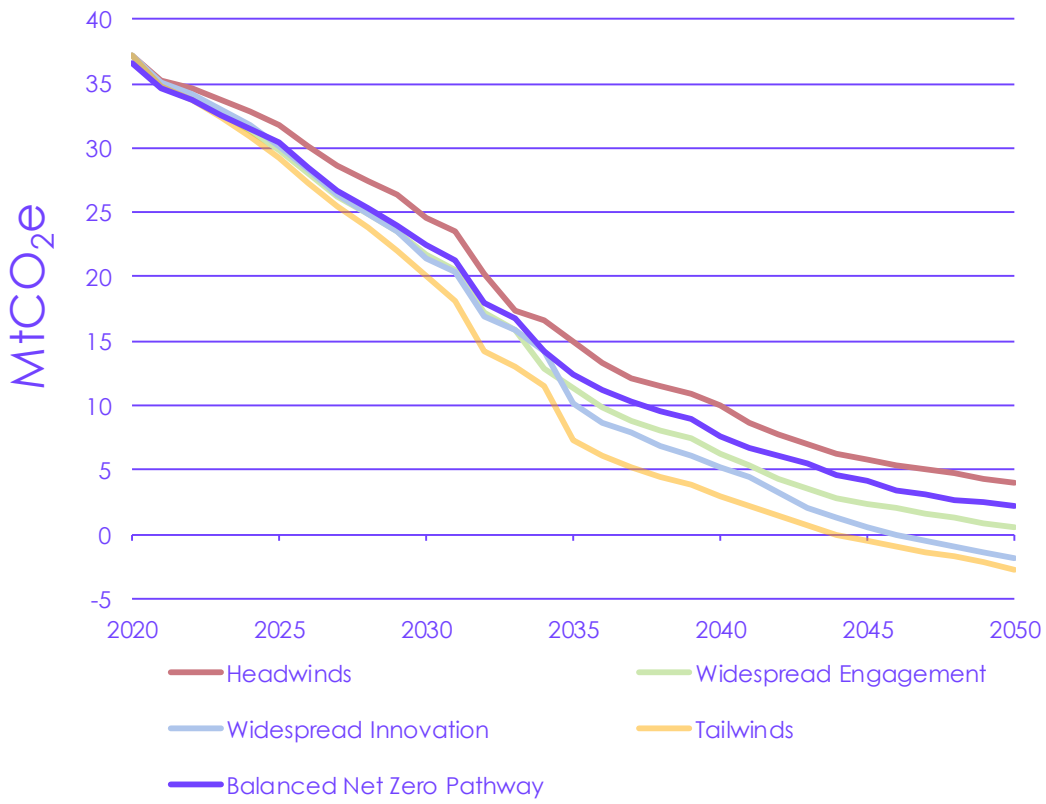
All emissions data in this section are presented without greenhouse gas removals (see Section 3 for more details).

a) Different emissions pathways for Wales

There is flexibility to meet Net Zero in a number of different ways. Our emissions scenarios for the next decade are very similar before the scenarios diverge in the 2030s.

Our exploratory scenarios have different balances of measures to reduce emissions. Each scenario has its own set of measures contributing to differing extents with differing timings, so the resultant emissions pathways deviate somewhat in the transition to Net Zero (Figure 2.9), although they are relatively close together in the 2020s during the Second and Third Carbon Budget periods before 2030.

Figure 2.9 The Balanced Net Zero Pathway and exploratory scenarios for Wales without greenhouse gas removals



Source: CCC analysis.

b) Contributions of different decarbonisation options

The 'Balanced Net Zero Pathway' for the UK has a relatively balanced mix of contributions from demand-side action, electrification, hydrogen, and both natural and greenhouse gas removal technologies (GGRs).

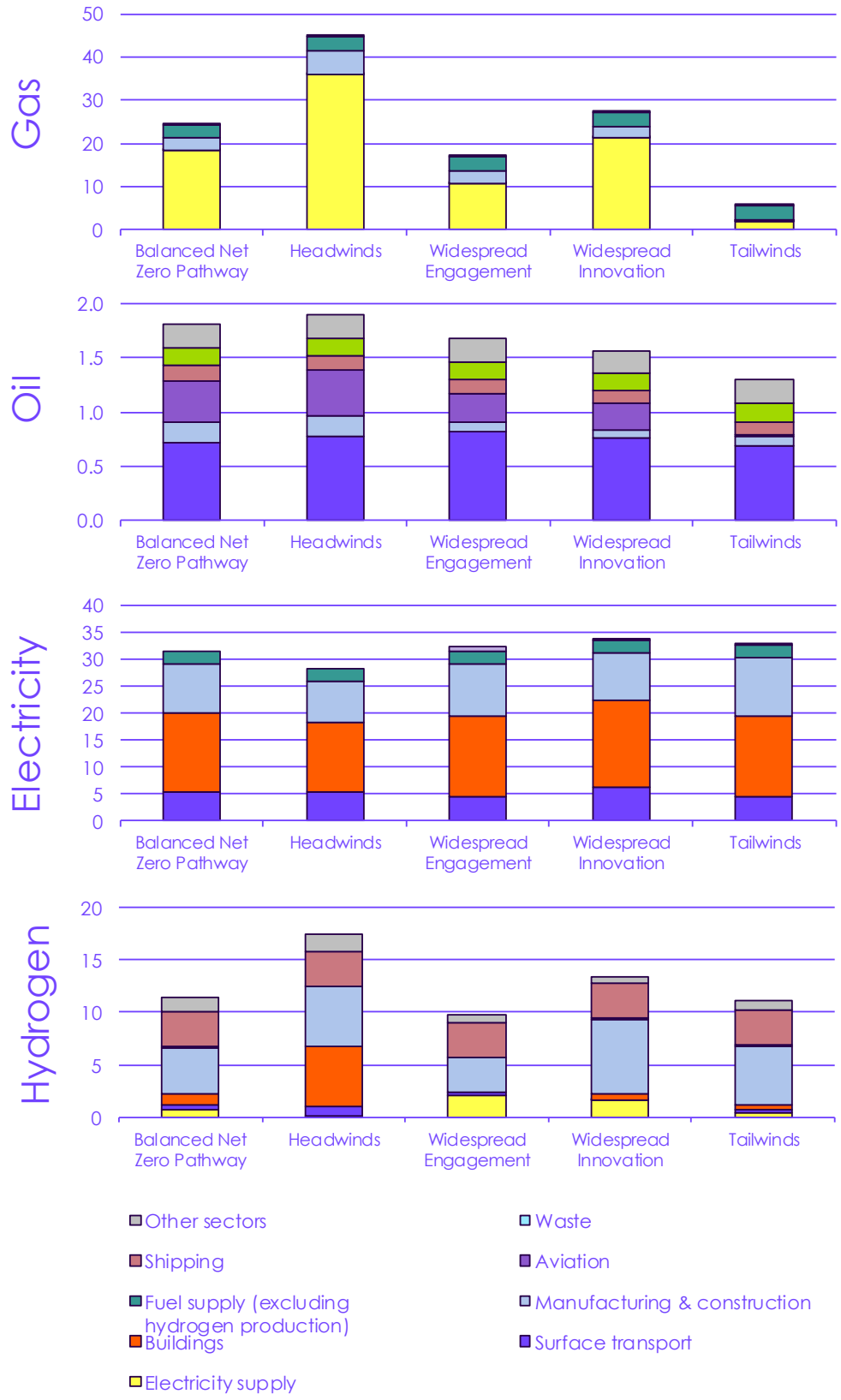
The exploratory scenarios deliver Net Zero with different mixes of these measures. To some extent, this affects the timings of their emissions reductions:

The Headwinds scenario is most dependent on the use of CCS, whereas the Widespread Engagement scenario and Widespread Innovation scenarios both use less CCS than the Balanced Pathway.

- **Headwinds.** The greater reliance of the Headwinds scenario on use of hydrogen and carbon capture and storage (including for hydrogen production) means that some of the emissions reductions in this scenario happen less quickly than the other exploratory scenarios.
- **Widespread Engagement** involves greater societal shifts in behaviour, including a reduction in consumption of all meat and dairy of 50% by 2050 compared to today's levels, a reduction in flying of 10% compared to pre-COVID levels, and up to one third of all car journeys being replaced by walking, cycling or public transport. Similarly, increased resource efficiency and energy efficiency measures in homes are also prevalent in this scenario.
- **Widespread Innovation** sees the costs of low-carbon technologies fall further than other scenarios, and technology efficiencies improve. New technologies also play a larger role, such as Direct Air Carbon Capture and Storage (DACCS) at UK level, high temperature heat pumps, autonomous vehicles and lab-grown meat.
- **Tailwinds** is a highly optimistic scenario, stretching feasibility in a wide range of areas and going beyond the current evidence in others.

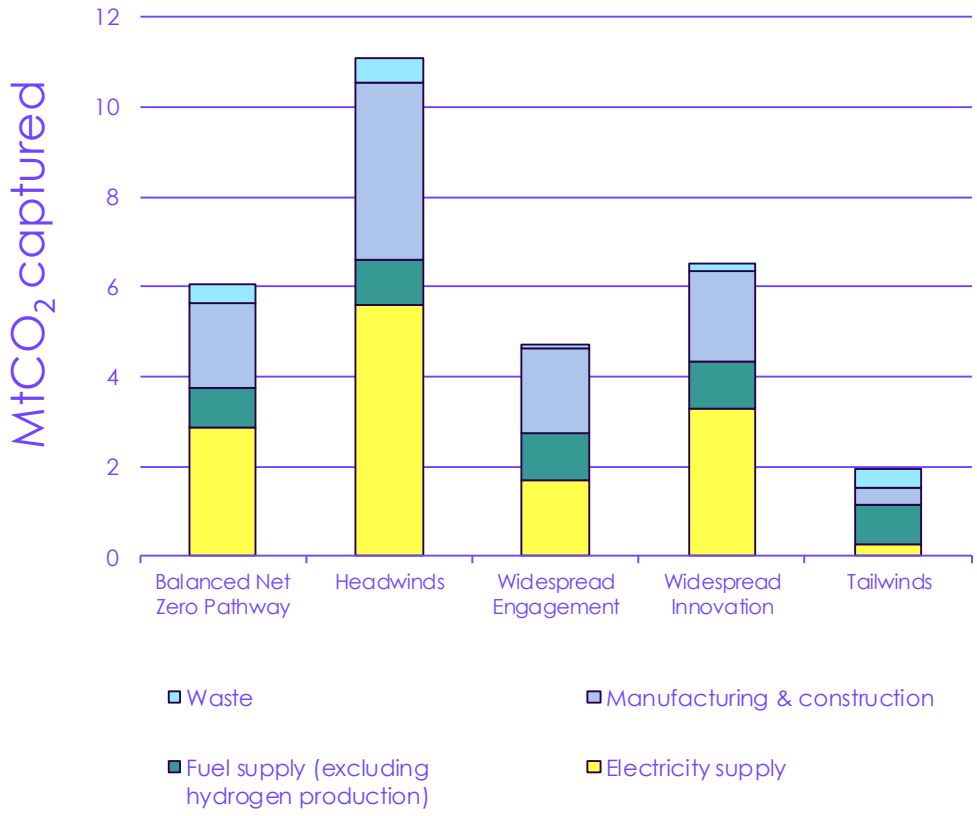
The choices within these exploratory scenarios have significant impacts on the UK energy system, CCS requirements and land use (Figures 2.10, 2.11, 2.12).

Figure 2.10 Energy demand (TWh) in 2050 by sector in the Balanced Net Zero Pathway and exploratory scenarios



Source: CCC analysis.
Notes: 'Fuel supply' is shown excluding energy demand for the production of low-carbon hydrogen production in Wales, due to uncertainty over where the hydrogen consumed in Wales will be produced.

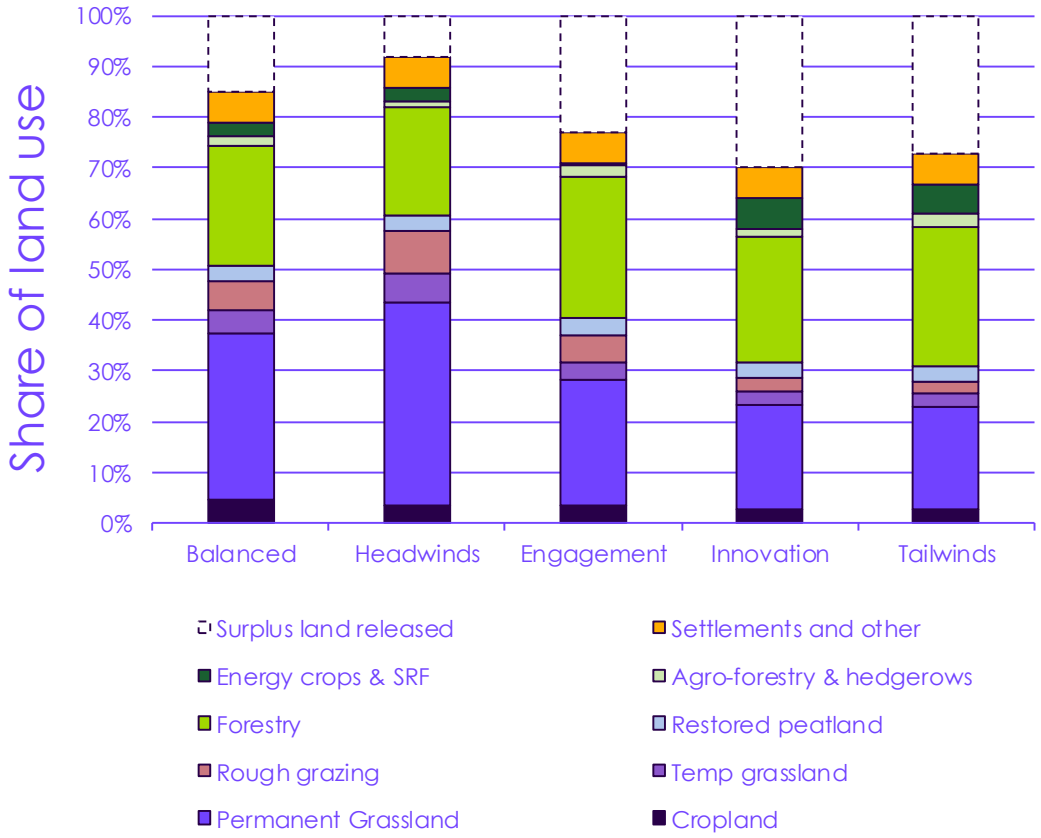
Figure 2.11 Total CO_2 captured in 2050 in the Balanced Net Zero Pathway and exploratory scenarios (excluding greenhouse gas removals)



Source: CCC analysis.
Notes: 'Fuel supply' is shown excluding CCS demand for the production of low-carbon hydrogen production in Wales, due to uncertainty over where the hydrogen consumed in Wales will be produced.

Our scenarios explore a range of ambition on land use, but each scenario involves transformational land-use change.

Figure 2.12 UK land use in 2050 under the Balanced Net Zero Pathway and exploratory scenarios



Source: Centre for Ecology and Hydrology (2020) and CCC analysis.
Notes: SRF = Short Rotation Forestry. Forestry area includes small woodland areas (less than 0.5 ha or less than 20 m in width) which are assumed to stay at current area. These areas are not accounted for in the Forestry Commission stats of forest coverage.

c) Flexibility in different sectors of the economy

Achieving the Net Zero target requires all sectors of the economy to contribute, including international aviation and shipping.

Our full sectoral analysis is available in Chapter 3 of the Advice Report on the UK Sixth Carbon Budget. This section sets out the key differences in sectoral scenarios for Wales. Many of these assumptions are the same in Wales as in the UK. Our key messages for sectoral emissions Wales are:

- Delivering Net Zero by 2050 will require all sectors to contribute.
- Each area of the economy must make substantial changes in the next decade to get on the path to Net Zero emissions for the whole of the UK. The transition must not be delayed.
- All sectors have multiple options to achieve a level of emissions reduction that is consistent with Net Zero by 2050 in Wales.

Surface transport

Table 2.4a
Summary of key differences in the surface transport scenarios for Wales

	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Behaviour change and demand reduction*	**Moderate behavioural change, with gradual reduction up to 17% of total car miles by 2050.**	Limited levels of behavioural change, with car demand falling to 12% below baseline by 2050.	High demand reduction, modal shift and ride-sharing, leading to 34% lower car demand and 11% higher rail demand by 2050.	Introduction of connected and autonomous vehicles leads to a net 5% increase in total car demand by 2050.	High levels of societal change leading to a 34% reduction in car demand by 2050.
Efficiency **(in addition to efficiency improvements for new ICEs, which are assumed in all scenarios)**	**80% of HGVs adopt efficiency measures; up to 200km/year of rail electrification and diesel efficiency improving by 2050 to 0.5kgCO_2/kWh (from current levels of 0.8kgCO_2/kWh).**	Slower BEV uptake so higher biofuel use; 50% of HGVs adopt efficiency measures; up to 200km/year of rail electrification and diesel efficiency improving by 2050 to 0.5kgCO_2/kWh.	80% of HGVs adopt efficiency measures; up to 250km/year of rail electrification and diesel efficiency improving by 2050 to 0.5kgCO_2/kWh.	80% of HGVs adopt efficiency measures; up to 200km/year of rail electrification and higher diesel efficiency improvements to 0.45kgCO_2/kWh by 2050.	All HGVs adopt efficiency measures; up to 250km/year of rail electrification and higher diesel efficiency improvements to 0.45kgCO_2/kWh by 2050.
Low-carbon technology	**2032 phase-out date for fossil fuel cars and vans; no clear technology choice for HGVs, so most cost-effective technology mix is deployed.**	2035 phase-out of fossil fuel cars and vans; large-scale use of hydrogen in HGVs.	2030 phase-out of fossil fuel cars and vans, with rapid EV uptake driven by engagement; deployment of a substantial ERS network for HGVs.	2030 phase-out of fossil fuel cars and vans, with rapid EV uptake driven by cost reductions; battery density and cost improve leading to high use of BEV HGVs with ultra-rapid charging.	2030 phase-out of fossil fuel cars and vans, with rapid EV uptake driven by cost reductions; max roll-out rates for technology and infrastructure allow deployment of mix of low-carbon HGV options at pace.

* These figures are before rebound effects, which will increase demand as EV uptake grows, due to lower fuel costs.

Table 2.4b
Summary of key differences in the buildings scenarios for Wales

	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Behaviour change and demand reduction (UK average)	**Moderate levels of behaviour change (homes).** **25% of eligible households pre-heat, 3% reduction in space heat demand from smarter heating management and use, low-flow shower heads.**	Moderate levels of behaviour change (homes). 25% of eligible households pre-heat, 3% reduction in space heat demand, low flow shower heads.	High levels of behaviour change (homes). 50% of eligible households pre-heat, 6% reduction in space heat demand, 50°C hot water temperature with daily legionella cycle,* low flow shower heads.	High levels of behaviour change (homes). 50% of eligible households pre-heat, 6% reduction in space heat demand, heat-as-a-service delivering higher performance, low flow shower heads.	High levels of behaviour change (homes) 50% of eligible households pre-heat, 6% reduction in space heat demand, heat-as-a-service delivering higher performance, low flow shower heads.
Efficiency	**Moderate energy efficiency uptake in homes. Loft and wall insulation for all fuel poor.** **Fast commercial uptake; Moderate-paced public uptake.**	Lower energy efficiency uptake in homes. Loft and wall insulation for all fuel poor. Slow commercial uptake; moderate-paced public uptake.	Moderate-high energy efficiency uptake in homes. Loft and wall insulation for all fuel poor. Fast uptake of energy efficiency in other buildings.	Lower energy efficiency uptake in homes. Loft and wall insulation for all fuel poor. Innovation drives down energy efficiency costs and delivers high performing deep retrofits. Moderate-paced uptake in other buildings.	High energy efficiency uptake in homes (full economic potential). Loft and wall insulation for all fuel poor. Fast uptake of energy efficiency in other buildings.

* Legionella bacteria are widespread in natural water systems and can cause Legionnaires' disease where conditions are conducive e.g. where water is maintained at a temperature high enough to encourage growth. Legionella bacteria can multiply where temperatures are between 20-45°C, but do not survive above 60°C. HSE is currently undertaking work with CIBSE looking at guidance for low-temperature systems to manage legionella risk.

Low-carbon fuels/ Technology (UK average)	**Hybrid hydrogen scenario in homes, with 11% of homes using hydrogen for heat. Limited use of biofuels in homes.** **Heat networks fully electrified.*** **Non-residential buildings heat and catering demands mainly electrified with some hydrogen.**	Widespread network conversion to hydrogen, with 71% of homes using hydrogen for heat. Smaller role for heat pumps across all buildings; 13 million in homes. In homes, hydrogen boilers in north and heat pump-hydrogen hybrids in south. Limited use of biofuels. Heat networks supplied by hydrogen and large-scale heat pumps. Catering and cooking demands predominantly met with hydrogen.	Fully electrified scenario (including heat networks). No biofuels in homes.	Hybrid hydrogen scenario in homes, with 10% of homes using hydrogen for heat. Widespread uptake of high-temperature heat pumps and flexible technology. No biofuels in homes. Heat networks fully electrified. Lower levels of low-carbon heat networks in non-residential buildings. Non-residential buildings heat and catering demands mainly electrified with some hydrogen. Higher efficiency of heat pumps and greater reduction in cost over time.	Buildings fully electrified, except for areas around industrial clusters which use H_2 boilers. 11% of homes using hydrogen for heat. No biofuels in homes. Higher efficiency of heat pumps and greater reduction in cost over time.

Manufacturing & construction

Table 2.4c
Summary of key differences in the manufacturing and construction scenarios for Wales

	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Resource efficiency	**High level driven by mix of behaviour and innovation.**	Moderate levels.	High level driven by consumer and business engagement.	Moderate-high level driven by innovative techniques and business models.	High level driven by behaviour and innovation.
Fuel-switching and CCS	**Balance of electrification and (mostly) blue hydrogen.**	More blue hydrogen than electrification. Wider use of CCS on combustion emissions.	Mostly electrification, some green and blue hydrogen.	Electrification and green hydrogen. Higher CCS capture rates.	Electrification and green hydrogen. Higher CCS capture rates.
Business attitude	**Most businesses follow incentives.**	Business resistant to change, prefer to retrofit despite of incentives.	Most businesses follow incentives. Faster supply chain development.	Most businesses follow incentives.	Businesses follow incentives and go beyond. Faster supply chain development.

* Dominated by water- and sewage-source heat pumps and waste heat from industrial sources.

Table 2.4d
Summary of key differences in the electricity generation scenarios for Wales and the UK

	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Electricity demand in Wales in 2050	**32 TWh**	29 TWh	32 TWh	35 TWh	34 TWh
Extent of electrification	**Cars & vans** **Partial heating** **Partial manufacturing**	Cars & vans Partial heating Partial manufacturing	Cars & vans* HGVs Heating Partial manufacturing	Cars & vans HGVs Partial heating Partial manufacturing DACCS	Cars & vans* Partial heating Partial manufacturing DACCS
Renewable generation & capacity (UK)**	**80% of total** **Wind: 125 GW** **Solar: 85 GW**	75% of total Wind: 90 GW Solar: 85 GW	85% of total Wind: 130 GW Solar: 80 GW	90% of total Wind: 175 GW Solar: 90 GW	90% of total Wind: 160 GW Solar: 75 GW
Dispatchable generation & capacity* (UK)**	**10% of total** **65 GW**	15% of total 50 GW	10% of total 55 GW	8% of total 65 GW	7% of total 65 GW
Nuclear capacity (UK)	**Multiple projects** **10 GW**	Multiple projects 10 GW	Contracted capacity 5 GW	Contracted capacity 5 GW	Contracted capacity 5 GW
Phase out of unabated gas (UK)	**2035**	2040	2035	2035	2035

Source: CCC analysis
Notes: *Although cars and vans electrify, these scenarios see a wider use of public transportation and active travel, thus reducing overall demand. **Variable renewables include wind and solar, including generation for electrolysis. ***Dispatchable low-carbon generation includes gas CCS, BECCS and hydrogen. These numbers do not include demand for producing hydrogen with electricity. Our scenarios produce electrolytic hydrogen using surplus electricity only, and with methane reformation if surplus electricity is not available. It does not therefore necessarily reflect an additional demand for electricity.

Table 2.4e
Summary of key differences in the agriculture sector scenarios for Wales

	Balanced Net Zero	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Behaviour change and demand reduction (UK average)	**Medium level: 20% cut in meat and dairy by 2030, rising to 35% by 2050 for meat only. All replaced with plant-based; and** **Medium level: 50% cut in food waste by 2030, 60% by 2050.**	Low level: 20% shift away from all meat types and dairy products to all plant-based by 2050; and Low level: 50% fall in food waste by 2030, with no further reduction.	High level: 50% less meat and dairy by 2050. All replaced with plant-based; and High level: 50% fall in food waste by 2030, 70% by 2050.	High level: 50% less meat and dairy by 2050 with 30% of meat replaced with lab-grown meat. Medium level: 50% cut in food waste by 2030, 60% by 2050.	Diet change aligned to Wider Innovation. Food waste reduction aligned to Widespread Engagement.
Other land release measures	**Aligned to Headwinds.**	Medium level for increasing average crop yields, livestock stocking rates on grassland and shifting horticulture indoors.	Medium level for increasing average crop yields and shifting horticulture indoors. Low level for increasing livestock stocking rates on grassland.	High level for increasing average crop yields, livestock stocking rates on grassland and shifting horticulture indoors.	Aligned to Widespread Innovation.
Low-carbon farming practices	**Aligned to Headwinds.**	Lower uptake: 50-75% for both behavioural and innovation measures.	High uptake of behavioural measures 60-80%; and lower uptake 50-75% for innovative measures.	High uptake of innovation measures 60-80%; and lower uptake 50-75% for behavioural measures.	Aligned to Widespread Innovation.
Agricultural machinery	**Aligned to Headwinds.**	Mix of electrification, hydrogen and later phase-out of biofuels.	Focus on electrification and biofuels.	Hydrogen, electrification and biofuels.	Aligned to Widespread Innovation.

Table 2.4f
Summary of key differences in the LULUCF sector scenarios for Wales

	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Afforestation (Wales)	**4,500 hectares/year by 2025 then rising to 7,500 hectares by 2035.**	4,500 hectares/year by 2035.	10,500 hectares/year by 2035, low yields, greater mix towards broadleaf.	7,500 hectares/year by 2030. High yields, high mix of conifers.	10,500 hectares/year by 2035, high yields.
Peatlands (Wales)	**Aligned to Widespread Engagement.**	All upland peat restored by 2050. 20% lowland cropland rewetted & 30% sustainably managed.	All upland peat restored by 2045. 40% lowland cropland rewetted & 35% sustainably managed.	All upland peat restored by 2045. 25% lowland cropland rewetted & 50% sustainably managed.	Aligned to Widespread Engagement.
Energy crops including short rotation forestry (Wales)	**Aligned to Headwinds.**	Medium energy crop planting (56,000 hectares by 2050) and yields.	Low energy crop planting (4,500 hectares by 2050) and yields.	High energy crop planting (135,000 hectares by 2050) and yields.	Aligned to Widespread Innovation.

Table 2.4g
Summary of key differences in the waste sector scenarios for Wales (most metrics at a UK level)

	Balanced Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Behaviour change and demand reduction	**UK: 51% fall in edible food waste by 2030 and 61% by 2050***	51% fall in edible food waste by 2030	51% fall in edible food waste by 2030 and 71% by 2050	51% fall in edible food waste by 2030 and 61% by 2050 (+50% fall in inedible food waste by 2050)	51% fall in edible food waste by 2030 and 71% by 2050 (+50% fall in inedible food waste by 2050)
	UK: 33% reduction in all waste by 2037**	13% reduction in all waste by 2037	33% reduction in all waste by 2037	28% reduction in all waste by 2037	33% reduction in all waste by 2037
	Wales: 70% recycling by 2025	70% recycling by 2025	70% recycling by 2025 and UK 79% by 2050	70% recycling by 2025	70% recycling by 2025 and UK 79% by 2050
Landfill	**Wales: 2025 ban on all wastes**	2025 ban on all wastes, 2050 full ban	2025 ban on all wastes	2025 ban on all wastes	2025 ban on all wastes
	UK: 80% CH_4 capture & 10% oxidation by 2050	68% CH_4 capture & 10% oxidation by 2050	68% CH_4 capture & 10% oxidation by 2050	80% CH_4 capture by 2030, 30% oxidation by 2050	80% CH_4 capture by 2030, 30% oxidation by 2050
Energy-from-waste	**UK: CCS is fitted to 100% of EfW plants by 2050, starting from early 2040s**	CCS is fitted to 100% of EfW plants by 2050, starting from late 2030s	CCS is fitted to 100% of EfW plants by 2050, starting from early 2040s	CCS is fitted to 100% of EfW plants by 2050, starting from early 2040s	CCS is fitted to 100% of EfW plants by 2050, starting from late 2020s
Wastewater treatment	**UK: Improves 21% by 2030**	Improves 21% by 2030	Improves 21% by 2030	Improves 21% by 2030, 50% by 2050	Improves 21% by 2030, 50% by 2050
Composting	**UK: Improves 23% by 2030**	Improves 23% by 2030	Improves 23% by 2030	Improves 23% by 2030	Improves 23% by 2030

* Measured from 2007 base year for household edible food waste, and 2011 for business edible food waste. Note that food waste has been analysed in our scenarios at a UK level, so these modelling assumptions are less ambitious than current Welsh policy of a reduction in food waste of 50% by 2025 vs. a base year of 2006-07.

** Measured in-year from a baseline of increasing household and commercial & industry waste arisings. Note that non-food waste has been analysed in our scenarios at a UK level (as have residual waste arisings used in energy-from-waste), and that Wales may well exceed 70% recycling after 2025.

a) Comparison to 2019 advice

The balance of sectoral emissions in Wales in our scenarios for 2050 is most sensitive to residual emissions from agriculture and the amount of CO_2 that can be removed from the atmosphere through forestry and greenhouse gas removals.

Figure 2.13 shows a breakdown of residual emissions in each scenario for Wales - excluding any greenhouse gas removals.

These charts also allow a comparison to the 'Further Ambition' scenario that was set out in our 2019 *Net Zero* report.[3] The Further Ambition scenario achieved a 93% emissions reduction in Wales by 2050 (increasing to a 96% with some engineered greenhouse removals), whereas the Balanced Net Zero Pathway gets to a 96% reduction before any potential use of greenhouse gas removals is accounted for.

Compared to the Further Ambition scenario:

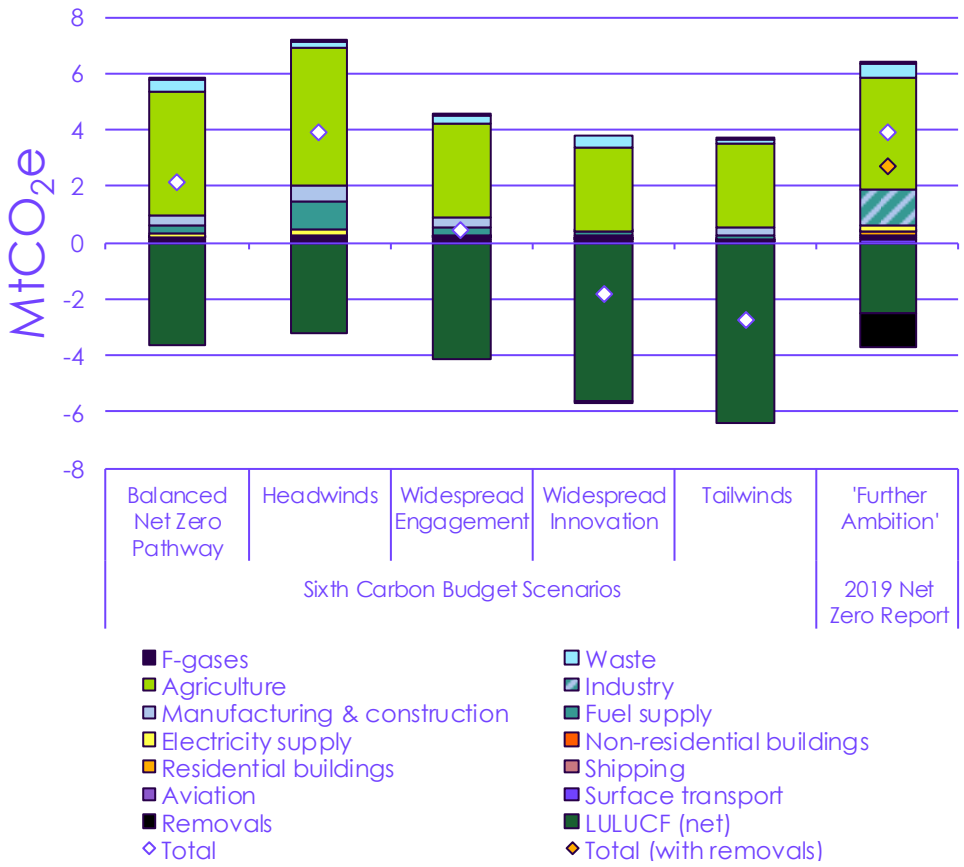
- The Balanced Pathway has lower emissions from manufacturing & construction and fuel supply (defined as 'industry' in our Further Ambition scenario). This is particularly important for Wales where our sectoral analysis has focused on the South Wales cluster.
- The Balanced Pathway typically has marginally higher emissions in the agriculture sector.
- Net scenario emissions are typically lower than in the 2019 Net Zero report, even without any greenhouse gas removals allocated to Wales.

The Headwinds, Widespread Engagement, Widespread Innovation and Tailwinds scenarios explore a wider range of sectoral pathways in 2050. For Wales, the sectors which have the biggest impact on emissions in 2050 are:

- The size of the net **land use** sink in 2050 which varies based on the scale of measures to remove carbon from the atmosphere, particularly tree planting.
- The potential for further reductions in the **agriculture sector** due to behaviour changes and technological innovations.
- The size of **residual emissions in all other sectors** – including manufacturing, construction and fuel supply.

Our latest assessment in this report therefore both identifies a smaller gap to Net Zero in Wales than previously through emissions reductions and a wider range of pathways to reach or get close to Net Zero.

Figure 2.13 Emissions in Wales in 2050 in the Balanced Pathway and exploratory scenarios compared to the 2019 Net Zero report



Source: CCC (2019) *Net Zero: The UK's contribution to stopping global warming*; CCC analysis.

b) Range of greenhouse gas removals needed to reach Net Zero

The scenarios set out in previous sections of this chapter are presented without any share of UK greenhouse gas removals. This section explores the range of greenhouse gas removals that would be required to reach Net Zero emissions in any given year (Table 2.5, Figure 2.14).

Wales may be able to get to Net Zero in 2050, depending on judgements around allocation of engineered removals.

Greenhouse gas removals are a key part of the UK's ability to reach Net Zero and can play a credible role in Wales' emissions pathway. Wales is capable of producing a significant proportion of the UK's biomass supply by 2050 and will have significant carbon capture infrastructure at industrial sites where BECCS plant could co-locate. However, the carbon storage constraints for most of Wales (Figure 1.6) means that targets should not be overly reliant on greenhouse gas technologies.

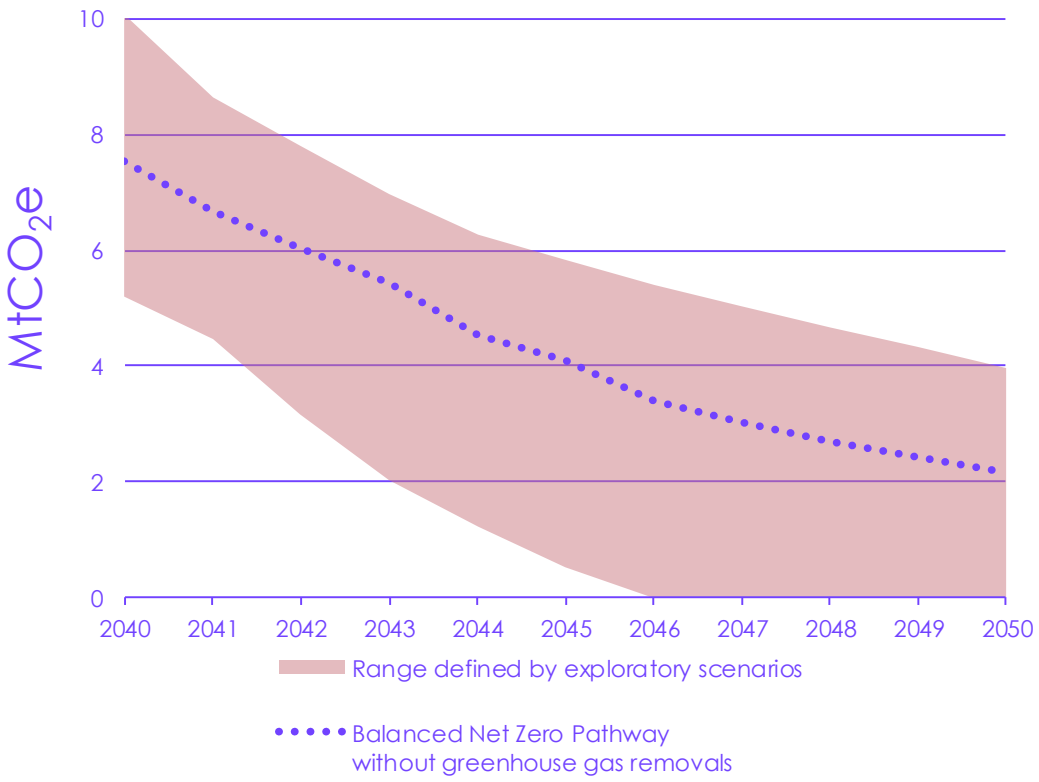
We have also identified some pathways for Wales to get to Net Zero emissions by 2050 without the use of any greenhouse gas removals technologies:

- The Balanced Pathway would require 2.2 $MtCO_2e$ of greenhouse gas removals in 2050.
- The Widespread Innovation scenario gets to Net Zero in 2046 without the use of greenhouse gas removal technology in Wales.
- The Widespread Engagement scenario gets to virtually Net Zero in 2050 (99.2% reduction) before any greenhouse gas removals are deployed.
- We have identified potential for around 1 $MtCO_2e$ of removals in the manufacturing and construction sector, including 1.0 $MtCO_2e$ of BECCS in manufacturing and around 0.2 $MtCO_2e$ from the use of wood in construction.

Table 2.5
Greenhouse gas removals (GGRs) required to meet Net Zero in Wales in 2050

	Required in Balanced Net Zero Pathway	Range (across Headwinds, Widespread Engagement and Widespread Innovation)	Potential for BECCS in manufacturing and wood in construction	Amount of GGRs identified in 2019 Net Zero Report
Required GGRs ($MtCO_2$)	2	0 - 4	0.5 - 1.3	1

Figure 2.14 Amount of greenhouse gas removals that would be required to reach Net Zero in Wales in a given year



Source: CCC analysis.
Notes: The range shown is defined by the Headwinds, Widespread Engagement and Widespread Innovation scenarios.

c) Defining a path from 2030 to Net Zero

There is credible evidence that Wales can reach Net Zero in 2050, either with limited deployment of engineered removals, or through some of the other technological and behavioural changes in the exploratory scenarios.

We therefore use the Balanced Net Zero Pathway as the base pathway to derive a target-setting pathway for Wales (Figure 2.15) beyond 2030.

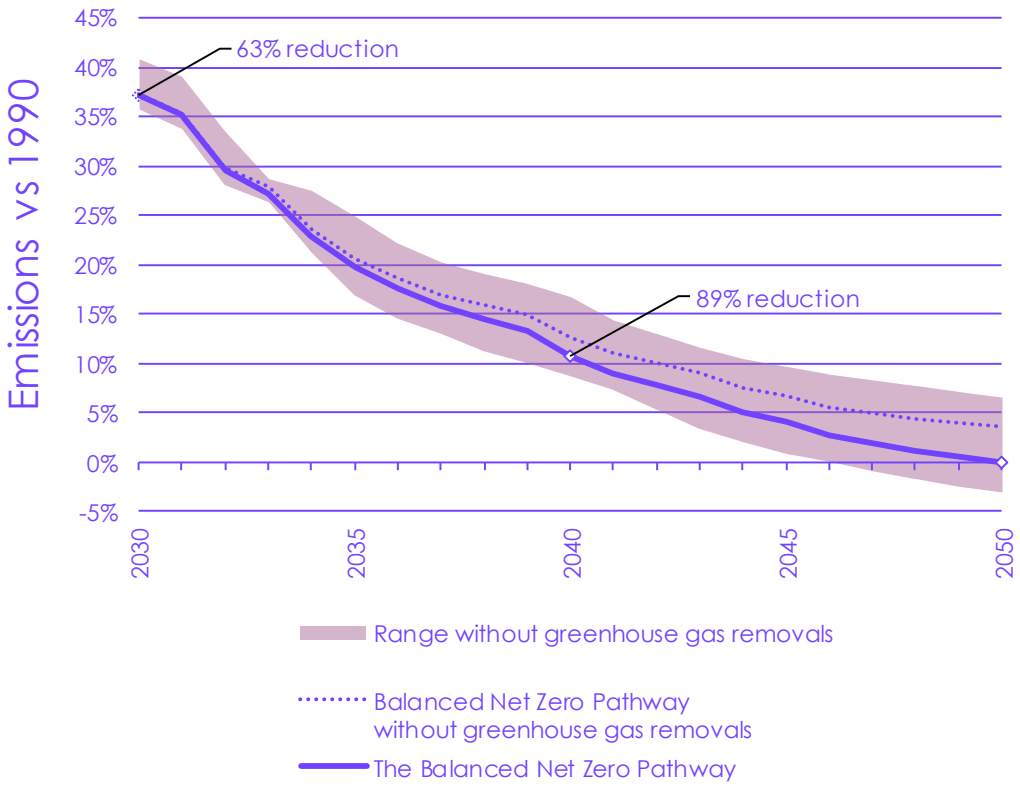
The additional emissions reductions in the 2040 and 2050 targets could either be met through greenhouse gas removals, further technological and behavioural changes, or changes to the Welsh inventory (Box 2.1). Compared to the Balanced Pathway without removals, the Net Zero goal could be reached through a combination of:

- **Greenhouse gas removals.** Deploying up to 2.2 $MtCO_2e$ of greenhouse gas removals – less than 4% of the UK's total removals under the Balanced Net Zero Pathway.
- **Further action in other sectors** in line with the exploratory scenarios which have explored areas that could go further – particularly relating to land use, agriculture, and manufacturing and construction.

- **Methodology changes** that result in lower residual emissions compared to our scenarios (i.e. a lower global warming potential (GWP) for methane).

This target-setting pathway diverges from the Balanced Pathway without removals between 2030 and 2050, to ensure that Wales' 2040 target is set in line with the Net Zero goal. This pathway is well within the range of possible emissions pathways defined by the exploratory scenarios.

Figure 2.15 Defining a path from 2030 to Net Zero in Wales



Source: CCC analysis.
Notes: The range shown is defined by the Headwinds, Widespread Engagement and Widespread Innovation scenarios. This pathway could either be delivered through the actions in the Balanced Pathway plus relatively low levels of greenhouse gas removals in Wales, or through increased behaviour change as demonstrated in the exploratory scenarios.

Endnotes

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

[2] Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] CCC (2019) *Net Zero – The UK's contribution to stopping global warming*.

Chapter 3

Investment, costs and impacts on future generations

Introduction and key messages

This chapter considers the investment requirements, costs, savings and co-benefits of the actions that will take place in Wales during the Net Zero transition.

How the costs and benefits of getting to Net Zero are distributed will be highly dependent on reserved fiscal, monetary and regulatory levers used by the UK Government. Chapters 5 and 6 of the Advice Report on the UK Sixth Carbon Budget set out the Committee's approach to assessing the costs and benefits of meeting the Sixth Carbon Budget for the UK and how those costs are distributed fairly and efficiently across society in more detail.

As the world increasingly embraces a trajectory towards Net Zero emissions around mid-century, the costs for any country of following that trajectory are likely to fall, while the risks of following an alternative path increase. Our scenarios for Wales reflect that, by transitioning as fast as possible within constraints (such as for stock turnover and supply chain capacity).

In the near term, against the backdrop of the economic damage from the COVID-19 crisis, the required investment can support Wales' economic recovery. It can deliver benefits for future generations in reduced operating costs, lower emissions and benefits to health and the environment, but this these positive co-impacts must be supported by policy.

Our key messages are:

- **Total low-carbon investment in Wales will need to increase to around £3 billion by 2030,** continuing at around that level through to 2050**.** That compares to total low-carbon investment in the UK of around £50 billion. The increase is deliverable, primarily by private companies and individuals, alongside other investment, provided effective policy is put in place.

The required investment leads to large reductions in operating costs.

- **Much of the investment spending can be recouped through lower operating costs.** These savings, many of which relate to reduced reliance on imported fossil fuels, will rise to around £800 million by 2030 and £2.5 billion by 2050.
- **Our estimate of annualised resource costs is less than £2 billion per year in Wales for the entirety of the period 2020 to 2050.** That is lower than our 2019 estimate for the cost of reaching Net Zero emissions (we previously estimated costs to be around £3-5 billion by 2050).
- **Many of the costs of reducing emissions in Wales will likely be paid for at UK level and/or socialised across the whole of the UK.** The costs in this chapter should not be interpreted as the costs that would be delivered via Welsh Government expenditure, nor as costs that only Welsh businesses and households have to bear.
- **A prosperous and resilient Wales.** In the near term, GDP is likely to be boosted, especially as the economy rebuilds after the COVID-19 crisis. Although investments will have to be repaid in later years, there will be offsetting from operating cost savings. Transformations in our land to restore peatland and to plant trees and hedges provide opportunities to deliver wider environmental and well-being benefits, as well as improving our resilience to the impacts of climate change.
- **A healthier Wales.** Our pathways to meet Net Zero in Wales involve several changes with wider benefits. Increased walking and cycling and healthier

diets will improve health, as will cleaner air resulting from reduced fossil fuel use, and more comfortable homes as energy efficiency is improved.

- **A strategy for a just transition to support other well-being goals.** Across many areas, including energy bills and regional employment, fairness is already an issue. The transition to Net Zero will require a shift of hundreds of thousands of workers into low-carbon roles, as well as large numbers shifting out of high-carbon roles, which could be in different places and use different skills. Navigating this transition must start now and will require effective plans, widespread public involvement and an embedding of the principle of fairness throughout climate policy. Regional and local considerations are vital.

1. Investment requirements, costs and savings

The Balanced Pathway to deliver our recommended targets in Wales involves a large sustained increase in investment in Wales, adding around £3 billion annually by 2030, as part of UK-wide required investment of around £50 billion by 2030 (compared to current UK-wide investment of nearly £400 billion). The largest increases in investment required are for low-carbon power capacity, retrofit of buildings and the added costs of batteries and infrastructure for electric vehicles.

Now is an ideal time to encourage investment in Wales. There are historically low interest rates and a potential demand shortage for that cheap capital. Economic recovery from the COVID-19 pandemic necessitates stimulus, and many of the measures detailed in this report have been shown to have high economic multipliers. The challenge for the UK and Welsh Governments is to make sure sufficient investment comes forward, and to design policies to ensure that is done at the lowest possible cost.

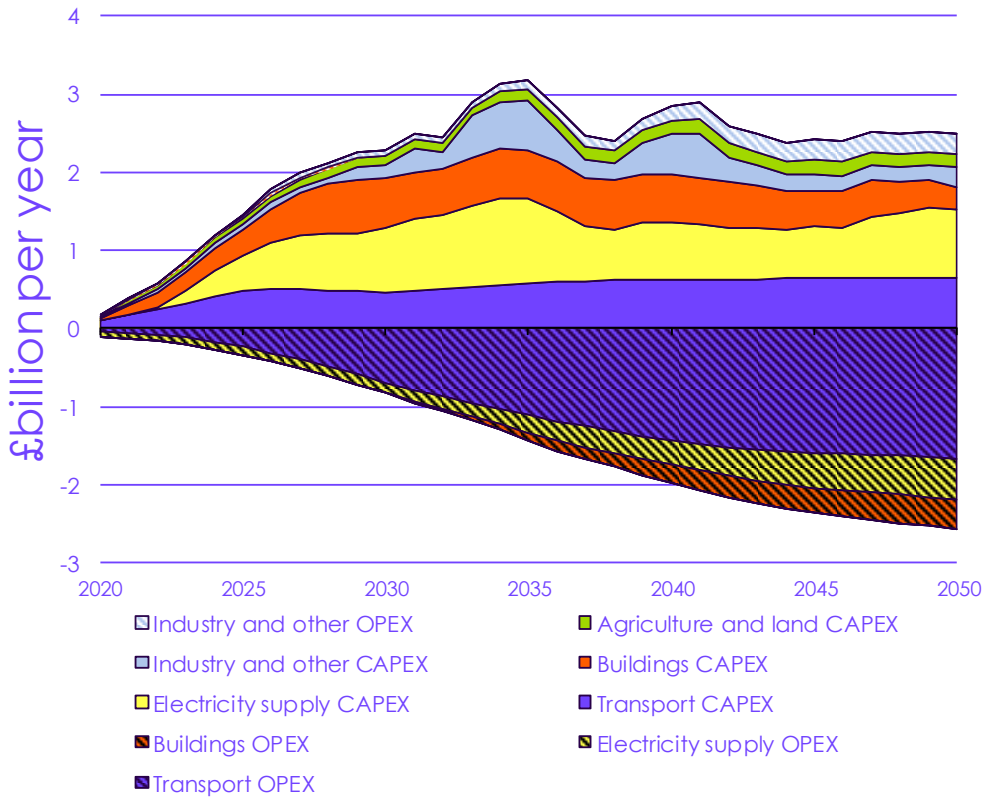
An expert advisory group convened by the Committee for our advice on the Sixth Carbon Budget and Welsh emissions targets suggested that the private sector could deliver the majority of the investments in a transition to Net Zero (see Chapter 5 of the Sixth Carbon Budget Advice Report). Key to scaling up financing will be implementing real-economy policies to ensure enough demand for finance (for example, stimulating the demand in the residential buildings sector to retrofit homes with low-carbon heating).

We are now able to demonstrate that savings in fuel costs (Figure 3.1) will broadly offset the investment costs in later years. As a result, our estimate of the *annualised resource cost* (which measures the net additional cost required each year to deliver the same services with lower emissions) has fallen to significantly less than £2 billion per year through to 2050 in Wales (Figure 3.2).

To calculate annualised resource costs, we annualise the capital investment costs over their lifetimes using a suitable cost of capital and subtract in-year operating cost savings. The result indicates the extra spend required each year to provide the same goods and services but in a low-carbon way. We report these annualised resource costs for comparability with our previous estimates, but they should not be taken to imply an overall economic effect. Resource costs do not account for the important stimulus benefits that an investment programme can bring during the recovery from the impact of the pandemic, other positive co-impacts of taking action, nor the avoided costs of additional climate change.

This is a reduction since our 2019 estimate for Wales to meet the Net Zero 2050 target of between £3-5 billion per year in Wales, reflecting our more detailed modelling and the falling costs of low-carbon technologies.

Figure 3.1 Capital investment costs and operating costs savings in the Balanced Pathway for Wales



Source: CCC analysis.
Notes: Costs of electricity are included in the energy supply sector, whereas costs of other low-carbon fuels, such as hydrogen and bioenergy, are included in the sectors that use these fuels. Wales' share of UK electricity costs is allocated based on electricity consumption rather than where the generation takes place. The 'Industry and other' category includes manufacturing, construction, fuel supply, waste and F-gases. CAPEX refers to additional annual capital investment. OPEX refers to costs and savings due to operational cost changes.

Estimates of overall resource costs for Wales do not imply that these costs will be borne locally.

The costs we report in this section should not be interpreted as the costs that would be delivered via Welsh Government expenditure, nor as costs that only Welsh businesses and households have to bear.

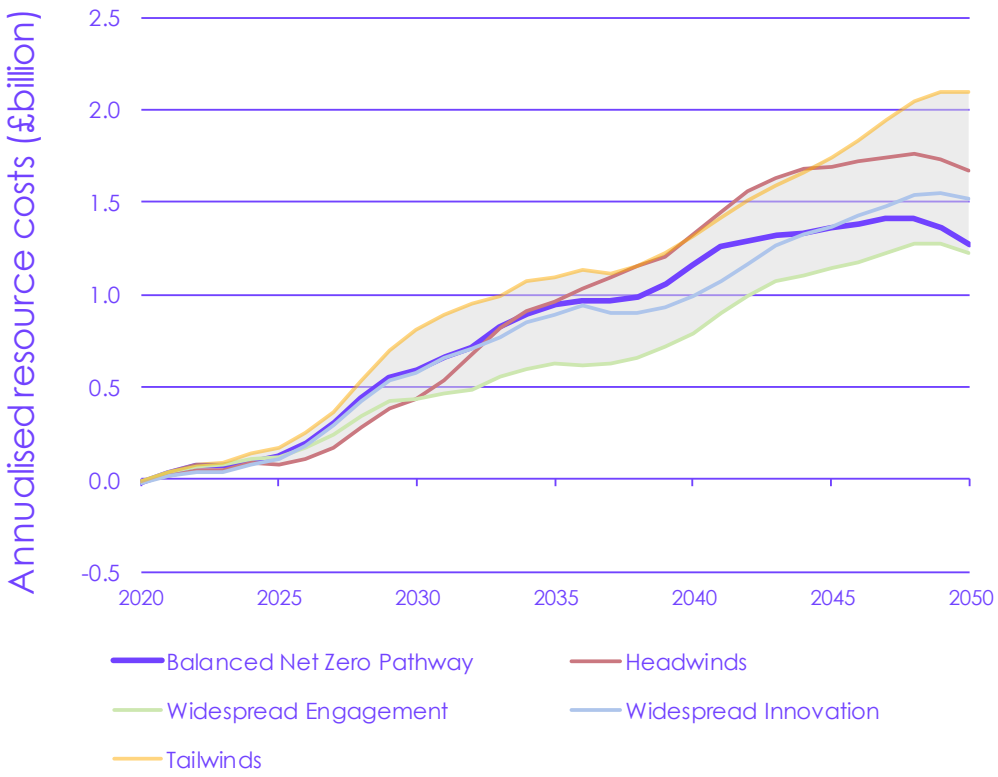
Many of the actions to reduce emissions will likely be paid for at UK level and/or socialised across the whole of the UK. For example:

- The costs associated with building new low-carbon generation will be shared across all consumers of electricity on the GB grid. We have reflected this by allocating resource and investment costs for electricity supply to Wales in proportion to consumption, rather than make assumptions on where new zero-carbon generating capacity is located.*
- The costs of decarbonising industrial clusters could be met through a combination of direct financing from the UK Exchequer and/or be passed through to the end-users of low-carbon products.
- A market mechanism for greenhouse gas removals could see the UK aviation industry offsetting emissions by paying for removals, including planting trees, in all areas of the UK.

* This assumption typically causes our estimate of Wales' share of UK costs to be lower than its share of UK abatement, because Wales is currently a significant net exporter of gas-fired power to the UK, but the costs of actions to decarbonise power will be shared by all electricity users in the UK.

The extent to which costs and savings are shared across the UK – including the amount of expenditure through Welsh budgets – will be determined by policy at both UK and Welsh Government level.

Figure 3.2 Annualised resource costs of the transition in Wales – excluding greenhouse gas removals



Source: CCC analysis.
Notes: Annualised resource costs are capital investment costs spread over their lifetimes using a suitable cost of capital, added to in-year operating cost savings and increases.

In addition to supporting Wales' global responsibilities, the pathway to Net Zero in Wales is well-aligned to the other Well-being Goals (Box 3.1) under the Well-being of Future Generations (Wales) Act 2015.

The Future Generations Commissioner's first Future Generations Report was published in May 2020. The report highlighted climate change as a priority area for Welsh Government policy and gave policy recommendations on both decarbonisation and climate change adaptation.

Box 3.1
Wales' Future Generations Report

The Future Generation Commissioner published the first statutory *Future Generations Report* in 2020. The report provides an assessment of the improvements public bodies should make in relation to their well-being objectives, and provides practical advice, guidance and tools for public bodies.

In addition to a comprehensive assessment of decarbonisation actions in Wales, the report makes specific decarbonisation policy recommendations for the Welsh Government and public bodies in Wales. The headline recommendations for decarbonisation in the first Future Generations Report align well with the recommendations in this report:

- The Future Generations Report recommends that the **Welsh Government** should:
  - Set out a **long-term investment plan of how they will fund the climate emergency** and support more ambitious commitments and targets for sectors within their control.
  - Ensure the new 'National Strategy for Flood and Coastal Erosion Risk Management' provides a **comprehensive and holistic plan for responding to flooding and coastal erosion**, with adequate funding that is focussed on preventative measures including nature-based solutions.
  - **Require all publicly funded buildings to be carbon-neutral**: urgently amend the building regulations (Part L and Part F) and enforce stricter building and infrastructure standards to ensure that we are not building "old" new schools, hospitals and other infrastructure that will contribute to climate change and not be fit for future generations.
  - **Assess the carbon impact of their spend**, especially capital spend, and should also publish details on the overall carbon impact of their budget and major investment/ infrastructure decisions.
  - Resource and prioritise **carbon and eco-literacy training for all politicians**, elected members and senior officers of public bodies in Wales to ensure we have the necessary skills and understanding to make the right decisions for the climate.
- All **public bodies in Wales** should:
  - Focus on **understanding Welsh emissions** and where to **prioritise action.**
  - Tackle the climate and nature crises through a **holistic approach, capitalising on the role of young people**.
  - Deliver a **just transition**.
  - Implement **solutions at scale to achieve multiple benefits**.
  - **Invest more** in tackling the Climate Emergency.

Source: Future Generations Commissioner for Wales (2020) Future Generations Report

a) A prosperous and resilient Wales

While they are a useful indicator, the estimates of annualised resource costs discussed in the previous section are not the same as macroeconomic impacts. In particular, the shift in spending from imported fossil fuels to UK investment is likely to affect the economy. Against the current backdrop of low investment, low interest rates and high unemployment, the impact is likely to be positive.

The actions needed for the transition to Net Zero in Wales can stimulate economic growth, create jobs, and aid a recovery from the pandemic, as well as increasing resilience to future climate risks:

- Legislating our recommended targets would send a clear **signal that Wales is open for low-carbon investment**. This will help to encourage private investment at low cost at a time when it is needed to support Wales' economic recovery from the COVID-19 health crisis. It could also help Wales secure competitive positions in growing global markets for low-carbon goods and services.
- Our pathway involves considerable opportunities for **job creation**. An important challenge for both the UK and Welsh Governments is to identify where jobs may be lost in Wales (for example in gas extraction and refining) and to support workers to transition to being a part of the new low-carbon workforce (e.g. energy efficiency retrofits in buildings or industrial carbon capture and storage).
- **Macroeconomic growth.** To identify the potential effect of our recommended pathway for the UK Sixth Carbon Budget, we commissioned Cambridge Econometrics (CE) to use their macro-econometric model. Their analysis suggests a boost to GDP growing to around 2% of GDP by 2030, with an accompanying boost to employment of around 1%.
- **A green recovery.** Accelerating action on climate change now can help to support the recovery from COVID-19 and rebuild the Welsh economy to be more resilient to the changing climate and future economic shocks.
- **Supporting climate adaptation.** The changing climate poses risks to meeting Wales' economic, social and environmental goals. Efforts to move to a Net Zero economy should be supported by actions to strengthen focus on climate adaptation and prepare for the climate change.

b) A healthier Wales

There is clear evidence for the health benefits of the Net Zero transition. Some of these come directly from changes required to achieve Net Zero (e.g. more active travel and dietary changes) and some indirectly from the implications of those changes (e.g. better air quality from reduced burning of fossil fuels and more liveable buildings as insulation is improved). These benefits are difficult to quantify, but unquestionably offset some, if not all, of the overall resource costs of achieving emissions targets.

The Committee appointed an expert advisory group on Health to support our advice on the Sixth Carbon Budget (Box 3.2). The group concurred strongly with the Committee's previous assessment that climate action could bring significant benefits to health.

They emphasised the importance of health inequalities and identified areas for prioritising climate actions that would bring benefits to public health and climate change, and they made a set of related recommendations.

The health benefits are generally higher on demand-side measures of abatement, such as diets and active travel.

- **Shift toward active travel.** Our scenarios include higher rates of walking and cycling, shifting from car trips. Active travel brings with it a host of health benefits.
- **Healthier diets.** Our scenarios explore different degrees of diet shift away from meat products. Shifting meat consumption more in line with Government guidance would have significant health impacts. A 2013 report that the Committee commissioned from Ricardo indicated that the health impacts of reducing red meat consumption by 50% amounted to an annual monetised benefit of 0.5% of GDP.[1]
- **Air quality.** Poor air quality causes significant harm to health. It is associated with heart disease and stroke, and particulates cause up to 40,000 deaths per year in the UK.[2] Many sources of air pollution are decreased by reducing GHG emissions. Ricardo's 2013 estimates suggest that air quality and noise impacts of a low-carbon scenario result in annual monetised benefits of close to 0.1% of GDP in 2030.
- **More liveable homes.** The health cost to the NHS due to poor housing exacerbating existing conditions is estimated to be £1.4-2 billion per year.[3] Thermally comfortable housing has the potential to reduce the risk of heat- and cold-related illness and death.
- **Mental health improvements.** There are a host of benefits to mental health that are also promised by a Net Zero Wales. The improved physical health resulting from and contributing to decarbonisation has knock-on impacts on mental health. Some of the changes in our scenarios, for example the expansion of mixed woodlands, have also been shown to have positive effects on mental health. Further to this, 'climate anxiety' is a growing phenomenon, and action contributes to alleviating this burden.

The transition to Net Zero must not place additional financial burden on regions or households suffering deprivation.

While noting the potential the above benefits will bring to public health, our advisory group noted that the biggest driver of health outcomes in the UK remains economic inequality. A just transition is therefore an essential part of a successful climate policy and health policy. It is vital for both acceptance and efficacy that policies that reduce emissions do not place burdens on those least able to pay.

Box 3.2
Findings of the Health Expert Advisory Group

The Health Expert Advisory Group was convened by the Committee in 2020 to advise on assessing the health impacts of setting the Sixth Carbon Budget and ensure the Committee's recommendations are aligned with improving public health in the UK. The Group was chaired by Professor Sir Michael Marmot, UCL Institute of Health Equity, and its members were drawn primarily from the academic community, with expertise in a variety of fields, plus representation from the NHS Sustainable Development Unit.

The central message of the Chair's report is that a strategy to achieve Net Zero emissions should have health equity – the fair distribution of health – as an explicit policy goal, and that a health equity in all policies approach be adopted. Action to improve health equity can be consistent with measures to reduce greenhouse gas emissions and adapt to climate change, but it is evident that this requires careful consideration of who benefits from and who pays for different policy measures.

The clear positive co-impacts of health outcomes and Net Zero

The Group found that the near-term benefits to health of taking action on climate change are manifold.

The group identified five key areas in which action would bring benefits to public health and reduction of health inequalities while contributing to the mitigation of – and adaptation to – climate change:

- **Improved air quality** improvements delivered by a move to cleaner energy system and moving away from fossil fuel combustion in most sectors of the UK.
- **Healthier modes of transport**, particularly due to the health benefits of walking and cycling and reducing air pollution from road vehicles.
- **More comfortable and efficient homes** that are low-carbon, energy efficient and designed for a changing climate.
- **Better diets** with a focus on healthy and sustainable alternatives to the highest-carbon foods.
- **Sustainable economic and employment models** that better support health and well-being.

Achieving the UK's target of reaching Net Zero by 2050 will necessitate transformational changes that have potential to generate significant health benefits in the near term, including via improved air quality, better diets, increased levels of physical activity, improved building standards and better work-life balance.

Health equity: the fair distribution of health

The health benefits of mitigation and adaptation measures will be maximised if they are designed to reach the people facing the greatest disadvantage; however, this is not inevitable. Decisions made in all Government departments have implications for health, health equity and climate change.

Action to improve health equity can be consistent with measures to reduce GHG emissions, but this requires careful consideration of who benefits and who pays for different policy measures: the costs should not be unfairly borne by people on low incomes, who bear least responsibility for the emissions that cause climate change. A failure to deliver a just transition would risk exacerbating the health inequality that already exists in the UK.

Meanwhile, policy measures that widen inequalities should be mitigated via greater redistribution of benefits. Minimising health inequalities will require systemic changes to enable and support all of the UK population to benefit from uptake of active travel, sustainable diets and energy efficiency measures, among others.

Factoring health equity effects into policies requires a more nuanced approach to both mitigation and adaptation: for example, home energy efficiency measures must also benefit indoor air quality and temperature, and reach those most exposed to temperature extremes and indoor air pollution; reducing meat and dairy consumption needs to involve substitution with healthy, lower-carbon alternatives that are affordable and accessible; and decarbonisation of transport must involve low pollution and safe forms of transport that are preferably active and, at the very least, accessible to all.

Recommendations for Government

The Group's headline recommendations for the UK Government to maximise the health impacts of meeting the Sixth Carbon Budget and Net Zero target are:

- **Health-equity-in-all-policies approach.** The UK Government should avoid increasing health and economic inequalities by ensuring the costs of measures to mitigate climate change are distributed progressively and that the benefits reach those who have the potential to be most positively impacted. The aim should be to reduce health inequalities and to advance health equity, for example by applying a health equity impact assessment to legislation, including the Sixth Carbon Budget.
- **Support a just energy transition that minimises air pollution from all sources.** Continue to reduce dependence on fossil fuels and accelerate the transition to clean energy sources with decarbonisation of power generation and industrial, commercial and domestic energy.
- **Design and retrofit homes to be energy efficient, climate resilient and healthy.** The dual need to reduce domestic CO_2 emissions whilst building and retrofitting healthy and climate-resilient homes requires a fine balance of interventions that will depend on the age, design and location of homes. New building standards should be revised to become near-zero or zero-carbon with flexibility to adapt to local environmental needs.
- **Build a sustainable and healthy food system.** Enable a wider range of national and local powers to shape food systems, and combine these with the resources and statutory duties to support the transition to healthier and more sustainable diets
- **Develop a transport system that promotes active travel and road safety, and which minimises pollution.** A transport system that is accessible to all and which maximises the physical and mental health benefits of active and decarbonised transport will require a range of policy interventions to encourage walking and cycling, more local journeys, the use of public transport and ride-sharing, and to reduce traffic. Electrification of transport will also play a necessary role in reducing transport-related CO_2 emissions, but continued private vehicle dependence does not constitute behaviour change towards more active and inclusive forms of travel, and will continue to be a significant source of harmful particulate matter.
- **Develop healthy and sustainable models of work**. Prioritise the health and well-being of citizens and environmental sustainability in economic recovery/growth policies. Shift from measuring economic success in terms of GDP to prioritising a well-being approach. Support more inclusive local economic growth and shift towards circular economy principles.

Many of the Group's recommendations apply to the Welsh Government and will require the use of devolved levers.

Source: CCC Advisory Group on Health (2020) Sustainable Health Equity: Achieving a Net Zero UK.

c) A just transition to support well-being

The International Labour Organisation (ILO) defines a 'just transition' as a transition towards an environmentally sustainable economy that is well-managed and contributes to the goals of decent work for all, social inclusion and the eradication of poverty.[4]

Only a just transition to Net Zero can support a **more equal Wales**, **a Wales of cohesive communities**, and **a Wales of vibrant culture and thriving Welsh language**.

Fairness is fundamental to public support and must be embedded throughout policy. Only a transition that is perceived as fair, and where all people, places and communities in Wales are well-supported, will succeed. Vulnerable people must be protected from the costs of the transition and the benefits must be shared widely.

Across many areas, including energy bills and regional employment, fairness is already an issue. The transition to Net Zero will require a shift of hundreds of thousands of workers into low-carbon roles, as well as large numbers shifting out of high-carbon roles, which could be in different places and use different skills.

Navigating this transition must start now and will require effective plans, widespread public involvement and an embedding of the principle of fairness throughout climate policy.

d) Natural capital and well-being

Natural capital comprises all ecosystem services that are provided by natural assets, including soil, air, water and all living things. Ecosystem services are the benefits people obtain from ecosystems.

The concept of ecosystem services and how they contribute to well-being in Wales is described in the 'State of Natural Resources Report. Chapter 5: Well-being in Wales' (Box 3.3). Based on this assessment, improving natural capital and enhancing ecosystem services supports the seven well-being goals of the Future Generations Act.

Each of our scenarios for Wales include measures that will improve Wales' natural capital:

- **Provisioning services.** Our scenarios include an increase in renewable energy generation – particularly wind – consistent with the Welsh Government's target to generate renewable electricity equivalent to 70% of Welsh consumption by 2030.
- **Regulation services.** Our scenarios include the planting of between 4,500 and 10,500 hectares of trees per year, which will also contribute to improved air quality. Trees filter rainwater before it reaches receiving waters, thus improving water quality. Strategic planting of trees on flood plains can also regulate flooding. Trees also reduce storm water runoff and slow storm flow. Significant areas of peatland will also be restored which – in addition to carbon sequestration – provide other vital services, such as water regulation, flood protection and habitats for wildlife.
- **Cultural services.** The natural environment provides a range of cultural services, such as increased amenity benefits, increased mental health, educational benefits and spiritual well-being.

- **Supporting Services.** In agriculture, our scenarios include soil and crop measures that aim to increase the efficiency of fertiliser use. These have benefits to water and soil quality, and biodiversity.

Box 3.3
State of Natural Resources report on ecosystem services and well-being

Chapter 5 of the State of Natural Resources report focuses on well-being. It provides an assessment of the ecosystem services that contribute to well-being in Wales, using the seven Well-being goals as a framework. The Millennium Ecosystem Assessment defines ecosystem services as:

- **Provisioning Services** are the products obtained from ecosystems, for example food or timber.
- **Regulating Services** are benefits obtained from the regulation of ecosystem processes, such as water regulation or purification.
- **Cultural Services** are the non-material benefits people obtain from ecosystems, for example through spiritual enrichment, recreation or aesthetic experiences.
- **Supporting Services** are necessary for the production of all other ecosystem services. Their impacts on people are either indirect or occur over a very long time, for example nutrient cycling, soil formation and provisioning of habitat.

The State of Natural Resources report outlines how our natural assets (i.e. the soil, air, water and living things in Wales) contribute to Well-being in Wales:

- **Resilient Wales Goal:** Natural resources and ecosystems support the functioning of social and economic systems, particularly the capacity to adapt to climate change. Welsh habitats contribute to social, economic and ecological resilience, ranging from purification of water by grasslands, flood risk management by woodlands or mental health and national identity provided by mountains, moorlands and heath.
- **Prosperous Wales Goal:** Food and fibre production and fisheries are significant contributors to Welsh GVA and employment. Other provisioning services include renewable energy and water supply. Water and hazard regulation, as well as the amenity value of 'green space' also contribute to a prosperous Wales.
- **Healthier Wales Goal:** Natural resources contribute to the physical health and mental well-being of people in Wales, both through health improvement and health protection. Regulation of air, water and soil quality offers significant health benefits and can increase people's life expectancy. Woodlands can contribute to flood management and other forms of hazard control, and also offer amenity and recreation benefits that have mental health benefits.
- **Equal Wales Goal:** Ecosystems can help reduce risks to vulnerable people, such as flood risks or overheating. For example, urban trees can provide cooling and prevent night-time overheating.
- **Cohesive Communities Goal:** Connections between natural resources and people can shape communities. The provisioning of well-managed and attractive green space can provide a safe space for residents and visitors.
- **Vibrant Culture and Welsh Language Goal:** Wales has three National Parks and five Areas of Outstanding Natural Beauty. Its landscape and nature are an important part of Welsh national identity and culture.
- **Globally Responsible Goal:** Ecosystems can play a significant role in reducing greenhouse gas emissions in Wales, contributing to the global effort to mitigate climate change. Ecosystems also contribute to Wales' international commitment to biodiversity improvements.

Source: Natural Resources Wales (2016) *State of Natural Resources Report (SoNaRR).* Box adapted from CCC (2017) *Building a low-carbon economy in Wales – Setting Welsh carbon targets.*
Notes: A second SoNaRR report is due to be published in 2020.

Endnotes

[1] CCC (2020) *Land-use policies for a Net Zero UK*.

[2] CCC expert advisory group on health (2020) *Sustainable health equity: achieving a Net Zero UK*.

[3] CCC (2019) *UK housing: Fit for the future?*

[4] International Labour Organisation (2015) *Guidelines for a just transition towards environmentally sustainable economies and societies for all.*

Chapter 4

Recommendations on Welsh Climate Targets

Introduction and key messages

This Chapter sets out the Committee's recommendations, based on the analysis set out in the rest of this report.

- **Net Zero in 2050.** Wales should legislate as soon as possible to reach Net Zero greenhouse gas emissions by 2050. The target can be legislated as a 100% reduction in greenhouse gases (GHGs) from 1990 and should cover all sectors of the economy.
- **The Third Carbon Budget (2026-2030)** should be set at a 58% reduction compared to 1990 levels.
- **Interim targets for 2030 and 2040** should be set on the Balanced Pathway to Net Zero at 63% and 89% respectively compared to 1990 levels.
- **The Second Carbon Budget (2021-2025)** must be tightened to a 37% reduction compared to 1990 levels as an absolute minimum to account for the early closure of Aberthaw power station (as set out in our 2017 advice). Emissions will likely have to fall more quickly than this to meet the Third Carbon Budget. However, it is extremely difficult to identify the appropriate level of emissions reduction over this period:
  - Future performance of the economy – and hence the level of economic activity that could cause emissions – is always uncertain to some degree. However, uncertainty over emissions in the next few years is much greater than usual, relating to how the economy will recover after the COVID-19 pandemic, together with any lasting societal and behavioural changes.
  - Much of the emissions reduction that we expect in Wales over the next few years, which could take Wales significantly beyond the 37% reduction in our previous advice, is anticipated to occur in the power sector, through reduced generation from gas-fired generation, and is not in the control of the Welsh Government.
  - These two factors are likely to make a considerably bigger difference to emissions in Wales than new policies developed and implemented by the Welsh Government, especially given the lead-times to do so. Strong policies to reduce emissions should be developed and implemented by the Welsh Government over a timeframe that enables them to make a significant difference (i.e. aimed at the ambitious reduction of 58% for the Third Carbon Budget).
- We therefore recommend that as a minimum the level of the Second Carbon Budget is revised in line with our 2017 advice to require a reduction of 37%, but that the clear aim of the Welsh Government is to outperform this on the way to meeting the ambitious Third Carbon Budget and 2030 target.
- **A Net Zero delivery plan.** We recommend that the next low-carbon delivery plan in Wales sets out a long-term vision for meeting the Net Zero goal, with a particular focus on the Third Carbon Budget and the 2030 target. Policies and proposals to reduce emissions take time to implement and to have impacts in the real world; the focus of Wales' should not be limited to emissions targets in the next five years. The expected impact of policies, including those in early planning, should be clearly quantified and in sum be enough to meet the third carbon budget.

- **Engineered removals.** We recommend that engineered CO_2 removal is allowed to contribute to meeting Welsh carbon targets under the Environment (Wales) Act. Achieving Net Zero will require sustainable, verified greenhouse gas removals.
- **Domestic action.** The aim should be to meet the target through domestic effort in Wales, without relying on international carbon units (or 'credits'). Emissions trading – including potentially within a UK scheme – can be a useful policy lever to reduce actual Welsh emissions (net of removals) as required to meet the recommended targets.

Our recommendations in this chapter our set out in three sections:

1. Setting a Net Zero target for Wales

2. The path for Welsh emissions on the path to Net Zero

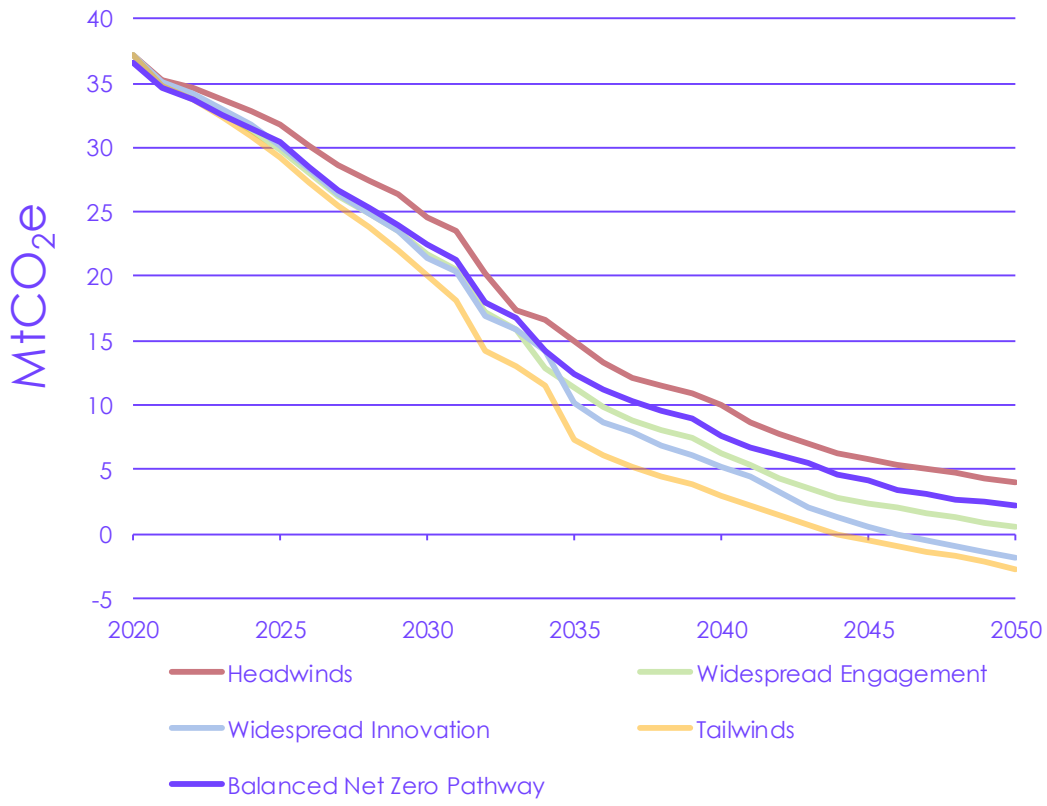
3. Assessing performance against targets

The Committee recommends that Wales changes its 2050 Target to Net Zero (i.e. a reduction of at least 100%).

The new recommendation is supported by the analysis and evidence presented in this advice. We have now identified multiple feasible routes to achieving Net Zero, either without the use of greenhouse gas removals or with a credible share of the UK total (Figure 4.1). This can be delivered at acceptable overall cost and in ways that deliver multiple benefits for Wales' well-being goals.

A Wales Net Zero target represents a full and fair contribution for Wales to meeting the overall UK Net Zero target, which in turn is an appropriate contribution to achieving the goals of the Paris Agreement.

Figure 4.1 Our pathways for Welsh emissions to 2050 excluding engineered removals



Source: CCC analysis.

The Environment (Wales) Act requires this advice also to state whether the recommendation reflects the 'highest achievable target'. It is the Committee's assessment that the recommended Net Zero target for 2050 presents the highest achievable target for Wales, given the current evidence available:

- **Contribution of greenhouse gas removals.** Greenhouse gas removal technologies could – in theory – be located anywhere in the UK and would count towards UK emissions reductions. However, there are reasons why they might be best located in certain areas of the country. Wales is less well-placed for CO_2 storage than England and Scotland and a Net Zero target for Wales should therefore not be overly reliant on the use of greenhouse gas removals.
- **Greater ambition may not feasible.** Although our advice considers a more ambitious 'Tailwinds' scenario that indicates that a more rapid transition to Net Zero could be feasible should it be possible to get larger behavioural/societal changes and cost reductions faster and to a larger extent than we assume in a central case, we cannot be confident that these changes will or can occur. The better performance under Tailwinds would be very welcome if feasible, and policy should seek to achieve the performance in this scenario where possible. However, it is the Committee's assessment that, given large questions over its feasibility, this scenario goes beyond what can be regarded as 'achievable' at this stage.

A Net Zero target for Wales is credible, but will be highly challenging to achieve and will require use of policy levers held both in Cardiff and in Westminster.

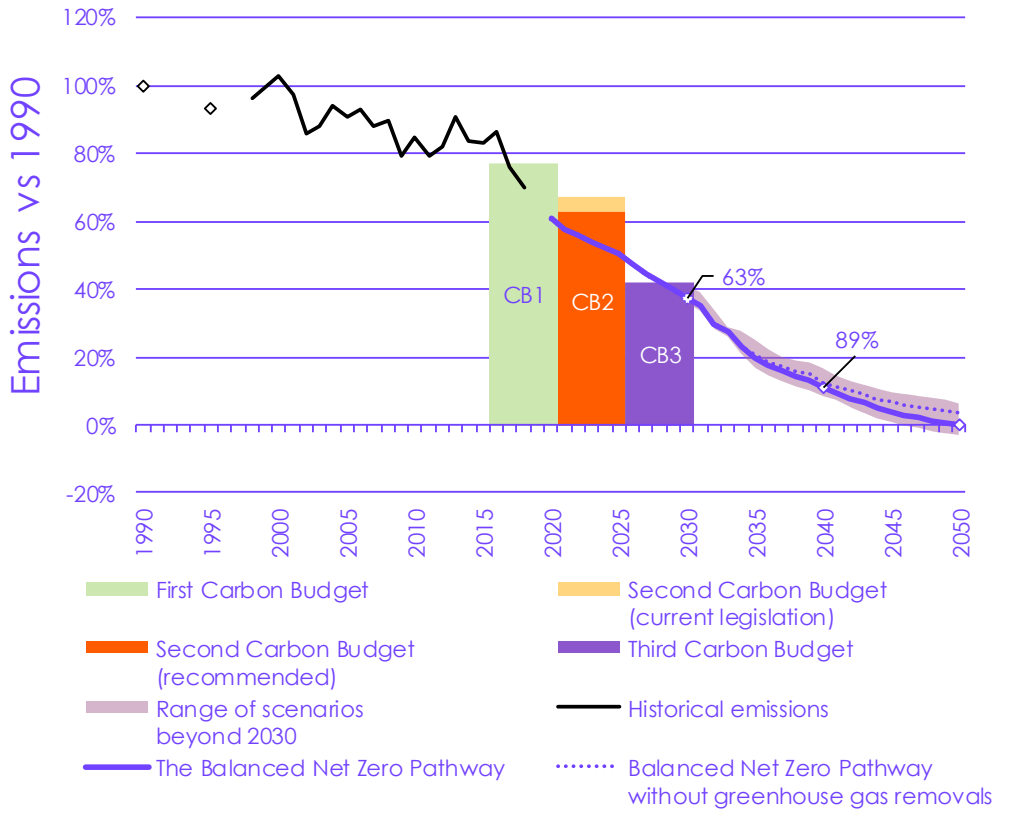
Increasing the ambition under Wales' 2050 Target means that the path for emissions over the next three decades will need to be different to that placed in legislation previously. We now turn to the targets on the pathway to Net Zero.

a) The revised path for emissions

Wales has already placed in legislation Interim Targets for emissions reduction for 2030 and 2040, as well as the Second Carbon Budget (covering the five-year period 2021-2025). The emissions path to Net Zero in Wales is necessarily steeper, requiring greater ambition (Figure 4.2).

We therefore provide updated advice on the levels for the Interim Targets for Welsh emissions for 2030 and 2040, consistent with the recommended Net Zero target.

Figure 4.2 Recommendations for Wales' climate targets



Source: NAEI (2020) *Greenhouse Gas Inventories for England, Scotland, Wales & Northern Ireland: 1990-2019*; CCC analysis.
Notes: Historical emissions data are not available for 1991-1994 and 1996-1997. Emissions shown are presented including all emissions from peatlands and using AR5 global warming potentials including carbon-cycle feedbacks. GGRs = greenhouse gas removals. Range is defined by our other exploratory scenarios.

b) Implications for the Third Carbon Budget and Interim Targets

Our recommended levels for the Interim Targets are based on the Balanced Net Zero Pathway for Wales, and assume that Wales either deploys a 4% share of UK-wide engineered removals occur in Wales by 2050, and/or sees wider technological and behavioural changes within the range of options in the exploratory scenarios in order to achieve Net Zero in Wales by 2050:

- **Third Carbon Budget (2026-30).** The emissions reduction required on average for the period 2026 to 2030 is 58% relative to 1990 baseline emissions. As the path for emissions across this budget period is essentially a straight line, the reduction required for the budget period on average is virtually the same as the reduction required by 2028, the middle year of the budget period.
- **2030 target.** The emissions reduction required by 2030 is 63% relative to 1990 levels. This represents a reduction of 46% relative to emissions in 2018.
- **2040 target.** The emissions reduction required by 2030 is 89% relative to 1990 levels. This comprises the Balanced Pathway excluding engineered removals, which achieves a reduction of 87% relative to 1990 emissions, together with a further reduction in net emissions of 2 percentage points delivered either via engineered removals or other behavioural and technological changes. The recommended 2040 target represents a reduction of 84% relative to emissions in 2018.

As with the Net Zero target, these revised Interim Targets for 2030 and 2040 represent the highest achievable target for Wales:

- The targets are recommended on the basis of the Balanced Net Zero Pathway for Wales. This pathway has been designed to be consistent with the Paris Agreement's principle of 'highest possible ambition', and therefore represents the Committee's assessment of the most ambitious path for emissions reduction that we can currently have confidence is feasible. This also means that required progress is relatively front-ended, with reductions in Welsh net emissions in the 2040s required at less than half the rate of reductions between 2018 and 2040:
  - **2018 to 2030.** The average annual emissions reduction required over the period 2018 to 2030 is 1.6 $MtCO_2e$.* 46% of the progress towards Net Zero from today is required to occur during this period.
  - **2030 to 2040.** The average annual emissions reduction required between 2030 and 2040 is 1.6 $MtCO_2e$. 39% of the progress towards Net Zero from today is required to occur during this period.
  - **2040 to 2050.** The annual emissions reduction required between 2040 and 2050 is 0.7 $MtCO_2e$. The remaining 15% of the progress towards Net Zero from today is required to occur during this period.
- As discussed in Section 1 in relation to the timing of Net Zero, developments on societal and behavioural changes and/or on costs and performance of technologies may mean it turns out to be feasible to reduce emissions more quickly than the recommended targets (e.g. under our Tailwinds scenario). The better performance under Tailwinds would be very welcome if feasible, and policy should seek to achieve the performance in this scenario where possible.

* 2018 is the most recent year for which there are emissions data for Wales. Emissions in Wales are likely to have fallen in the two years since then. For the period 2020 to 2030, the required rate of reduction is 1.4 $MtCO_2e$ per year.

However, it is the Committee's assessment that, given large questions over its feasibility, this scenario goes beyond what can be regarded as 'achievable' at this stage.

c) Implications for the Second Carbon Budget

The Second Carbon Budget period begins less than one month after this report is published, and runs from 2021 to 2025. The level of this budget was set in legislation in 2018, following the Committee's 2017 advice.[1]

At the time the Committee made its recommendations, it was uncertain for how long the Aberthaw coal-fired power plant, a large contributor to Wales' emissions, would continue generating. That made it very difficult to identify the right level for the Second Carbon Budget to reflect the necessary reductions in emissions elsewhere in the economy. We therefore recommended a budget level that assumed continued operation of Aberthaw, but with alternative levels should Aberthaw cease generating prior to 2025:

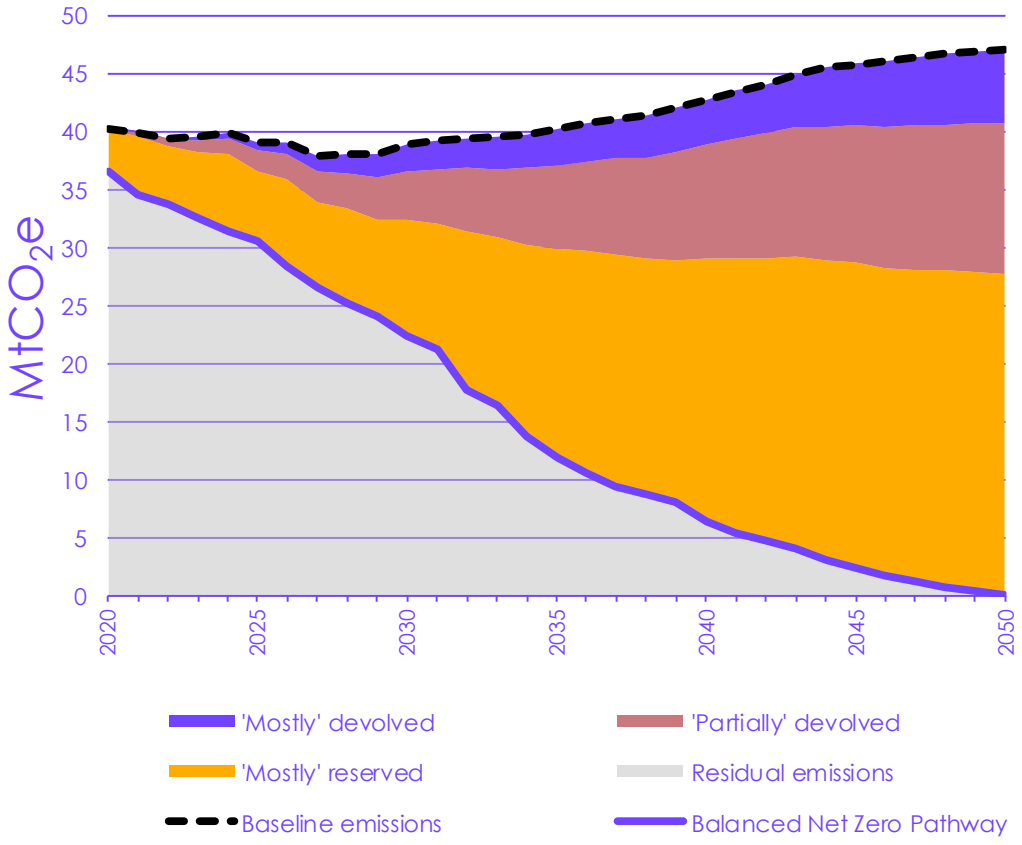
- **The legislated level** of the Second Carbon Budget was for a 33% reduction in emissions on 1990 levels on average across the budget period, on the assumption that Aberthaw continued to operate until the UK-wide phase-out of coal-fired power generation in 2025.
- **Tighter levels for the budget** were set out in the case that Aberthaw ceased generating prior to, or during, the budget period. In the case that Aberthaw closed by 2020, before the start of the period, the level of the budget was recommended to be for an average reduction of 37%.

Aberthaw closed in March 2020, so the legislated Second Carbon Budget is looser than was intended when the Committee provided its advice in 2017. As a minimum, therefore, it would be appropriate to tighten the Second Carbon Budget to align with our previous advice. However, there are other factors that are relevant to the appropriate level of emissions in the first half of the 2020s:

- **Greater ambition on the path to 2050.** The increase in ambition to 2050 already committed to by the Welsh Government must mean more concerted efforts to reduce emissions during the 2020s, to get on track to Net Zero. However, although this should start to affect the level of emissions by 2025, the impact that is achievable is relatively small, given lead-times for policies to be developed and then for their implementation to have a significant impact on emissions. Furthermore, within the steeper path we have identified for emissions on the path to Net Zero in Wales, relatively little of the emissions reductions over the period to 2025 would derive from policy areas devolved to the Welsh Government (Figure 4.3).
- **The lasting effects of the COVID-19 pandemic.** The lockdown in response to the COVID-19 pandemic this year has had a substantial impact on emissions during 2020, due to a combination of economic impacts and changes in behaviours. It remains unclear what the impacts will be on a lasting basis, both in terms of the level of economic activity in different parts of the Welsh economy and in terms of enduring changes to behaviours.
- **Output from gas-fired power stations.** Reductions in emissions from electricity supply make up 65% of the abatement in the Second Budget period, and Wales has very little legislative power to influence these emissions. Our analysis has applied a GB-wide load factor to each type of generation technology in Wales, but individual power stations in Wales (e.g. Pembroke) may not follow that trajectory depending on market conditions.

If emissions from fossil-fired generation remain near current levels for the first years of the budget period, Wales could miss a target even if all other sectors of the economy decarbonise in line with our Balanced pathway.

Figure 4.3 Responsibility for abatement in the Balanced Pathway for Wales is shared by the UK and Welsh Governments



Source: CCC analysis.
Notes: The significant portion of abatement in the early 2020s is abatement of electricity supply that falls under 'mostly' reserved policy.

Therefore, while it is clear that the previously recommended level of the Second Carbon Budget is very likely to be too loose to drive the actions necessary to get on track to Net Zero, the 'right' level to which the budget level should be changed is would be extremely difficult to determine with any precision, based on the evidence currently available.

Given the extent of the uncertainty due to the lasting impacts of COVID-19 and load factors of Welsh gas-fired power stations, these factors are likely to dominate over extra emissions reductions that can be achieved on this timescale from devolved Welsh policies.

We therefore recommend that, as a minimum, the Second Carbon Budget is amended to the level we previously advised, in the case that Aberthaw closes in or before 2020, for a 37% reduction, but that the clear aim of the Welsh Government is to outperform this on the way to meeting the ambitious Third Carbon Budget and 2030 target.

The focus of Wales' climate policy should not be limited to emissions targets in the next five years. Instead, the focus for climate policy in Wales should be on taking the actions required to decarbonise over the period to 2030, and to get on track to Net Zero.

We therefore recommend that the next low-carbon delivery plan in Wales sets out a long-term vision for meeting the Net Zero goal, with a particular focus on the Third Carbon Budget and the 2030 target. The expected impact of policies, including those in early planning, should be clearly quantified and in sum be enough to meet the third carbon budget.

Although the aim should be for Wales' emissions targets to be met through domestic reductions in emissions, the Committee is required to provide advice on the limit on the use of carbon units (i.e. international offset credits) to contribute to the Second Carbon Budget.

As our recommendation is to amend the level of the Second Carbon Budget to a level that will likely need to be outperformed in order to get on track to meeting the Third Carbon Budget and the 2030 target, it is not appropriate to meet the Second Carbon Budget with any use of carbon units.

We recommend there is no allowance of carbon units to contribute to meeting this carbon budget.*

* This can be legislated as a nominal 0.01% of the total budget level.

a) Forthcoming changes to the emissions inventory methodology

Our recommend targets include full estimates for emissions from peatlands and uses the latest estimates from the IPCC for the global warming potentials of methane and other non-CO_2 gases. These changes are not currently reflected in the emissions inventory, but are due to be included over the next few years.

The precise impact of these changes is not yet certain.

However, some uncertainty remains over exactly how these changes will be incorporated in the emissions inventory (reflecting uncertainty over which possible approach best captures the true level of these emissions – see Box 2.1).

The definition of Welsh emissions targets as percentage reductions from the level of emissions in 1990 helps to mitigate the impact that inventory changes can have in taking the targets out of line with the action that they were intended to drive. This is because it tends to be the case that upward or downward revisions to current and future estimates of emissions also tend to lead to revisions of estimates for 1990 in the same direction.

However, for some changes to the inventory methodology for estimating emissions there will still be an impact on the percentage reductions that need to be achieved.

While the Committee's recommendation take account of the 'current-worst-case' estimates for the impact of the forthcoming inventory changes on estimates of Welsh emissions, for comparison with earlier targets we also present in Table 4.1 the emissions reductions on a basis that exclude these inventory changes or assume that the changes are less significant.

Inventory changes also affect the size of the 1990 baseline, so equivalent pathways under different inventory assumptions give very similar percentage reductions in Wales. This is by design. The Welsh Government's decision to use percentage reduction targets rather than set them on an absolute $MtCO_2e$ basis makes measuring target performance less sensitive to future changes to the emissions inventory.

Table 4.1
Required emissions reductions on different bases

	Third Carbon Budget (2026-2030)	2030	2040
Higher inventory changes (i.e. the basis for our recommended targets)	**58%**	**63%**	**89%**
Lower inventory changes	58%	63%	91%
Current inventory basis	58%	63%	91%

Territorial emissions are the best basis for Welsh targets, but we will track consumption emissions.

As required by the Environment (Wales) Act and by the standard international accounting approach agreed by the UNFCCC, legislated emissions targets for Wales are set on a territorial basis (i.e. based on emissions arising from Welsh sources, not emissions embedded in goods and services consumed in Wales).

However, the Committee is clear that progress must also be made in addressing emissions measured on a consumption basis (also known as Wales' carbon footprint).

While territorial emissions remain the best basis for Welsh emissions targets, the Committee will continue also to scrutinise progress on consumption emissions and recommend policies that reduce both.

b) Enabling engineered greenhouse gas removals to contribute

Under section 34 of the Environment (Wales) Act, 'Welsh removals' are defined as "*removals of that gas from the atmosphere due to land use in Wales, land-use change in Wales or forestry activities in Wales*".

While such 'natural removals' are vitally important in achieving Net Zero at UK level, our assessment is that it currently appears unlikely that Net Zero could be achieved cost-effectively without also a significant contribution from 'engineered' removals of CO_2 (e.g. use of bioenergy with carbon capture and storage (BECCS) or direct air capture of CO_2 with storage (DACCS) – see Section 4 of Chapter 1).

The UK's engineered removals are not guaranteed to be located in Wales, and we have set out pathways in which Wales can achieve Net Zero without greenhouse gas removals. However, if these technologies can be deployed in Wales they should count towards Wales' targets.

For CO_2 removal to contribute effectively to the carbon budgets it must be genuine and permanent removal. Strong, effective sustainability standards and verification processes will be vital for including the contribution of CO_2 removal.

'Engineered' removals may be necessary for Net Zero. They must be allowed to contribute.

We recommend that engineered CO_2 removal is allowed to contribute to meeting Welsh carbon targets under the Environment (Wales) Act.

This need not require amendment of the Act. For example, a UK removals credit (or 'carbon unit' under the Act) could be defined, such that these domestic removals can contribute to meeting carbon budgets and the Net Zero target.

c) Calculating perfomance against carbon budgets

The carbon budgets set out in the Climate Change (Interim Emissions Targets) (Wales) Regulations 2018 do not have a statutory methodology for how they will be assessed.

The Welsh carbon budget recommendations in this report are based on the assumption that performance is assessed against a single inventory published after the budget period is finished. This should be the first inventory published that covers all years of the budget period (e.g. performance towards the Second Carbon Budget should be assessed against on the inventory published in 2027 that covers emissions data 2021 to 2025). This is comparable to how the UK's Carbon Budgets under the Climate Change Act are measured and ensures that performance is measured against the most recent scientific understanding of Welsh emissions.

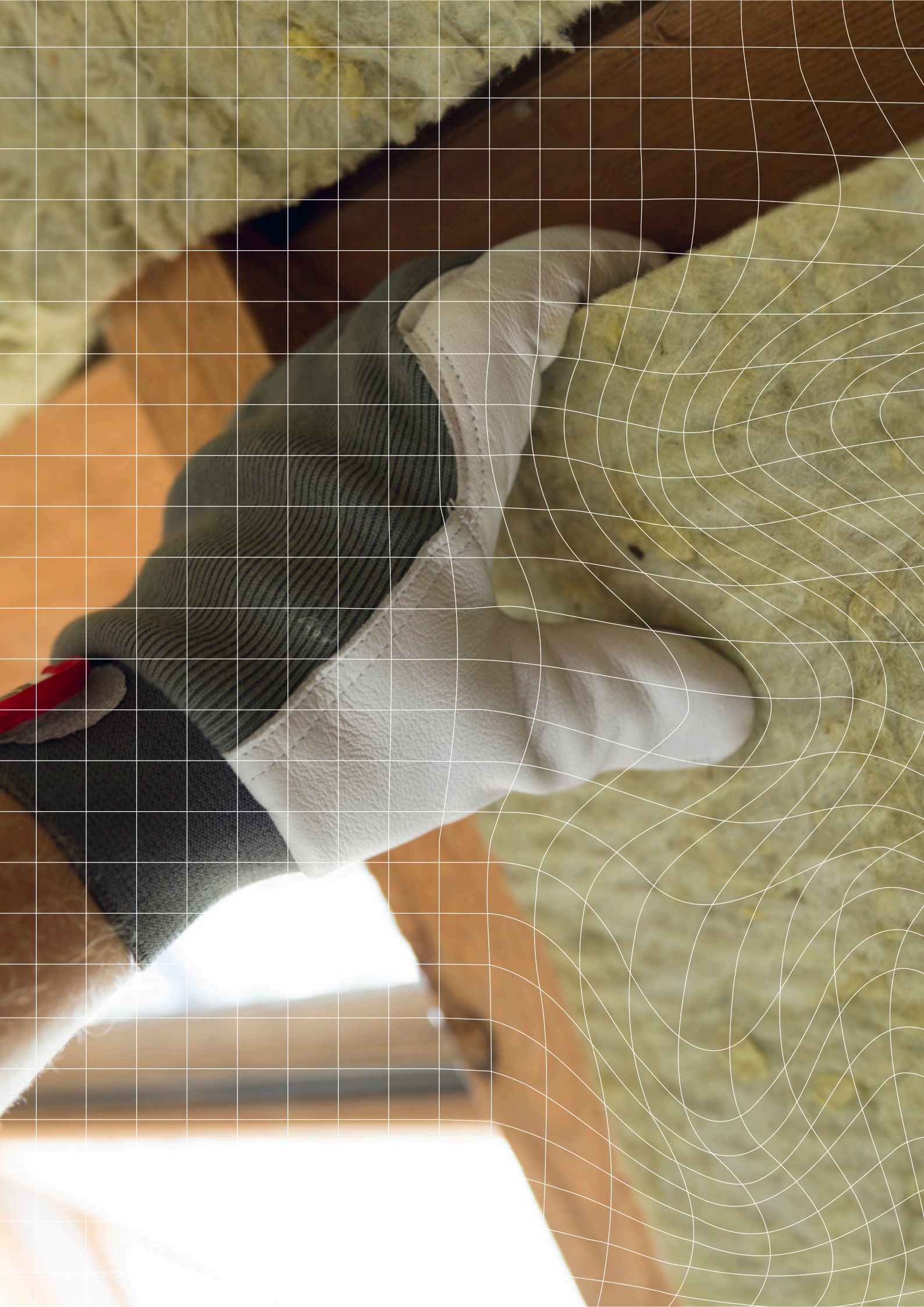
It is ultimately a decision for the Welsh Government to clarify how performance against the First Carbon Budget is measured, but in our 2020 Wales Progress Report assessment of performance against the First Carbon Budget we assume that it is measured on an equivalent basis (i.e. the First Carbon Budget will be assessed against the inventory containing data for 2016 to 2020 that is published in 2022).

Endnotes

[1] CCC (2017) *Building a low-carbon economy in Wales – Setting Welsh carbon targets*.

Chapter 5

Policy to meet the targets



Introduction and key messages

The Environment (Wales) Act requires the Welsh Government to set out proposals and policies for meeting carbon budgets. After legislating the first carbon budget in 2018, the Welsh Government published a low-carbon delivery plan for Wales in 2019, outlining how it intended to meet this budget.

As noted in the Progress Report that accompanies this Advice Report, the First Carbon Budget is likely to be met in Wales. However given the Welsh Government's ambitions to set a Net Zero target for 2050, and the stretching targets we have recommended on the path to that goal, the Government's forthcoming 'All Wales Plan' for the second carbon budget, will need to recognise these new ambitions, and deliver the action required also to get on track to meeting the more stretching targets for 2030 and beyond.

Meeting the recommended targets will require concerted policy effort across a wide range of sectors. Some policy areas are fully devolved to the Welsh Government, while others are reserved or only partially devolved. In the areas where powers are reserved to the UK Government, it will be important for the Welsh and UK Governments to work together to ensure that the policy framework is strong. The Welsh Government should also seek to support Welsh public bodies and businesses to access UK-wide funding wherever feasible.

Our policy recommendations include areas where powers are devolved, together with actions that the Welsh Government can take indirectly in areas such as planning, procurement and the potential to act as a convenor to facilitate action.

Our key messages in this chapter are:

The green stimulus measures put in place in response to the COVID-19 pandemic can form the foundations of a decade of climate action.

- **Build climate policy into the recovery from the pandemic.** There is evidence that a range of low-carbon and climate adaptation 'green stimulus' measures fulfil both the short-term and long-term requirements of policies to support an economic recovery from COVID-19, while also building resilience to climate change and driving the transition to Net Zero. The Welsh Government has taken some positive early steps to bring forward green investment to support the recovery.
- **The full range of devolved and reserved policy levers must be used together.** Delivering the transition in Wales will require effective collaboration between the Welsh and UK governments, and a strong policy framework that works across all levels of government. The UK cannot achieve Net Zero in 2050 without strong policy from Wales across key areas – including planning, agriculture, land use, housing regulations, and local government – and the Welsh Government cannot meet its target without the right policy and financial commitments from Westminster.
- **Net Zero must become the responsibility of all Welsh Ministers and all public bodies.** Historically, climate action has been led by the parts of government which deal with energy and the environment. Increasingly, action on reducing emissions to Net Zero and ensuring policies are resilient to climate change will need to be led by all parts of government and driven from the centre. The Welsh Government's structure and the Well-being of Future Generations Act give the Welsh Government a head start in building the type of coordinated, cross-government policy that is needed to address climate change.

- **The 2020s will be crucial in mainstreaming Net Zero solutions.** Scale up of low-carbon technologies and behaviours will be needed in all areas to set the conditions for mass rollout from the 2030s onwards. By the 2030s choices in all areas should default to the low-carbon, rather than high-carbon, option.
- **Specific sectoral challenges will need to be tackled**, including action by Welsh Government to deliver low-carbon buildings, electric vehicle infrastructure, reduced waste, plans for industrial decarbonisation, and transformational changes in land use.
- **A major delivery challenge remains** to extend action to reduce emissions into all areas of the economy, within a portfolio of cross-economy policy that accelerates a fair and just transition to Net Zero. This will need:
  - **Consistent low-carbon policy packages** for all sectors, developed within a systems approach, including a clear long-term direction, investable incentives, removal of non-financial barriers and investment in innovation and skills.
  - **Regulation,** acting to phase out high-carbon technologies and behaviours, supported by **a rebalancing of carbon pricing** to favour low-carbon options in all applications.
  - **Public engagement** around the need for climate action, information about how to reduce emissions and involvement in decisions on how best to achieve a transition.
  - **A plan for achieving a just transition for Wales** for people, workers, consumers and regions, building on HM Treasury's Net Zero Review.
  - **Encouragement and enabling of businesses and local authorities** to deliver ambitious climate objectives, through workable business models, removal of barriers to action, and a strategy for how local action can complement action at the national level.

This chapter summarises the Committee's recommendations for Welsh climate policy in the following sections:

1. Building a resilient recovery from the pandemic
2. Setting the foundations for Net Zero in the 2020s
3. Cross-cutting priorities for Net Zero in Wales
4. Sectoral priorities for Net Zero in Wales

1. Building a resilient recovery from the pandemic

The months ahead have huge significance. The steps that the world and the UK take to rebuild from the COVID-19 pandemic and its economic damage can accelerate the transition to low-carbon activities and improve our climate resilience. Short-term choices that lock-in emissions or climate risks must be avoided.

In April 2020, we wrote to the Prime Minister and to the First Minister of Wales advising on why climate change measures should play an integral role in the recovery from the pandemic, and setting out six principles for a resilient recovery (Box 5.1).[1]

Our Costs and Benefits Advisory Group on Net Zero, which we reconvened for our 2020 Progress Report to Parliament, endorsed those principles and concluded that *"the economic recovery from COVID-19 gives the UK a chance to grow back in a way that is fit for the low-carbon future to which it aspires, and that can benefit from the industrial and economic developments that this future offers."*

Following this, we set out strong evidence in our 2020 Progress Report to Parliament, to support a range of low-carbon and climate adaptation 'green stimulus' measures. Many can be delivered quickly and have high multipliers, high numbers of jobs created, and boost spending. In the long term, a transition to a low-carbon, efficient and resilient economy will bring productivity benefits throughout the economy. This includes:

- Investments in low-carbon and climate-resilient infrastructure.
- Support for reskilling, retraining and research for a Net Zero, climate-resilient economy.
- Upgrades to our homes and other buildings ensuring they are fit for the future.
- Action to make it easy for people to walk, cycle, and work remotely.
- Tree planting, peatland restoration, green spaces and other green infrastructure.

Our recommendations also covered the increasing need for a just transition and avoiding 'lock-in' of greenhouse gas emissions or increased climate risk. Fiscal measures were also considered, particularly carbon taxes or trading scheme auctions which can support the public finances and strengthen incentives to reduce emissions.

They are particularly attractive when global oil prices, and therefore consumers' energy costs, are low, as they are now. Particular attention is needed to where the costs and benefits of action fall, given the uneven effects of the COVID-19 crisis.

The Committee has set out six principles to guide an economic recovery from the COVID-19 pandemic.

Box 5.1
Six principles for a resilient recovery from COVID-19

The Committee's principles to guide the recovery are as follows:

1. Use climate investments to support the economic recovery and jobs.
There is a detailed set of investments needed to reduce emissions and manage the social, environmental and economic impacts of climate change. Many are labour-intensive, shovel ready, spread geographically across the UK and will have high multiplier effects. Government can act to bring these investments forward, often without direct public funding or by co- financing to accelerate private investment, as part of a targeted and timely stimulus package with lasting, positive impacts.

2. Lead a shift towards positive long-term behaviours.
There is an opportunity to embed the new social norms, especially for travel, that benefit wellbeing, improve productivity, and reduce emissions. Government can lead the way through its own operations (e.g. encouraging home working and remote medical consultations), through public communications and through infrastructure provision (e.g. prioritising resilient broadband investments over the road network, improving safety for cyclists), and investing in measures to facilitate social distancing on public transport.

3. Tackle the wider 'resilience deficit' on climate change.
This crisis has emphasised the importance of evidence-led preparations for the key risks facing the country. Comprehensive plans to reduce emissions and to prepare for climate change are not yet in place. Strong policies from across government are needed to reduce our vulnerability to the destructive risks of climate change and to avoid a disorderly transition to Net Zero. Business must also play its part, including through full disclosure of climate risks. Plans must be implemented alongside the medium-term response to COVID-19 and will bring benefits to health, well-being and national security.

4. Embed fairness as a core principle.
The crisis has exacerbated existing inequalities and created new risks to employment in many sectors and regions, placing even greater priority on the fair distribution of policy costs and benefits. The response to the pandemic has disproportionately affected the same lower-income groups and younger people who face the largest long-term impacts of climate change and will be most affected by the transition to a Net Zero economy. The benefits of acting on climate change must be shared widely, and the costs must not burden those who are least able to pay or whose livelihoods are most at risk as the economy changes. It is important that the lost or threatened jobs of today should be replaced by those created by the new, climate-resilient economy.

5. Ensure the recovery does not 'lock-in' greenhouse gas emissions or increased climate risk.
It is right that actions are taken to protect jobs and industries in this immediate crisis, but the Government must avoid 'lock-in' to higher emissions or increased vulnerability and exposure to climate change impacts over the long term. Support for carbon-intensive sectors should be contingent on them taking real and lasting action on climate change, and new investments should be resilient to climate change.

6. Strengthen incentives to reduce emissions when considering fiscal changes.
Changes in tax policy can aid the transition to Net Zero emissions. Many sectors of the UK economy do not currently bear the full costs of emitting greenhouse gases. Revenue could be raised by setting or raising carbon prices for these sectors, and low global oil prices provide an opportunity to offset changes in relative prices without hurting consumers. The UK's future carbon pricing mechanism should be designed to ensure that an appropriate price for carbon is maintained even in times of external shocks, for example through a well-designed floor price.

The Welsh Government is already taking steps towards integrating these principles in its policy plans:

- The Counsel General has convened several roundtables and an advisory group to advise Ministers on the priority areas for a post-pandemic recovery. The group provides independent expert advice on how services such as the NHS, schools and transport can operate in a post-COVID world, and includes two members of the Climate Change Committee.
- The Committee welcomes the focus on decarbonisation within the Welsh Government's list of policy priorities published In October 2020. The *Challenges and Priorities* report takes into account the unequal distributional impacts of the pandemic, and sets out the Welsh Government's short- and long-term priorities to address them.[2] It links the post-COVID-19 reconstruction to the Well-being of Future Generations Act, particularly on the provisions on prosperity, equality, and a greener Wales.

The UK Government has also taken action, though more can be done. The key immediate step was a policy for England only, with the introduction of the Green Homes Grant scheme, though this scheme has increased the amount funding available to the Welsh Government in 2021/22 in the Spending Review.

Further big announcements with potential impacts for Wales include doubling the capacity to be contracted in next year's Contract-for-Difference (CfD) auction for renewable electricity and major new announcements for industrial decarbonisation funds.

The principles that the Committee published will continue to apply, and should continue to inform the development of Wales' post-COVID recovery plans.

- In the short term, with the economy operating well below capacity, action by Government must **protect workers and businesses, restore confidence, stimulate spending and rebuild a greener economy**, particularly for the most affected regions and sectors. These objectives can be strongly complementary to Wales' climate goals and must avoid locking into carbon-intensive activities in the long term.
- For the longer term, Wales must **invest in key assets to build capacity and enable productive activity in the future**. This means investing in climate-resilient low-carbon infrastructure, job creation in low-carbon and climate-resilient industries, training and reskilling of the workforce. It also requires investments in building knowledge, and natural, social and institutional capital. Public money should not support industries or infrastructure in a way that is not consistent with a future Net Zero economy or that increase exposure to climate risks.

The scenarios we set out in Chapter 2 demonstrate that action is needed across the Welsh economy for the entire period from now through to 2050. The scale-up over the coming decade will arguably be the most challenging part of the programme, and the most fundamental to delivering the Net Zero 2050 target. Delivering that scale up will depend on effective policy being developed in the coming year and rolled out over the 2020s (Table 5.1).

The pathways to Net Zero laid out in this report broadly involve two distinct phases for climate policy, with the next decade being vital:

Progress across every sector in the 2020s can ensure the conditions are set for a mass rollout of low-carbon technologies over the 2030s.

- **The 2020s: scale-up.** The UK and Wales must build supply chains and new markets for low-carbon consumer offerings (e.g. electric cars and heat pumps) so that these can scale from being niche offerings to dominate the market and fully push out high-carbon alternatives by 2030 or soon after. Alongside, we must develop and scale up new options for industrial decarbonisation such as carbon capture and storage (CCS), low-carbon hydrogen and engineered emissions removals. Tree planting rates must increase from just 80 hectares in 2019 to at least 4,500 hectares per year by 2025 in Wales and continue to rise to 7,500 hectares per year by 2035.

By 2030, the low-carbon option should be the default option in all areas.

- **From the early 2030s to 2050: roll-out.** Having scaled up the required markets, these will then take around 15 years to flow through the stock of vehicles and houses. Instruments driving implementation in industry and land use should be well developed and continue to drive roll-out at similar rates. But policy will be less about aiming to scale up markets, instead focusing on continuing achieved rates of roll-out, tackling emerging barriers and systems challenges and ensuring fairness across society.

Our scenarios have been developed with a particular attention to the pace at which change is feasible, allowing time for supply chains to scale up and for consumer choices to change. They move in step with the natural turnover of long-lived assets like vehicles and boilers, avoiding increases in embedded emissions or emissions leakage.

Having made more progress to date, the electricity sector is moving to the second phase already. Costs of renewables have plummeted so that subsidies are no longer required, and annual roll-out rates have already ramped up close to levels that will be needed through to 2050. Policy must continue roll-out (e.g. by continuing regular auctions of long-term contracts), unblock barriers (e.g. by better coordinating the onshoring of transmission lines to offshore wind farms) and deal with the system challenges (e.g. through strengthening flexibility markets to accommodate intermittency).

Delivering the changes required to meet Welsh climate targets will only be possible if comprehensive programmes of infrastructure and skills are developed over the same period. Policy must be designed to support business models that will work in the growing markets for low-carbon solutions. Alongside this, focus should be placed on supporting innovation, and bringing forward policy that lowers the cost of finance.

If the required scale-up over the coming decade is to be a success, the key building blocks of policy must be introduced in the coming months.

The next year will be key to setting the foundations of a decade of delivery for climate action, ahead of COP 26.

That takes on added significance as the UK hosts the UN climate talks in Glasgow in November 2021 – setting out a strong and credible policy package to deliver the scale up over the next decade would put the UK firmly on track to Net Zero, greatly strengthening its credibility as a climate leader.

Key milestones for policy to deliver on are set out in Table 5.1.

Table 5.1
Key outcomes to target over the next few years, and milestones towards 2050

Cross-cutting priorities	• Legislate the Sixth Carbon Budget at 965 $MtCO_2e$, including emissions from International Aviation and Shipping (IAS). • Finalisation of multiple strategies and decisions, including: – Net Zero strategy – Final HMT Net Zero review – Decision on carbon pricing following departure from the EU ETS, working with Scotland, Wales and Northern Ireland • Public engagement strategy. • Consistent policies for each sector that: – Provide clear long-term direction – Ensure investable incentives – Remove non-financial barriers to uptake – Prepare for future challenges by supporting innovation	• Legislate a Net Zero target for Wales and targets on the path to Net Zero. • Publish a low-carbon delivery plan that looks beyond the Second Carbon Budget, recognises Wales's Net Zero ambitions and delivers deep emissions reductions across all sectors to 2050. • Build on the UK Climate Assembly process and consider the creation of Welsh Climate Assembly. • Set out strategies for public engagement and to support a just transition. • Ensure that Net Zero is integrated into all policy decisions (e.g. via the Well-being of Future Generations Act) and public bodies are sufficiently resourced to take action. • Accelerate low-carbon investments to support a green recovery. • Work with the UK Government to ensure climate policy remains a core national objective.
Surface transport	• Develop a comprehensive policy package to deliver on the Government's commitment to phase out new petrol and diesel cars and vans by 2030. • Introduce plans for large-scale trials for low-carbon HGVs to be in place by 2024, ahead of a phase-out of new diesel HGVs by 2040.	In Wales' next transport strategy: • Strengthen schemes to support walking, cycling and public transport to reduce demand for higher-carbon travel. This should include maintaining positive behaviour shifts and addressing risks resulting from the COVID-19 pandemic, as well as provision of cycling infrastructure and investment in public transport. • Ensure local transport planning delivers a widespread electric vehicle charging network • Tackle other non-financial barriers (e.g. through parking, use of priority lanes, raising awareness and public procurement). • Set out plans to decarbonise rail in Wales.

Buildings	• Produce a robust and ambitious heat strategy which sets the direction for the next decade. This must include clear set of standards; plans to rebalance policy costs while making low-carbon more financially attractive; plans to introduce green building passports, and a role for area-based energy plans.	• Develop a heat decarbonisation strategy that includes engagement with the public, which can help to secure a local mandate for infrastructure and can help avoid costs and delay. • Provide funding and 'soft' support for building energy efficiency and low-carbon heat, focusing on what has worked elsewhere: local area-based schemes, zoning of incentives well supported by advice, a local list of trusted installers and 'one-stop shop' communication. • Bring together industry and community stakeholders to develop plans to use waste heat from industry to heat Welsh buildings. • Implement a strong set of standards – with robust enforcement – that ensure buildings are designed for a changing climate and deliver high levels of energy efficiency, alongside low carbon heat. • Publish a robust set of standards for new-build homes and legislate in advance of 2023.
Manufacturing & construction	• Publish an industrial decarbonisation strategy that establish business models for both electrification and hydrogen-use in manufacturing, as well as CCS. • By 2030: All ore-based steel-making near-zero emissions. • By 2040: All cement production near-zero emissions.	• Ensure decarbonisation plans are developed in partnership with members of the South Wales Industrial Cluster that are consistent with Net Zero, including deep decarbonisation during the 2030s. • Set out new policies for resource efficiency in industry in the forthcoming circular economy policy package. • Support Welsh businesses to access UK-wide funding. • Develop and implement plans for training and skills for the Net Zero transition, with low-carbon manufacturing being a priority area in Wales.
Electricity generation	• Use the forthcoming Contract-for-difference auction to ensure 40 GW of offshore wind installed in UK waters by 2030, reducing emissions from electricity generation to less than 50 gCO_2/kWh. • Publish the Energy White Paper. • Deliver plans to phase out the unabated combustion of fossil gas for electricity generation (by 2035).	• Drive progress towards the Welsh Government's target of 70% of Welsh electricity consumption being generated from renewables in Wales by 2030 through calling for ambitious deployment of renewables through the UK's contract-for-difference mechanism. • Continue to work with local communities and developers on low-carbon generation projects.
Fuel supply	• Develop and deploy low-carbon hydrogen supply and applications through the 2020s. • Hydrogen strategy, including consideration of the incentive framework and the potential roles for regulation.	• Ensure that decarbonisation plans are developed for gas processing and refining facilities consistent with Net Zero, including deep decarbonisation during the 2030s. • Consider opportunities for low-carbon hydrogen production and use in Wales.
Agriculture and land use, land-use change and forestry (LULUCF)	• Environmental Land Management (ELM) scheme up and running by 2024. • Implement a trading or auctioning system to deliver private sector investment in tree planting. • UK annual tree planting rates of at least 50 kha/year. • National food strategy and white paper.	• Deliver a Sustainable Farming Payment scheme to replace the Common Agricultural Policy. • Strategy to achieve annual tree-planting rates of at least 4,500 hectares/year in Wales by 2030, rising to 7,500/year by 2035.

Aviation and shipping	• Strategies for aviation and shipping (including IAS) that reflect UK Net Zero.	• Continue to pursue international policy action (rather than unilateral action) to reduce emissions in these sectors.
Waste	• Widespread roll-out of CCS, including on energy-from-waste plants. • Recycling rate of at least 70% achieved across the UK, food waste 50% reduction. • No more biodegradable municipal and non-municipal waste sent to landfill from 2025.	• Deliver on the ambitious commitments in Wales' recent 'Beyond Recycling' strategy.
F-gases	• Phase-out of the most harmful F-gases and restricting the use of all F-gases by 80%.	• Participate in the planned GB-wide F-gas cap scheme, either administered by the Environment Agency or through a Welsh regulator. • Review the use of F-gases in Wales' health service and take action to educate clinicians and patients on the global warming impacts of inhalers.
Greenhouse gas removals	• Develop business models for scaling up GGRs, with first plants being built in the second half of the 2020s.	• Work with UK Government to ensure Wales contributes appropriately to UK-wide emissions removals, which will also help to achieve Net Zero in Wales.

Source: CCC analysis based on the milestones to delivering the Sixth Carbon Budget pathway, and HMG (2020) The Government Response to the Committee on Climate Change's 2020 Progress Report to Parliament, Policy Exchange (2020) UK Energy & environment policy timeline.

3. Cross-cutting priorities for Net Zero policy in Wales

Just two years ago, Wales was aiming to reduce emissions to at least 80% below 1990 levels, by 2050. The Committee now recommends that the 2050 goal for Wales should be for an emissions reduction of at least 100% ('Net Zero'), and we now recommend an 89% reduction in Welsh emissions by 2040.

This shift in ambition is necessary to meet the requirements of the UK Net Zero goal and the Paris Agreement, and is possible given the rapid progress in low-carbon technologies and the increasing levels of ambition around the world. Welsh Government policy needs to ramp up to match.

The early foundations for a decade of delivery are being put into place. The Welsh Government has signalled its intent to legislate a Net Zero target for 2050 and has set out ambitious draft plans for waste management, draft transport strategy and a rural support programme that provides funding for public goods, including decarbonisation. Action is ramping up in Westminster that will have significant impacts on decarbonisation Wales.

Delivering Net Zero will require overarching challenges to be addressed, such as public engagement, and a just transition.

A major delivery challenge remains to extend action to reduce emissions into all areas of the economy within a portfolio of cross-economy policy that accelerates a fair and just transition to Net Zero. Historically, climate action has been led by the parts of government which deal with energy and the environment. Increasingly, action on reducing emissions to Net Zero and ensuring policies are resilient to climate change will need to be led by all directorates and driven from the centre of government.

The next Welsh Government will need to recognise this, driving climate ambition from the centre while ensuring all parts of the economy see emissions reduced. This will need:

- **Consistent low-carbon policy packages** for all sectors, developed within a systems approach, including a clear long-term direction, investable incentives, removal of non-financial barriers and investment in innovation and skills. Welsh Government should work with the UK Government on developing policy packages which meet these criteria.
- **Regulation,** acting to phase out high-carbon technologies and behaviours, supported by **a rebalancing of carbon pricing** to favour low-carbon options in all applications.
- **Public engagement** around the need for climate action, information about how to reduce emissions and involvement in decisions on how best to achieve a transition.
- **A plan for achieving a just transition** for people, workers, consumers and regions, building on the Treasury's Net Zero Review.
- **Actions to encourage and enable of businesses and local authorities** to deliver ambitious climate objectives, through workable business models, removal of barriers to action, and a strategy for how sub-national action can complement action at the national level.

This section sets out our advice on the priorities for cross-economy climate policy. It draws heavily on the advice from an expert group that we convened on Net Zero policy (Box 5.2, Figure 5.2), as well as our own analysis, the advice of our advisory groups on health and finance (see Chapter 5 of the Sixth Carbon Budget Advice Report), assessments we commissioned on the role of business and local government, and the proposals from other independent organisations.

This section is set out in six sections:

a) The full range of devolved and reserved policy levers must be used together

b) Net Zero must become the responsibility of all Welsh Ministers and all public bodies and integrated into all decisions

c) Public sector leadership, planning and infrastructure

d) Working with people and businesses

e) A just transition for current and future generations

f) Delivering Net Zero at local level

Box 5.2
Summary of the Expert Advisory Group report on policy for Net Zero

Alongside our work on the UK Sixth Carbon Budget we convened an export policy advisory group to provide input on how cross-sectoral policy can complement the Committee's existing approach to policy advice. The group was chaired by Professor Cameron Hepburn, and consisted of Tera Allas, Laura Cozzi, Michael Liebreich, Jim Skea, Lorraine Whitmarsh, Giles Wilkes and Bryony Worthington.

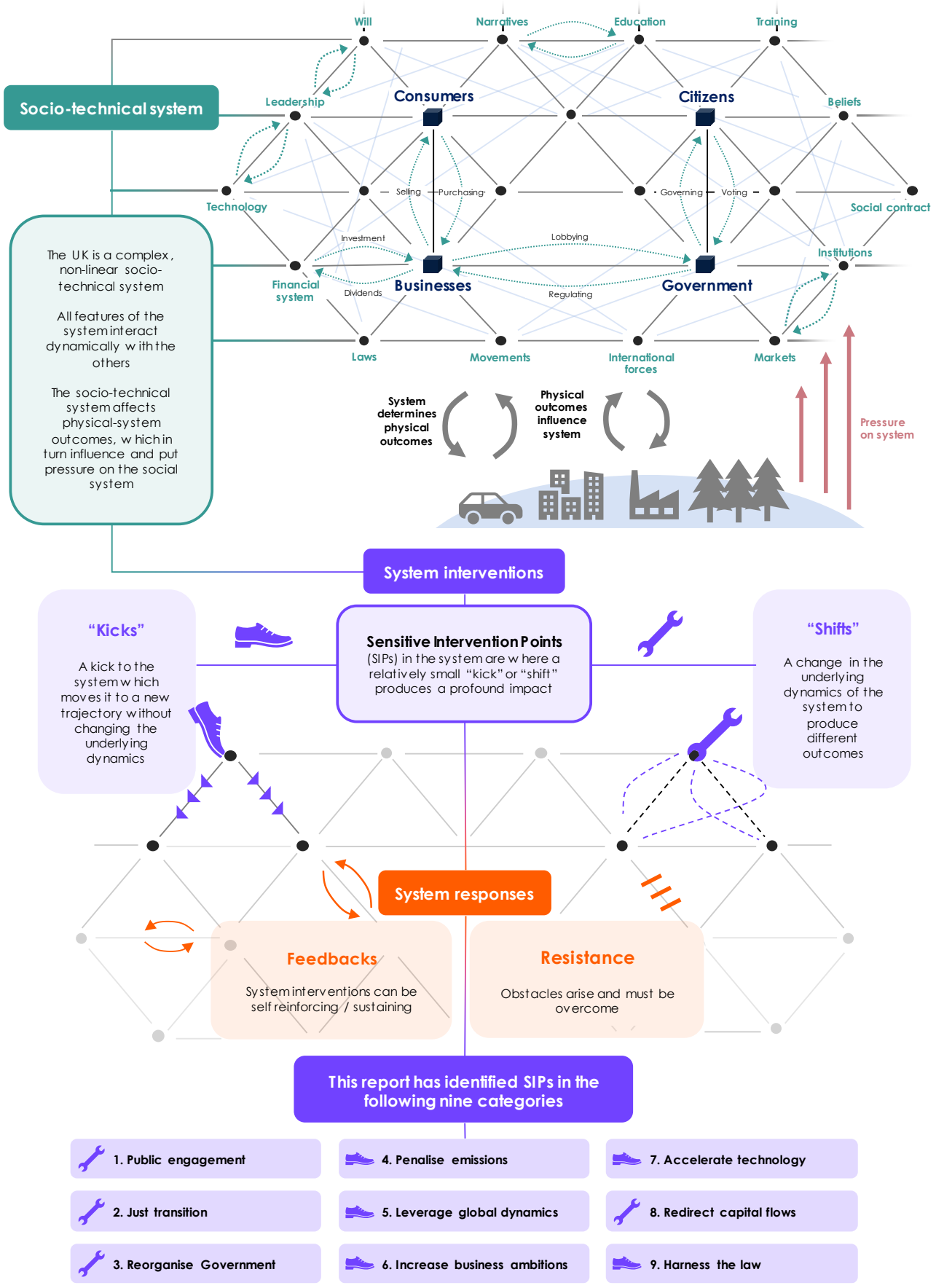
The remit of the advisory group was to think beyond sectoral targets and to suggest cross-cutting, top-down views of how policy could accelerate progress towards achieving Net Zero emissions by 2050. The group had three meetings between July and September 2020. Their report is published alongside our advice on the Sixth Carbon Budget.

The group concluded that the transition to Net Zero can and will occur, and will leave a positive legacy for future generations. They examined the UK as a complex adaptive system and identified recommendations for accelerating progress and reducing the risks of failure (Figure 5.1). The Group recognised an opportunity for Sensitive Intervention Points (SIPs) coinciding with these recommendations, pointing to opportunities to accelerate a transition towards Net Zero by exploiting socio-economic tipping points. These included:

- **Deepening public engagement** through investments to support measures to lower 'thresholds' to behavioural change, such as energy efficiency or dietary alternatives. This can form part of a public engagement strategy for Net Zero that educates the public, involves people in decision-making and provides trusted information at key decision points
- **Delivering social justice** via a clear long-term vision for specific regions coupled with mechanisms that reward the private sector for building industries in otherwise deprived areas, starting now
- **Government leading on Net Zero** by requiring any company meeting with ministers and secretaries of state to have a plan to reach net zero emissions
- **Leveraging global dynamics** by introducing a border carbon adjustment, and consider forming bilateral and multilateral preferential trading arrangements for environmental goods and services
- **Penalising emissions** by committing in the UK's NDC to sequester 10% of CO2 emissions generated by fossil fuels and industry by 2030
- **Increasing business ambition** by identifying businesses that shape industries – celebrate and elevate them
- **Accelerating technology** via Pathfinder cities that can deliver comprehensive steps towards Net Zero, and demonstrate the interactions required across complex systems of low-carbon electricity, heat and transport
- **Redirecting capital flows** by introducing Net zero aligned and transparent accounting and auditing
- **Harnessing legal avenues** by legislating all regulators to regard the Paris Agreement, Sixth Carbon Budget and 2050 Net Zero target in their duties.

Source: Advisory group on cross-cutting policy for the CCC (2020) *Sensitive intervention points to achieve net-zero emissions.*

Figure 5.1 A complexity economics framework for the transition to Net Zero emissions



Source: Advisory group on cross-cutting policy for the CCC (2020) *Sensitive intervention points to achieve net-zero emissions.*

a) The full range of devolved and reserved policy levers must be used together

Delivering the transition in Wales will require a strong policy framework that works across all levels of government. Some key relevant policy levers are devolved to the Welsh Government, while others are held by the UK Government (i.e. they are reserved).

Wales' contribution is particularly important to the UK target due to its large agricultural and manufacturing sectors. The UK cannot achieve Net Zero in 2050 without strong policy from the Welsh Government across key devolved areas including planning, agriculture and land use, public engagement, housing and local government.

The Welsh Government, together with local authorities, can use devolved policy levers on the demand side even where supply-side policies are reserved to the UK Government (e.g. introducing low emission zones, policies to encourage walking and cycling, working from home, and reducing the need to travel long distances through appropriate planning), provide 'soft' support (e.g. advice on low-carbon heat) to support UK-wide or GB-wide policies, and use planning and procurement powers to drive decarbonisation.

While all sectors will require a significant degree of interdependent policy from both the UK and Welsh governments, the nature of devolution means that the balance of policy action varies across different sectors of the economy. This balance can be broadly classified in three ways (Table 5.2):

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

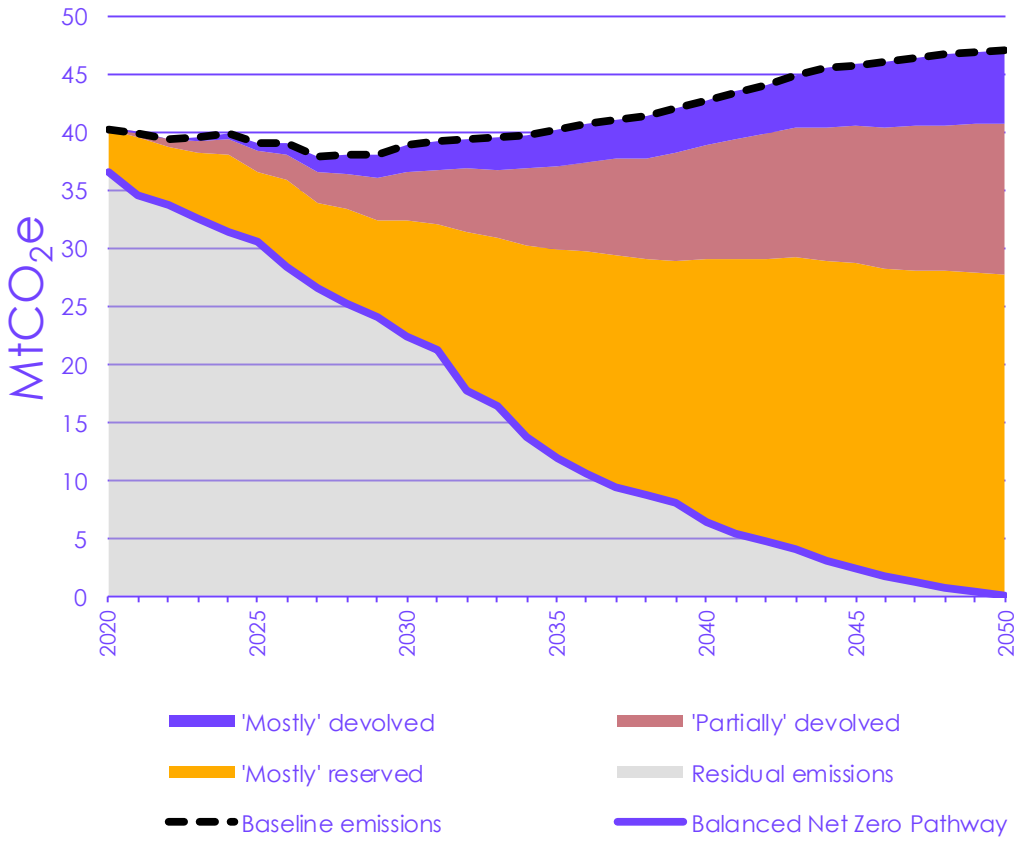
Achieving Net Zero means the full range of policy levers must be deployed. In the Balanced Net Zero pathway, the balance of required action between sectors where levers are devolved and reserved is shared relatively evenly across the economy (Figure 5.2).

Table 5.2
Balance of devolved and reserved powers in Wales for different sectors

'Mostly' devolved	'Partially' devolved	'Mostly' reserved
• Agriculture • Land use, land-use change and forestry • Waste management • F-gases*	• Buildings • Surface transport	• Electricity supply • Fuel supply • Manufacturing & construction • Aviation • Shipping • BECCS for power generation

* A GB-wide scheme is being introduced from 2021.

Figure 5.2 Responsibility for abatement in the Balanced Pathway for Wales is shared by the UK and Welsh Governments



Source: CCC analysis.

b) Net Zero must become the responsibility of all Welsh Ministers and all public bodies, and integrated into all decisions

In our 2019 Net Zero advice, the Committee noted the need for the Net Zero challenge to be embedded and integrated across all levels of Government and in all major decisions that impact on emissions.

Net Zero and adaptation will require cross-government action, led from the centre and integrated to economic strategy. As discussed in the previous section, success will be reliant on co-ordinated action across the UK and Welsh Governments.

As well as collaborating more closely with Westminster to ensure that UK policy works for Wales and vice-versa, the Welsh Government can ensure its own internal structures, public agencies and delivery bodies are well-equipped to deliver the net zero transition and integrate climate ambition with Wales' broader strategic objectives.

Existing structures and systems give the Welsh Government a head start in building the type of coordinated, cross-government policy that is needed to address climate change:

- **Organisational structure.** There are no formal departmental divisions and the Welsh Government instead operates as a single organisation. Within this there are five 'groups', led by four directors general and the Permanent Secretary of the Welsh Government.

  - This structure can help to minimise departmental 'silos' and encourage cross-government working towards shared government objectives). This system is – in principle – suited to working towards the Net Zero goal, provided that objective is strongly endorsed and driven by the centre of the Welsh Government.

  - As action shifts into all sectors of the economy – including those where key policies are devolved such as agriculture, land and waste (Figure 5.2) – the Welsh Government must be adequately resourced to fulfil its decarbonisation objectives under both the Environment (Wales) Act and the Climate Change Act.

- **The Well-being of Future Generations Act** enshrines Wales' global and domestic responsibilities on climate change into Welsh law, and requires all public bodies to consider climate change in their decisions.

c) Public sector leadership, planning and infrastructure

Increasingly, all policy and infrastructure decisions will need to be checked against their consistency with the Net Zero target and the need to adapt to the impacts of climate change.

- **The Welsh Government should lead by example**, by reducing emissions and ensuring climate resilience across its estate, using zero-carbon vehicles, ensuring public bodies report on progress in reducing their own emissions, and assessing climate risks, in line with best practice in the business community.

- **Welsh Government planning frameworks** should be closely aligned to Net Zero (and adaptation) providing a favourable planning and consenting regime for a low-carbon and efficient energy system and climate-resilient infrastructure. Planning guidance should be reviewed (e.g. Planning Policy Wales, and the use of HM Treasury's Green Book) to ensure consistency against this objective. Some commentators also suggest a need for new institutions, such as a Net Zero delivery body to help the delivery of these objectives.

- **The National Infrastructure Commission for Wales** should reflect the Net Zero ambition in its advice to Government on Wales' infrastructure priorities.

- **Procurement.** The public sector in Wales can use procurement rules positively to help drive emissions reductions in a number of areas (e.g. uptake of ultra-low emission vehicles, energy efficiency and low-carbon heat in buildings, low-carbon products).

- **Adaptation must also be integrated into all Government policy** and Wales' plans for reaching Net Zero must be consistent with a changing climate. Climate change brings significant risks to Wales and the Net Zero target does not preclude the need to adapt. Across multiple areas, and in particular on buildings and land use, there are benefits to thinking holistically about how policy can reduce emissions, while ensuring it improves resilience to the UK's changing climate.

d) Working with people and businesses

People will have a crucial role in delivering Net Zero in Wales. An effective policy approach to deliver the Net Zero transition must inform, engage and involve people and business.

People should understand why and what changes are needed, see a benefit from making low-carbon choices and have access to the information and resources required to make the change happen. The engagement strategy should recognise the importance of co-benefits such as improved air quality, comfort and health and the need to adapt to the impacts of climate change, alongside reducing emissions.

A successful public engagement strategy for Net Zero in Wales is likely to require the following:

The public should be engaged around the need for climate action, provided with information about how to reduce emissions and involved in decisions on how best to achieve a transition.

- **Involvement of people in decision-making**, not just persuading them to change, as part of a national conversation on the options available for achieving Net Zero. This should be done in a way that allows people to understand and deliberate over the options available, at a point where people's input is most useful in policy-making – which is likely to differ according to the policy being developed - and in a way that is transparent about how people's decisions will influence the course of action taken.
- **Trusted information** available about the choices being made in the UK's transition towards Net Zero, the reasoning behind and impact of these choices as well as the provision of information available at critical decision points, such as buying a new car or home, delivered using trusted messengers and intermediaries. Tools like the Mackay Carbon Calculator* have been used in promoting an understanding of choices available in the UK, and globally. Further tools, such as a carbon footprint calculator, should also be considered.
- **Educating the public** on the need for climate action to reduce emissions and to adapt to climate change, on the options available for reducing emissions, and on the challenges and opportunities likely to arise during the transition.

People have to be fully engaged and empowered to achieve Net Zero. To date, much of the success in reducing UK emissions has been invisible to the public. Government policy has enabled emissions reductions to proceed in a way that has not required mass engagement, by reducing the 'supply' of emissions into the economy. For example, low-carbon power now provides over 50% of the UK's electricity supply, with no change to the service that electricity provides.

Public engagement will be instrumental in giving Welsh citizens a sense of ownership of and participation in designing climate policy that benefits everyone. Reaching Net Zero emissions will require more involvement from people in engaging with the emissions reductions required, and reducing or adapting demand for energy intensive services:

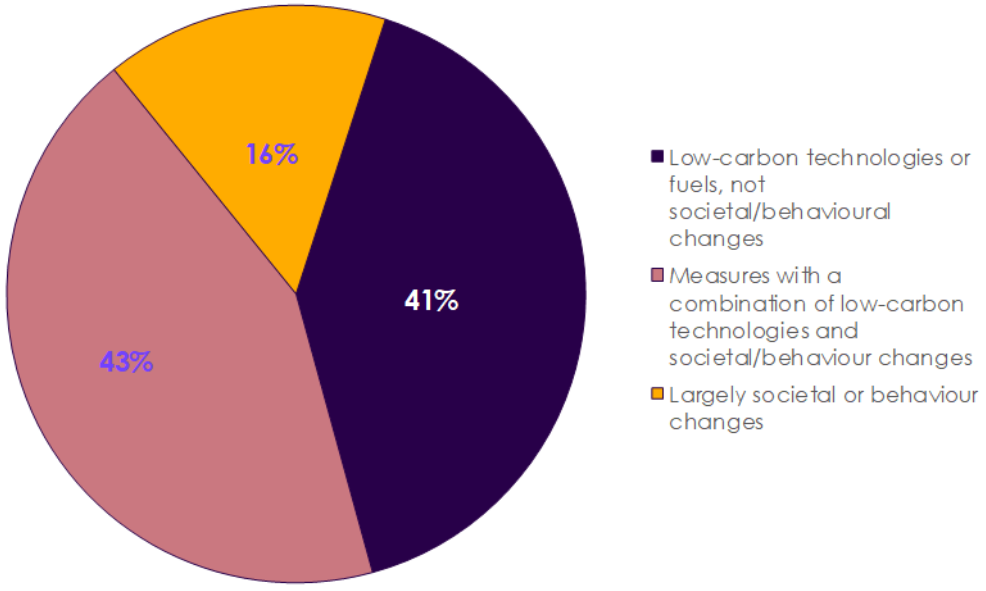
- Over 40% of the abatement in our scenarios to 2035 involves some behaviour changes from consumers as they adopt new low-carbon technologies (e.g. driving an electric car, or installing a heat pump instead of a gas boiler) (Figure 5.3).
- Over 15% of the abatement requires consumer choices – both to reduce demand and improve efficiency. Shifting quickly towards healthier diets, reducing growth in aviation demand and choosing products that last longer and therefore improve resource efficiency are all key. In the Widespread Engagement scenario this is even higher, at 19%.

* The Mackay Carbon Calculator is an online tool, developed by Government, that allows users to make choices on how to meet the UK's 2050 target and see the impact of these choices.

Over half the emissions reductions in our scenarios requires some level of behaviour change.

Figure 5.3 shows that nearly 60% of the changes in the Committee's Balanced Net Zero Pathway for the UK rely on societal or behavioural changes.

Figure 5.3 Role of societal and behavioural changes in the Balanced pathway for the UK (2035)



Source: CCC (2020) The Sixth Carbon Budget.

It will not be possible to get close to meeting a Net Zero target without engaging with people or by pursuing an approach that focuses only on supply-side changes:

Reaching Net Zero will not be possible without involving people in the transition.

- At the moment, the public are generally supportive of action to tackle climate change. 80% of the public are concerned about climate change and 66% of people are now aware of 'Net Zero' specifically, up from around half of people earlier this year.[3] However, only half of people are aware that their gas boiler produces greenhouse gas emissions.[4] People who wish to reduce their impact on emissions are not provided sufficient support to make decisions that achieve this.
- People will need help to make low-carbon choices, both in terms of behaviours and in adopting low-carbon technologies. This will require making low-carbon choices more available and easier to use, provision of information, trials to see what works and policy that learns by doing. Some of the difficult decisions that will be required, (e.g. on the balance of electrification and hydrogen that replaces natural gas heating), will only be possible if people are engaged in a societal effort to reach Net Zero emissions and understand the choices and constraints.

Wider engagement around the need for climate action will be essential in reaching Wales' climate objectives, including public information about how to reduce emissions and involvement in decisions on how best to achieve a transition.

- The UK's Climate Assembly that was convened by UK Parliament has been a welcome step towards understanding public attitudes to achieving Net Zero.

- The Welsh Government has not summoned a Climate Assembly, but it can apply the lessons learned from the UK Climate Assembly. Any programme to engage with citizens and understand the considerations in Wales that are distinct and different from the rest of the UK would be welcomed by the Committee.

While government must set the frameworks for the transition, and citizens must make low-carbon choices, the private sector must invest and transform their business models. This will often be driven and supported by the third sector. Recognising the critical role of the private sector, the Committee is publishing a dedicated briefing note to make the Sixth Carbon Budget recommendations relevant to business in the UK.*

Welsh Government policy should encourage businesses to make these investments and give them the confidence to do so at low cost. Real-economy policy will be key to making low-carbon investments attractive and to overcoming barriers, including on skills and the just transition. However, softer levers and financial rules will also have a role in a complete policy package:

- **Convening role.** It is important the Welsh Government maximises its potential to bring stakeholders together, and facilitate dialogue and strengthen relationships, to enable the development of mutually-beneficial projects that contribute to decarbonisation.
- **Working with the UK Government** to ensure that UK-wide industrial policy works for Wales.
- **Access to UK-wide funding.** The Welsh Government should seek to ensure that businesses have good access to UK-wide funding opportunities where possible and appropriate.

* See CCC (2020) *The role of business in delivering the UK's Net Zero ambition*.

e) A just transition for current and future generations

Fairness is fundamental to public support for decarbonisation, and must be embedded throughout policy. Only a transition that is perceived as fair, and where people, places and communities are well-supported, will succeed. UK Government policy, including on skills and jobs, must join up with Welsh Government and local policy on the just transition. Vulnerable people must be protected from the costs of the transition and benefits should be shared broadly.

Scotland's Just Transition Commission was appointed to advise on a Net Zero economy that is fair for all. It has identified four priorities for achieving a just transition:

1) **Planning ahead** – clear transition plans need to be developed down to the sectoral level so that surprises are minimised. Unplanned transitions tend to be unjust transitions.

2) **Engagement** – people need to be brought into the decision-making process and derive a sense of ownership of the Net Zero project.

3) Bringing **equity** to the heart of climate change policies. Climate policies need to be systematically screened for their impact on vulnerable and excluded groups and for the opportunity to address existing inequalities.

4) **Start now.** The transition is already underway both in the UK and around the world. A strategy that recognises this can put the UK at the forefront of addressing fairness in a transition to Net Zero.

The transition to Net Zero is already underway, so a strategy for a just transition is needed now.

Planning for a just transition must start now. Investing in green jobs, safeguarding livelihoods, and ensuring the costs and benefits of decarbonisation are distributed fairly are crucial aspects of the transition to Net Zero.

- Areas of particular concern in Wales are the decarbonisation of heavy industry and reducing emissions from agriculture. The Welsh Government's commitment to a Climate Just advisory group is an important first step, while the HM Treasury Net Zero review will have important implications for people in Wales.
- Lessons can be learned from Scotland's Just Transition Commission, which identified the key elements of an effective just transition strategy for Scotland, including developing transition plans across the economy, widespread public engagement, fair sharing of costs and support for the vulnerable, starting from today.

f) Delivering Net Zero at a local level

The 22 local authorities in Wales have a duty under the Future Wellbeing of Generations Act 2015 to place sustainable development at the heart of their work. More than half of all local authorities in Wales have declared Climate Emergencies, with the majority of targets focused on making emissions reductions by 2030.

Local authorities, combined authorities and regional agencies have a key role in delivering projects and strategies that reduce emissions and help the UK adapt to a changing climate, and their climate plans can be an effective means of delivering national objectives, but are currently under-resourced for these tasks:

Plans by local authorities can represent 'locally determined contributions' towards meeting the UK' and Wales' climate objectives.

- **Local authorities have direct control of a small proportion of a local area's emissions, but have strong potential influence** over a much larger proportion of emissions through land use and transport planning policies and decisions, housing and waste services and other activities).
- **Local authorities are proposing ambitious climate action at the local level**, which meets, or in some cases exceeds, the top-down climate objectives of the UK and Wales. These action plans can represent 'locally determined contributions' to deliver climate action across Wales. However, there is significant uncertainty around how comprehensively these plans will be delivered, as well as how they fit into national, or indeed neighbouring local, strategies for achieving Net Zero.
- **In Wales local councils and regional bodies are integrated into national climate strategies** through regional energy strategies in Wales.[5]
- **Local authorities have a range of levers at their disposal**, which can shape and deliver climate action in their local area (Box 5.3). However, these levers alone are unlikely to result in sufficient action, without further policy and funding support from Government as part of a comprehensive Net Zero strategy that clarifies the role of local authorities in delivering Net Zero.
- **Local authorities are a cornerstone of climate change partnerships** across the country that link key delivery organisations to deliver Net Zero, resilient and well adapted places that foster nature recovery and support good jobs and skills.

Recognising the critical role of local authorities, the Committee is publishing a dedicated report on the how local authorities can deliver emissions reductions (and how Government should enable them to do so).

Alongside this report and our work on the Sixth Carbon Budget, we are publishing an accompanying report on the role of local authorities in delivering climate action across the whole of the UK. This report summarises the key powers and levers available to local authorities, and provides recommendations to local and national governments on how local authorities can be empowered to deliver climate action, as part of a national strategy to achieve Net Zero (Box 5.3).

Government should support local and regional authorities to deliver climate action, as part of the national strategy to deliver Net Zero.

The Welsh Government should support local authorities to deliver climate action as part of the national strategy to deliver Net Zero, and without mandating how local areas should achieve their climate goals. This is likely to require additional funding for staffing and resources for local delivery plans, alongside a 'duty to collaborate' to encourage authorities to work with local, regional and national partners to deliver their climate ambitions. Without additional support, and some level of coordination there is a risk that local plans fragment a national Net Zero strategy.

- Building on local climate ambition, **Government should consider introducing a duty to act for local authorities, in accordance with Net Zero** and to develop climate action plans within a common reporting system* that can devolve climate accountability to the local level, and empower local authorities to take action.
- **Local authorities will need to be properly resourced and supported** to develop the skills and capacity needed to plan and implement climate action across both emissions reduction and climate adaptation in their local areas.

* Local authorities in Scotland already use a common reporting system. See CCC (2020) *Local Authorities and the Sixth Carbon Budget*.

- **Local areas should work together** as part of a broader dialogue around how local and national action can coordinate action towards Wales' climate objectives. Local area energy plans can be used to increase understanding of how individual areas can achieve Net Zero, and Government should consider introducing a 'duty to collaborate' for local authorities and regional partners and national agencies, so that the plans of neighbouring areas and regions are taken into account in local decarbonisation strategies.

A lack of coordination of sub-national climate strategies, risks missed opportunities.

- **The UK Government's Net Zero Strategy** should align and clarify the roles of national, sub-national, regional government, public bodies and local authorities in delivering the UK's climate objectives. This should provide a clear direction to reduce uncertainty, and additional powers where needed. The recent NAO review on how the Government is coordinating for Net Zero notes that local authorities are currently absent from the Government's coordination strategy.[6] A lack of coordination risks missing opportunities and synergies across local and national plans that could increase costs and slow down the pace of the transition.

Box 5.3
The role of local and regional government in delivering the Sixth Carbon Budget

Local authorities are increasingly ambitious in their plans to tackle climate change. As of October 2020, over 300 UK local authorities had declared climate emergencies – including the majority of local authorities in Wales - and many are now in the process of developing plans to deliver against ambitious Net Zero targets. Local authorities have a range of existing levers that can be used to deliver local action that reduces emissions and prepares local areas to a changing climate. Key powers and duties include:

- A local leadership role to support the economic, health and social wellbeing of communities
- Planning powers over building and transport
- Duties to prevent homelessness and prevent hazards in housing
- Powers to ensure buildings meet basic energy efficiency standards
- Duties to manage risk including climate risks such as flooding
- Duties and powers to protect the environment, wildlife and heritage
- Duties to collect and dispose of waste
- Borrowing and investment powers

However, these levers alone are unlikely to be sufficient to deliver local authorities' Net Zero ambitions, due to gaps in powers, policy and funding barriers, and a lack of capacity and skills at a local level. Additionally, without some level of coordination from Government, the UK risks pursuing a fragmented strategy towards Net Zero.

Alongside our work on the Sixth Carbon Budget and Wales' climate targets, we are publishing an accompanying report on the role of local authorities in delivering the UK's Net Zero ambition. The report aims to provide a framework for aligning climate action at the local level with the CCC's pathways for the UK, as well as recommendations for local, regional and national Governments aiming to remove barriers to delivering local climate action in the UK.

Source: CCC (2020) *Local Authorities and the Sixth Carbon Budget.*

4. Sectoral priorities for Net Zero in Wales

Building on the cross-cutting policy priorities identified in Section 3, progress will need to be made in developing climate policy in all areas of the economy, in order to drive the emissions reductions required by our scenarios.

This section is set out in six parts:

a) Transforming Wales' buildings

b) Decarbonising transport

c) Helping Welsh industry to cut carbon and increase resource efficiency

d) Delivering low-carbon land use and supporting farmers

e) Moving towards a zero-waste economy

f) A low-carbon, flexible energy system

a) Transforming Wales' buildings

Wales' buildings will need to move entirely over to low-carbon heating systems by 2050 at the latest. Boiler lifetimes of around 15 years imply that markets and supply chains for low-carbon heating need to scale up to cover all new installations in Wales by the first half of the 2030s. Sales of new fossil fuelled heating appliances should be phased out by 2028 for homes off the gas grid, and by 2033 for buildings on the gas grid.

The current expectation is that low-carbon heating will have higher financial costs than continuing to install and operate fossil gas boilers. This points to the need for energy efficiency to improve more quickly, and further innovation and investment is also required to drive down installation costs while continuing to improve quality.

As these changes are taking place, resilience measures also need to be included to make homes safe and comfortable in the changing climate, including passive cooling, water efficiency and flood protection.

The Welsh Government has devolved powers on building standards for new-build properties. These should be used to ensure new buildings have a high standard of energy efficiency and are designed for low-carbon heating systems. This will avoid costly retrofit in future and ensure energy bills are no higher than needed. This is an area in which Wales can play a leading role in UK action to reduce emissions. However, regulation of energy markets, oil and gas, electricity and gas networks and consumer protection remain reserved to the UK Government.

Priority areas for the Welsh Government

A clear direction is needed for buildings heat and efficiency in Wales, which sets the direction for the next 30 years, reaching zero emissions from Welsh buildings by 2050 at the very latest, and clearly defines where key actions fall under devolved or reserved powers.

- **Heat decarbonisation strategy.** The Welsh Government should develop a heat decarbonisation strategy* that includes engagement with the public, helping to secure a local mandate for infrastructure and helping to avoid costs and delay:
  - This must be consistent with the forthcoming UK Heat and Buildings Strategy and wider UK Net Zero Strategy, particularly relating to reserved decisions on energy pricing, the gas grid, and reserved powers to regulate energy efficiency in buildings.
  - There should be clear trajectories of standards across the building stock for both efficiency and a phase-out of the installation of new oil and gas boilers, by the late-2020s and mid-2030s at the latest, respectively. Areas designated for low-carbon district heat networks and hydrogen conversion will need to be identified well in advance, to enable buildings in these areas to be given exemptions from fossil phase-out dates where necessary.
  - Electrification, alongside low-carbon district heating schemes where viable, is of primary strategic importance; hydrogen is particularly valuable where it can provide flexibility and could play a role in regional grids, particularly in areas near industrial clusters.
  - Hybrid heating systems (e.g. with a heat pump installed alongside a gas boiler) can play a useful role both on and off the gas grid, at least over the next decade and with scope for enduring benefits beyond.
  - Standards should encourage holistic building designs and retrofit opportunities that incentivise low-carbon heat and energy efficiency, while ensuring buildings are resilient to the future impacts of climate change.
- **New buildings.** The Welsh Government has devolved powers on building standards for new-build properties. These should be used to ensure new buildings have ultra-high standards of energy efficiency and are heated through low-carbon heating systems from the outset. This will avoid costly retrofit in future and ensure energy bills are no higher than needed. As a devolved power, this is an area in which Wales can play a leading role in UK action to reduce emissions.
- **Low-carbon heat and energy efficiency in existing buildings** should be a high priority for the Welsh Government. Heating and regulations around retrofit of energy efficiency are both reserved areas of policy, although the Welsh Government is able to provide funding to retrofit programmes. Despite limited policy levers, under existing powers there are important actions that can be taken to drive and facilitate emissions reductions from buildings:
  - Wales currently participates in the GB-wide Renewable Heat Incentive (RHI), which is due to end in 2022. The Committee's recommendation is that this funding is extended beyond this date, and supplemented by a programme of funding and standards that incentivises the uptake of low-carbon heat and energy efficiency.

* Potentially as part of the low-carbon delivery plan.

  - The Welsh Government can provide funding and 'soft' support for buildings energy efficiency and low-carbon heat, focusing on what has worked elsewhere: local area-based schemes, zoning of incentives well supported by advice, a local list of trusted installers and 'one-stop shop' communication. We recommend regional and local area planning is used to facilitate decisions on the future of heat, sitting within a decision-making framework spanning national, regional and local levels.

  - Local authorities already play key roles in areas such as enforcement of building regulations as well as duties to enforce Energy Performance Certificate (EPC) legislation.[7] This must be a priority. Existing regulations require all privately-rented properties in England and Wales to be at least EPC band E by April 2023. There are proposals for tightening domestic and non-domestic PRS standards in England and Wales. There remain gaps in the Government's regulatory framework to meet the EPC ambitions set out in the Clean Growth Strategy. We recommend a delivery mechanism for social homes and minimum standards at point of sale.

- **Low-carbon heat networks** are a competitive and flexible solution in heat-dense areas such as cities. The Welsh Government can bring together industry and community stakeholders to develop plans to use waste heat from industry to heat Welsh buildings, and use regional and local area planning to identify areas for heat network development now.

- **Supporting actions.** Alongside these priority areas, the Welsh Government should:

  - **Deliver enabling measures to remove barriers to uptake of low-carbon heat.** This includes information provision, skills development and favourable planning regimes.

  - Continue to tackle **the challenges of fuel poverty** (e.g. through the next Fuel Poverty Strategy) and wider issues of housing condition, including overheating, poor indoor air quality and sustainable drainage.

b) Decarbonising transport

Decarbonising emissions from Wales' vehicles will require take-up of low-carbon technologies, low-carbon fuels and efficiency improvements for petrol and diesel vehicles and behaviour change to reduce travel demand and shift journeys onto lower-carbon modes of transport.

- In our scenarios 9% of **car-miles can be reduced** (e.g. through increased home-working) or shifted to lower-carbon modes (such as walking, cycling and public transport) by 2035, increasing to 17% by 2050.

- A high take-up of **electric vehicles** (EVs), resulting in the end of sales of new conventional cars, vans and plug-in hybrids (PHEVs) by 2032 at the latest. From 2030, regulatory approval to drive fossil fuel cars, vans and motorbikes should be limited to 2050 so that remaining fossil fuel vehicles are removed from the fleet at that point. High take-up of EVs will require significant roll-out of charge points.

- **Heavy goods vehicles.** There is currently considerable uncertainty over the most cost-effective and feasible decarbonisation option for heavy goods vehicles (HGVs), and Government will need to fund large-scale trials of different technologies to gain a better understanding of options and for the market to develop.

A comprehensive policy package will be needed from UK Government to deliver on its new commitment to phase out sales of new petrol and diesel cars and vans by 2030, including ensuring that plug-in hybrids play no more than a niche role by then.

A further commitment should be made to phase out sales of diesel heavy goods vehicles no later than 2040, supported by large-scale trials in the near term. Recharging and refuelling infrastructure will need to develop to meet the range of emerging needs.

Effective demand-side policy is also essential – we identify significant opportunities and advantages to reducing travel demand, but this will not happen without support from both UK and Welsh Government to make low-carbon modes of transport the default option.

The COVID-19 pandemic is already changing how people travel, and provides an opportunity to encourage sustainable behaviours such as working from home and active travel (e.g. walking and cycling). Some cities are already redesigning streets to encourage walking and cycling instead of car use. Without Government support in these areas there is a risk of lower use of public transport and increased use of cars, in the short term.

Priority areas for the Welsh Government

The main devolved policy levers for transport are on the demand side. We therefore focus on ways that Wales can cut emissions by using these levers, which also have wider benefits, together with actions that can facilitate uptake of ultra-low-emissions vehicles.

- **Public transport and especially active travel** can reduce emissions from road transport, especially in the nearer term. Walking and cycling can have considerable health benefits, whilst reduced car use will improve air quality. There is potential to recycle revenue from clean-air zones into cycling infrastructure and public transport, including procurement of ultra-low-emissions buses. The Welsh Government should strengthen schemes to support walking, cycling and public transport to reduce demand for higher-carbon travel, and to lock in positive changes to travel habits in response to the COVID-19 pandemic. Wales' should set out a plan to decarbonise its rail network, which will be nationalised from February 2021.

- **Supporting uptake of ultra-low-emission vehicles**. Uptake of electric vehicles has been slow in Wales to date. It is important to develop a better network of charging points, especially in mid-Wales, and tackle other non-financial barriers (e.g. through parking, use of priority lanes, raising awareness and public procurement). More progress is needed to support EV charging for those without off-street parking, for shared car parks and renters. Development of charging infrastructure will benefit from grants made available by either the UK or Welsh Governments but will also require private investment, including by regulated electricity network companies, notably the Distribution Network Operators (DNOs) that are developing investment business cases that will be submitted to Ofgem for the period 2023-2028.

These can be delivered through the upcoming Welsh Transport Strategy. The draft Strategy contains promising proposals that place active travel and public transport at the top of the transport hierarchy, encourage remote working, and make commitments on public charging infrastructure.

c) Helping Welsh industry to cut carbon and increase resource efficiency

Our Balanced Net Zero Pathway sees manufacturing & construction emissions in Wales reduced by 33% by 2030, 95% by 2040 and 97% by 2050 from 2018 levels, based on fuel switching, carbon capture and storage (CCS) and improvements to resource and energy efficiency. Additionally, production of fossil fuels will be much lower by 2050, and bioenergy resources will increase in line with expanding UK production of forestry residues and perennial energy crops, with a wholesale shift to use with CCS accelerating during the 2030s.

- Improvements in resource and energy efficiency lead to the largest emissions reductions in the early 2020s, with smaller contributions from electrification, biofuel use and material substitution. Fuel switching and CCS deployment scale up from 2025.
- Infrastructures for CCS and hydrogen are deployed from 2025 in the pathway, starting near industrial clusters. Electricity network connection capacity is also increased around newly electrifying sites. The 2030s sees substantial scale-up across these three major networks.
- Policy develops rapidly to ensure that it pays for companies to implement societally cost-effective measures and that non-financial barriers are addressed.
- Supply chains scale up at pace in the pathway. More workers acquire skills to implement low-carbon measures, the supply of necessary technologies and equipment grows, and the availability of finance increases.

For the decarbonisation of manufacturing, construction and fuel supply industries to succeed in Wales, **the UK Government must move from the current piecemeal approach to a comprehensive transition support framework**. Taxpayer funding will be key in early years to ensure industries stay internationally competitive while reducing emissions. The development of longer-term policies, such as border carbon tariffs or carbon standards, should begin immediately, for example through development of improved measurement of carbon-intensity. Policy must tackle both the demand-side and supply-side for low-carbon products and ensure relevant infrastructure is available.

Priority areas for the Welsh Government

The Welsh Government has roles to play in industrial decarbonisation, particularly through schemes which promoting energy efficiency and resource efficiency, incentivising low-carbon heat in industry, and developing a skilled workforce for the low-carbon jobs of the future.

- **Set out new policies for resource efficiency in industry in the forthcoming circular economy policy package.** This should encourage the reuse, repair and remanufacture of products and materials, and maximise the economic and social opportunities of a more circular economy, with a particular focus on policies for encouraging efficiency within manufacturing and construction. Further funding should also be made available through Wales' Circular Economy Fund, which has made £3.5m of funds available, as part of Wales' post-COVID response.[8]

- **Support Welsh businesses in accessing UK-wide funding.** Some current funding is available to support the decarbonisation of UK industry, via the Industrial Energy Transformation Fund (IETF), Clean Steel Fund, Industrial Decarbonisation Challenge and others. Welsh Government can provide 'soft' support for Welsh businesses to access this funding.

- **Skills and training.** Develop and roll-out of plans for training and skills for the Net Zero transition, with low-carbon manufacturing being a priority area in Wales. As a key constraint for the pace of the Balanced Pathway, the capacity of skills and supply chains needs to be increased. While this can be partially achieved through demonstration projects, additional work on mapping supply chains and future skills gaps is likely to be needed. As part of this, the Welsh Government can consult engineering, procurement and construction organisations and training institutions on new training courses for the required upskilling.

d) Delivering low-carbon land use and supporting farmers

Delivering emissions reductions in agriculture and land-use in Wales will require a transformation in the use of land while supporting Welsh farmers.

Our scenarios for deep reductions in land-based emissions balance the need to reduce emissions with other essential functions of land, including maintaining food production (which will help prevent the off-shoring of emissions), climate change adaptation and biodiversity. They require the rapid adoption of low-carbon farming practices, a shift to less carbon-intensive diets and sustainable improvements in crop yields, such that at least 19% of agricultural land in Wales is released by 2050 for actions that reduce emissions and sequester carbon.

- By 2030 our Balanced Pathway involves planting a cumulative 43,000 hectares of mixed woodland in Wales to remove CO_2 from the atmosphere as they grow, increasing to a total of 180,000 hectares by 2050.

- Our Balanced Pathway involves a 20% shift away from meat and dairy products by 2030, with a further 15% reduction of meat products by 2050. These are substituted with plant-based options. This is within range of the Climate Assembly's recommendations for a 20-40% reduction in meat and dairy consumption by 2050. Our pathway results in a reduction in livestock numbers and grassland area, delivering annual abatement of 1 $MtCO_2e$ by 2035 in Wales, rising to nearly 1.3 $MtCO_2e$ by 2050.

- We assume food waste is halved across the supply chain by 2030 in line with the Waste and Resources Action Programme's (WRAP) *UK Food Waste Reduction Roadmap*. This would reduce total UK emissions by almost 1 $MtCO_2e$ in 2035.

- A further 56,000 hectares of agricultural land can shift to bioenergy production (including short rotation forestry) by 2050. Peatlands must be restored widely and managed sustainably. Low-carbon farming practices must be adopted widely, while raising farm productivity.

- Alongside nature-based removals, the UK is very likely to need bioenergy (largely grown in the UK) with CCS to deliver engineered removals of CO_2 at scale – though this may not necessarily be located in Wales.

We set out detailed recommendations on policy for land and agriculture in January 2020. These must be implemented in a way that is fair to farmers. The priorities remain: a strengthened regulatory baseline to ensure low-regret measures are adopted; incentive schemes such as auctioned contracts to drive afforestation; and enabling measures to address issues such as skills, supply chains and barriers for tenant farmers. Policy design must account for the challenges of the changing climate and reflect wider environmental priorities, including for biodiversity, to harness potential synergies and avoid unnecessary trade-offs. Policies are also needed to cut food waste and encourage a reduction in consumption of meat and dairy.

Priority areas for the Welsh Government

Wales' Net Zero and climate resilience goals will not be met without changes in farming and land use. The agriculture, land-use and waste sectors present an opportunity for the Welsh Government to demonstrate its low-carbon credentials by mobilising the full range of devolved powers in these sectors. Sufficient funds must be made available to Wales by the UK Government to replace the Common Agricultural Policy (CAP), commensurate with the scale of contribution that Wales' land can make to reducing UK emissions. Some schemes will benefit from UK-wide co-ordination, including a market mechanism for tree planting – which would, for example, allow Welsh land managers to be paid to offset emissions from flights taking off from England – and a UK-wide Bioenergy Strategy.

- The **Welsh Government's successor to the EU's Common Agricultural Policy** (CAP), will be critical. Wales are considering responses to its consultation to replace the CAP with a similar type of payment scheme for delivering environmental benefits ('Sustainable Farming Payment'). A second mechanism is being developed to help farm businesses (Business Support Payment).
    - Multiple opportunities exist, including transitioning to plant-based food (e.g. cereals and legumes), growing bioenergy crops, lower-carbon livestock production and receiving income for low-carbon land management (such as increased tree-planting or peatland restoration, much of which in our scenarios occurs on land released from raising livestock).
    - For farmers, raising awareness and the provision of training on the adoption of sustainable management practices is crucial.
- **Forestry**. Whilst the Welsh Government has previously announced highly ambitious tree-planting targets, current rates are far below the level needed to reach these. The Welsh Government should simplify and streamline the process for supporting tree planting, in order to reduce the barriers to action.
- **Introduce new schemes to address non-financial barriers** to change such as retraining and awareness raising, tackling tax treatment of woodland creation and tenancy and landlord constraints.
- **Encourage consumers to shift to lower-carbon diets and reduce food waste**. The Welsh Government should implement low-cost, low-regret actions to encourage a shift away from meat and dairy (e.g. the public sector taking a lead in providing plant-based options with all meals. A food waste reduction strategy should include immediate low-cost measures (e.g. target setting in the public and private sectors); measures to 'nudge' consumers towards best practice and mandatory separate food waste collection.

- **Support wider public interest objectives.** Reducing emissions and increasing carbon sequestration sit alongside many other public interest objectives for Wales, including adaptation to climate change and biodiversity. Policies to increase carbon sequestration should be implemented in a way that also supports these wider objectives, for example by aligning the timing and security of payments for different environmental goods.

e) Moving towards a zero waste economy

Achieving significant emission reductions in the waste sector requires a step-change towards a circular economy, moving away from landfill and energy from waste* (and the associated methane and fossil CO_2 emissions), and towards a reduction in waste arisings and collection of separated valuable resources for re-use and recycling. This applies at local, regional and national levels.

Overall, Wales' waste policy and long-term targets are ambitious and – if delivered successfully – would put Wales on track to substantially reduce emissions from this sector.

Priority areas for the Welsh Government

Wales currently recycles 62.8% of municipal waste today, which is one of the highest recycling rates globally. In December 2019, the Welsh Government consulted on a new circular economy strategy '*Beyond Recycling*'. This contains a number of ambitious near-term and longer-term targets:

- A 'zero waste' goal for 2050, aiming to phase out residual waste to landfill and incineration (an effective 100% recycling rate from all sectors).
- Development of minimum preparation for re-use targets for local authorities, and prioritising re-used and remanufactured content in the goods that the public sector procures.
- A 50% reduction in food waste by 2025, against a 2006-07 baseline, and looking to go further after 2025.
- 70% recycling of all waste by 2025, as well as statutory local authority recycling targets at the same level. A £6.5 million fund is available for local authorities and public bodies to increase their recycling rates. Improved waste collections for Welsh businesses are also being implemented,[13] with bans on the landfilling or incineration of specified separately collected recyclable materials.

If all successfully enacted, the above goals would substantially reduce future waste sector emissions. Wales currently has a target of an 80% reduction in waste sector emissions by 2020, and 92% by 2030, compared to 1990 levels. However, the 2020 target looks extremely challenging, given the latest 2018 data of a 62% reduction and little change since 2016. Wales' Landfill Allowance Scheme, which focused on reducing landfill of biodegradable municipal waste, also ended in March 2020.

Wales' current 'Towards Zero Waste' strategy from 2010 has similar recycling targets, along with targets for <10% of municipal waste to be landfilled by 2020, and <5% by 2025. These existing targets may be built on or superseded by other metrics when Wales' final circular economy strategy is published.

* Including Energy from Waste (EfW) incineration along with other waste to power/heat conversion technologies, such as gasification and pyrolysis plants classified as 'Advanced Conversion Technologies' (ACT) by BEIS.

The Welsh Government should:

- **Introduce the ambitious actions on material efficiency**, including material substitution, that were announced in the Beyond Recycling consultation.
- **Introduce mandatory business food waste reporting** to help achieve reductions in food waste, building on the current voluntary approach,[9] alongside reductions in household food waste. Wales achieving the UN's Sustainable Development Goal 12.3 (halving per capita food waste by 2030) would also free up more land for carbon sequestration.
- **Ensure new energy from waste plants are future-proofed for CCS.** New energy from waste plants (and plant expansions) above a certain scale should only be constructed in areas confirmed to soon have CO_2 infrastructure available, and should be built 'CCS ready' or with CCS.[10] Local councils should be carefully considering the fossil emissions from waste to energy plants, and how these plants will retrofit CCS in the future.
- Legislate for and **implement a ban on landfilling of all biodegradable municipal and non-municipal waste from 2025**. There must be sufficient recycling/composting/AD treatment capacity made available before the ban comes into force, so that significant increases in energy-from-waste are avoided.

f) A low-carbon, flexible energy system

Most levers related to the UK's energy system are reserved. The decarbonisation of the power sector has been a strong UK success story so far, where a combination of policies – including carbon pricing, regulation, de-risking of investment and planning policy – have enabled the electricity supply sector to lead UK decarbonisation ahead of other sectors. UK policy will still have an important role in future to ensure the market delivers sufficient scale and flexibility to support the decarbonisation of the rest of the economy.

Carbon pricing is an important element of power sector decarbonisation. Emissions trading is a devolved matter (although other possible mechanisms for pricing carbon – such as a carbon tax – may be reserved). Until now the UK has participated in the EU Emissions Trading System (EU ETS), and the UK Government has led negotiations with the other EU Member States regarding what follows from 2021.

At the time of writing, the future of UK carbon pricing beyond 2020 was still uncertain.

Priority areas for the Welsh Government

The Welsh Government should:

- **Set out an updated assessment of how much renewable and dispatchable low-carbon electricity generation will be required to meet Net Zero in Wales** and contribute cost-effectively to Net Zero in the UK, with a clear trajectory to 2050. This will require working with energy network companies and local authorities to develop a clear vision of changes to gas and electricity demand that might be expected within Wales as heat, transport and industry are decarbonised in line with Welsh emissions targets and UK-wide carbon budgets.
- **Work with the UK Government to deliver a phase-out of the burning of unabated gas for electricity generation by 2035,** ensuring that existing gas plant in Wales are given opportunities to switch to low-carbon hydrogen or fit CCS, within their economic lifetime.
- In partnership with the UK Government and the governments of Scotland and Northern Ireland, **ensure that the UK's future carbon pricing strategy reduces emissions from the power sector.**
- **Align Planning Policy Wales (PWP) to a Net Zero energy system** by ensuring Wales has a favourable planning and consenting scheme for onshore wind and other renewables, and supporting repowering and life extension of existing wind power in Wales.

Endnote

[1] CCC (2020) Letter: *Building a resilient recovery from the COVID-19 crisis to Prime Minister Boris Johnson*.

[2] Welsh Government (2020) *COVID-19 reconstruction: challenges and priorities*.

[3] BEIS (2020) *Public Attitudes Tracker*.

[4] BEIS (2020) *Public Attitudes Tracker;* Energy Systems Catapult (2020) *Net Zero: A Consumer Perspective.*

[5] NAO (2020) *Achieving Net Zero*.

[6] NAO (2020) *Achieving Net Zero*.

[7] CCC (2019) *UK housing: Fit for the future?*

[8] Welsh Government (2020) *£3.5m Circular Economy fund for public bodies to support a green recovery opens.*

[9] WRAP (2020) *Food Waste Reduction Roadmap*.

[10] DECC (2009) *Carbon Capture Readiness (CCR)*.

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Advice Report:
The path to a Net Zero Wales

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